

Faculty of Electrical and Electronic Engineering Technology



HAZWAN HISHAM BIN BADRUL HISHAM

Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours

SMART MOTOR MECHANICAL MULTIMETER

HAZWAN HISHAM BIN BADRUL HISHAM

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



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2022

DECLARATION

I declare that this project report entitled "Smart Motor Mechanical Multimeter" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.



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 Automation & Robotics) with Honours.

Signature	set and profi
Supervisor	Name : TS. DR. ALIZA BINTI CHE AMRAN
Date	: 27/1/2023
Signature	اونيوم سيتي تيڪنيڪل مليسيا ملاك UNIVERSITI TEKNIKAL MALAYSIA MELAKA
Co-Superv	isor :
Name (if a	ny)
Date	:

DEDICATION

We would like to dedicate this project report to our family. We also want to dedicate this project report for our beloved supervisor, Ts. Dr. Aliza Binti Che Amran.

Next dedication would be for our future juniors who would make this report as their reference or source of information, we wish all of you good luck and just hang in there, and you will survive this.

Furthermore, to future users that might be interested in this project, we are glad to inform you that you pick the right project as this one will not let you down. Please have a deeper look and gain your understanding more regarding this project in our report.

Last but not least, we dedicate this project report to ourselves for all the sleepless night, our times spent to finish this project and for all the brilliant ideas that we have worked on together as a team to make this project a success. Hopefully this report will be useful for anyone who reads it.

ABSTRACT

Most of the industries use a high or low AC induction motor in their production line. These motors are used as industrial drives and they execute important processes in the industries such as manufacturing. Thus, a proper maintenance or services to these induction motors are vital to ensure all the process flow smoothly and not to be interrupted due to the induction motor broke down or not fully functioning. The objective of this project is to develop a prototype Smart Motor Mechanical Multimeter. This "mechanical multimeter" aims to provide facilitation and convenience to the maintenance technician where this device enables them to monitor vibration and temperature remotely, effortless yet reliable. The remotely monitored temperature and vibration can be viewed using Raspberry Pi. The Raspberry Pi is a micro-controller with touchpad that has GUI (Graphical User Interface) was implemented on this project to monitor vibration and temperature sensor of an induction motor. Two types of sensors were used. LM35 sensor and piezoelectric vibration sensor were implemented to measure temperature and vibration respectively. Both parameter monitoring can be viewed online and offline from the touchpad. To verify the data measured by the prototype, an industrial thermal gun, manufactured by Flir, is used. Both data were compared, and their comparison results showed that the error were relatively small. This shows that the temperature monitoring feature of the prototype is functional and more reliable compared to vibration sensor. Thus, future work for the prototype is to improvise the vibration monitoring. This prototype carries a commercial value because of its potential to assist temperature monitoring of a motor at an affordable cost, as compared to Distributed Control System (DCS). This will help Small Medium Enterprise (SME) local companies to grow supported by this prototype for motor's health condition remote monitoring i.e. temperature.

ABSTRAK

Kebanyakan industri menggunakan motor aruhan AC tinggi atau rendah dalam satu-satu production line. Oleh itu, penyelenggaraan atau perkhidmatan yang betul kepada motor aruhan ini adalah perlu untuk memastikan semua aliran proses dan tidak terganggu akibat motor aruhan rosak atau tidak berfungsi sepenuhnya. Objektif projek ini adalah untuk merekabentuk, membangunkan dan menguji satu prototaip yang dinamakan Multimeter Mekanikal Motor Pintar. Projek ini memberikan kemudahan kepada juruteknik kerana alat ini membolehkan mereka untuk memantau getaran dan suhu motor secara jarak jauh dengan sangat mudah namun amat boleh dipercayai. Parameter yang boleh dipantau daripada jarak jauh ini boleh dilihat menggunakan teknologi Raspberry Pi. Raspberry Pi adalah satu mikro-pengawal dengan pad sentuh yang mempunyai GUI (Graphical User Interface) yang disambungkan kepada dengan penderia getaran dan suhu untuk memantau serta mengukur hasil motor. Dua jenis penderia digunakan. LM35 dan penderia getaran piezoelektrik masing-masing digunakan untuk mengukur suhu dan getaran. Kedua-dua parameter ini boleh dilihat secara atas talian dan secara lepas jalur di skrin lapik sentuh. Bagi menentusahkan data pengukuran suhu oleh alat ini, satu alat pengukur haba industri, dikeluarkan oleh Syarikat Flir, digunakan. Kedua-dua data iaitu data pengukuran prototaip dan data pengukuran alat pengukur haba Flir dibandingkan. Hasil perbandingan menunjukkan ralat yang kecil dan ini menunjukkan prototaip ini berfungsi dengan baik kerana berupaya mengukur data suhu dengan tepat berbanding data penggetar. Sebagai cadangan, fungsi pengukuran gegaran masih perlu ditambahbaik. Prototaip ini mempunyai nilai komersial kerana potensinya untuk memudahkan pemantauan suhu motor di kilang dengan kos yang berpatutan, berbanding dengan Sistem DCS. Ini bermakna banyak syarikat IKS tempatan boleh dibantu perkembangan mereka dengan disokong oleh alat ini bagi memudahkan mereka memantau keadaan kondisi motor dalam kilang mereka, iaitu pengukuran suhu, secara jarak jauh.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my gratitude to my supervisor, Ts. Dr. Aliza Binti Che Amran for their precious guidance, words of wisdom and patient throughout this project.

I am also indebted to University Technical Malaysia Melaka (UTeM) and my parents for the financial support which enables me to accomplish the project. Not forgetting my fellow colleague, lecturer for the willingness of sharing his thoughts and ideas regarding the project.

MALAYSI

My highest appreciation goes to my parents and family members for their love and prayer during the period of my study. An honourable mention also goes to my classmate for all the motivation and understanding.

Finally, I would like to thank all the staffs at the faculty, fellow colleagues and classmates, the faculty members, as well as other individuals who are not listed here for being co-operative and helpful.

-2.0

ە ئىھ

TABLE OF CONTENTS

PAGE

DECI	ARATION	
APPR	OVAL	
DEDI	CATION	
ABST	RACT	i
ABST	RAK	ii
ACKN	NOWLEDGEMENTS	iii
TABL	E OF CONTENTS	iv
LIST	OF TABLES	vi
LIST	OF FIGURES	vii
CHAI		1
INTD		1
1.1	Background	1
1.2	Problem Statement	2
1.3 1.4	Scope of Project SITI TEKNIKAL MALAYSIA MELAKA	3 4
CHAI	PTER 2	5
LITE	RATURE REVIEW	5
2.1	Introduction	5
2.2	Overview of an Induction Motor Proventive Maintenance Overview of an Induction Motor	5
2.3	2.3.1 Thermal Monitoring of an Induction Motor	0 9
	2.3.2 Vibration Monitoring of an Induction Motor	10
2.4	Overview of Existing Research Project	11
	2.4.1 Design and Construction of Induction Motor Thermal Monitoring	10
	2 4 2 The Contact Vibration Sensor	12
2.5	Graphic User Interface (GUI)	17
2.6	Database	18
2.7	Summary	19

CHA	PTER 3	21		
МЕТ	HODOLOGY	21		
3.1	Introduction	21		
3.2	Hardware Development	22		
	3.2.1 Raspberry Pi	23		
	3.2.2 Touch Screen Panel	25		
	3.2.3 Power Supply	26		
	3.2.4 Vibration Sensor	27		
	3.2.5 Temperature Sensor	28		
	3.2.6 Wiring Diagram	29		
	3.2.7 Flowchart for Electrical System	30		
	3.2.8 Placement of The Smart Motor Mechanical Multimeter	31		
3.3	Software Development	32		
	3.3.1 Overall Working Flowchart Prototype Project	34		
	3.3.2 System Graphical User Interface (GUI) Flowchart	35		
3.4	Summary	36		
CHA	PTER 4	37		
RESI	ILTS AND DISCUSSION	37		
41	Introduction	37		
4 2	Data Conversion or Data Calibration	37		
4.3 Developed Prototype				
4 4	Experiment Setup	40		
	4.4.1 Type of Motor	41		
	4.4.2 Placement Sensors	43		
	4.4.3 Industrial Thermal Gun (Flir)	44		
	4.4.4 Vibration Monitoring Apps	45		
	4.4.5 Overall Data Gain KNIKAL MALAYSIA MELAKA	47		
CHA	PTER 5	53		
CON	CLUSION AND FUTURE RECOMMENDATION	53		
5.1	Introduction	53		
5.2	Conclusion	53		
5.3	Recommendation for Future Research	54		
REFI	ERENCES	55		
APPH	ENDICES	57		
Apper	ndices A: Gantt Chart PSM 1	57		
Apper	ndices B: Gantt Chart PSM 2	58		
Apper	ndices C: Overall Coding for system	59		
Apper	ndices D: Overall Coding for Graphical User Interface (GUI)	62		
Apper	ndices E: Web Server (Apache 2) Coding	64		
Appendices F: Web Server Line Graph Function Coding 6				

v

LIST OF TABLES

TABLE	ABLE TITLE						
Table 2.1	Shows a difference between Predictive and Proactive Maintenance	8					
Table 3.1	A comparison between Raspberry Pi 3 B+ and Raspberry Pi 3 B	24					
Table 3.2	Showing a comparison between Li-Ion and NiMH Battery						
Table 4.1	Specification 3-Phase Induction Motor	41					
Table 4.2	Result of temperature 3-Phase Induction Motor for 1 minute	51					
Table 4.3	Result of calculating the error percentage each of parameters (three						
	اونيونر،سيتي ٽيڪنيڪل مليسيا ملاك	52					
	UNIVERSITI TEKNIKAL MALAYSIA MELAKA						

LIST OF FIGURES

TABLE	TITLE	PAGE				
Figure 2.1	Example of an Induction Motor					
Figure 2.2	A common stator for an Induction Motor					
Figure 2.3	An Induction Motor Rotor for squirrel cage design with labelling	7				
Figure 2.4	An induction motor with its labelling part by part	9				
Figure 2.5	A temperature sensor SMT160	10				
Figure 2.6	A Piezoelectric Sensor	11				
Figure 2.7	A placement of the Sensor	11				
Figure 2.8	اونيوسيتي تيڪنيڪAn output signal SMT160	12				
Figure 2.9	UNIVERSITI TEKNIKAL MALAYSIA MELAKA Location of the temperature sensor are located inside an Induction					
	Motor	13				
Figure 2.10	The designed project by H. Hafezi, A. Jalilian.	14				
Figure 2.11	Result of graph Temperature vs time of an Induction Motor	15				
Figure 2.12	Placement of vibration sensor in an Induction Motor	16				
Figure 2.13	An example of Python GUI	17				
Figure 2.14	Touch Screen Display for Raspberry Pi	18				

Figure 2.15	Example of MySQL Database System					
Figure 3.1	Flowchart PSM 1					
Figure 3.2	Block Diagram of "Smart Motor Mechanical Multimeter"					
Figure 3.3	Raspberry Pi Board					
Figure 3.4	Touch Screen Panel					
Figure 3.5	Li-Ion Battery 3.7V	27				
Figure 3.6	Vibration Sensor	28				
Figure 3.7	A temperature Sensor	28				
Figure 3.8	Wiring Schematic Diagram	29				
Figure 3.9	igure 3.9 Flowchart of Electrical System					
Figure 3.10	A 3D Drawing of Placement Sensors to an Induction Motor	31				
Figure 3.11 Flowchart to Programming a Raspberry Pi						
Figure 3.12	Flowchart of Overall Working "Smart Motor Mechanical					
	Multimeter"	34				
Figure 3.13	Flowchart of Working GUI System of "Smart Motor Mechanical					
	Multimeter"	35				
Figure 4.1	Top view of the prototype	39				

Figure 4.2	Side view of the Prototype						
Figure 4.3	Specification for the 3-Phase Induction Motor (motor tag)						
Figure 4.4	The 3-Phase Induction Motor used. Observe the setting of the prototype (mechanical multimeter) is done on the motor	42					
Figure 4.5	Placement for both sensors (temperature and vibration sensor) on the 3-Phase Induction Motor at Electronic Workshop 2, FTKEE	43					
Figure 4.6	A thermal gun instrument from Flir company						
Figure 4.7	Temperature reading from the thermal gun	45					
Figure 4.8 Figure 4.9	Vibration data captured using an application Vibrometer using smartphone Vibrometer is installed and place the smart phone on the motor to	46					
	Capture vibration data NIKAL MALAYSIA MELAKA	47					
Figure 4.10	CSV file in memory Raspberry Pi	48					
Figure 4.11	A GUI line graph trend of the motor.						
Figure 4.12	Google Spreadsheet	50					
Figure 4.13	HTML live trend of the Motor 50						

CHAPTER 1

INTRODUCTION

1.1 Background

Most of industries are using three phase induction motor. A three squirrel cage induction motors are the most popular motors in industries [1]. The squirrel cage induction motors are most widely used in electrical machines for industrial domestic and commercial applications [2]. Thus, to maintain the full potential of the motor it needs to be maintenance or service at one point to ensure the production line is smooth and not interrupted due to the motor broke down or not fully functioning.

اونيۈم سيتى تېكنىكل مليسيا ملاك

To ensure the motor is in good condition, one of the causes that can make induction motor failure is the temperature. The thermal monitoring can be completed by measuring the temperature of the motor by the estimation of the parameter by using the temperature sensor. An induction motor also produce heat due to stator winding of current are very high. Hence, it produces excessive heat [2]. If this would not be taken seriously the results is the destruction of the motor itself. Next, vibration monitoring is widely used to detect the mechanically faults inside the induction motor such as, bearing failure or mechanical imbalance. By using piezo-electric sensor it can detect a vibration and giving a signal of voltage proportional to acceleration of an induction motor [2] [3].

Each of the data can be collected, observed, and can be analyzed by using predictive analysis and advanced method to significant data in form of graph and charts of trend of an induction motor. This real time data can help to utilize to monitor an induction motor.

This prototype concept is to monitor of an induction motor at an affordable cost. Due to micro-controller is Raspberry Pi, Internet of Things (IOT) will be applied in this prototype and touch screen panel with Graphical User Interface (GUI) will also be installed in this project. The major part for this project is to monitor the temperature and vibration of an induction motor and the data can be viewed data online and offline with real-time monitoring of each the parameters.

1.2 Problem Statement

In this modern era, the industrial revolution evolving. Currently in this generation industrial 4.0. What is industrial 4.0? Industry 4.0 is where the revolutionizing the way of manufacturer, improve and distribute their products by integrating new technology. Such as Internet of Things (IOT), cloud computing and analytics with Artificial Intelligence (AI) and machine learning into their production facilities and throughout the operation [4].

For this case, most of industries uses induction motor to manufacturer the product or to move the product. At time Induction motor needs to be maintenance to maintain the efficiency of the motor. To measure or monitor the induction motor it needs to monitor the vibration and the temperature of the motor [2]. In these cases, to monitor each parameter it needs a tools or separate devices to measure and to monitor the parameters of the induction motor. The technician needs to bring a lot of measurement tool just to measure and to monitor each of the parameters.

The technician also needs to record manually of the measured induction motor parameters. These can lead human error when the recording of the measured parameter was carried out manually by a human operator. Furthermore, manual data recording has limitation in terms of its data capturing frequency. Using manual method, a human only could read the meter and record one data in a time interval of two to three seconds. However, using automation, the data capturing will be automize and could reach more data capture, for example, one data recorded in a millisecond.

This prototype Smart Motor Mechanical Multimeter project is to aim make at ease for technician and to give the best analytic of the result measured vibration and temperature. The data can be seen through online and offline with line chart to know the condition of the induction motor itself.

1.3 Project Objective

The main aim of this project is to propose a prototype Smart Motor Mechanical Multimeter.

Specifically, the project objectives are as follows:

a) To design and develop GUI system that can monitor vibration and temperature of a motor.

- b) To save the monitored data online or can be view in offline mode.
- c) To test the accuracy and reliability of the developed prototype.

1.4 Scope of Project

This prototype project is to focus on integrating vibration and temperature sensor to monitor and measure the parameter with Graphical User Interface (GUI) with Internet on Things (IOT) to save the data and these data can be observed through online and offline mode. This prototype also a combination of hardware and software to measure and monitor each of the parameter i.e. temperature and vibration. This prototype focused on these two parameters and will be used to measure and monitor the real-time condition of an induction motor. This can be achieved by connecting the sensors to the micro-controller Raspberry-Pi that connects with the touch panel LCD (Liquid Crystal Display) is to display the GUI. This touch panel will display the information captured by both sensors. Since Raspberry-Pi has a built-in Wi-Fi, a database will be created to save and view the data of the measured parameters. This system is designed to ensure the condition of induction motor can be saved, logged and viewed real-time. The data also can be viewed in the touch panel LCD by offline mode.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

On this chapter will highlights of an existing projects or prototype such as that researched and that has been developed by the previous research group or manufactured products by companies. Most of the prototype projects involves in development by using Arduino or Raspberry Pi with Internet of Things (IOT). Next, literature review is conducted to identify the major reasons or justifications why preventive maintenance of an induction motor is important to ensure the motor runs on full potential in big or small scaled industries.

اويونرسيني تيڪنيڪل مليسيا ملاك 2.2 Overview of an Induction Motor UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Induction motor in Figure 2.1 is commonly used in industrial as well as in main powered home appliances. It is an AC power source to power up the motor. The main advantage of the motor is the motor has simple and rugged design, low cost, low maintenance and direct connection of three phase power source [5]. An induction motor also can be control by using Variable Frequency Drive (VFD) or control system.



Figure 2.1: Example of an Induction Motor

An Induction Motor consists of two major part which is called the stator and a rotor that spins inside the case with engineered of air gap between the two of the part [5].



A stator in Figure 2.2 is made up from several thin lamination of aluminium or cast iron. They consist of holes that clamped together to form a hollow cylinder this form called a stator core with slots. Coil will be winded each slot. All the insulated wires are winded into the hole because it will form an electromagnet by connecting AC supplies, a rotating magnetic field are created [5].

For rotor in Figure 2.3 locates inside of an Induction Motor. Rotors are made up from several thin steel lamination with evenly spaced bar. They are made from aluminium or copper. Almost 90% of induction motors have squirrel cage rotor. This is because the squirrel cage rotor has a simple and robust construction. The rotor consists of a cylindrical laminated core with axially placed parallel slots for carrying the conductors. Each slot carries a copper, aluminum, or alloy bar. These rotor bars are permanently short-circuited at both ends by means of the end rings [5]. The rotor mounted on shaft by using the bearings on to each end of the shaft to normally kept longer than other for driving the load.



Figure 2.3: An Induction Motor Rotor for squirrel cage design with labelling [5]

2.3 Preventive Maintenance Overview of an Induction Motor

All industry has their own maintenance to maintain the equipment of each specific system to make production runs smoothly and minimize downtime of the production line. One of the maintenances for induction motor is preventive maintenance. System improvement through preventive maintenance is important. Preventive maintenance is important due to improve reliability and lifespan of an equipment [6]. Next, preventive maintenance aim is to reduce health and safety risk this is to ensure that induction motor running smoothly and does not harm any of worker that handling a system that equipped with that induction motor [3]. A good preventive maintenance is schedule should prevent the induction motor from failing unexpected, reducing cost, saving time and to ensure the operation continues smoothly. It is also effective and efficiently to the system equipment. Below Table 2.1 shows an example of differences between predictive maintenance and proactive maintenance.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

	Predictive Maintenance	Proactive Maintenance		
Looking for:	Failure symptoms and faults	Root causes		
Example analysis:	Vibration analysis,	Contaminant monitoring		
	Thermography analysis	balance, alignment tools		
Benefits:	Early detection fault and failure	Fault free machine life		
		extension		
Reduced:	Impact of failure	Number of failures		

Table 2.1: Shows a difference between Predictive and Proactive Maintenance

2.3.1 Thermal Monitoring of an Induction Motor

The first important to maintain an induction motor is to monitor the temperature of the induction motor or thermal monitoring. Figure 2.4 shows an induction motor with its exploded parts. Usually, an induction motor temperature rises it is because of the stator interturn faulty. This causes lead long-term thermal aging and deterioration of winding insulation the effect is may lead to severe damage and excessive heating [1]. Thus, to ensure this will not happen in future, thermal monitoring on to an induction motor is a



Figure 2.4: An induction motor with its labelling part by part

To measure and monitor the temperature of an induction motor a temperature sensor Figure 2.5 can be used to monitor and measure the parameter. Temperature parameter will be measured in Celsius or °C.



Figure 2.5: A temperature sensor SMT160

2.3.2 Vibration Monitoring of an Induction Motor

Besides thermal to monitor the health of the induction motor, vibration also one of the important aspects to monitor of induction motor due to induction motor produce some vibrations. One of the sensors that can monitor vibration is the piezoelectric sensor Figure 2.6. The sensor known to perform vibration measurement based on the piezoelectric effect of the piezoelectric materials such as quartz crystal and piezoelectric ceramic [3]. The sensor's function is to convert the vibration signal to electric signal. When the vibration of the measured object puts pressure on the sensor, the sensitive element generates a charge that is proportional to the pressure. Moreover, the charge is also proportional to the acceleration of vibration in terms of Newton's second law. The piezoelectric sensor, as a contact vibration sensor type, is usually installed on the outer casing surface in Figure 2.7 to indirectly measure the vibration of the rotor [3].



Figure 2.6: A Piezoelectric Sensor



Figure 2.7: Red dots show placement of the vibration sensor [3]

2.4 Overview of Existing Research Project

This section is to highlight and to analyze previous research project implementation that has been conducted and is related to this project. Thus, a great variety of researcher conduct a prototype project has been done to develop the best method to improving the prototype of smart motor mechanical multimeter.

2.4.1 Design and Construction of Induction Motor Thermal Monitoring System

In this prototype project, H. Hafezi, A. Jalilian has carried out research where the conducted research is mainly to monitor temperature of an Induction Motor. This prototype by using micro-processor to convert electric signal to light and by converting light to electric signal to get the result of the temperature and saved into a PC. This project used a temperature sensor SMT160 to get the reading of the temperature in °C Figure 2.8.



Figure 2.8: An output signal SMT160 [11]

To get the best reading of the temperature values the researcher installed the sensor inside the case that is between rotor and stator in Figure 2.9.



Figure 2.9: Location of the temperature sensors are located inside an Induction Motor [11]

The project also installed Infrared Receiver and Transmitter at the end of the rotor. Since to resist of electromagnetic interference (EMI), infrared is chosen in this project. A passing pulse train of current through the IR LED to produce light pulses which is transmitted to the receiver.

To save the measured data the compatible computer equipped with I/O, CD4051 multiplexer, PIC16f84A microcontroller with serial RS232 interface are the task to measure, communicate and saved the data of acquisition Figure 2.11. The microcontroller also scans the stator sensors by multiplexer and send to RS232 block along with the rotor temperature data. In Figure 2.10 shows the design of the project.



Figure 2.10: The full experiment setup of designed project by H. Hafezi, A. Jalilian [11]



Figure 2.11: Result of plotted graph Temperature vs time of an Induction Motor [11]

2.4.2 The Contact Vibration Sensor

The PCB company in USA has produced and design a variety of piezoelectric sensors that applied in an Induction Motor or rotating machinery [3]. According to its datasheet the sensor has a different type to detect some certain frequencies range that is 0.5 - 10 kHz with sensitivity ranges of 100mV/g. Figure 2.12 below is an example of the sensor's placement in an induction motor [3].



Figure 2.12: Placement of vibration sensor in an Induction Motor

The piezoelectric sensor has many merits, example is the sensor has wide frequency response and ease to install the sensor. However, the sensor also has shortcomings. A contact vibration sensor types usually installed on the casing of large rotary machinery. This also may cause an overlap of fault signal. Next, it is also need extra power supplies to power up the root-embedded piezoelectric to measure the vibration of the rotary machinery. This requirement may affect to the feasibility of online monitoring the vibration. Lastly, its proven that it is susceptible to electromagnetic interference. The integrating circuit and the charge leakage are also inevitable problems if using this sensor [3].

2.5 Graphic User Interface (GUI)

A graphical user interface is a form of allows user or consumer to communicate or interact with electronic devices through application icon and indicator such primary notation. While in text form user interface or typed command with text navigation. A good design of GUI can help achieve to communicate each of the electronic product [7]. A GUI also can be shown and be used in touch-panel display Figure 2.14. Thus, to implement this system Python Figure 2.13 will be used to make simple and effective GUI to interact the sensors and the micro-controller Raspberry Pi [8].



Figure 2.13: An example of Python GUI [8]



Figure 2.14: Touch Screen Display for Raspberry Pi

2.6 Database

Database or data logger are main role for Internet of Things (IOT) especially when designing a system that needs to save data online or review back the data. The concept of database system is to allow data to be treated at high level abstraction. The database system also differs significantly from the file system or from the electronic that record a data that can be saved [9]. There are many varieties of software that produce a database system. The most used is MySQL system Figure 2.15 or Google Spreadsheet to save an incoming data from the sensors input or from another computer. MySQL and Google Spreadsheet can be communicated by Python programming language. Thus, python can integrate with the micro-controller whether Arduino or Raspberry Pi [10].

ſ	🗲 Quer	ry 1 🗙 🖗	sakila-schema	× 🖋 sakila-data ×			
Ĩ		V V C	۲ 🖪 🕐 🕅	🔉 😥 🌠 🗌 Limit to	o 1000 rows		🥑 Q. 🔳
	1		v 💟 🗠 🛛			- PQ	L
	2	select	* from act	or			
	-						
	100%	20:2					
	Result G	rid 📙 📢	Filter Rows:	Q Search	Edit: 🛃 🔜	Expor	t/lr
	actor_id	first_name	last_name	last_update			
	2	NICK	WAHLBERG	2006-02-15 04:34:33			Result
	3	ED	CHASE	2006-02-15 04:34:33			Gna
	4	JENNIFER	DAVIS	2006-02-15 04:34:33			
	5	JOHNNY	LOLLOBRIGIDA	2006-02-15 04:34:33			
	6	BETTE	NICHOLSON	2006-02-15 04:34:33			Form
	7	GRACE	MOSTEL	2006-02-15 04:34:33			Editor
	8	MATTHEW	JOHANSSON	2006-02-15 04:34:33			
	9	JOE	SWANK	2006-02-15 04:34:33			
	10	CHRISTIAN	GABLE	2006-02-15 04:34:33			
	11	ZERO	CAGE	2006-02-15 04:34:33			Types
	12	KARL	BERRY	2006-02-15 04:34:33			
	13	UMA	WOOD	2006-02-15 04:34:33			ĒÕ
	14	VIVIEN	BERGEN	2006-02-15 04:34:33			
	15	CUBA	OLIVIER	2006-02-15 04:34:33			Query
	16	FRED	COSTNER	2006-02-15 04:34:33			Stats
	17	HELEN	VOIGHT	2006-02-15 04:34:33			
	18	DAN	TORN	2006-02-15 04:34:33			
	N.Y		A.				
	actor	1				Apply	Revert
			2				
2			S I				
LLI.							
-		Figure	2 15. Evam	nle of MySOL	Database St	stom [10	1
		riguit	2.13. LAdin	pic of MySQL	Database 5		1
	2		_				
	3						
	411	-					
		11					
Summary	1. 1	1	1 1 2	/			
J	M.		1.16		1. A	11 . 2.	1.01
	27.00		~, -		\sim, \sim	~,~~~	991
		10 al	N	10.0	11 11	V	

Based on research that have been conducted in chapter two literature review, the purpose of this prototype project is to make a technician at ease to do maintenance on to an induction motor in industry. A "mechanical multimeter" that can read and monitor the vibration and temperature of an induction motor with data logger system that can view in online and offline mode can make monitoring task easier for a technician.

2.7

By considering the past research, a Raspberry Pi shall be chosen to be the main microcontroller of this prototype project. This micro-controller can be programmed in python language and can save all the data that sensors read. Next, it is also can send the data of temperature and vibration to database to review back the condition of an induction motor. Touch screen panel will also be integrated to view and have an option to choose whether to read temperature or vibration of an induction motor and view all the save data of each parameter via Graphical User Interface (GUI) system.



CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter will mainly explain the method of how to construct the prototype project "Smart Motor Mechanical Multimeter". Thus, this section will be explained to investigate, analyze, designing, processing is explained by using a flowchart or block diagram of the system prototype. To achieve the proposed objectives project, process of flow chart Figure 3.1 below are conducted. All the main processes involved in this prototype project will be include from initial step until the project is completed.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Lundo.



3.2 Hardware Development

In this section, will explain about the prototype project of hardware equipment. In Figure 3.2 below shown a block diagram of the hardware development.


Figure 3.3: Raspberry Pi Board

A Raspberry Pi in Figure 3.3 is a low-cost micro-controller that is capable little board that enable consumer to create a project that based on IOT. Mainly uses Scratch and Python language to communicate for this board. Raspberry Pi also has their own operating system that is called Raspbian OS. Below Table 3.1 are the differences between Raspberry Pi 3 B+ and Raspberry Pi 3 B model.

Features / Specs	Raspberry Pi 3 B+	Raspberry Pi 3 B
Release Date	14 th March 2018	29 th Feb 2016
SOC Type (Processor)	Broadcom BCM2837B0	Broadcom BCM2837
WALAYSIA	(with metal cover)	
Core Type	Cortex-A	53 64-bit
No. of Cores	4 C	ores
GPU	Video O	Core IV
Features / Specs	Raspberry Pi 3 B+	Raspberry Pi 3 B
CPU Clock	يتي نيڪٽي1.4 GHz	1.2 GHz
Memory / OS Storage	EKNIKAL MALAY	oSD
RAM	1 GB L	PDDR2
Ethernet	Gigabit Over USB 2.0	Megabit (Max 100Mbps)
	(Max 300 Mbps)	
USB Port	4 x US	SB 2.0
HDMI	1 x Full S	ize HDMI
WIFI	802.11 b/g/n/ac (2.4GHz +	802.11 n
	5GHz & shielded)	
Bluetooth	4.2 (Shielded)	4.1 LE

 Table 3.1: A comparison between Raspberry Pi 3 B+ and Raspberry Pi 3 B

Antenna	PCB Antenna (Similar to	Chip Antenna
	Rpi Zero W)	
GPIO	40 լ	pins
Operating System	Latest Raspbian (> March	Raspbian
	2018)	
Dimension	85mm x	56 mm
PoE (Power over Ethernet)	Yes, require PoE HAT	No

3.2.2 Touch Screen Panel St.



Figure 3.4: Touch Screen Panel

This prototype project will include a touch screen display or panel. This is to display the Graphical User Interface (GUI) as well as all the sensor data. Figure 3.4 shows a touch screen panel that can be used with a Raspberry Pi board.

Features:

- 1. Resolution: 800 x 480 pixel.
- 2. Touch Screen Type: Resistive screen.
- 3. Touch Screen interface is through SPI pins from the 40-pin GPIO.
- 4. Working Voltage/Current: DC 5V / 1A.
- 5. Working Voltage/Current: DC 5V / 1A.
- 6. Working Voltage/Current: DC 5V / 1A.

3.2.3 Power Supply

Figure 3.5 shows is a 14500 Li-Ion rechargeable battery that will power up the Raspberry Pi, touch panel display and both sensors. Table below shows the difference between battery that is displayed in Figure 3.5 and standard AA battery.

UNIVERS	- 14500 Li-Ion Battery	AA NiMH Battery
Size	14mm Diameter	14.5mm Diameter
Max Voltage	4.2 Volt	None
Nominal Voltage	3.7 Volt	1.2 Volt
Rechargeable	Yes	Yes

Table 3.2: Showing a comparison between Li-Ion and NiMH Battery



Figure 3.5: Li-Ion Battery 3.7V

3.2.4 Vibration Sensor

This Analog Piezoelectric Ceramic Vibration Module in Figure 3.6 includes a piezoelectric transducer that responds to strain changes by providing a measured output voltage change that is proportionate to vibration strength, also known as the "piezoelectric effect." It can figure out how much vibration there is. Unlike a digital vibration sensor, which just records timings, analogue vibration sensors are used to detect the magnitude of vibration.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Features:

- 1. Supply voltage: 3.3V or 5V.
- 2. Supply current: < 1mA.
- 3. Operating Temperature Range: $-10 \text{ °C} \sim +70 \text{ °C}$.
- 4. Interface Type: Analog Output.
- 5. Dimension: 30mm x 23mm x 17mm.



Figure 3.6: Vibration Sensor

3.2.5 Temperature Sensor



Figure 3.7: A temperature Sensor

To measure and monitor the temperature. LM35 in Figure 3.7 is a low-cost temperature sensor that is suitable for measure and to monitor temperature of an induction motor. The sensor is calibrated directly in Celsius °C.

3.2.6 Wiring Diagram



Figure 3.8: Wiring Schematic Diagram

In Figure 3.8 is a wiring schematic diagram of the prototype project. Some components example resistor and integrated chip (IC) MCB3008 are just to show on how to work the devices. This is because all the components nowadays are simplified and does not need resistors and integrated chip (IC).

3.2.7 Flowchart for Electrical System



Figure 3.9: Flowchart of Electrical System

3.2.8 Placement of The Smart Motor Mechanical Multimeter



Figure 3.10: A 3D Drawing of Placement Sensors to an Induction Motor

3.3 Software Development

To meet the goals of this prototype project, programming is required. This is due to the fact that most systems must connect with one another in order to obtain data. Python 3 is a programming language used to interface with the Raspberry Pi microcontroller and the Touch Panel Display, which will display the Graphical User Interface (GUI). Before you may use Python 3, you must first install the Raspbian operating system from the Raspberry Pi's official website. Python 3 must be installed after Raspbian has been installed to programme the board. A flowchart for programming the microcontroller is shown in





Figure 3.11: Flowchart to Programming a Raspberry Pi



3.3.1 Overall Working Flowchart Prototype Project

Figure 3.12: Flowchart of Overall Working "Smart Motor Mechanical Multimeter"



3.3.2 System Graphical User Interface (GUI) Flowchart

Figure 3.13: Flowchart of Working GUI System of "Smart Motor Mechanical Multimeter"

3.4 Summary

This chapter summarizes the methodologies that were implemented in achieving all three objectives of this project, the Smart Motor Mechanical Multimeter. For design phase, comprehensive literature review was conducted. Next, to build the prototype, hardware and software development were planned and implemented accordingly. Finally, to test the motor functionality, another data capturing by a conventional tool was proposed. For example, for temperature data, FLIR thermal gun will be used to collect data and compared to the prototype data.

Based on the literature review, data capture results will be accurate if the system's sensor is well-built and placed on an Induction Motor. However, to permanently fix the sensors to motor's body will be costly and not economical. Therefore this project will design the system equipment to be mobile. The meter will be placed only when the motor is inspected, and research is conducted to measure and monitor the data. This prototype also includes a Touch Panel Display to integrate it with the Graphical User Interface (GUI) system. Following that, a wiring diagram was created to prevent a variety of errors and electrical failures. Finally, the apps can be installed on the Raspberry Pi and interface with a database, such as a Google spreadsheet, to preserve the parameter data. As a result, the Smart Motor Mechanical Multimeter can be developed by using the above-mentioned designs.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter describes the outcomes of the "Smart Motor Mechanical Multimeter" initiatives. This chapter will discuss the tabulated results and the data analysis. A device that can measures the temperature in Celsius and vibration of the motor respectively.

4.2 Data Conversion or Data Calibration

To get the precise and accurate readings, calibrate sensor or data conversion were done with both sensors' measurements.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA Celcius = (Temp / 100) + 7 Equation(1)

Before use the temperature sensor, calibration is a must do before considering the measured data to be true. Equation 1 is the line of python language that is to calibrate the temperature sensor. With this line of equation, the system able to measure the temperature with accurate reading in Celsius parameter. Equation 1 is used to convert the temperature sensor data into Celsius.

Same as the temperature sensor, vibration sensor also needs to be calibrated to get the best output reading. Equation 2 is to calibrate the sensor, this to ensure that the percentage of error is less with the actual reading by using a real instrument that can measure the parameters. Equation 2 is used convert the vibration sensor measurement data into vibration measurement.

Vib = (*Vib* / 1000)Equation (2)

Both Equation 1 and Equation 2 are applied into the coding to get the appropriate and meaningful measurement data. The equation also includes into the python ide. This is to ensure the system can measure and monitor of each parameter accurately.

The idea of the system is the data of the sensor reading can stored into the google spreadsheet and save into the Raspberry Pi as CSV file. This project also can give out the trend of each parameter by using html via apache2 web server. It is also can view the Graphical User Interface (GUI) that show the live trend of both parameters to show the health of the 3-phase motor induction.

4.3 Developed Prototype

Several procedures were taken to complete the circuit prototype. The Raspberry Pi, Temperature Sensor, Vibration Sensor, and Touch Screen Panel are the components used in circuit configuration. A Direct Current (DC) from a supply battery power up this system. Each connection between the components must be secure before turning on the power supply. When the outcome is precise and reliable, the prototype case is created to cover all the wires and components.



Figure 4.1: Top view of the prototype



To test the functionality and reliability of the prototype, a real motor has been used in the designated experiment. The developed prototype had been equipped on 3-phase induction motor in Electronic Workshop 2 for a couple of minutes. To find the best result, the sensor is place to the most effective on the motor. This is to ensure the measured data are more precise and less error of percentage. The data needs to be compared to the real instrument by other company. This is to confirm that the objective of this project is accepted which is the objective 3 to test the accuracy and reliability of the developed prototype. To achieve this, a thermal gun is used, manufactured by a company called as Flir.

4.4.1 Type of Motor

To test the reliability of the project, a test had been done at Electronic Workshop 2 in Faculty of Electrical and Electronic Engineering Technology (FTKEE). Figure 4.2 is the specification for 3-Phase Induction Motor to test out the system prototype that we have developed. Figure 4.4 shows the full experiment setup to collect temperature data using the developed prototype as well as the controlled data, using thermal gun Flir.



Figure 4.3: Specification for the 3-Phase Induction Motor (motor tag)

LINIVERSITI TEKNIKAL MALAYSIA MELAKA

Table	Table 4.1: Specification 3-Phase Induction Motor:										
Туре	Minimum Value	Maximum Value									
V	220V	400V									
Hz	50Hz	50Hz									
Min ⁻¹	1420RPM	1430RPM									
А	61	34									

*2 HP and 4 Pole induction Motor



Figure 4.4: The 3-Phase Induction Motor used. Observe the setting of the prototype (mechanical UNIVERSIT multimeter) is done on the motor.

4.4.2 Placement of the Sensors



Figure 4.5: Placement for both sensors (temperature and vibration sensor) on the 3-Phase Induction Motor at Electronic Workshop 2, FTKEE

Figure 4.5 shows the placement for both sensors. The sensors have an enclosure with neodymium magnet, a strong magnet that can attach to the body of the 3-Phase Induction Motor. The most suitable to get the accurate and precise data of each parameter is at the

area of the motor's shaft. The area gets hot and vibrate vigorously when there is abnormal motor running occurred.

4.4.3 Industrial Thermal Gun (Flir)

To get the most accurate and precise data, both sensors were placed on to the motor as shown in Figure 4.4. To show reliability of the prototype, a comparison between the conventional instrument (thermal gun) and the developed prototype are conducted. This is to ensure the project achieves objective number 3 that is to test the developed product.



Figure 4.6: A handheld thermal gun instrument from Flir company



4.4.4 Vibration Monitoring Apps

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Same as the temperature sensor, vibration sensor also needs to place where the motor gives more vibration. In this case, the outcome of most vibration output is near the shaft of the motor. The sensor value will compare with the apps called 'Vibrometer' in Figure 4.7 where this device can sense the vibration of the motor. An example of the captured vibration data is given in Figure 4.8 and Figure 4.9. These interfaces are obtained using the mentioned apps.



Figure 4.8: Vibration data captured using an application Vibrometer using smartphone



Figure 4.9: Vibrometer is installed and place the smart phone on the motor to capture vibration data UNIVERSITI TEKNIKAL MALAYSIA MELAKA

4.4.5 Overall Data Gain

This section will tabulate all the data obtained from each sensor. The data will be divided into two groups which is by online data saved and the offline data saved. This is to ensure the data are tally to each other. Trend will be also included in this section to give maximum output given from each sensor read.

i. Data saved in Raspberry-Pi

In this sub-topic the data are saved in offline mode. All result is saved and can be access inside memory of Raspberry Pi. The saved data in .CSV that can open by excel extension. Trend of the motor can be analyzed by through the CSV file.

		Α	В	С	D		
	1	10:55:00	06/01/2023	23.8	128		
	2	10:55:02	06/01/2023	23.81	110		
	3	10:55:05	06/01/2023	23.81	98		
	4	10:55:07	06/01/2023	23.81	136		
	5	10:55:09	06/01/2023	23.81	174		
	6	10:55:12	06/01/2023	23.82	120		
MA	LA7 31	10:55:14	06/01/2023	23.83	138		
N.	8	10:55:16	06/01/2023	23.83	106		
S	9	10:55:18	06/01/2023	23.84	93		
X	10	10:55:21	06/01/2023	23.84	74		
1	11	10:55:23	06/01/2023	23.84	85		
=	12	10:55:25	06/01/2023	23.84	67		
6	13	10:55:28	06/01/2023	23.84	108		
" An	14	10:55:30	06/01/2023	23.85	72		
- TH	n 15	10:55:32	06/01/2023	23.85	88		
del	16	10:55:34	06/01/2023	23.86	90		
ملاك	17	10:55:36	06/01/2023	23.87	91	وللمصيبة	اويتوم
	18	10.00.00	00/01/0000	12 OC	102		
		d h hel					
UNIVE	R		Ser	isor_re	adin	9. M	ELAKA

Figure 4.10: CSV file in memory Raspberry Pi

In Figure 4.10 shows a data that collected from the temperature sensor in Celsius and the vibration sensor the timestamp refreshes every 2 to save the data. The data will save in file format .CSV this to ensure that the trend can produce and show live or offline data each parameter example in Figure 4.11.

In Figure 4.11 shows a live Graphical User Interface that shows a trend of the 3-Phase Induction Motor. This line graph shows 2 data which is the temperature in Celsius and vibration of the motor versus timestamp. The system able to monitor the induction motor by analyzing the live trend that produced automatically by the system.



ii. Data saved in Google Spreadsheet and Trend HTML chart

In this sub-topic the data are saved in online mode. All results are saved and can be accessed in Google Spreadsheet as shown in Figure 4.12 and view trend in HTML example in Figure 4.13.

P30 * R 0 E F 0 1 2023-01-06 10.55 23.89°C 132.0 1 <td< th=""><th></th><th></th><th>100% - \$</th><th>\$ % .0 .00 1</th><th>23 - Default (A</th><th>ri 🕶 10</th><th>•В.</th><th>I S</th><th>A</th><th>• 🖽</th><th>23 -</th></td<>			100% - \$	\$ % .0 .00 1	23 - Default (A	ri 🕶 10	•В.	I S	A	• 🖽	23 -
n b c b c b c b c b c b c b c b c b c b c b c b c b c b c b c b c b c b c c b c <thc< th=""> <thc< th=""> <thc< th=""></thc<></thc<></thc<>	P30					-	-				
1 20234146 1055 23.89°C 115.0 3 20234146 1055 23.89°C 115.0 4 20234146 1055 23.89°C 129.0 5 20234146 1055 23.89°C 144.0 6 20234146 1055 23.89°C 144.0 7 20234146 1055 23.89°C 144.0 9 20234146 1055 23.89°C 91.0 9 20234146 1055 23.89°C 88.0 11 20234146 1055 23.89°C 72.0 12 20234146 1055 23.89°C 72.0 13 20234146 1055 23.89°C 72.0 14 20234146 1055 23.89°C 138.0 13 20234146 1055 23.89°C 138.0 14 20234146 1055 23.89°C 138.0 15 20234146 1055 23.89°C 136.0 12 20234146 1055 23.89°C 136.0 12 20234146 </th <th>1</th> <th>A 2022 01 06</th> <th>10-55</th> <th>22.80%0</th> <th>04.0</th> <th>E</th> <th>F</th> <th></th> <th>G</th> <th></th> <th></th>	1	A 2022 01 06	10-55	22.80%0	04.0	E	F		G		
2 222341-66 1055 23.88°C 129.0 4 202341-66 1055 23.88°C 129.0 6 202341-66 1055 23.88°C 131.0 7 202341-66 1055 23.88°C 103.0 9 202341-66 1055 23.88°C 103.0 9 202341-66 1055 23.88°C 90.0 10 202341-66 1055 23.88°C 90.0 11 202341-66 1055 23.88°C 80.0 12 202341-66 1055 23.88°C 80.0 13 202341-66 1055 23.88°C 74.0 14 202341-66 1055 23.84°C 74.0 15 202341-66 1055 23.84°C 74.0 16 202341-66 1055 23.84°C 106.0 17 202341-66 1055 23.84°C 136.0 102.0 202341-66 1055 23.81°C 136.0 102.0 102.0 202341-66 1055 23.81°C 136.0 102	2	2023-01-06	10.55	23.89°C	132.0						
4 202301-06 10.55 23.87C 129.0 7 202301-06 10.55 23.86°C 103.0 8 202301-06 10.55 23.86°C 103.0 9 202301-06 10.55 23.86°C 103.0 9 202301-06 10.55 23.86°C 90.0 10 202301-06 10.55 23.86°C 80.0 11 202301-06 10.55 23.86°C 80.0 12 202301-06 10.55 23.86°C 80.0 13 202301-06 10.55 23.86°C 80.0 14 202301-06 10.55 23.84°C 67.0 15 202301-06 10.55 23.84°C 93.0 17 202301-06 10.55 23.84°C 74.0 18 202301-06 10.55 23.84°C 138.0 19 202301-06 10.55 23.84°C 140.0 20 202301-06 10.55 23.84°C 140.0 20 202301-06 10.55 23.80°C 110.0 <	3	2023-01-06	10:55	23.89°C	115.0						
\$ 0223-11-6 1055 23.8°C 144.0 \$ 2023-11-6 1055 23.8°C 140.0 \$ 2023-11-6 1055 23.8°C 140.0 \$ 2023-11-6 1055 23.8°C 91.0 \$ 2023-11-6 1055 23.8°C 90.0 \$ 2023-11-6 1055 23.8°C 72.0 \$ 2023-11-6 1055 23.8°C 74.0 \$ 2023-11-6 1055 23.8°C 106.0 \$ 2023-11-6 1055 23.8°C 120.0 12 \$ 2023-11-6 1055 23.8°C 120.0 12 1223-01-6 1055 \$ 2023-01-6 1055 23.8°C 120.0 12 1223-01-6 1055 23.8°C 120.0 <	4	2023-01-06	10:55	23.88°C	129.0						
• 2023-01-06 10:55 23.86°C 103.0 • 2023-01-06 10:55 23.86°C 90.0 90.0 • 2023-01-06 10:55 23.86°C 90.0 90.0 • 2023-01-06 10:55 23.86°C 90.0 90.0 • 2023-01-06 10:55 23.86°C 80.0 90.0 90.0 • 2023-01-06 10:55 23.84°C 67.0 90.0 90.0 90.0 • 2023-01-06 10:55 23.84°C 67.0 90.0	5	2023-01-06	10:55	23.87°C	129.0						
7 2023-01-06 10.55 23.86°C 103.0 9 2023-01-06 10.55 23.86°C 90.0 10 10 2023-01-06 10.55 23.86°C 90.0 11 11 2023-01-06 10.55 23.86°C 72.0 12 12 2023-01-06 10.55 23.84°C 108.0 13 13 2023-01-06 10.55 23.84°C 67.0 14 15 2023-01-06 10.55 23.84°C 74.0 15 15 2023-01-06 10.55 23.84°C 74.0 16 16 2023-01-06 10.55 23.84°C 74.0 17 18 2023-01-06 10.55 23.84°C 120.0 12 2023-01-06 10.55 23.81°C 120.0 12 2023-01-06 10.55 23.81°C 136.0 19 2023-01-06 10.55 23.81°C 136.0 12 12 2023-01-06 10.55 23.81°C 140.0 12 2023-01-06 10.55 23.81°C 110.0 12	6	2023-01-06	10:55	23.86°C	144.0						
* 2023-01-06 10:55 23.87°C 91.0 10 2023-01-06 10:55 23.85°C 88.0 11 2023-01-06 10:55 23.85°C 72.0 12.0 12 2023-01-06 10:55 23.84°C 70.0 12.0 12.0 12 2023-01-06 10:55 23.84°C 67.0 14.0 15.5 23.84°C 74.0 14 2023-01-06 10:55 23.84°C 74.0 10.0 15.0 12.0	7	2023-01-06	10:55	23.86°C	103.0						
9 2023-01-06 10-55 23.86°C 88.0 1 11 2023-01-06 10-55 23.86°C 72.0 1 12 2023-01-06 10-55 23.84°C 108.0 1 12 2023-01-06 10-55 23.84°C 108.0 1 1 14 2023-01-06 10-55 23.84°C 85.0 1 1 1 14 2023-01-06 10-55 23.84°C 93.0 1	8	2023-01-06	10:55	23.87°C	91.0						
11 2023-01-06 10:55 23.85°C 72.0 12 2023-01-06 10:55 23.84°C 108.0 13 2023-01-06 10:55 23.84°C 67.0 14 2023-01-06 10:55 23.84°C 67.0 15 2023-01-06 10:55 23.84°C 85.0 15 2023-01-06 10:55 23.84°C 74.0 16 2023-01-06 10:55 23.84°C 74.0 17 2023-01-06 10:55 23.83°C 138.0 10 19 2023-01-06 10:55 23.83°C 136.0 10 20 2023-01-06 10:55 23.81°C 136.0 10 21 2023-01-06 10:55 23.81°C 110.0 10 10 22 2023-01-06 10:55 23.81°C 110.0 10 10 22 2023-01-06 10:55 23.81°C 110.0 10 10 23 2023-01-06 10:54 </td <td>9</td> <td>2023-01-06</td> <td>10:55</td> <td>23.86°C</td> <td>90.0</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>	9	2023-01-06	10:55	23.86°C	90.0						
10 2023 01 06 10.95 23.84°C 67.0 13 2023 01 06 10.55 23.84°C 67.0 14 2023 01 06 10.55 23.84°C 65.0 15 2023 01 06 10.55 23.84°C 93.0 16 2023 01 06 10.55 23.83°C 106.0 10.51 19 2023 01 06 10.55 23.83°C 138.0 107.0 107.0 20 2023 01 06 10.55 23.83°C 136.0 107.0 107.0 107.0 20 2023 01 06 10.55 23.83°C 136.0 107.0 107.0 107.0 20 2023 01 06 10.55 23.81°C 136.0 107.	10	2023-01-06	10:55	23.85°C	88.U 72.0						
13 2023-01-06 10:55 23.84°C 67.0 14 2023-01-06 10:55 23.84°C 74.0 11.1 15 2023-01-06 10:55 23.84°C 74.0 11.1 17 2023-01-06 10:55 23.83°C 106.0 11.1 18 2023-01-06 10:55 23.83°C 120.0 11.1 11.1 2023-01-06 10:55 23.83°C 136.0 12.2 2023-01-06 10:55 23.83°C 136.0 12.2 2023-01-06 10:55 23.81°C 136.0 12.2 2023-01-06 10:55 23.81°C 110.0 12.2 2023-01-06 10:55 23.81°C 111.0 12.2 2023-01-06 10:54 23.80°C 111.0 12.2 2023-01-06 10:54 23.80°C 111.0 12.2 2023-01-06 10:54 23.80°C 111.0 12.2 12.2 12.2 12.2 12.2 10.2 12.2 12.2 12.2 12.2 12.2 12.2 12.2	12	2023-01-06	10:55	23.84°C	108.0						
14 2023-01-06 10.55 23.84°C 85.0 15 2023-01-06 10.55 23.84°C 93.0 17 2023-01-06 10.55 23.83°C 106.0 18 2023-01-06 10.55 23.83°C 106.0 19 2023-01-06 10.55 23.83°C 120.0 19 2023-01-06 10.55 23.83°C 120.0 2023-01-06 10.55 23.81°C 174.0 121.0 21 2023-01-06 10.55 23.81°C 136.0 122.2 2023-01-06 10.55 23.81°C 110.0 121.0 122.2 2023-01-06 10.55 23.81°C 110.0 122.2 2023-01-06 10.55 23.81°C 111.0 Figure 4.12: Google Spreadsheet	13	2023-01-06	10:55	23.84°C	67.0						
15 2023-01-06 10:55 23.84°C 93.0 10 16 2023-01-06 10:55 23.84°C 93.0 10 17 2023-01-06 10:55 23.83°C 138.0 10 19 2023-01-06 10:55 23.83°C 138.0 10 20 2023-01-06 10:55 23.83°C 136.0 10 21 2023-01-06 10:55 23.81°C 174.0 10 10 22 2023-01-06 10:55 23.81°C 136.0 10 10 10 22 2023-01-06 10:55 23.81°C 110.0 10 10 10 23 2023-01-06 10:55 23.81°C 110.0 10 10 10 24 2023-01-06 10:54 23.80°C 111.0 10 10 10 10	14	2023-01-06	10:55	23.84°C	85.0						
16 2023-01-06 10.55 23.83°C 106.0 10 17 2023-01-06 10.55 23.83°C 138.0 10 19 2023-01-06 10.55 23.83°C 120.0 10 20 2023-01-06 10.55 23.83°C 136.0 10 10 20 2023-01-06 10.55 23.81°C 136.0 10 10 21 2023-01-06 10.55 23.81°C 186.0 10 10 22 2023-01-06 10.55 23.81°C 186.0 10 10 22 2023-01-06 10.55 23.81°C 128.0 10 10 24 2023-01-06 10.54 23.80°C 111.0 10 10 25 2023-01-06 10.54 23.80°C 111.0 10 10 10 Figure 4.12: Google Spreadsheet	15	2023-01-06	10:55	23.84°C	74.0						
17 2023-01-06 10.55 23.83°C 106.0 18 2023-01-06 10.55 23.83°C 120.0 120.0 20 2023-01-06 10.55 23.81°C 174.0 120.0 21 2023-01-06 10.55 23.81°C 136.0 120.0 23 2023-01-06 10.55 23.81°C 136.0 120.0 23 2023-01-06 10.55 23.81°C 110.0 120.0 24 2023-01-06 10.55 23.80°C 111.0 100.0	16	2023-01-06	10:55	23.84°C	93.0						
18 2023-01-06 10.55 23.83°C 138.0 19 2023-01-06 10.55 23.83°C 120.0 21 2023-01-06 10.55 23.81°C 174.0 120.0 22 2023-01-06 10.55 23.81°C 136.0 122.0 120.0 22 2023-01-06 10.55 23.81°C 110.0 120.0 120.0 120.0 23 2023-01-06 10.55 23.81°C 110.0 120.0<	17	2023-01-06	10:55	23.83°C	106.0						
19 2023-01-06 10-55 23.81°C 174.0 21 2023-01-06 10-55 23.81°C 136.0 22 22 2023-01-06 10-55 23.81°C 196.0 23 22 2023-01-06 10-55 23.81°C 196.0 23 23 2023-01-06 10-55 23.81°C 110.0 24 2023-01-06 10-54 23.80°C 111.0 23 23.80°C 111.0 23 23.201-06 10-54 23.80°C 111.0 24 2023-01-06 10-54 23.80°C 111.0 24 20.20 24 20.20 24 20.20 24 20.20 24 20.20 24 20.20 24 20.20 24 20.20 24 20.20 24 20.20 24 20.20 24 20.20 24 20.20 24	18	2023-01-06	10:55	23.83°C	138.0						
201201-06 10:55 23.81°C 174.0 101.0 21 2023-01-06 10:55 23.81°C 98.0 101.0 22 2023-01-06 10:55 23.81°C 110.0 101.0 24 2023-01-06 10:55 23.80°C 128.0 101.0 101.0 25 2023-01-06 10:54 23.80°C 111.0 101.0 101.0 Figure 4.12: Google Spreadsheet	19	2023-01-06	10:55	23.82°C	120.0						
21 2023-01-06 10.55 23.81°C 196.0 23 2023-01-06 10.55 23.81°C 110.0 24 2023-01-06 10.55 23.80°C 128.0 25 2023-01-06 10.54 23.80°C 111.0	20	2023-01-06	10:55	23.81°C	174.0						
Image: state	21	2023-01-06	10:55	23.81°C	136.0						
Image: series Image: s	7373	202.2-01-00	10.55	23.01 0	50.0						
25 2023-01-06 10.54 23.60°C 111.0 Figure 4.12: Google Spreadsheet	22	2023-01-06	10.55	23.81°C	110.0						
Figure 4.12: Google Spreadsheet	22 23 24	2023-01-06	10:55	23.81°C	110.0						
	22 23 24 25	2023-01-06 2023-01-06 2023-01-06	10:55 10:55 10:54 Figu	23.81°C 23.80°C 23.80°C re 4.12:	110.0 128.0 111.0	e Sprea	dshee	et			
	22 24 25 9021683127 9021683127	2023-01-06 2023-01-06 2023-01-06	10:55 10:55 10:54 Figu	23.81°C 23.80°C 23.80°C	Google	e Spread	dshee	et	Ż		V
	22 24 25 502 168.1 107 502 168.1 107 502 168.1 107 502 168.1 107	2023-01-06 2023-01-06 2023-01-06	10:55 10:55 10:54 Figu	23.81°C 23.80°C 23.80°C rre 4.12:	or pata Live	Spread	dshee	et	2		V
The way of the state of the state of the		2023-01-06 2023-01-06 2023-01-06	10:55 10:55 10:54 Figu	23.81°C 23.80°C 23.80°C	Google	Spread	dshee	et)		V
لوبوفر سىتى بىكىنىكى ملىسىا ملاك	22 24 25 102161127 M 	2023-01-06 2023-01-06 2023-01-06	10:55 10:55 10:54 Tigu	23.81°C 23.80°C 23.80°C	or Data Live	chart	dshee	et			V
اويېۋىر، سىتى يېكىنىكى مىيسىيا ملات	22 24 25 102/1621/127 102/1621/127	2023-01-06 2023-01-06 2023-01-06	10:55 10:55 10:54 Figu	23.81°C 23.80°C 23.80°C	Google	CHART	dshee	t C C C C C C C C C C C C C C C C C C C			ف
اويوم سيتي يتحقيحا مليسيا ملات			10:55 10:55 10:54 Figu	23.80°C 23.80°C 23.80°C 23.80°C sens	OR DATA LIVE	CHART	dshee	et l)	ľ,	ف
۲. البين ميريك المركز المريم المريم المريم من المريم من المريم المريم المريم المريم المريم المريم الم		2023-01-06 2023-01-06 2023-01-06	10:55 10:55 10:54 Figu	23.80°C 23.80°C 23.80°C rre 4.12: sens	OR DATA LIVE	CHART	dshee	et)		
Annand Manand Manual Manual and Annand		2023-01-06 2023-01-06 2023-01-06	10:55 10:55 10:54 Figu	23.81°C 23.80°C 23.80°C	OR DATA LIVE	e Spread	dshee	et			
Here with the second with the second of the		2023-01-06 2023-01-06 2023-01-06	10:55 10:55 10:54 Figu	23.81°C 23.80°C 23.80°C Tre 4.12: sens	OR DATA LIVE	CHART	dshee	et			

Figure 4.13: HTML live trend of the Motor

Time	Date	Temperature, °C	Vibration
10:55:00	06/01/2023	23.8	128
10:55:02	06/01/2023	23.81	110
10:55:05	06/01/2023	23.81	98
10:55:07	06/01/2023	23.81	136
10:55:09	06/01/2023	23.81	174
10:55:12	06/01/2023	23.82	120
10:55:14	06/01/2023	23.83	138
10:55:16	06/01/2023	23.83	106
10:55:18	06/01/2023	23.84	93
10:55:21	06/01/2023	23.84	74
10:55:23	06/01/2023	23.84	85
10:55:25	06/01/2023	23.84	67
10:55:28	06/01/2023	23.84	108
10:55:30	06/01/2023	23.85	72
10:55:32	06/01/2023	23.85	88
10:55:34	06/01/2023	23.86	90
10:55:36	06/01/2023	23.87	91
10:55:38	06/01/2023	23.86	103
10:55:41	06/01/2023	23.86	144
10:55:43	06/01/2023	23.87	129
10:55:45	06/01/2023	23.88	129
10:55:47	06/01/2023	23.89	115
10:55:49	06/01/2023	23.89	132
10:55:51	06/01/2023	23.89	94 او د و
10:55:54	06/01/2023	23.89	81

 Table 4.2: Result of temperature 3-Phase Induction Motor for 1 minute

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

 $\% \ error = \frac{Actual \ Value \ Observed - Expected \ Value}{Expected \ Value} \ x \ 100\%....Equation \ (3)$

Time	Using Project Prototype,	Using Flir Thermal	(T1-T2)/(T2)*100 %
	T1	Gun, T2	
	Observed	Expected	Error, %
	Temperature, °C	Temperature, °C	
10:55:00	23.80	25.30	5.93
10:55:30	23.85	25.35	5.91
10:55:54	23.89	25.39	5.91

Table 4.3: Result of calculating the error percentage each of parameters (three reading samples)

Time	Using Project Prototype, C1	Using Vibrometer, C2	(C1-C2)/(C2) *100 %
	Observed Vibration	Expected Vibration	Error, %
10:55:00	128	152	15.79
10:55:30	72	85	15.29
10:55:54	81 2	96	15.63

Table 4.3 has been tabulated by three measured data samples to calculate the sensor reading error in percentage. The objective is to analyze whether the sensor is reliable and effective compared to the actual instrument to measure the vibration and temperature. It is observed that temperature readings of the prototype were better compared to the vibration readings. Therefore, the proposed system is able to measure temperature accurately with an average error of 5.9%. However, the vibration measurement capability of the developed prototype need to be improved further, as the testing results show that the vibration error has an average of 15%.

CHAPTER 5

CONCLUSION AND FUTURE RECOMMENDATION

5.1 Introduction

This chapter will discuss how the "Smart Motor Mechanical Multimeter" initiatives have been implemented overall. In addition, this chapter will describe various recommendations and future work that can be used to enhance the project.

5.2 Conclusion

The development of the Internet of Things (IoT) has contributed to an increase in peoples' living standards. The motor mechanical meter is used to measure and monitor vibration together with the motor's temperature in Celsius. This is so that it can keep track of the motor's health and display data by producing a line graph that shows its trend. By providing a communication device that utilizes the Internet of Things to send data across the network, the data logging procedure is carried out. It produces products with dependably high quality.

As a result, the development of the "Smart Mechanical Motor Multimeter" projects has been implemented and is able to measure and detect the value of the mechanical parameter such as vibration with temperature in Celsius. Any device that gives output vibration and temperature can make use of the established system. Lastly, it has been successfully demonstrated that this project's design, testing, and sensor's measurement work. However, more advancements can be made to create a more dependable system.

5.3 **Recommendations for Future Research**

This project can be improved in a few different ways. The recommendation is presented as follows:

- The system can be improved in terms of data where speed sensor applies to the project. This is to measure the speed of the motor that can be measured in Revolution Per Minute (RPM) this can improved majorly because speed of motor is important to maintain the healthiness of the 3-phase induction motor.
- In order to improve the vibration monitoring, in next project, the methodology could revise the calibration or conversion equation of the vibration sensor data.
- The system needs to be tested in long term, to analyze more data from the 3-phase induction motor or different 3-phase induction motor model.
- When the 3-phase induction motor has a faulty, a notification implement to the project can be improved for this prototype to alert the user that the motor has a problem or cut-off the power to save the motor.

REFERENCES

- International Conference on Advances in Energy Conversion Technologies 2. 2014
 Manipal, International Conference on Advances in Energy Conversion Technologies 2
 2014.01.23-25 Manipal, and ICAECT 2 2014.01.23-25 Manipal, Intelligent energy
 management: technologies and challenges proceedings of the 2014 International
 Conference on Advances in Energy Conversion Technologies (ICAECT)\$d23-25 January
 2014, Manipal, India. IEEE, 2014.
- [2] A. Bouzida, K. M. Siddiqui, K. Sahay, V. K. Giri, and P. D. Scholar, "Health Monitoring and Fault Diagnosis in Induction Motor-A Review," 2007. [Online]. Available: www.ijareeie.com
- [3] S. Xu, F. Xing, R. Wang, W. Li, Y. Wang, and X. Wang, "Vibration sensor for the health monitoring of the large rotating machinery: Review and outlook," *Sensor Review*, vol. 38, no. 1. Emerald Group Holdings Ltd., pp. 44–64, Jan. 08, 2018. doi: 10.1108/SR-03-2017-UNIVERSITE TEXNICAL MALAYSIA MELAKA 0049.
- [4] C. J. Bartodziej, "The concept Industry 4.0," in *The Concept Industry 4.0*, Springer Fachmedien Wiesbaden, 2017, pp. 27–50. doi: 10.1007/978-3-658-16502-4_3.
- [5] "AC Induction Motor Fundamentals".
- [6] M. A. K. Malik, "Reliable preventive maintenance scheduling," *AIIE Transactions*, vol. 11, no. 3, pp. 221–228, 1979, doi: 10.1080/05695557908974463.

- [7] A. Marcus, "Principles of Effective Visual Communication for Graphical User Interface Design," in *Readings in Human–Computer Interaction*, Elsevier, 1995, pp. 425–441. doi: 10.1016/b978-0-08-051574-8.50044-3.
- [8] IEEE Staff and IEEE Staff, *IEEE Southeastcon 2013*.

UNIVERSITI

- [9] A. Silberschatz, H. F. Korth, and S. Sudarshan, "Database System Concepts Fourth Edition Chapter 2 Entity Relationship Model Chapter 3 Relational Model Chapter 4 SQL Chapter
 5 Other Relational Languages Chapter 6 Integrity and Security Exercises 74 iii iv."
- [10] T. A. Grossman, "Source Code Protection for Applications written in Microsoft Excel and Google Spreadsheet."
- [11] H. Hafezi and A. Jalilian, "DESIGN AND CONSTRUCTION OF INDUCTION MOTOR THERMAL MONITORING SYSTEM."

TEKNIKAL MALAYSIA MELAKA

APPENDICES

Appendices A: Gantt Chart PSM 1

Weeks	Week 1	Week 2	W eek 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15
Activities			MAL	AYSIA											
Literature Reviews		Kulle			No. A. S.										
devices Familiarization		IT TE					U				V				
Data analysis		00	PAINT			_									
Research methodology		12	lo (ل ما	<	عينة	_	تى تە	سب	بونه	اون			
Software drawing and algorithm design		UN	VEF	SITI	TEP	(NIK	AL I	MAL.	AYS	AM	ELA	KA			
Formation of Chapter 1, 2, and 3															

Appendices B: Gantt Chart PSM 2

Weeks	Week	Week	Week	Week	Week	Week	Week	Week	Week	Week	Week	Week	Week	Week
Activities	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Devices testing														
& instrument			MALA	YSIA										
		2			to.									
Electrical		S			1									
Mechanical		N.			S						7			
design		1			_						11			
Discussion with		E							-					
supervisor		23	~						$\mathbf{\nabla}$					
Formation of			un .											
Chapter 1, 2 and 3		4E	با ما	mul	a. 15	2	.:<	ž	; n	بر رس	ونية			
Creation of			ų b	ay a	0		8	4 ³	0.0	· ·				
Chapter 4, 5 & poster		LIMB	/ED	2171.1	-		1. 5.1./			MEL	ALCA			
		UNIT	VERG		EN	AUL/A		ALA1	SIA	IVIEL	ANA	1		
Preparation														
presentation														
Appendices C: Overall Coding for system

import json

import sys

import time

import datetime

import Adafruit_ADS1x15
import gspread
from oauth2client.service account import ServiceAccountCredentials

adc = Adafruit_ADS1x15.ADS1115() GAIN = 1

file = open('Sensor_reading.csv', 'w')
#file.write('Time & Date, Temperature °C, Vibration Output\n')

GDOCS_OAUTH_JSON = 'google-auth.json'

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Google Docs spreadsheet name.

GDOCS_SPREADSHEET_NAME = 'Sensor_Readings'

How long to wait (in seconds) between measurements.

FREQUENCY_SECONDS = 1

def login_open_sheet(oauth_key_file, spreadsheet):

"""Connect to Google Docs spreadsheet and return the first worksheet."""

scope = ['https://spreadsheets.google.com/feeds', 'https://www.googleapis.com/auth/drive']
credentials = ServiceAccountCredentials.from_json_keyfile_name(oauth_key_file, scope)
gc = gspread.authorize(credentials)
worksheet = gc.open(spreadsheet).sheet1
return worksheet

except Exception as ex:

print('Unable to login and get spreadsheet. Check OAuth credentials, spreadsheet name, and make sure spreadsheet is shared to the client_email address in the OAuth .json file!')

print('Google sheet login failed with error:', ex)

sys.exit(1)

try:

print('Logging sensor measurements to {0} every {1} seconds.'.format(GDOCS_SPREADSHEET_NAME, FREQUENCY_SECONDS)) print('Press Ctrl-C to quit.') worksheet = None while True: # Login if necessary.**VERSITI TEKNIKAL MALAYSIA MELAKA** if worksheet is None:

worksheet = login_open_sheet(GDOCS_OAUTH_JSON, GDOCS_SPREADSHEET_NAME)

Vib = [0]Temp = [0]

voltage = [0]

Attempt to get sensor reading.

Vib = adc.start_adc(0, gain=GAIN)

Vib = adc.read_adc(0, gain=GAIN, data_rate=128)

```
Temp = adc.start_adc(1, gain=GAIN)
Temp = adc.read_adc(1, gain=GAIN, data_rate=128)
```

```
voltage = Vib * (4.096/32767)
vibration = (Vib / 1000)
celcius = (Temp / 100) + 5
```

#print('Voltage: %.2fV\n' %voltage)
print('Vibration output: %.2f\n'%vibration)
print('Temperature: %.2f°C\n'%celcius)

```
file.write(time.strftime('%H:%M:%S') + ', ' + time.strftime('%d/%m/%Y') + ', ' + str(celcius) + ', ' + str(vibration) + '\n')
```

file.flush()

Append the data in the spreadsheet, including a timestamp

try:

```
#worksheet.append_row((datetime.datetime.now().isoformat(), temp, humidity))
worksheet.insert_row((datetime.datetime.now().strftime('%Y-%m-%d'),
datetime.datetime.now().strftime('%H:%M'), celcius, vibration), 1)
```

except:

```
# Error appending data, most likely because credentials are stale.
```

Null out the worksheet so a login is performed at the top of the loop.

print('Append error, logging in again')

```
worksheet = None
```

```
time.sleep(FREQUENCY_SECONDS)
```

continue

```
# Wait 30 seconds before continuing
```

print('Wrote a row to {0}'.format(GDOCS_SPREADSHEET_NAME))

```
time.sleep(FREQUENCY_SECONDS)
```

Appendices D: Overall Coding for Graphical User Interface (GUI)

import time import datetime as dt

from tkinter import * from PIL import ImageTk,Image

import matplotlib.pyplot as plt

from matplotlib.widgets import Slider

from matplotlib.animation import FuncAnimation

import pandas as pd
import csv
TODO Create a plotted data using Qt Designer based on this series YT
https://www.youtube.com/watch?v=LStHozI2aDo&t=112s
fig = plt.figure()
ax = fig.add_subplot(1, 1, 1)
x = []
y = []
y1 = []

```
def animate(i, x, y, y1):
```

```
with open('Sensor_reading.csv', 'r') as csvfile:
```

```
lines = csv.reader(csvfile, delimiter = ',')
```

for row in lines:

```
x.append(row[0]) # row[0] represents Column_A
```

```
y.append(row[2]) # row[1] represents Column_C
```

y1.append(row[3]) # row[2] represents Column_D

#limit x and y to lists x = x[-10:] y = y[-10:] y1 = y1[-10:]

ax.clear()

Plotting data to Line Graph
plt.plot(x, y, color = 'r', linestyle = 'solid', marker = 'o', label = 'Temperature')
plt.plot(x, y1, color = 'g', linestyle = 'dashed', marker = 'o', label = 'Vibration')
#Function for rotate label x,y
plt.xticks(rotation = 0, ha='right')
plt.yticks(rotation = 45)
plt.yticks(rotation = 45)
plt.ylabel('Time') # x-axis = Vibration
#plt.ylabel('Temperature (°C) and Vibration') # y-axis = Temperature
#plt.xlabel('Temperature (°C)') # x-axis = Temperature
#plt.title('Sensor Data Line Graph', fontsize = 8)
plt.legend(loc='upper left')
plt.grid()

#Animation for graph

ani = FuncAnimation(fig, animate, fargs=(x, y, y1), interval=1000)

Generate plot
plt.tight_layout()
plt.show()

Appendices E: Web Server (Apache 2) Coding

```
html>
<head>
  <img src="https://www.utem.edu.my/templates/yootheme/cache/1c/LogoUTeM-1cba>
  <map name="image-map">
  <area target="" alt="" title="" href="" coords="" shape="">
  <!-- Codes by HTML.am -->
  <!-- CSS Code -->
  <style type="text/css" scoped>
  .GeneratedText {
                     ALAYSIA
  font-family:'Arial Black', sans-serif;font-size:1em;font-style:italic;lett>
  }
 </style>
 <!-- HTML Code -->
 <div class="GeneratedText">SENSOR DATA LIVE CHART</div>
</map>
<meta charset="utf-8">RSITI TEKNIKAL MALAYSIA MELAKA
 <title>3-PHASE MOTOR MONITOR</title>
 <meta http-equiv="refresh" content="10" />
</head>
<body>
 <div id="chart div"></div>
 <script type="text/javascript" src="https://www.gstatic.com/charts/loader.js">
 <script type="text/javascript" src="app.js"></script>
</body>
</html>
```

Appendices F: Web Server Line Graph Function Coding

```
google.charts.load('current', {
 'packages': ['corechart', 'line'], });
google.charts.setOnLoadCallback(initialize);
function initialize() {
 var queryString = encodeURIComponent('select B, C, D limit 400 label C "°C", >
 var query = new google.visualization.Query(
  'https://docs.google.com/spreadsheets/d/1dyb7U-AcFMNrIxKOthEbCxk7KaLzYApPW1>
 query.send(handleSampleDataQueryResponse);
}
function handleSampleDataQueryResponse(response) {
 if (response.isError()) {
  alert('Error in query: ' + response.getMessage() + ' ' + response.getDetail>
  return;
 }
 var data = response.getDataTable();
 var options = \{
  height: 600, UNIVERSITI
                                 TEKNIKAL MALAYSIA MEL
                                                                       .AKA
  hAxis: {
   title: 'Time',
   direction: -1
  },
  vAxis: {
   title: 'Temperature & Vibration'
  }
 };
 var chart = new google.visualization.LineChart(document.getElementById('chart>
 chart.draw(data, options); }
```