UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Terminal Identifier Design for Single Phase AC Motor using Microcontroller-based Voltmeter

This report is submitted in accordance with the requirement of Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours.

By

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelors of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours. The member of the supervisory is as follow:

……

(DR. MOHD BADRIL BIN NOR SHAH)

ABSTRAK

Peranti ini dibangunkan dengan menggunakan mikropengawal berdasarkan litar pengecam terminal motor arus ulang-alik (AU) fasa tunggal dan bertujuan memudahkan penguna mengenalpasti terminal motor tersebut dengan serta-merta. Agak selalu, pengeluar motor arus AU tidak menyediakan penandaan terminal motor. Tambahan pula, tidak ada piawaian warna wayar untuk terminal motor digubal dalam industri. Masalah ini telah menyukarkan pengenalpastian terminal motor terutamanya oleh juruteknik pembaikan semasa proses penyelesaian masalah atau kerja penggantian motor. Walaupun pengecaman terminal motor ini boleh dilakukan dengan menggunakan meter ohm pada multimeter, tetapi ia kurang sesuai dari segi antara muka dengan pengguna. Pengguna perlu untuk mengukur rintangan lintas antara terminal motor dan menentukan label terminal berdasarkan nilai rintangan yang diperolehi. Proses ini memakan masa dan terdedah kepada kesilapan keputusan. Oleh itu, cara yang lebih mudah untuk menentukan terminal motor AU fasa tunggal yang memiliki pengantaramuka yang lebih baik untuk pengguna telah dibangunkan. Peranti ini direka untuk mempunyai tiga kuar uji; kuar uji pertama disambungkan pada bekalan kuasa 5V, dan dua lagi disambungkan ke bumi. Setiap kuar uji diwakilkan oleh paparan tujuh-segmen satu digit untuk menunjukkan nama terminal apabila kuar uji disambungkan ke terminal motor. Kuar uji ini juga disambungkan ke port penukar-analog-ke-digital (PAD) pada mikropengawal untuk menyediakan algoritma pengecaman. kuar uji pada peranti ini disambungkan motor AU penguji, seterusnya beberapa peraturan ketidaksamaan boleh dihasilkan berdasarkan nilai PAD yang diperolehi. Walaubagaimanapun, tidak semua kemungkinan sambungan kuar uji ke terminal motor boleh dirangkumi oleh peraturan ketidaksamaan, oleh itu fungsi penunjuk 'putaran kuar uji diperlukan' telah ditambah. Pada akhir projek ini, peranti yang dibangunkan telah berjaya mengenalpasti terminal motor AU fasa tunggal apabila kuar uji disambungkan kepada terminal masukan.

ABSTRACT

This device is developed by using microcontroller based on circuit for terminal identifier of single phase alternate current (AC) motor and purposely to make user can easily identify the terminal motor instantly. Quite often, AC motor manufacturer does not provide marking of motor terminals. Furthermore, there is no standard of wire color motor terminals has been enacted in industry. These problems have obscure the motor terminal identification especially by repair technician during troubleshooting process or motor replacement work. Even though the identification of this motor terminal can be done by using ohmmeter of a multimeter, but it is less appropriate in term of user interface. A user has to measure the resistance across terminal of the motor and decide the terminal labels based on obtained resistance value. This process is time consuming and prone to decision error. Hence, a simpler way of determining the terminals of an AC single phase which posses a better user interface is developed the device is designed to have three probes; first probe is connected to 5v power supply and the other two probes is connected to ground. Each probe is presented by single digit of seven segment display to show the terminal name when the probe is connected to terminal of the motor. These probes also is connected to the analog–to-digital-converter (ADC) port of microcontroller to prepare the identifying algorithm. The probes of the device is connected to testing AC motor, subsequently several inequality rules can be produced based on the obtained ADC value. However, not all possible probe connection to the terminal can be covered by inequality rules, therefore the feature of 'probe rotation required' indicator is added. It the end of the project, the developed device successfully identify the motor terminal of single phase AC motor when the probes is connected to the input terminal.

DEDICATION

To my beloved parents

To my kind supervisors

And not to forget to all my fellow friends

Thank you for all their love, sacrifice, encouragement, and best wishes

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Before, while and after I doing my job to complete this project, I have received so many help from my supervisors, lecturers, researchers, family members and also my fellow friends.

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CHAPTER 1
INTRODUCTION

1.0 Project Background

AC motor is an electrical device that is powered by AC sourse. Many home appliances such as refrigerator, air-conditonioner, washing machine, vacuum cleaner, to name a few, are using AC motor to operate. Internally, an AC motor consists of two basic parts, stator and rotor, as shown in Figure 1.1. Stator and rotor itself consist of winding that is responsible to generatre electromagnetic force for the rotor part to rotate. In order for AC motor to rotate, AC source must be supplied to the stator winding to create electromagnetic field. It will induce current in rotor winding, thus creating magnetic field at rotor part, subsequently generate an eletromechanial force to rotate the rotor.

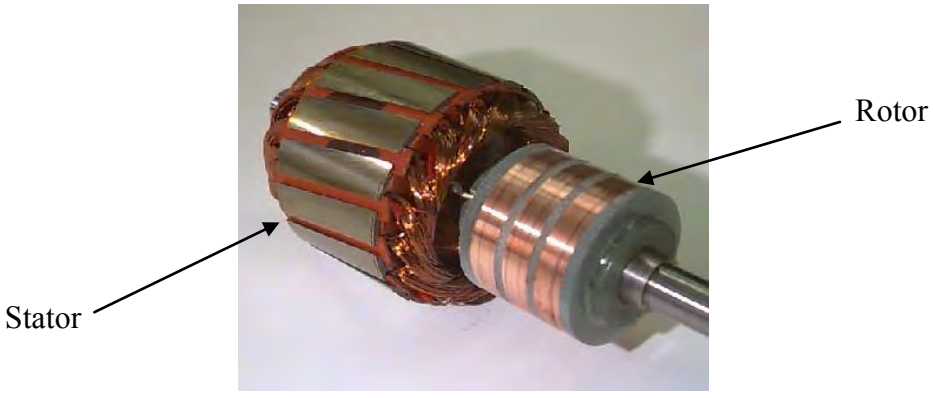

Figure 1.1: Internal structure of AC motor

AC motor can be powered by single phase or three phase AC soure, depending on their winding structure For single phase AC motor, the stator part consists of starting and running windings. The starting winding usually is to provide additional force during motor start-up. The existence of starting and running windings will create three terminal at motor input: start, run and common terminal as shown in Figure 1.2.

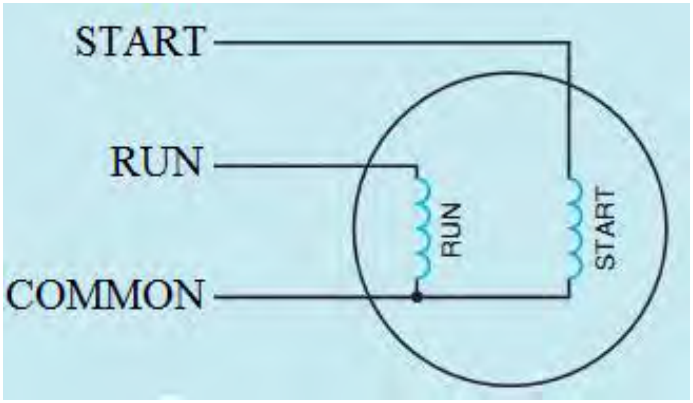

Figure 1.2: Run, start and common terminal of single phase AC motor

Since AC motor usually involve rotational movement and used in harsh and heavy duty applications, faulty and damage AC motor is common occurrences. However, repair technician always having problem in identifying terminals of single phase AC motor since motor manufacturer oftenly does not provide markings for the motor. In addition to that, there are also no standard color of wire that to recognize those terminals. These terminals can be identified by measuring the resistance between those terminals. The start and common terminal are manually identified based on the highest and the lowest reading of the terminal resistance. This process is time consuming and prone to decision error.

Inspired by this problem, terminal identifier device for single phase AC motor will be developed to identify the common, start and run terminal. By using this device, repair technician can easily identify the terminal of single phase AC motor thus speed up the rectification jobs.

1.1 Problem Statement

Single phase AC motor consists of start, run and common terminals. Quite often, AC motor manufacturer does not provide marking or level of motor terminals. Furthermore, there is no standard of wire color motor terminals has been developed in industry. These problems have obscure the motor terminal identification especially by repair technician during troubleshooting process or motor replacement work. Figure 1.3 and Figure 1.4 show the terminal of AC motor for compressor of refrigerator and air-conditioner. Figure 1.5 and Figure 1.6 show the different color used for terminal AC motor.

Figure 1.3: Compressor for refrigerator that does not have terminal markings (Brand: Embraco, Model: EGY90HLP)

Figure 1.4: Compressor for air-conditioner that does not have terminal markings (Brand: Nordyne, Model: FS3BA-018KA)

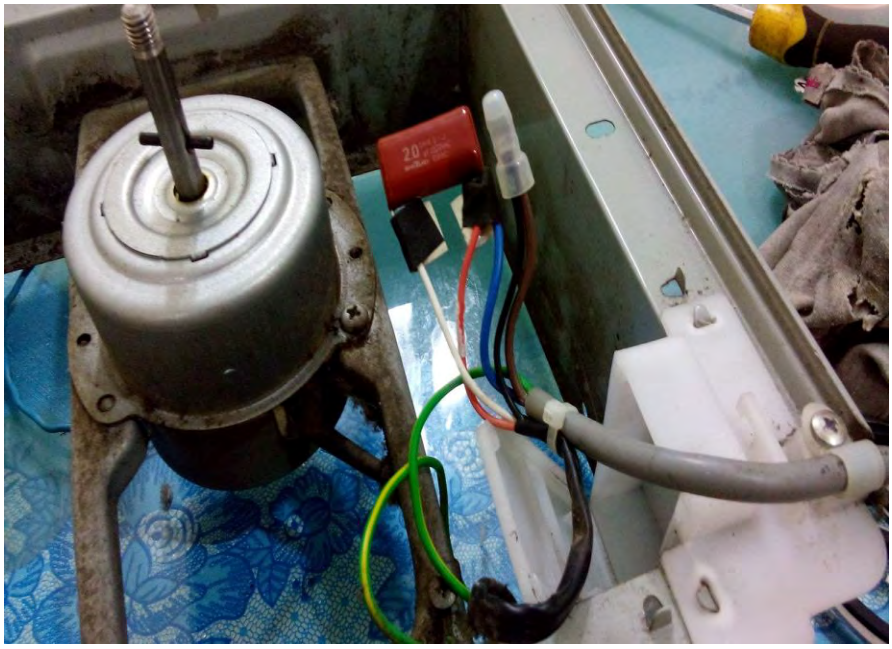

Figure 1.5: Single phase AC motor for exhaust fan Panasonic FV-20AUM8 (black wire - common terminal, white wire - start terminal, red wire - run terminal)

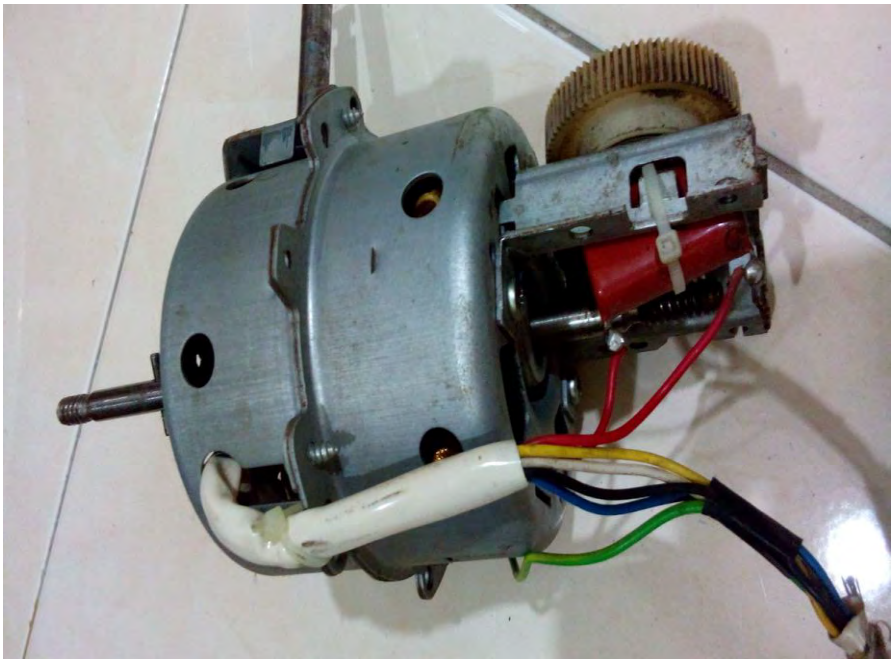

Figure 1.6: Single phase AC motor for stand fan KDK KC40H (black wire – common terminal, red wire – start terminal, white wire – run terminal)

Even though the identification of these motor terminal can be done by using ohmmeter of a multimeter, but it is less appropriate in term of user interface. A user has to measure the resistance across terminal of the motor and decide the terminal labels based on obtained resistance value. This process is time consuming and prone to decision error. Hence, a simpler way of determining the terminals of an AC single phase which posses a better handling experience for users is to be created.

1.2 Objective

The aims of this project are:

a) To design a microcontroller based circuit for terminal identifier of single phase AC motor.
b) To build hardware prototype which is easy to handled and can identify the motor terminal instantly.

1.3 Work Scope

Scope of the project are as follows:

a) **AC motor**
   The device will be designed to identify the terminals of single phase AC motor with single speed. This kind of motor widely used in air conditioner, ceiling fan, exhaust fan, to name a few.

b) **Circuit design and simulation**
   The circuit of this project will be designed by using microcontroller – based ohmmeter and will be simulated by using proteus 8 professional.

c) **Hardware prototype development**

   A hardware prototype will be developed to verify the efficiency of the designed circuit.

1.4 Thesis Outline

This thesis consists of five chapter and are organized as follows. Chapter 2 provides a literature review on information that is related in developing this project. The review of hardware components and several related previous works are also include in this chapter.

Chapter 3 provides the details methodology of process development. It covers the circuit design, hardware and programming development.

Chapter 4 discussed the results from simulation model circuit and hardware prototype. The analysis of results are also explained in this chapter

Finally, Chapter 5 presents the conclusion of this project. The recommendation for future works is also included.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter will discuss the study and analysis of previous project and will describe in detail about the components that is used for terminal identifier for single phase AC motor using microcontroller-based voltmeter as well as a description on the technology used. Before stating any project, some ideas from other researchers or other inventors are very useful. The ideas from their research likes mechanical design, control technique, program development and methodology serve a good input in developing this project. Thus, literature review is the beginning step to understand the ideas to develop this terminal identifier.

2.1 Microcontroller

Arduino is a software company, project, and user community that designs and manufactures computer open-source hardware, open-source software, and microcontroller-based kits for building digital devices and interactive objects that can sense and control physical devices. According to Wang et al., (2014) Arduino is outlined as open-source gadgets prototyping stage giving schematics and adaptable advancement packs for eager clients who mean to deliver intuitive items or situations. Arduino can be

utilized to sense surroundings by using different transducers to examine and unravel inputs with a specific end goal to make reactions for instance through the controlling of engines or exchanging of information. As a bit of equipment, the Arduino can work either independently (like in a robot), connected directly with a PC (accordingly giving your PC access to sensor information from the outside world and giving input), or joined with different Arduino's, or other electronic gadgets and controller chips. Anything can be associated and is limited just by creative ability, readiness to put eventually and exertion into discovering some new information, and the accessibility of segments. Figure 2.1 shows how Arduino connected to the PC directly using USB cable:

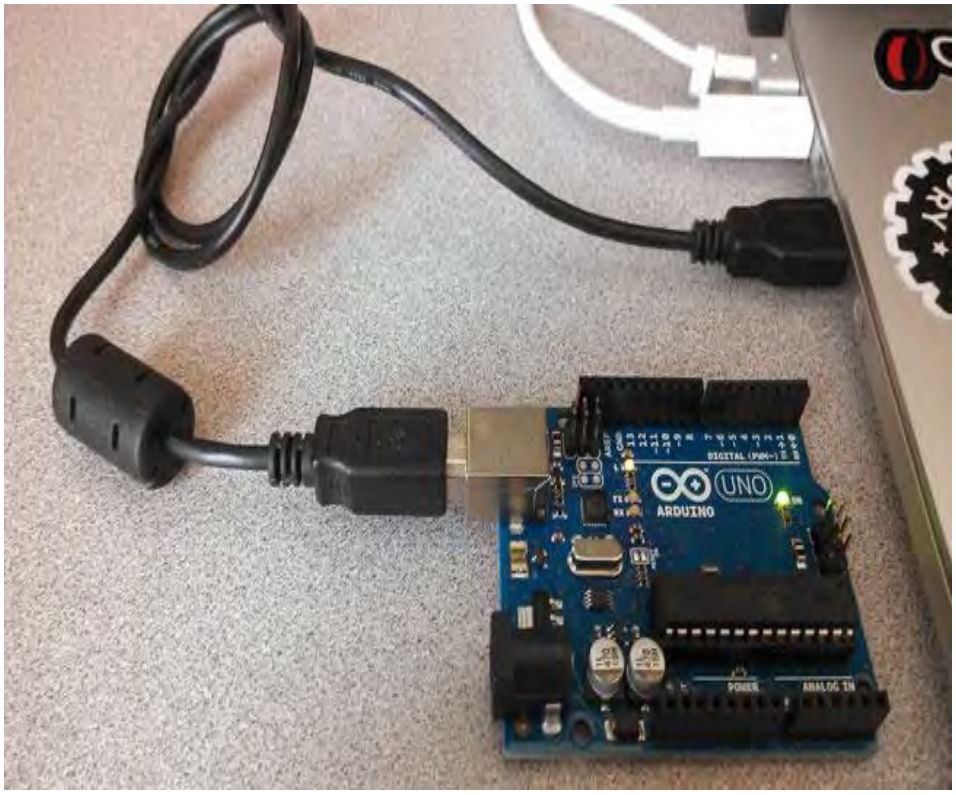

Figure 2.1: Arduino connected to PC

With assistance of the Arduino integrated development environment (IDE) in the PC, sketches are compiled and uploaded into the Arduino board via a USB transmission line. The probe will sense the value of voltage each terminal and send to Arduino Uno to

read the value. Current sensor also will give the value of current to Arduino Uno and then Arduino Uno will calculate based on formula ohms law's and decide which terminal are start, common, running based on programming that will been build.

The Arduino Uno is a microcontroller board based on the ATmega328 . It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter. "Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduno, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform. The Figure 2.2 is shown below

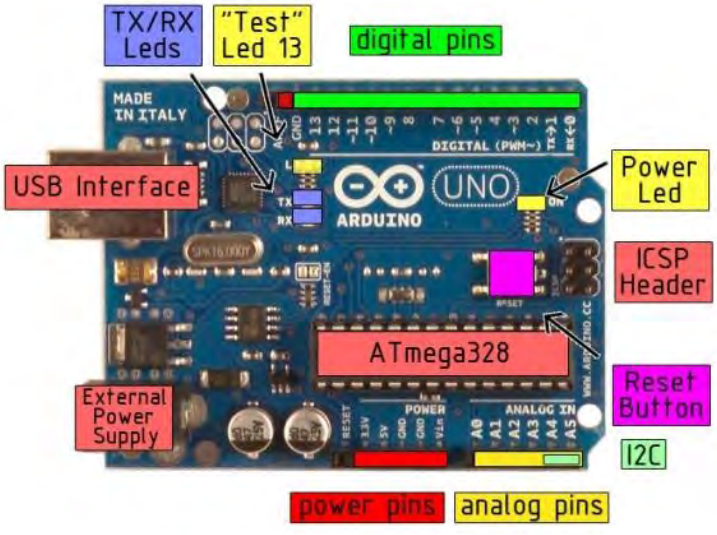

Figure 2.2: Technical specification of Arduino Uno board

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB of which 0.5 KB used by bootloader
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz

2.1.1 Power

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the