# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

# ARDUINO BASED AUTOMATIC POWER FACTOR CORRECTION

This report is submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (Industrial Power) (Hons.)

by

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2020

# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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Tajuk: Arduino Based Automatic Power Factor Correction

Sesi Pengajian: 2020

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"I hereby declare that I have read through this report entitled "Arduino Based Automatic Power Factor Correction" and found that it has complied with the partial fulfilment for awarding the degree of Bachelor of Electrical and Electronic Engineering Technology (Industrial Power) with Honours. The members of the supervisory is as follow:

Signature : .....

Supervisor : Associate Professor Mohd Ariff bin Mat Hanafiah

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Co- supervisor : Encik Ahmad Fairuz Bin Muhammad Amin

# ABSTRAK

Dalam revolusi perindustrian sekarang, tenaga kuasa adalah sesuatu yang sangat bermakna. Kualiti kuasa sistem AC telah menjadi satu kebimbangan kerana penggunaan beban induktif yang bertambah. Tenaga elektrik dibazirkan kerana faktor daya ketinggalan dalam beban induktif penggunaan pelanggan tersebut. Seterusnya, ada keperluan untuk menghindari pembaziran tenaga ini, angka kuasa yang lebih rendah berakhir dengan kualiti yang tidak tergoyahkan, masalah kesejahteraan, dan kos tenaga yang tinggi. Faktor daya sistem kuasa berubah secara konsisten kerana perbezaan dalam ukuran dan jumlah beban yang digunakan sekaligus. Ini menjadikannya berusaha mengatur beban induktif dan kapasitif secara konsisten. Banyak teknik kawalan untuk mengawasi faktor daya. Makalah ini menyajikan kaedah yang tepat secara komputasi untuk merancang dan memperbaiki dan membetulkan faktor kuasa fasa tunggal menggunakan cip kawalan skala Arduino Nano. Pelaksanaan peralatan dibuat dengan menggunakan papan Arduino Nano, yang mengeksploitasi ATmega328 sebagai Mikrokontroler, struktur yang dicadangkan mempunyai kepakaran untuk mengesan faktor daya dengan berkesan dan dengan menggunakan metodologi yang sesuai, cukup kapasitor dihidupkan untuk mengenakan faktor daya reaktif, sepanjang ini garisan menarik kembali faktor daya yang hampir dengan kesatuan sehingga menghasilkan keberkesanan yang lebih tinggi dan output AC yang lebih berkualiti. Dalam proposisi ini, ada perincian rencana dan kemajuan reaktor faktor daya fasa tunggal yang diprogramkan berdasarkan mikrokontroler di samping litar pembetulan untuk mengaktifkan pemindahan ketika faktor daya tidak dapat ditangani. Tesis ini berkisar pada pengukuran faktor kuasa menggunakan mikrokontroler dan selepas itu menggunakan pengiraan yang sesuai untuk menghidupkan dan mematikan bank kapasitor untuk mencapai faktor daya nominal yang ditentukan oleh beban.

# ABSTRACT

In the present industrial revolution, power is incredibly precious. The power quality of the AC system has become an unbelievable worry because of the quickly expanded utilization of inductive loads. The electrical energy is wasted because of the lagging power factor in the inductive loads of that client's utilization. Subsequently, there is a dire have to evade this wastage of energy, lower power figures end in poor unwavering quality, wellbeing issues, and high energy cost. The power factor of the power system is consistently changing because of the contrasts within the size and number of the loads being utilized at once. This makes it trying to regulate the inductive and capacitive loads consistently. Many control techniques for the Power Factor Correction (PFC) were proposed. This paper presents a computationally precise method to plan and improvement of a single-phase power factor correction using Arduino Nano miniaturized scale controlling chip. The hardware execution was made by using Arduino Nano board, which uses the ATmega328 as the Microcontroller, the proposed structure has the skill to identify power factor viably and by using an appropriate methodology enough capacitors are turned on to remunerate the reactive power factor, along these lines pull back power factor close to unity accordingly procures higher effectiveness and better quality AC output. In this proposition, there is a detail of plan and advancement of microcontroller-based programmed single-phase power factor revision alongside a correction circuit to actuate the transfers when the power factor cannot be redressed. This thesis revolves around the measurement of power factor using microcontroller and afterward using an appropriate calculation to turn on and off the capacitor bank to accomplish the nominal power factor specified by the loads.

**DEDICATION**

To by beloved parents, siblings and friends

## ACKNOWLEDGEMENT

I would like to express my gratefulness to complete this project. First of all, I would like to express my deepest gratitude to my supervisor, Associate Professor Mohd Ariff bin Mat Hanafiah and for helping and guiding me to complete this project. This project could not be completed successfully without his supervision. Through this project, he had provided me a lot of knowledge that motivated me to complete this project. His information and ideas are very helpful in completing this project. Moreover, he also guided me to think systematically to solve the problem.

Then I would like to thank my parents for their moral and financial support. Their support was very helpful throughout my project. Finally, I would like to thank my friends and lecturers that helped directly and indirectly to complete this project. They had also given me some suggestions and ideas to solve the problem that occurs during my project.

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## LIST OF SYMBOLS

| | | |
|---|---|---|
| kV | - | Kilo voltage |
| V | - | Voltage |
| Hz | - | Hertz |

## LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| AC | - | Alternating Current |
| LCD | - | Liquid Crystal Display |
| TRIAC | - | Triode for Alternating Current |
| APFC | - | Automatic Power Factor Controller |
| GSM | - | Global System for Mobile |
| THD | - | Total Harmonic Distortion |
| OP-AMP | - | Operational Amplifier |
| DC | - | Direct Current |
| PFC | - | Power Factor Controller |
| SCR | - | Silicon Controlled Rectifier |
| SVC | - | Switched Virtual Circuit |
| ZCD | - | Zero Crossing Detector |
| USB | - | Universal Serial Bus |

# CHAPTER 1

# INTRODUCTION

## 1.1 Project background

In this era of technology development, electrical power is one among the foremost debated chapters in society. This is often because the increase within the usage of inductive loads will eventually offer a sway on the power factor. The rise in usage of inductive loads in industry will give impact to the power factor value of the system and thus due to that the efficiency of the power system decreases (Ravi Dhameliya et al. 2017). All inductive loads require active power to perform the real work, and reactive power to maintain the field. This reactive power is important to operate the equipment.

On the other hand, this reactive power imposes an undesirable burden to the supply, which causes the current to lag with the voltage or in other words, this is out of phase with the voltage. Basically, from the electrical theory referred, for inductive loads the voltage will lead the current where the power factor is going to be lower. Besides, for capacitor loads, the current will lead the voltage where the power factor is going to be higher. The losses and low power factors occur due to the reactive current that presence within the system.

This problem can be eliminated by using power factor controller. Power factor correction can be done by connecting a sufficient number of static capacitors parallel to the load, because it can adjust the power factor as close to unity as possible. Power factor correction using capacitor banks reduces reactive power consumption which will result in minimization of losses and at the same time increases the electrical system's efficiency (Ravi Dhameliya et al. 2017). In other word, capacitor will make this to lead the voltage as it will make the power factor to extend.

## 1.2 Problem Statement

In this sophisticated and modern millennium, whether we realize or not, the issue of electrical power is becoming widen day by day. This issues awakens due to the rapid increase of inductive load usage. This inductive burdens drawn inductive current and this inductive current outcome into large phase angle among voltage and current of source and this avoidance between them cause lagging power factor(Er. Gaurav Goyal et al. 2017). The problems that consumer may face from the low power factor is in most industries, the usage of large induction motor is higher to drive their conveyors, pumps and other machinery. This induction motor tends to decrease the value of the power factor. This will lead to the power factor surcharge by the premises as the costumers are advised to maintain a consistent power factor index. The index that has to be maintained is for customers taking supply at 33 kV or below, the value of the power factor to be maintained is more than equal 0.85 and for the customer taking supply 132 kV or above, the value of the power factor to be maintained is more than equal 0.90. On the other hand, demand charges will be higher.



This is because many electric utility companies charge for maximum metered demand when higher registered in kilowatts or higher registered in apparent power. Low power factor loads increases losses in power supply and distribution system and it increases the cost in electricity in bills (Ararso Taye, 2018) Furthermore, a low power factor will make the current to increase. The increase in current will eventually make the voltage drop which will lead to more power loss due to the low voltage fluctuations. This will result in equipment overheating, overload and also short service life.

## 1.3 Objectives

The objectives of this project are:

1. To improve the current AC power factor yield by inserting capacitance parallel to the load.

2. To increase energy efficiency and reduces electricity costs by maintaining the power factor to near unity.

3. To develop an automatically corrected power factor to establish design parameters.

## 1.4 Scope of Project

This project mainly concerns to correct the power factor automatically using Arduino Nano. It is mainly focused on industrial and also domestic usage. Furthermore, this project is mainly on the advancement of the hardware.

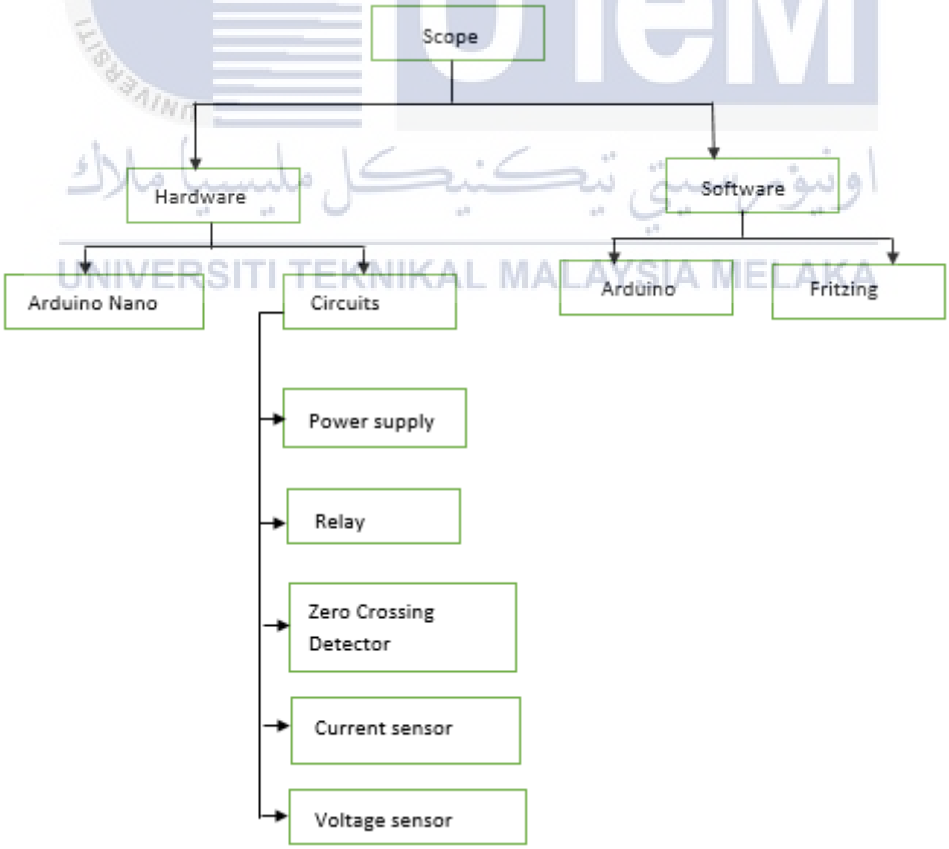


Figure 1.4: Division of Work Scope.

## 1.5 Organization of Report

This report consists of five chapters that begin with the report introduction and end with a conclusion. The remaining chapters are literature review, methodology, and results as well as the discussion. The literature review covers an overview and method to measure and correct the power factor automatically. Meanwhile, methodology shows a sequence of works to develop this project. The results of the implementation of this project will be written in chapter four along with its discussion. Chapter five will deliver a conclusion and recommendation for future planning. However, results with discussion and conclusion will be continued in Bachelor Degree Project II.

## 1.6 Summary

This part covers the foundation of the undertaking and the issue proclamation which gives a reasonable insight concerning this extend and urge to continue with the conduction of this venture. Then again, the objectives of this report additionally consider right now. Besides, the extent of this undertaking is likewise examined to ensure this report is directed methodically and guided by its goals.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

This chapter expatiates the overall information about the power factor, the abnormalities that might happen in the power factor. On the other hand, this section also discusses the procedures that can be overlooked in order to solve the abnormalities. This chapter also elaborates on the reasons that lead to power factor corrections.

## 2.2 Theory: Overview of Power Factor

### 2.2.1 Definition of Power Factor

The power factor is defined as the ratio between the actual load power and the apparent load power drawn by an electrical load. It is simply a measure of how efficiently the load current is being converted into useful work output (Yasin Kabir et al. 2017). In a simple alternating current (AC) circuit comprising of a source and a direct load, both the current and voltage are sinusoidal. A load with a power factor unity is the purely resistive load because the sinusoidal voltage and sinusoidal current waveform are in phase or the phase angle difference between voltage and current is zero (Ararso Taye, 2018). There are three types of powers involved in the power factor. Active power is the actual amount of the power being used, or being dissipated in a circuit is called active power, and it is measured in watts.

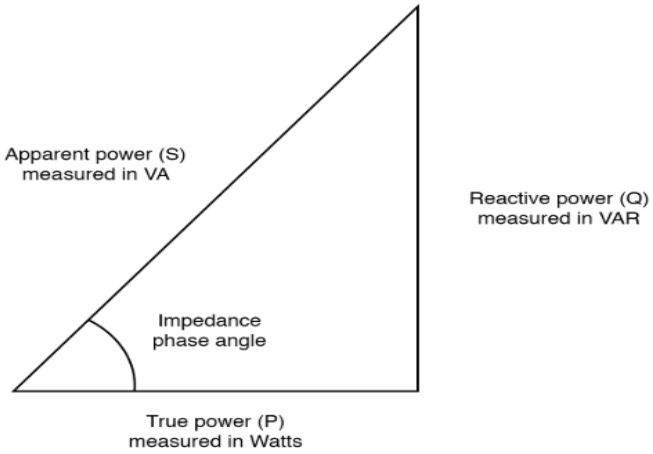


Figure 2.2.1.1: Power triangle (Source: https://electricalbaba.com/power-triangle/).

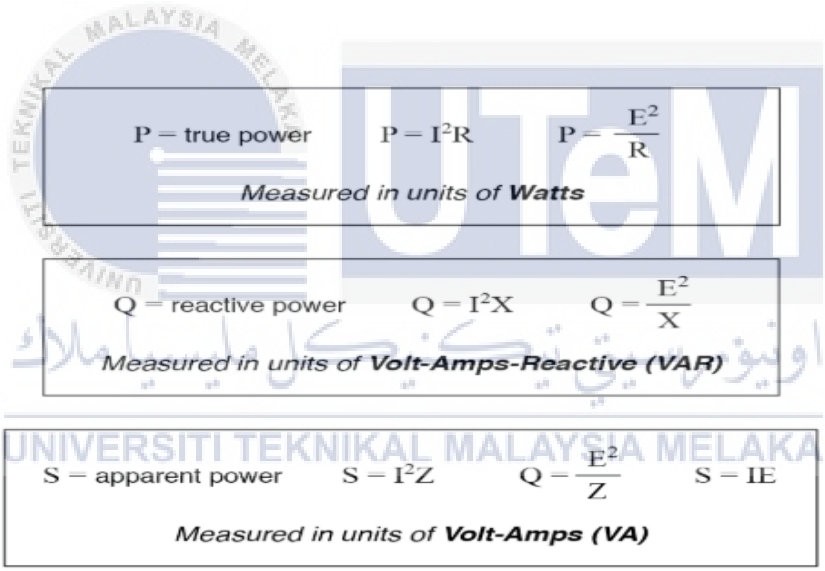


Figure 2.2.1.2: Formula for power triangle (Mr. Anant Kumar Tiwari et al. 2014).

### 2.2.2 Leading and lagging current

The terms 'leading' and 'lagging' allude to where the load current phasor lies consistent with the supply voltage phasor. They are dictated by the indication of the point in time between current and voltage waveforms. The two loads that play the most role within the power factor is capacitor and inductor. The capacitance will cause the leading of power factor and inductance