



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**DESIGN OF SINGLE PHASE POWER FACTOR CORRECTION  
FOR DOMESTIC USE**

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

by

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2015**

## BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Design of single phase power factor correction for domestic use**

SESI PENGAJIAN: **2014/15 Semester 2**

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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 Bachelor of Engineering Technology ( Department of Electrical Engineering Technology ) ( Bachelor of Electrical Engineering Technology [industrial power] with Honours ). The member of the supervisory is as follow:



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## **ABSTRACT**

Power factor is the ratio between the real or average power and the apparent power forms a very essential parameter in power system. It is indicative of how effectively the real power of the system has been utilized. The low of power factor will cause a trouble to a power supply company which need to supply apparent power to consumer, but need to pay in true power. Other than, the lower of power factor can cause a high current flowing in line system and more negative impact to the system. The way to overcome this problem is applying a power factor correction. The power factor correction (PFC) is a technique of counteracting the undesirable effects of electric loads that create a power factor that less than one. There are two type of power factor correction which is active power factor correction and passive power factor correction. This project was being develop to design a system counteracting a low power factor at industry that have load which motor. This is because of a lot of motor used in industry for operating system and can be cause of low power factor due to higher inductive loads. The MATLAB software being choose create and stimulate the circuit for this project. The system will detect the lower of power factor and will turn on or off the capacitor in order to correct power factor. This capacitor will be placed in parallel with the loads. The main expected of this project is to get the ideal of power factor.

## ABSTRAK

Faktor kuasa ialah nisbah diantara kuasa sebenar atau kuasa purata dengan kuasa setara dimana yang jelas membentuk parameter yang sangat penting dalam sistem kuasa. Ia menunjukkan bagaimana keberkesanan kuasa sebenar sistem yang telah digunakan. Faktor kuasa yang rendah juga boleh mendatangkan keburukkan kepada bekalan kuasa syarikat kerana yang perlu untuk membekal kuasa ketara kepada pengguna, tetapi bil mereka dalam kuasa sebenar. Selain itu, faktor kuasa yang rendah juga menyebabkan arus tinggi mengalir di dalam sistem talian dan kehilangan kuasa akan meningkatkan kadar arus yang berkadar terus. Cara mengatasi masalah tersebut ialah dengan menggunakan sistem pembetulan faktor kuasa. Pembetulan faktor kuasa adalah cara dimana mengimbangi kesan-kesan yang tidak diingini beban elektrik yang mewujudkan faktor kuasa yang kurang atau rendah dari satu. Faktor kuasa boleh dibahagikan kepada dua iaitu pembetulan faktor kuasa yang pasif atau pembetulan faktor kuasa yang aktif. Projek ini bertujuan untuk membentuk satu sistem yang boleh mengawal faktor kuasa yang rendah di bahagian industry. Ini kerana penggunaan motor yang banyak di dalam sistem operasi dan menyebabkan faktor kuasa menjadi rendah kerana terdapat beban induktif yang tinggi. Projek ini menggunakan sistem MATLAB untuk membentuk dan merangsang prestasi sistem. Sistem ini akan mengesan faktor kuasa yang rendah dan sistem akan menghidupkan atau mematikan sistem kapasitor untuk membetulkan faktor kuasa. Kapasitor akan dipasang selari dengan beban. Jangkaan utama pada projek ini adalah untuk mendapatkan faktor kuasa yang hampir kepada satu.

## **ACKNOWLEDGEMENT**

In the name Allah, the Most Merciful and Most Gracious. I thank to Allah The Almighty, for all His guidance, blessing and strength that He gives me while completing this project.

Firstly, I would like to give my deepest gratitude to my final year project supervisor, Pn Intan Mastura Binti Saadon for all the encouragement, guidance, enthusiasm, supports, knowledge, ideas and keep motivating me to do this final year project.

Furthermore, special thanks to my beloved family, which is my mother, father, sister and brothers that keep supporting, loving and praying for me in here to finish my project and degree.

Last but no least, I want to thank to all my friends, laboratory staffs, and those who are directly or indirectly helping, supporting and guiding me in this project. The knowledge and moment that I had which only Allah can pay the service. Thank you so much to all.

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## LIST OF SYMBOLS AND ABBREVIATIONS

TNB	=	Tenaga Nasional Berhad
PPFC	=	Passive Power Factor Correction
APFC	=	Active Power Factor Correction
HPFC	=	Hybrid Power Factor Correction
Cos	=	Cosine
Sin	=	Sinus
Var	=	Voltage Amperes Reactive
VA	=	Voltage Amperes
W	=	Watt
V	=	Volt
I	=	Current
P	=	Real Power or Active Power
Q	=	Reactive Power
S	=	Apparent Power
AC	=	Alternating Current
$\text{Cos } \emptyset$	=	Power Factor
$\Omega$	=	Ohm
Rms	=	Root Mean Square

# CHAPTER 1

## INTRODUCTION

### 1.0 Background of the Study

Electric are important for environment for lighting, switching and other. The usage of electric energy must be in effective way to avoid of wasting of energy. In power system, the quality of power factor need to be concerned which can cause trouble to the system. The quality of electric power can be related to power factor. Power factor is very important part for economic for users that used a lot amount of power like light or heavy industries. The lower of power factor is not effective to the users and electric utilities. With a low power factor value the supply system need to generate a higher current to consumer needed. The system need to supplies using a transmission and distribution for active energy that have power factor closed to unity. With the high current flowing in the distribution system, the cable of distribution purposes must be change into bigger size by electric utilities with can more costly. Due to that condition, the equipment and cost of cable using in the system will increased also in energy losses.

As we know, Tenaga Nasional Berhad (TNB) is the one company used to supplied power for consumer. The power that being delivered to the consumer is an apparent power. TNB meter is measure a real power while reactive power is not include in that meter which measured in KVARh. The TNB need to supplied a apparent power to customer while the billing in real power. Therefore, the quality of electric power is concern by electric utilities.



Figure 1.1 Actual Power Meter

The TNB must maintain the electric power supply to the customer at any cost. The reactive power need to be supplied to the customer to maintain a good electric power supply. The average power factor of surcharge that above a month will be charge by the TNB. For the electricity supply above 132Kv, it will be charge of the power factor below 0.90 and below while below 132Kv it will be charge of power factor below 0.85.

Power factor value month in range below of 0.85 to 0.75 lagging, a supplementary charge of one and one-half per cent of the bill for that month for each one-hundredth part (0.01) will be adding into that month billing. Other than that, the power factor value below of 0.75 to 0.65 lagging, the supplementary charge of three per cent (3%) of the bill for that month for each one-hundredth (0.01) part below 0.75 lagging power factor will be added to the bill for that month.

In order to avoid paying montly surcharge imposed by utility, the system must have power factor value above 0.85 by using capacitor bank as corrector. With a high value of power factor, the electric power supply will transfer a great power without no losses in cable system and transformer. To get a great power supply yto the system, power factor value must or have above 0.85 or unity value. By using a power factor correction into the system,the power can be great to be deliver and can avoid surcharge in month billing by supplier.



Figure 1.1 Capacitor Bank

## 1.1 Problem statement

The low of power factor will cause a high current flow in cable system. In way to reduce the losses in transmission line, the power factor must be improved which is closest to unity. The active power factor corrector (APFC) or passive power factor corrector (PPFC) is needed to reduce the losses plus improved the power factor value. The PPFC is always be choose to improve a poor power factor because of cheaper cost and circuit design is not to complicated compare to APFC that more costly and complicated circuit.

The using of passive power factor correction will have disadvantage which is using open loop system. The using of open loop system will be effect to the output system because there no feedback output of system to correct and cannot adding system of corrector for driving signal. The using of passive power factor correction, it will correct the output by using capacitor in off or on condition including timer. The result of using a PPFC is when it comes to critical when the system is running for over time. This is because it will set only for peak hours to operate by industries to operate. The power factor cannot be corrector during over time system can cause system have no feedback.



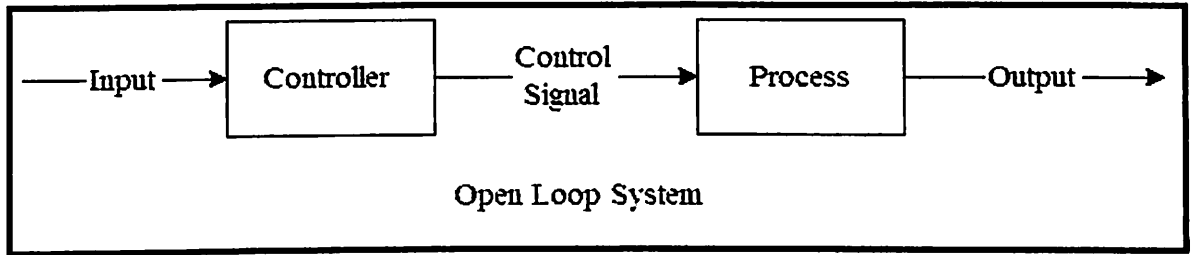


Figure 1.2 Open loop system

The closed loop system will have a feedback of output. The active power factor correction is using a closed loop system. The closed loop system have a feedback system which is can be monitor for output condition. The system can correct for any disturbances and compensate for output system. For example, if the output of power factor is poor in overtime period the system will monitor the output for correction. The power factor will be correct and good value.

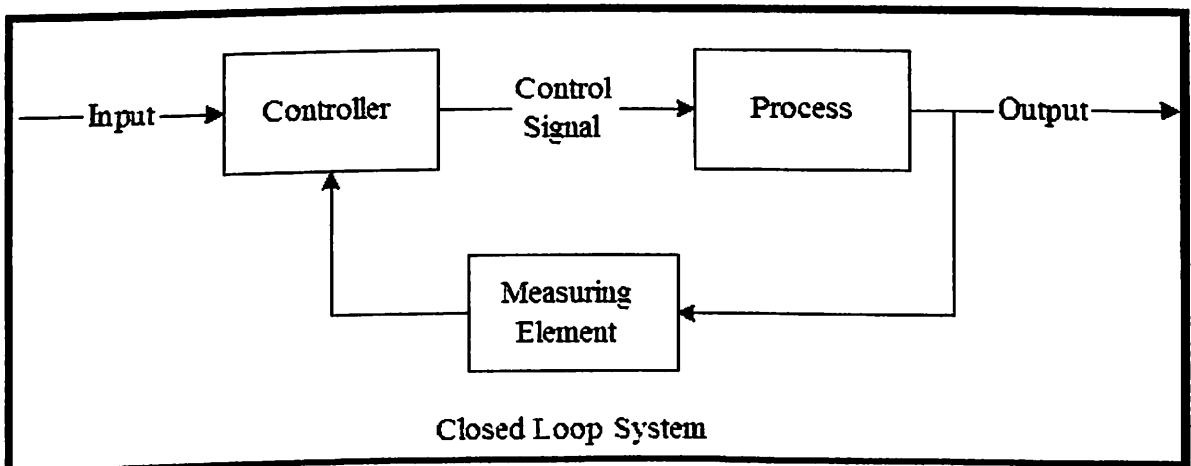


Figure 1.3 Closed loop system

## **1.2 Objectives of this project**

There are three objective need to be achieved after this project:

1. The main objective of this project is to study and understanding the role of PPFC. APPC and HPPC also will be study.
2. To improve the value of power factor of the system closest to one and reduce power losses in cable system during a transmission line.
3. To find out and compared the output of power factor after system completely build.

Using this system, the power factor will will corrected and maintain to get a good power system to utilities. Power factor also effect the power quality on the transmission line of the power system. Other than that, a good power system supplies and maintaining power will help customer and electric utilities in optimum of usage.

## **1.3 Scope of study**

The three objective of this project need to be achieved. The PPFC was choose to main power factor closest to unity by utilizing the capacitor bank topology. This project was develop in closed-loop system of PPFC. This is because the closed-loop system is more effective and high efficiency compare to open-loop system. The using of closed-loop system because it will be monitor the output of power factor time by time compare to open-loop system. A PPFC model will be develop as a computer model only. After a computer model of PPFC successfully being develop and need to test the performance of the system. The PPFC model must need to be maintain the power factor in 0.90 respectively. The system is built in three phase system by located at near light industry. MATLAB R2014b software will be choose to stimulate and develop of this project.

## **1.4 Project Report Outline**

Generally this project report is divided into six chapters, where it consists:

**Chapter 1: Introduction**

**Chapter 2: Literature Review**

**Chapter 3: Methodology**

**Chapter 4: Result and Discussion**

**Chapter 5: Conclusion and Recommendation**

Chapter 1 is an introduction for this final report that provided what is all about power factor correction. In this chapter the problem statement and objective for this project are include to give the direction of this report are.

Chapter 2 will introduce to literature review for this project, what theory and component that used for develop this project. Literature reviews are previous study in this project that can be used to guide and give improvement to the project. It gives the better chance to success will to develop and innovation in this project. Theory and component are given a general knowledge about this project and it will use to develop on this project.

Chapter 3 will introduce to methodology that used on this project and it give a surface guided how this project are build. All these steps are complete shows how all step, start with research on literature review to get result worked from experiment in the lab.

Chapter 4 will introduce the results and discussion for this project. Result that get from experiment and testing are compiled and discuss in detail of this chapter. From result and discussion in this chapter it will give if this project successfully or not bases on data that get from this experiment.

Chapter 5 will introduce to conclusion and recommendation for this project. It give all information for a previous work and presented. It will be followed by recommendations. It give conclude all the works and had been presented in previous chapter and all the results of the project. This is followed by recommendations for the future study work.

# **CHAPTER 2**

## **LITERATURE REVIEW**

### **2.0 Introduction**

This chapter reviews existing project created to get an idea about the project design, conception and any information that related to improve the project. There are many creations and innovations of project that have been done by other people with differences concept and design. This will provide clearer understanding of the system and its designs. This project is all about power factor correction.

### **2.1 Power factor**

In an AC circuit, power factor is the ratio of the real power that is used to do work and apparent power that supplied to the circuit. Power factor value is about range between 0 to 1. When all the power is reactive power with no real power (usually inductive load), the power factor is 0. But when all the power is real power with no reactive power (resistive load), the power factor is 1.

$$PF = P/S \quad (2.1)$$

P = True or Real Power (Watt)

S = Apparent Power (VA)

For another meaning, the power factor is usage of in to do work. The 0.707 of power factor lagging can effectively expand to donates a load of 70.70 percent apparent power in stated of volts-amperes (VA) and convert to doing work The

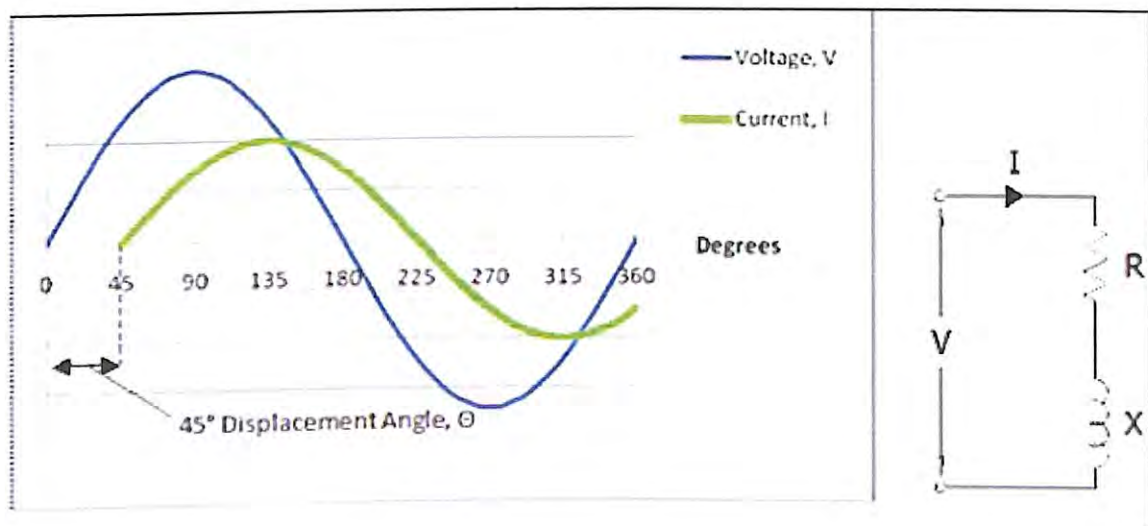


Figure 2.1 the lagging by 45 degree below mean that the current is lagging behind the voltage

For the sinusoidal case, the phase angle between current and voltage can be say as cosine of phase. The cosine of phase is likely being referred as displacement of power factor.

$$\text{Power Factor, PF} = \cos \phi \quad (1.1)$$

The phase angle between voltage and current:

$$\text{PF, } \cos \phi = \cos(\phi_v - \phi_i) \quad (1.2)$$

The power factor angle also can be referred as load impedance (the angle of  $\phi_v - \phi_i = \phi$ ). When the power factor is equal to 1 or 0, the position of angle will be in two condition which is purely resistive load where  $\phi = 0$  and purely reactive loads where  $\phi = \pm 90^\circ$ . The unity power factor will be get by having a circuit that have R, L including C. The value of this element must in zero phase angle in certain operating frequency.

In AC circuit load with having a purely resistive load, the angle between voltage and current are actually in phase. The changing of polarity in time of cycle will get  $\phi_v - \phi_i = 0$  and power factor equal 1. It shows that average and apparent power are in equal will all power actually consumed.

The power factor is equal to 0 when is purely reactive load such as inductor or capacitor in circuit with phase angle between  $\phi_v - \phi_i = \pm 90^\circ$ . The average power of this condition is zero. Power factor also can be call as lagging or leading. The leading of power factor mean that current will lead that voltage by implying capacitive load. The lagging of power factor mean that current will lags voltage by implying inductive load.

The present of inductors or capacitor in system will become a different a difference in energy storage. The result will become different between waveform of voltage and current. The power factor angle will become  $-90^\circ < \phi < 0^\circ$  of their limit if the present of load with RL together with equivalent. The power factor angle will become  $0^\circ < \phi < 90^\circ$  of their limit if the present of load with RC together with equivalent. The leading of power factor and lagging power

factor showed in power factor triangle in figure 2.2 below. In upper triangle, power factor is in lagging condition while in lower triangle show that power factor is leading condition. The lagging of power factor is cause by inductive load such as motor and for the leading is cause by capacitive loads like capacitor. If the case of non-sinusoidal, the power factor cannot be defined as an equation 1.1.

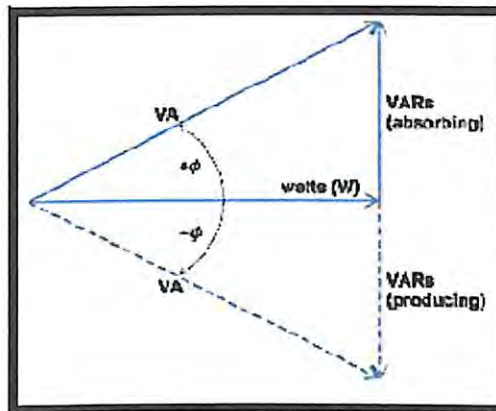


Figure 2.2 Power factor triangle

## 2.2 Measuring power factor

Power factor is defined as the cosine angle between the current and voltage in ac circuit. The  $\cos \phi$  is called the power factor of the circuit. Ratio of between the true power (watt) and apparent power (VA) in a system is called power factor ratio. The power factor can be determine by using relationship