

**FAKULTI KEJURUTERAAN ELEKTRIK
UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**LAPORAN PROJEK
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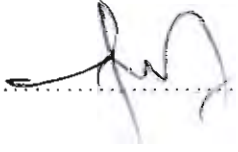
**DESIGN OF A REACTIVE POWER COMPENSATION FOR
TRANSMISSION LINE VOLTAGE SAGS DUE TO FAULTS**

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**Bachelor of Electrical Engineering (Control, Instrumentation and
Automation)**

June 2013

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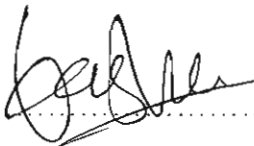
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**A report submitted in partial fulfillment of the requirements for the degree of Bachelor
of Electrical Engineering (Control, Instrumentation & Automation)**

**Faculty of Electrical Engineering
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2013

I declare that this report entitle "*Design Of A Reactive Power Compensation For Transmission Line Voltage Sags Due To Faults*" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any degree.

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Name : AIN NATASHA BINTI MARAFI

Date : 19 JUNE 2013

Specially dedicated:

To my beloved father Marafi bin Madun,

To my beloved mother Fatimah binti Madon,

My beloved sister and brothers,

My supervisor and all my lecturers

All my friends

For their encouragement, support and motivation

through my journey of education.

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ABSTRACT

Voltage sags is one of the most important for power quality problem that affect industrial customers. Generally, voltage sags are caused by fault in transmission and distribution system. Many of these industrial customers are suffered because of sag that affect the sensitive equipments. This project focused on the reactive power compensation for mitigating voltage sags. The main objective of this project is to design as well as to improve the level of voltage in the transmission system. First, the characteristic of reactive power compensation for compensating voltage sags are studied such as required shunt compensation current. The results of this project show that the shunt compensation current, injected reactive power decrease as impedance, where the source of impedance in parallel with the load impedance, increases. It also shows that reactive power compensation is the main requirement for voltage sags injecting by current source controlled. All the result are verified and simulated in PSCAD.

ABSTRAK

Voltan lendur merupakan masalah yang sangat penting dalam kualiti kuasa yang menjejaskan pelanggan perindustrian. Secara umumnya, voltan lendur adalah disebabkan oleh kesalahan dalam sistem penghantaran dan sistem pengagihan. Ramai pelanggan perindustrian yang menggunakan peralatan sensitif mengalami kerugian akibat daripada voltan lendur. Projek ini memberi tumpuan kepada pampasan kuasa reaktif untuk voltan lendur bagi mengurangkan risiko. Objektif utama projek ini adalah untuk merekabentuk serta meningkatkan tahap voltan dalam sistem penghantaran. Pertama, ciri-ciri pampasan kuasa reaktif untuk meningkatkan voltan lendur seperti pampasan arus reaktif selari. Hasil projek ini menunjukkan pampasan kuasa reaktif selari, dengan disuntik penurunan kuasa reaktif sebagai impedans, di mana sumber impedans dan beban impedans meningkat. Ia juga menunjukkan bahawa pampasan kuasa reaktif adalah keperluan utama untuk voltan lendur disuntik oleh sumber arus terkawal. Semua keputusan telah disahkan dan disimulasi dalam PSCAD.

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CHAPTER 1

INTRODUCTION

This chapter briefly discussed about background and problem statement of this project. The objective and scope that should be achieved at the end of this project also attach in this chapter.

1.1 PROJECT BACKGROUND

Recently, there are more power electronics equipments that are called 'sensitive equipment', used in industrial process to attain high automatic ability. In the industrial applications, power quality problems concerned a wide range of disturbances such as voltage sags, swells and short interruptions, which can bring substantial financial losses to the end customer [1]. Voltage sags are the most common disturbance encountered.

Ideally, power should be supplied without any interruptions at constant frequency, constant voltage and with perfectly sinusoidal and in the case of three phase, symmetrical waveforms. In the power system, there are non-zero impedances. Then, by increasing in current can cause a corresponding reduction in voltage. These reductions usually small and the normal tolerances in but when in the impedance is high, the voltage can drop immediately [2].

A method to mitigate these disturbances is needed, since the effects due to some disturbances that usually the production costs have a high impact and thus ways to prevent it can be formulated. In order to reduce the level of voltage sags as well as the equipment that sensitive to voltage sags, there are a few things that need to be done by utility, customer and equipment [2].

Voltage and reactive power compensation are very important issue in power system, involving operational, economical and quality of services in consumer loads aspects (industrial, residential, etc.) impose active and reactive power demand, and its depend on their characteristics [3]. There are two effective measures which are reactive power compensation and voltage regulation in order to improve the voltage quality.

Generally, reactive power compensation problems are referred from two aspects which are voltage support and load compensation. The objective for load compensation is to increase the value of the system power factor, to balance the real power, to compensate the voltage regulation and the others [3].

This study described how to design a controller and apply the reactive power compensation for transmission line voltage sags due to fault. By injecting reactive power compensation, the voltage will maintain even there is a fault occurs.

1.2 PROBLEM STATEMENT

Voltage sags is one of the hot topics that often discussed among the researchers. Normally, voltage sags occur at utility systems which are at transmission system and distribution system. Besides that, voltage sags are ordinarily caused by faults in power grid along by heavy loads that are switching, transformer energizing and starting of large motor [4].

Through these systems, normally voltage sags occur when there are faults such as single line faults and three phase faults. Due to these problems, it causes a lot of losses in industries that can affect the whole system.

In the electrical power system, the voltage control is very important for proper operation to prevent the electrical power equipments from damage such as overheating. Overheating motors can happen in generators and transmission line.

Faults occur in the transmission line that will be affect the transmission line voltage will be commonly used in transmission line systems. Power system analysis and related areas will need some knowledge about how to maintain the level of voltage even there is fault occur.

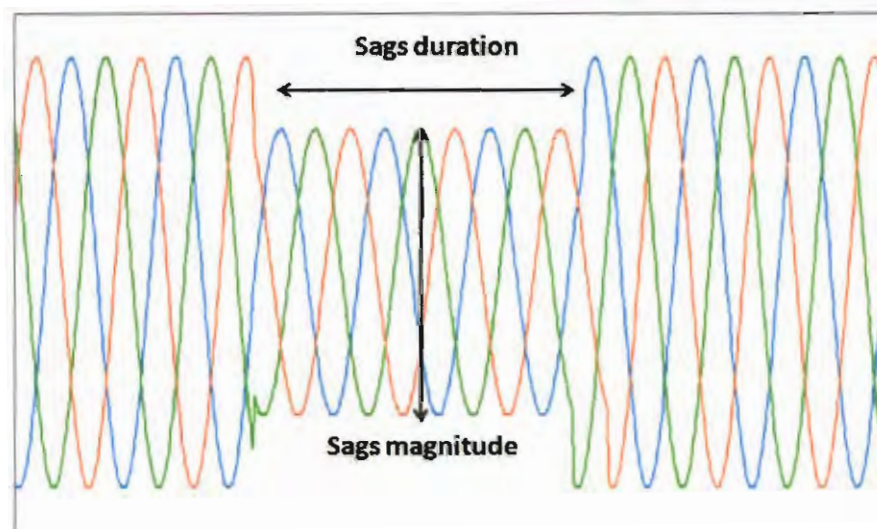


Figure 1.1: Voltage sag waveform

1.3 OBJECTIVE OF PROJECT

There are two main objectives of this project which are:

- i. To design a controller to apply reactive power compensation in order to maintain voltage level even there is fault occurs in transmission line system.

- ii. To simulate and analyze the voltage sags in transmission line system by using PSCAD software.

In general, the objectives of this project are to utilized reactive power compensation in order to maintain voltage level in transmission line system.

1.4 PROJECT SCOPE

This project will focus on injection of reactive power compensation into transmission line system. The projects elements will be studied based on basic design of a reactive power compensation controller in transmission line system network during faults occur. After designing reactive power compensation controller, simulate on transmission line model by using PSCAD software. Lastly, the scope of this project is analyzing and evaluating the performance of transmission line voltage level with or without injecting reactive power compensation during fault occurs.

CHAPTER 2

LITERATURE REVIEW

This chapter describe about previous project that is related to this project, which is there is a lot of relevant information has been published is discussed in this chapter. The theory and information obtained from the published paper is very useful and can be used as a guide to complete this project.

2.1 INTRODUCTION

A transmission line is a medium or structure that forms a path for directing the transmission of energy from one place to another place, for example electromagnetic waves or acoustic waves along with electric power transmission. The types of transmission line are wires, coaxial cables, strip lines, dielectric slabs and optical fibres [5].

Power system disturbances and the continually changing demand of consumers give rise to voltage variation. Deviation from the sinusoidal voltage supply can be due to transient phenomena or to the presence of nonlinear components. The power network is not only the main source of energy supply but also the medium of possible interferences between consumers.

A wide range of disturbance of power quality problems such as voltage sags and swells interruption and harmonic distortion need to be concerned for the industrial application [6]. Therefore, for such phenomena need to avoid is very important because almost in the industrial processes have increasing in heavy automation. Since that the failures refer to such disturbances normally because of a high impact on production cost, so a high quality in power supply is needed.

2.2 VOLTAGE SAGS

Voltage sags is a necessary terms used in this project. Therefore, the next section will be discussed about the basic idea of the voltage sags, general cause of voltage sags and how voltage sags affected the power system network.

2.2.1 INTRODUCTION

Voltage sags is short term duration in rms voltage caused by faults in power system. Voltage sags is rms voltage or current decrease at power frequency for duration 0.5 cycles to 1 minute reported as the remaining voltage [7][8][9][10][11]. In generally, sags magnitude range from 0.1 to 0.9 pu [8][9][11]. Voltage sags is usually measured in percentage where the measurement is the remaining voltage from the nominal voltage and stated as the percentage value.

Actually, voltage sags is not a complete power interruption but only temporary drop below 90% from the nominal voltage. Usually, most of the voltage sags drop below 50% of

the nominal voltage and occur at last from 3 to 10 cycles of approximately 50 to 170 milliseconds. More information of voltage sags can be referred in appendix A.

This is very important the difference between an interruption and voltage sags. Interruption occurs when any protective device totally interrupts in the circuit. Voltage sags case occurs at the power system during the period of fault [12]. Faults at parallel at wide part of power system or transmission system can give a result voltage sags but not in actual interruption results.

The voltage sags can characterize into four which are duration and magnitude, voltage waveform record, the voltage with sequence components and the shifting of angle of phase associated [8][13]. Both phase angle shift and unbalanced give an impact on tripping of equipment.

For the duration of sags are at the fault-clearing time. Generally, fault at the transmission system are cleared faster than the faults at the distribution system. Fault divided into two which symmetrical and unsymmetrical faults. For three phase fault the voltage sag is symmetrical while it will be unsymmetrical fault when occur single or double phase fault [8].

2.2.2 CAUSES OF VOLTAGE SAGS

There are many situations that showed the causes of voltage sags, for example whether, construction activity, pollution, equipment failure and many more. But 70% of them that can cause voltage sags are fault [10].

The location of the fault happen showing the magnitudes of the voltage sags. If near the fault happened, then the large magnitude of the voltage sags will be. The magnitudes of voltage sags are also depending on the fault impedance, pre-sag voltage level and the system configuration that is the system impedance and the transformer connection [14].

Voltage sags also causes the starting of electric motor either individually or in groups which is a group of facilities or an industrial facility. If the utility line voltage remain at the constant nominal value, then the large current in rush on starting will cause voltage sags [10].

Faults at the transmission line system will affect to the customers. Customers live hundreds of kilometer from the faults location still can feel the voltage sags effect on the disoperation of the equipment when the fault is on the transmission line system [12].

2.2.3 EFFECT OF VOLTAGE SAGS

Modern electronic equipment needs more precise voltage regulation than traditional devices such as induction motor. In manufacturing industry, some of mechanical devices as well as gearboxes that control the processes speed were slightly slow [10].

Automation has carried out to high speed processes, automatic electronic sensing and control. A precise machine tool that has advanced electronic controls need to be replaced and it will be more expensive if unplanned manufacturing stoppage [10].

Some degree susceptible to voltage sags are sensors, electronic process controls and computer controls, as well as electrical relays. Normally, if the voltage sags less than 90% from nominal voltage, the device maybe tripping even the duration is only one or two cycle such as less than 100 milliseconds. In order to restart production time after such an unplanned stoppage can typically be measured in every second. It will because the cost per event is losing for an industry [10].

Voltage sag is not yield with the sensitive equipments that is used in modern industrial plant such as process controllers, adjustable speed drive (ASD), programmable logic controllers (PLC) and robotics [15]. In order to mitigate or reduce voltage sag, various methods had been applied to the power system.

2.3 REACTIVE POWER COMPENSATION

Reactive power is supply power to the stored energy in the reactive elements. Basically, two components of power are active and reactive power. Apparent power is the total of active and reactive power. The precise control of active and reactive power flow is the main requirement in power transmission system in order to maintain the stability of voltage. However, the problems with power quality is not completely solved because of uncontrollable reactive power compensation and the cost of new feeders is very high [15].

2.3.1 GENERAL BACKGROUND

Lat two decades, the power industry had received highly demanding in electrical energy. There are many power plants; substation and transmission lines are needed to be constructed [16].

At the beginning distribution system, the uses of reactive power compensation are very slightly. The synchronous generator is supplied for any reactive power requirement by the components of the system or by the load. These can cause to the system become inefficient utilization, as well as developing rate structures by the utility company in order to penalized load of the low power factor [3].

In AC circuit, energy stored in the inductive and capacitive elements, the periodic reversal of energy between the source and the load is resulted. Real power completed all the useful work whereas the reactive power supports the controlled voltage for the system reliability. Reactive power has a major effect on the power system security due to the voltage affecting in throughout the system [3].

The reactive power produced by AC power source which is stored in capacitor and reactor during the cycle, it sending back to the power sources. On the other hand, reactive power compensation can be implemented with Var generators that are connected either in series or parallel.

2.3.2 IMPORTANCE OF REACTIVE POWER

Reactive power and voltage control are two aspects of both facilitates and reliability commercial transaction across the transmission network.

Theoretically, to maintain the voltage to deliver the active power through the transmission line, the reactive power is required. Furthermore, motor loads need reactive power to convert the flow of electrons into useful work. If the reactive power needed is not enough, the voltage down and it is no possible to push the power demanding by load [3].

Reactive power consumes transmission and generation resources. In order to maximize the amount of the real power which can transferred across the transmission interface, the amount of reactive power flow must be minimized [17].

2.3.3 BENEFIT OF REACTIVE POWER COMPENSATION

There are a few benefits of using of the reactive power compensation in power system. Reactive power compensation has better efficiency than others in power generation, transmission system and distribution system. Furthermore, it also can improve the voltage and