# OVERVOLTAGE SURGE IN LOW VOLTAGE CONSUMER EQUIPMENT

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To my beloved wife, mother, and families, thanks for all your supports.

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# ABSTRACT

These papers present the study on the effects of Overvoltage Surges in low voltage consumer equipment by the use of PSCAD software simulation. In this approach, the combination of Shock Protection Devices installed at different locations will result in ascertaining the most suitable numbers and appropriate locations of SPDs to be installed in the safe protection zone away from the surge origin. Overvoltage Surges can neither be destroyed nor be prevented. Also commonly known as Transient Overvoltage, it is a type of electrical overstress that is conducted on wires which brings damage to electrical equipment especially on low voltage consumer equipment such as computers, modems, electronic devices and even electric motors. In the absence of protective devices that could limit the voltage, magnitude of the peak surge is usually at least twice the normal system voltage. In order to protect the low voltage electrical installations and equipment, this project is being carried out to study the effectiveness of Surge Protective Devices installed at various locations from the load. The locations are 0 metres, 100 metres, 200 metres, 300 metres and 400 metres away from the distribution transformer. The essential criteria in protecting the equipment during surge is the suitable locations of the SPDs besides the optimum quantity to be introduced for protecting the Low Voltage Consumer equipment. Thus, proper selection of the locations and numbers of SPDs must be really put into consideration. Simulation and experimental results are presented demonstrated that SPDs are also essential to protect low voltage consumer segment of electrical distribution system although presently they were in existence in the high voltage installations to improve power quality.

# ABSTRAK

Kertas kerja ini membentangkan pengkajian mengenai kesan Voltan Pusuan Lampau ke atas peralatan pengguna elektrik voltan rendah secara simulasi perisian PSCAD. Kaedah yang digunakan adalah secara menggabungkan Peranti Perlindungan Voltan Lampau yang dipasang pada lokasi yang berbeza yang menghasilkan pengenalpastian bilangan peranti serta lokasi peranti SPD yang paling sesuai dipasang di dalam zon perlindungan yang selamat, jauh dari punca voltan pusuan tersebut. Voltan Pusuan Lampau bukan hanya tidak boleh dimusnahkan malahan juga tidak boleh dihindarkan. Juga dikenali sebagai Transien Voltan Lampau, ia adalah sejenis tekanan lampau kuasa elektrik yang mengalir melalui kabel pendawaian yang boleh mengakibatkan kerosakan ke atas peralatan elektrik terutamanya peralatan pengguna voltan rendah seperti komputer, modem, peranti elektronik dan malahan juga motor elektrik. Tanpa peralatan perlindungan yang berupaya menghadkan nilai voltan, magnitud puncak Voltan Pusuan kebiasaannya menjadi tidak kurang dua kali ganda nilai voltan sistem pengagihan. Demi untuk melindungi pepasangan dan peralatan elektrik voltan rendah, projek ini telah dilaksanakan bagi mengkaji keberkesanan peranti SPD yang dipasang di beberapa lokasi dari beban. Lokasi tersebut adalah 0 meter, 100 meter, 200 meter, 300 meter dan 400 meter dari alatubah pengagihan. Kriteria yang perlu dititkberatkan dalam memberi perlindungan ke atas peralatan pengguna semasa keadaan Voltan Pusuan Lampau adalah lokasi yang sesuai untuk pemasangan SPD selain dari kuantiti optima demi melindungi peralatan pengguna voltan rendah. Sedemikian, pemilihan lokasi dan bilangan SPD yang bersesuian perlulah diberi pertimbangan yang wajar. Kaedah simulasi dan keputusan pengujian membuktikan bahawa SPDs juga adalah perlu bagi melindungi segmen pengguna voltan rendah di dalam sistem pengagihan elektrik walaupun peranti tersebut telah wujud dalam pepasangan voltan tinggi bagi menambahbaik kualiti kuasa.

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| | | |
|---|---|---|
| TNB | - | Tenaga Nasional Berhad |
| SPDs | - | Surge Protection Devices |
| LV | - | Low Voltage |
| EPRI | - | Electric power Research Institute USA |
| I/O | - | Input Output |
| PSCAD | - | Power Simulation Computer Aided Design |
| OCPDs | - | Overcurrent protective devices |
| TOVs | - | Temporary overvoltages |
| SCRs | - | Semiconductor controlled rectifiers |
| UPSs | - | Uninterrupted Power Supplies |
| UTM | - | Universiti Teknologi Malaysia |

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

Electricity consumers at residential areas (Low Voltage Power Consumers) are expected to get pure sinusoidal waveforms of electricity supply being fed to their house. So, it is the responsibility of the power utility provider to maintain a uniform voltage to be distributed to the consumers but existence of external and internal disturbances can jeopardise their efforts. Under-voltage (sag), over-voltage (swell), surges and harmonics are the disturbances that can happen in power quality. The overvoltage surge may cause severe system failures and destructive to consumer appliances which translate to monetary losses in replacing the damaged items, one example was in Kulim as reported in the national newspaper on March 2011. This is due to power switching by Tenaga Nasional Berhad (TNB) substation . There were aslo incidences experienced by consumers in Perak suffering of damaged electrical appliances due to copper busbars theft in the TNB substations due to “floating neutral’. As a conclusion, all the disturbances are very dangerous not only to the equipments, and also can endanger the people nearby the disturbance vicinity.

The voltage surge (sudden electrical energy interruption voltage) and the sag are probably, the most important disturbances the power quality in electrical system. Because of lightning traveling waves are produced in the system. These traveling waves cause the temporary increase in voltage in the transmission line system. The increase in voltage is harmful for the insulator of lines and devices connected to the transmission line. Therefore, it is necessary to analyze such increase in voltage in order to design the surge arrester (or the insulator) suitable for the investment, the good performance of the system and the reliability of transmission line system [1]. Because of this finding, this final year report is done to prove that the Surge Protection Devices (SPDs) should be installed at suitable locations at residential distribution areas. The installation of the SPDs should not be a burden to the consumers for the installation of the SPDs at their respective house. Looking at this factor, suitable location has been selected and tested for the simulation to prove the effectiveness of the SPDs installed.

Overvoltages in power systems may be generated by external events, such as lightning; by internal conditions including faults, switching, ferroresonance, load rejection, loss of ground, and so on, or by any combination of the above. The magnitude of these overvoltages can be above maximum permissible levels and therefore need to be reduced and protected against if damage to equipment and possible undesirable system performance are to be avoided [2].

Normally, for the low voltage (LV) consumers, they can be affected by surge voltage from the switching of transformers, motors or inductances in general, and sudden variation of load, disconnection of circuit breakers or cut outs (i.e in the distribution circuits) lead to overvoltages that penetrate the user’s building. Significantly, the closer the building or house is to a generating station or substation, the higher the risk of overvoltage to them.

In general terminology, SPD located at the service entrance is usually called “arrester”, while SPD located near equipment is usually called “suppressor”. In the low–voltage AC power circuits many users assume that application of only one suppressor will provide overall protection for all equipment [3].

## 1.2 Problem Statements

Every now and then, more and more equipment losses and down time are subjected to over-voltage events. This increase in damage is due to both the increased usage of microprocessors in a greater range of products, and the continuing miniaturization of these microelectronic components. The damages of the products/appliances are due to the internal and external disturbances of the power systems. The surges emerging in the power-supply network would bring faults to or destroy this equipment. Various overvoltages yielded by lightning strikes and operating switches are the major origin of faults. The system overvoltage usually results from lightning strikes, but it does not result from the direct lightning strikes. Actually, the damage of devices is mostly caused by the inrushing surge along various metal pipelines and electric cables. Therefore, surge protective devices (SPDs) are widely used in low-voltage distribution systems to immunize the interference of the invaded lightning surge.

Overvoltage especially surge voltage during the switching activity by TNB can cause a lot of problems to TNB itself and could be vulnerable the consumers. By installing a proper and with suitable location of the SPDs, it can reduce the magnitude of the voltage and protect the equipments from any potential damages. The installation of SPDs by the utility provider must not be impose any burden to the consumers, in the other hand it enables in increasing the level of protection of the electricity being supplied to them.

In 2003, Electric power Research Institute USA (EPRI) published a report which stated that the cost of unplanned production interruption to US industry due to variations in electrical power supply was of the order of US$100 billion per annum. EPRI forecast that this course will grow as the use of power electronic devices has provided industry with much greater process control, but these devices have proved much more susceptible than traditional equipment to power variations and particularly to voltage disturbances [4].

In Malaysia lately, increasing trend of using power electronic devices as part of controlling the speed of electronics motors (ASD) for efficient energy usage will surely contribute to voltage disturbances. To make matter worst, 80% of LV consumers are without any Shock Protective Device in their systems.

To overcome the problem, there is a need for coordinated protection in terms of introducing a suitable Surge Protection Devices as part of comprehensive protection. Each of this is independent disciplines that need a holistic design approach to ensure the LV consumers are not left with vulnerable “blind sport”. The investments of surge protection devices can be wasted if the “blind sport” is still exist. For example, installing an SPD to the programmable logic controller is of little value of the I/O lines are not protected. Equally, even the most expensive SPDs are poor performers if a low impedance equipotential ground is not provided.

## 1.3 Objectives

Objectives that need to be met in this project are:

i. To study how to do a simulation using PSCAD,
ii. To study types of disturbances in power quality that affects the quality of electric supplied to the consumers.

iii. To evaluate the ability and effectiveness of the SPDs installed before the electric being distributed to the low voltage (LV) consumers using the software simulation i.e PSCAD.

## 1.4 Scope of Work

The scope of work for this project can be divided into two parts. In the first part it will cover the understanding of the most destructive overvoltage and the way of minimizing the effect of the overvoltage surge by implementing the Surge Protection Devices to the LV consumers

The second part of this project is analyzing the performance of the SPDs installed at proposed location by using PSCAD/EMTDS. From the simulation results, it will prove that the SPDs need to be installed at the Low voltage consumers.

## 1.5 Project Report Organization

This project report is organized in the following way:

Chapter 1 provides the introduction and background to the topic. Chapter 2 covers the literature review and theoretical analysis of the SPD. Chapter 3 presents the research methodology used in the project. The results and discussions from the studies will be presented in Chapter 4 in order to give a clear understanding of the research objectives and this is then followed by the last chapter, Chapter 5, which is the conclusion of the whole research study.

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