UNIVERSITI TEKNIKAL MALAYSIA MELAKA
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LAPORAN PROJEK SARJANA MUDA

SURGE PROTECTION DEVICE (SPD): EFFECT OF DIFFERENT DESIGN OF GROUNDING SYSTEM

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"I hereby declare that I have read through this report entitle "Surge Protection Device (SPD): Effect of Different Design of Grounding System" and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

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A report submitted in partial fulfilment of the requirements for the degree of Bachelor of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2017

I declare that this report entitle “Surge Protection Device (SPD): Effect of Different Design of Grounding System” 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 other degree.

Signature : ……

Name : ……

Date : ……

To my beloved mother and father

ACKNOWLEDGEMENT

In the name of Allah SWT the Most Beneficent and Merciful, all praises and glory be upon Him. Blessing and Greeting upon our beloved prophet Muhammad SAW, his family and companions.

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ABSTRACT

This study is about the impact of the difference value of grounding impedance for surge protection device (SPD) in the low voltage system. High grounding impedance will reduce effectiveness of the surge current to flow through earth which increase possibility users and equipment exposed to surge current. The important characteristics when to choose SPD is the SPD voltage protection level (*Up*) must be less or equal to equipment withstand voltage (*Uw*). This study also considered the important criteria for SPD coordination such as the length of cable to the equipment. This study was conducted by software simulation and real equipment experiment. Simulation was use circuit modelling software known as PSCAD. It used to analyze the characteristics of SPD and investigate the oscillation phenomenon. In order to prove it is a reliable simulation it requires validation using experiment. Therefore, experiments using actual equipment was be carried out at the High Voltage Laboratory, University of Technical Malaysia Melaka (UTeM). Results of the data from the two experiments are compared and analysed. The analysis shows that the effect of the increment of impedance grounding was affected the discharge surge current from SPD to earth.

ABSTRAK

Kajian ini adalah mengenai kesan perbezaan nilai impedan pembumian untuk peranti perlindungan lonjakan (SPD) pada sistem voltage rendah. Nilai impedan pembumian yang tinggi akan mengurangkan keberkesanan arus lonjakan untuk mengalir ke bumi malah meningkatkan kemungkinan pengguna dan peralatan terdedah pada arus lonjakan. Antara ciri-ciri penting semasa pemilihan SPD adalah tahap perlindungan voltan SPD (*Up*) mesti kurang atau sama nila dengan voltan menahan peralatan (*Uw*). Kajian ini juga mengambil kira kriteria penting semasa kordinasi pemasangan SPD seperti panjang kabel dari SPD kepada peralatan. Kajian ini telah dijalankan mengunakan perisian simulasi dan juga ekperimen mengunakan peralatan sebenar. Ekperimen simulasi telah mengunakan perisian model litar simulasi PSCAD. Ia digunakan untuk menganalisa ciri-ciri SPD serta menyiasat fenomena ayunan. Walaubagaimanapun untuk mencapai simulasi dipercayai ia memerlukan pengesahan daripada ekperimen. Oleh itu ekperiment mengunakan peralatan sebenar akan dijalankan di Makmal Voltage Tinggi, Universiti Teknikal Malaysia Melaka (UTeM). Keputusan data dari kedua-dua ekperimen telah dibandingkan dan dianalisa. Hasil analisa menunjukan bahawa kesan dari kenaikan nilai impedan pembumian telah memberi kesan kepada pelepasan arus lonjakan dari SPD ke bumi.

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CHAPTER 1

1.1 Project Background

Surge phenomenon can cause occurrence over-voltage and over-current at low-voltage power system. This phenomenon can cause damage or functions failure to the electrical and electronic equipment [1]. Engineers usually recognizes two sources of voltage surges. This is classified as a source of internal and external causes.

According to the white paper presented by Phoenix Contact, an estimated 63 percent of the surge comes from within a facility. However, the remaining 37 percent of surges originate from outside of the affected facility [2]. Figure 1.1 shows the percentage source of surge from internal and external causes. Surges are caused by internal events such as motors starting and stopping, load dynamic changes on larger production machines, light load panels switching on and off, etc. Beside that, surges are caused by external events such as lightning strikes, utility grid switching, switching of capacitor banks, electrical accidents, etc.

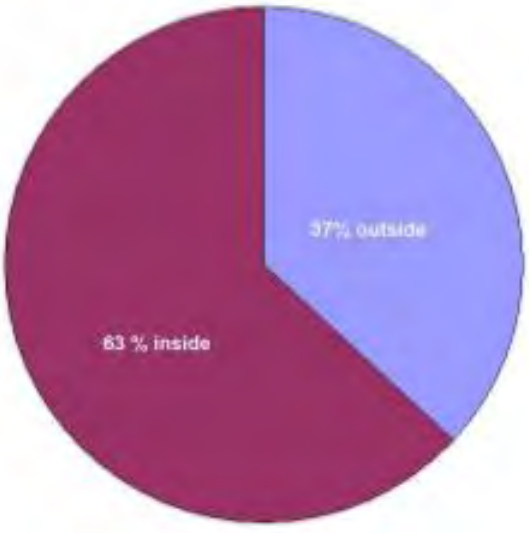

Figure 1.1: Percentage Source of Internal and External Causes Surge [2].

Therefore, the perfect surge protection system must be applied in every building that might be exposed to the risk of surge. The perfect surge protection system including the grounding arrangement, bonding arrangement, and coordination surge protection device (SPD) for protect at any surge coming [3]. Besides that, the installation air termination and down conductor as an addition protection surge especially for protect from lightning surge. Coordination SPD in building can limit the surges voltage on electrical equipment by absorbs and divert or limit high surge current to ground. It also can bypass the surge without through that equipment. It also able to repeat these functions as described depend on the manufacturer.

1.2 Problem Statement

Electrical and electronic equipment sometimes can be damaged during the occurrence of surge coming even protected by SPD. The issue of the value impedance circuit protective conductor (CPC) and value impedance in the grounding system correlates to the performance of the SPD. This is because the current surge bypass by SPD to the earth depends on the system grounding arrangement. Besides that, the oscillation phenomenon also causes the over-voltage will increase again in the terminal equipment. These oscillation phenomena depend on the characteristics of the SPD, the properties of the protected loads, the length of the connecting cable and system grounding arrangement. It also needs to be taken into consideration because the SPD potentially may are not working in supposed condition. The damage to the equipment still can occurs when be ignored this consideration.

1.3 Objective

Objective studies on Surge Protection Device (SPD): Effects of different design of grounding are:

- To evaluate SPDs protection level (*Up*) in order to limit surge voltage across the load.
- To analyse the performance of surge protection device (SPD) by referring the variation of impedance grounding.

- To investigation oscillation phenomena when different impedance grounding applying.

1.4 Project Scope

This project limit will cover simulation and hardware only for installation one SPD in the building at low-voltage system for single phase. The protection SPD only cover from surges are caused by internal events. The system grounding arrangement will consider use TT system. The type 2 SPD will be choosing because is the main protection system for low-voltage installation. Other than that, one load is used on fixed value impedance. Length of the connecting cable from SPD to the load will consider fixed at 5 meter and 10 meter. The value surge current flow to the load and bypass surge current flow to the grounding will be taken for analyse the performance SPD.

1.5 Expected Project Outcome

After the project is done, hopefully it can help to understand clearly the impact of surge for SPD and load. The efficient SPD, it design to limit the surges current on electrical equipment by absorb and will divide again and again until it finally reached the grounding electrode system where it will eventually travel into the grounding and disappearing. In order to do so, the characteristic performance SPD with different impedance value grounding should be analysing successfully.

In summary, the project should be:-

- Successful analyse the surge current flow of the SPD designed by using simulation PSCAD software.
- Successful understand the impact of surge current for SPD and load.
- Successful analyse the characteristic performance SPD with different impedance value grounding.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter will explain detail about the theory and basic principle in the developing project. Moreover, there will be a review and results discussion of the previous studies in the same area for this project. All the findings obtained in the previous study that are related with project could help in enhance the knowledge and understanding.

2.2 Surge

According to Curtis McCombs [4], a surge or transient is a voltage spike that only lasts a few millionths of a second. It can contain thousands of volts and thousands amps. The surge can come from two type of source that is from internal and external event. The surge from internal events such as from air conditioners, compressors, elevators, blower motor and office copiers. This surge known as oscillatory surge. It can produce a smaller surge and lower energy during start and off that equipment. Another surge is from external events such as from lightning, electrical accidents, switching capacitor banks and utility grid switching. This surge known as impulse surge. It more danger that can cause a large over voltage and over current at higher energy. Figure 2.1 shows the voltage waveform between normal voltage and during surge events. The peak voltage during the surge event higher than peak voltage at normal. This situation is more danger for the equipment especially for sensitive equipment.

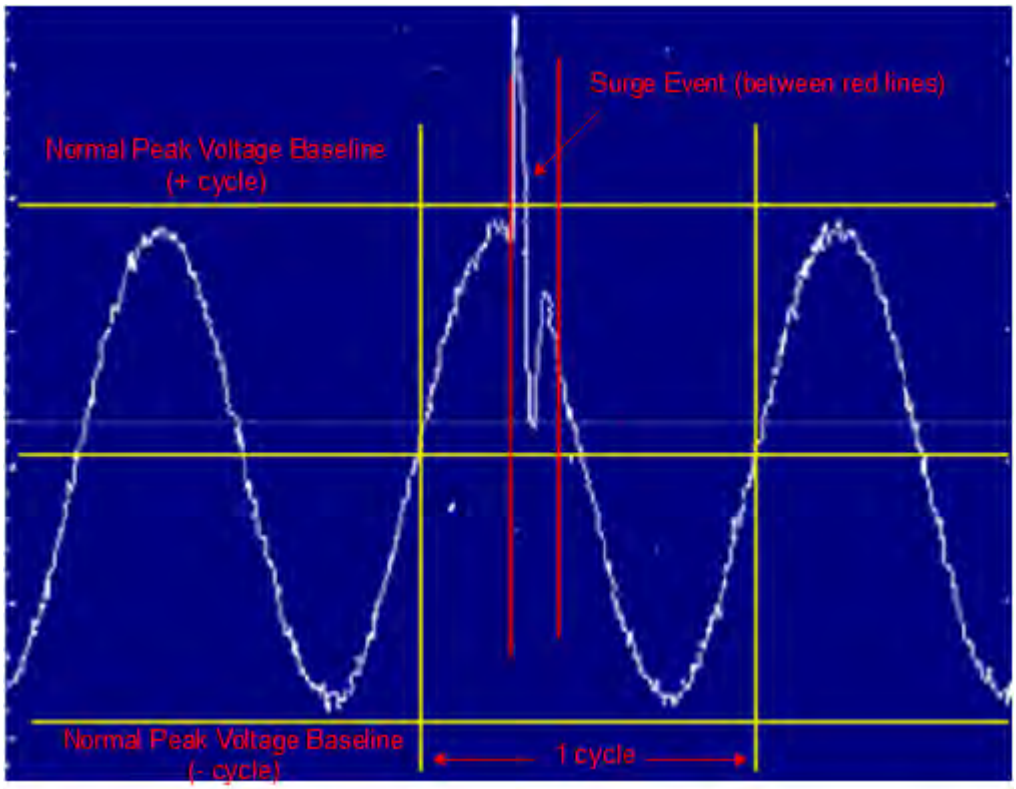

Figure 2.1: Voltage Waveform between Normal Voltage and Surge [4].

2.3 Surge Protection System

According to Curtis McCombs [4], the best surge protection system is only as good when its location and installation is suitable. This matter should consider the source surge it can come from especially from external event surge. According to T. Kisielewicz [5], electrical and electronic appliances modern structure is sensitive to surges. Surge protection system is used to reduce the impact of damage during lightning strikes to a structure. It protects the building and structures from fire or material damage, failure of electrical and electronic equipment, and persons from injury or event death. According to IEC Standard [6], a lightning protection system consists of external and internal lightning protection. External lightning protection system is needed to protect the direct impact of the lightning stroke on the building. While the internal lightning protection system is used for protect from indirect impact of the lightning stroke on the building. As shown in Table 2.1, the possible of the external and the internal lightning protection is as follows.

Table 2.1: The External and Internal Lightning Protection System [7].

No	External	Internal
1.	Air-termination system • is to capture the lightning strike to a selection point.	Equipotential Bonding (EB) • to minimizing potential differences.
2.	Down-conductor system • discharge current can be directed through the down conductor to the earth-termination system.	Grounding Cable • to distribution of the lightning current into the earth-termination system.
3.	Earth-termination system • to distribution of the lightning current into the earth.	Surge Protection Device (SPD) • to protection of internal systems against lightning surges (voltage and current).

2.4 Surge Characteristics

According to Sreten Skuletic and Vladan Radulovic [8], characteristics lightning surge voltage and current depends to the location and selection SPD. According to Y. Du, Binghao and Mingli Chen [9], evaluate and analyse characterize the surge environment in buildings is important for protection sensitive equipment. The specified waveform and amplitude of surges in different locations must considered. The characteristics surge current and voltage related to the direct and indirect impact of the lightning strikes on the building.

2.4.1 Characteristics Lightning Surge

The IEC Standard [6,7] specify two current impulse waveform for the testing of surge protective devices. The two specified waveforms are referred as 10/350 μs waveform for direct impact lightning strikes. Other waveforms referred as 8/20 μs waveform for indirect impact lightning strikes. The first number refers to the rise time in micro seconds. The second number refers to the half peak width in micro seconds. These two types

waveform are used to specify tests on SPD immunity to lightning currents. The intensity of lightning stroke can determined base on the peak value of the current wave. The value intensity requirement is a at 10kA, 3kA, 0.5kA and 0.2kA. Figure 2.1 and figure 2.2 shows the characteristics waveform from direct and indirect lightning stroke.

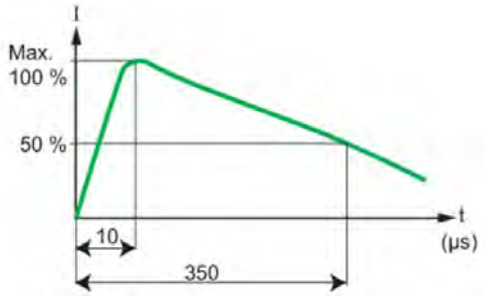

Figure 2.2: 10/350 µs current wave direct impact [6].

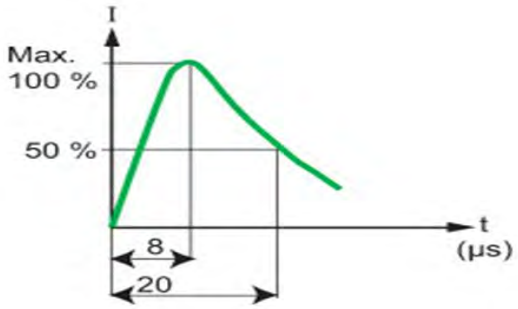

Figure 2.3: 8/20 µs current wave indirect impact [6].

According to IEC Standard [6,10] the voltage impulse waveform created by lightning strokes are characterized by a 1.2/50 µs voltage wave. This waveform is used to verify equipment's withstand to over-voltage of lightning stroke. The requirement over-voltage is at 10kV and 6kV. Figure 2.4 shows the characteristics voltage pulse or wave form from lightning stroke.

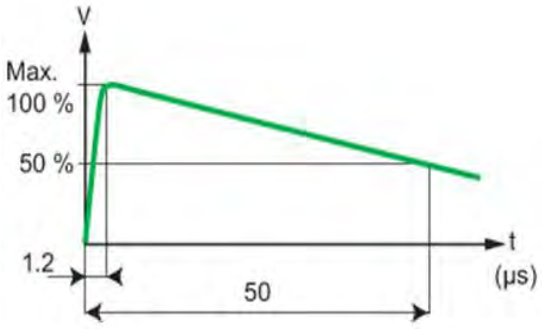

Figure 2.4: 1.2/50 µs voltage wave [6].

2.4.2 Characteristics Switching Surges

Another type of characteristics surge is a switching surge. According to IEC Standard [6,10] the voltage impulse waveform created by switching surge are characterized by a 250/2500 µs voltage wave. This waveform is used to verify equipment's withstand to over-voltage of switching. The requirement over-voltage is at 6kV to 10kV. Figure 2.5 shows the characteristics voltage switching surge wave form.

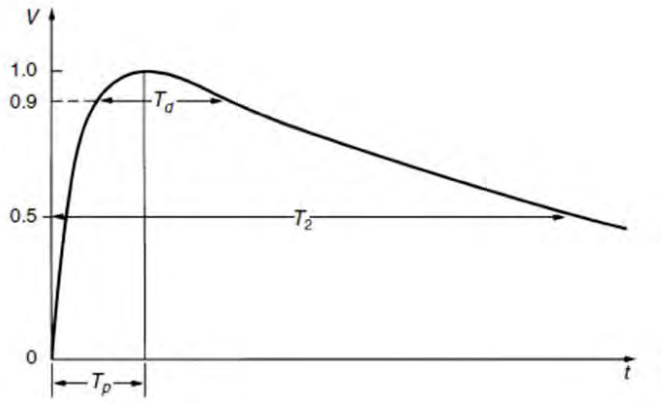

Figure 2.5: 250/2500 µs voltage wave [10].

2.5 Surge Protection Device (SPD)

Another research [11] stated that the surge protective devices (SPD) can reduce the probability of electrical equipment damage. The SPD has high impedance before the transient over-voltage appears in the system. The impedance of the SPD will decrease when the transient overvoltage appears in the system. The surge current is driven through the SPD, bypassing the sensitive equipment. It can also be used at all levels of the power supply network. Figure 2.6 shows the principle of protection system in parallel from lightning stroke and switching surge.

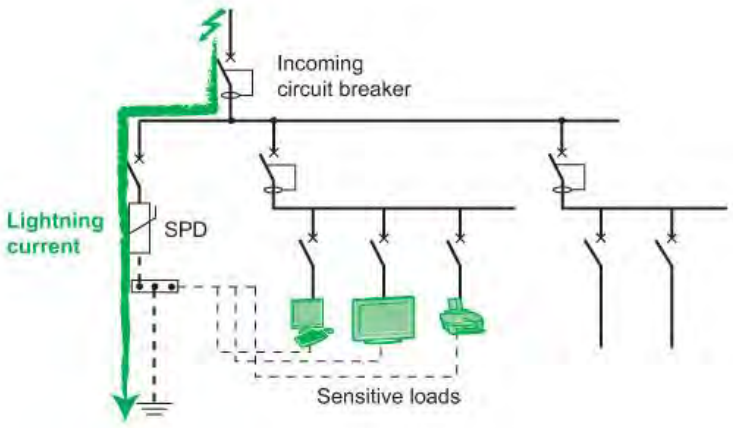

Figure 2.6: Principle of protection system in parallel [10].

2.5.1 Types and Classes Test of SPD

Base on IEC Standard [10], three types and three classes test are requirement for SPD. The three types SPD are namely Types 1, 2 and 3 SPDs. Type 1 SPD is for protect against direct lightning strikes. Type 2 SPD is for protection the low-voltage electrical installation. It installs at each electrical switchboard. While the Type 3 SPD for protect the sensitive equipment. It must install with combination Type 2 SPD. The three classes test is a Class I test for SPD Type 1, Class II test for SPD Type 2 and Class III test for SPD Type 3. Table 2.2 show the types and classes test of SPD.

Table 2.2: Types and Class Test of SPD [10].

Item	Direct lightning stroke	Indirect lightning stroke	
Type SPD	Type 1	Type 2	Type 3
Class Test	Class I	Class II	Class III
Type of test wave	10/350	8/20	1.2/50 + 8/20

2.5.2 Performance Characteristics SPD

According to [11], two main categorise of SPD are used for the protection against lightning surges. These categories depend on the characteristics construction component inside in the SPD. The two categories are namely switching type SPD (spark gap) and