THE EFFECTS OF FAST RISE MULTIPLE LIGHTNING IMPULSE ON THE ELECTRICAL BREAKDOWN CHARACTERISTICS OF MOV

SIN CHOK TEAN

UNIVERSITI TEKNOLOGI MALAYSIA

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UNIVERSITI TEKNOLOGI MALAYSIA

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ABSTRAK

Kecekapan alat perlindungan kilat seperti metal oxide varistor dibawah kajian gelombang dedenyut berbilang adalah berbeza dengan gelombang dedenyut piawai. Disebabkan metal oxide varistor adalah alat perlindungan kilat yang paling ekonomi dan luas digunakan dalam peralatan voltan rendah dan telekomunikasi, jadi satu cara penentuan ciri-ciri kecekapan MOV yang betul harus dilakukan bersesuaian dengan gelombang dedenyut kilat semulajadi. Dalam projek ini, kerja makmal harus dilakukan terhadap MOV yang berjulat voltan 1kV dan julat arus yang 250A. Sampel MOV hendaklah dikenakan terhadap gelombang dedenyut berbilang dengan masa menaik yang cepat yang dijanakan oleh janakuasa dedenyut kilat. Sampel MOV yang telah dikenakan gelombang dedenyut berbilang akan dikaji untuk menentukan keadaan rintangan and ciri-ciri voltan pecah tebat pada MOV.

ABSTRACT

The behavior and performance of lightning protective devices such as metal oxide varistor under the application of multiple lightning impulses are different from the standard single stroke test. Since metal oxide varistor is the most common, economical and reliable device for low voltage and telecommunication systems lightning protection, a precise method of testing has to be adopted based on natural characteristics of lightning to accurately determine its performance and capability. In this work, laboratory studies are to be carried out on 1kV voltage and 250A current ratings metal oxide varistor (MOV). The test samples are to be subjected to multiple lightning impulses with fast rise time using the constructed Multiple Impulse Generator (MIGe). The electrical responses of the device such as resistance and breakdown voltage characteristics are then being analyzed to determine the effect on the varistors characteristics.

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LIST OF SYMBOLS

A	-	Ampere
L	-	Inductor
R	-	Resistor
AC	-	Alternative Current
DC	-	Direct Current
mA	-	mili Ampere
kA	-	kilo Ampere
mV	-	mili Volt
kV	-	kilo Volt
µF	-	micro Farad
µH	-	micro Henry
µs	-	micro second
ms	-	mili second
s	-	second
Hz	-	Hertz
Ω	-	Ohm
MO	-	Metal Oxide
ZnO	-	Zink Oxide
MIGe	-	Multiple Impulse Generator
HV	-	High Voltage

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Many industries nowadays, such as telecommunication and computing are prone to dangerous and damaging transients and surges which are caused by power switching, electrostatic discharge and lightning strike. These surges and transients can cause erroneous equipment operation or corruption of process controllers resulting in system failure. Uncontrolled surges and transients can lead to expensive equipment repairs, considerable production downtime, loss of revenue and loss of profits. In order to reduce equipment damage and system downtime, many types of protection devices are being introduced to the system in order to reduce the cost of system maintenance and economic looses.

Metal Oxide Varistor (MOV) is a small electronic component that most commonly used to suppress transients in many applications such as, Uninterruptible Power Supplies (UPS), Transient Voltage Surge Suppressors (TVSS) and other protection devices. MOV contain of about 90% zinc oxide (ZnO) as basic ceramic, in a matrix of other metal oxides (10%), sandwiched between two metal plates (the electrodes). The boundary between each grain and its neighbors forms a diode junction, which allows current to flow in only one direction. At low applied voltages, the metal-oxide-type varistor looks like an open circuit because its unique two-phase material assumes the properties of an insulator. When applied voltage exceeds rated clamping voltage, MOV effectively becomes a short circuit and protects the device by allowing large current flow to ground. Their resistance (>1MΩ) breaks down within nano-seconds in the case of an overvoltage, dropping in extreme cases below 1Ω. The result of this behavior is a highly nonlinear current-voltage characteristic, in which the MOV has a high resistance at low voltages and a low resistance at high voltages.

Lightning is a random phenomenon, where typically 90% of cloud-to-ground flashes transfer negative charge. Such a flash consists of a sequence of one or more high amplitude, short duration current impulses or strokes, the subsequent strokes are sometimes called restrikes. Therefore, it is very important to study the behavior and performance of MOV under the different applications of multiple lightning impulses and standard single lightning strike. Some electrical characteristics such as electrical breakdown characteristics and insulation resistance of MOV are then being analyzed to determine the effect on MOV after multiple lightning strikes.

Another goal of this research project is to explore the operation of Multiple Impulse Generator (MIGe). By constructing a proper multiple impulse waveshaping circuit using MIGe; it can generate a desired standard lightning waveshape as well as fast rise multiple lightning impulse for the purpose of striking MOVs test sample. Laboratory studies will be carried out in 1 kV voltage and 250A current ratings of metal oxide varistor (MOV). Laboratory experimental results are expected to show a significant effect on the electrical characteristics of Metal Oxide Varistor (MOV) when subjected to fast rise multiple lightning impulse, as compared to the standard lightning impulse.

1.2 Project Objectives

There are three main objectives that need to be achieved at the end of this research work:

1. To generate the standard lightning impulse and fast rise multiple lightning impulse by using Multiple Impulse Generator (MIGe)
2. To test the respond of metal oxide varistor (MOV) by applying the generated lightning impulse on it
3. To analyze the electrical characteristics of MOV under standard lightning and fast rise multiple lightning waveform

1.3 Scope of Work

This research work involves a study on the electrical responses of metal oxide varistor (MOV) under multiple lightning strikes. Some electrical characteristics such as the electrical breakdown characteristics and resistance are then being analyzed to determine the effect on MOV. On the other hand, the research works also focus on the operation of Multiple Impulse Generator (MIGe) by setting up this equipment for laboratory experiment purpose. Laboratory studies will be carried out in 1 kV voltage and 250A current ratings metal oxide varistor (MOV). The tests samples are to be subjected to fast rise time multiple lightning impulses using the constructed Multiple Impulse Generator (MIGe).

1.4 Thesis Outlines

This research project is divided into six chapters. Generally, some basic principals, theories, equations, previous researches references, experiment result and discussion were included in these six chapters based on the contents requirements of each chapter.

In chapter 1, the author has included the project overview and the main objectives of conducting this research project. Chapter 2 presents some background information of the research project, such as the issue of natural lightning and metal oxide varistors (MOVs). This chapter briefly explains the formation of natural lightning as well as the importance of conducting a research on the multiple lightning impulses. On the other hand, this chapter also explains the basic operation of metal oxide varistor (MOV) and the electrical characteristics of MOV. Comes to the end of the chapter, the author will present the current research works done by other researchers and of course based on their valuable recommendations.

Chapter 3 presents the methodologies of doing multiple lightning impulse experiment as well as the procedures of carrying out diagnosis test. The method will be presented in flow chart fort together with a brief explanation.

Equipment setup procedures and functionality of multiple impulse generator (MIGe) will be covered in Chapter 4. Four major parts of MIGe are power supply unit, triggering units, lightning impulse waveshaping circuit and measurement unit will be explained in details in this chapter.

Chapter 5 will discuss the experiment results of voltage lightning impulse as well as current lightning impulse test. The performance of MOV in term of resistance and electrical breakdown voltage will be discussed in details. The final section of this chapter will explain the reasons of MOVs' degradation after lighting impulse test.

Finally, Chapter 6 will conclude all the works and studies that had been presented in the pervious five chapters. Besides, some recommendations as well as the contributions to the field will be mentioned.

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