

**THE EFFECT OF MULTIPLE LIGHTNING IMPULSES ON THE  
ELECTRICAL CHARACTERISTIC OF OPTO-ISOLATOR  
AS LIGHTNING PROTECTIVE DEVICES**

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## ABSTRACT

The behavior and performance of surge protective devices such as opto-isolator under the application of multiple lightning voltage impulse are different from the single lightning voltage impulse test. Since opto-isolator is becoming the most common, economical and reliable device for low voltage systems surge protection, a precise method of testing has to be adopted based on natural characteristics of lightning. This is to ensure that the performance and capability of the device is precisely determined. In this work, laboratory studies are carried out on opto-isolator subjected to 1/1000 $\mu$ s, 1kV multiple voltage impulses by using the Multiple Impulse Generator, MIGe. The electrical responses such as collector emitter breakdown voltage,  $V_{(BR)CEO}$ ; emitter collector breakdown voltage,  $V_{(BR)ECO}$  and collector base breakdown voltage,  $V_{(BR)CBO}$  are then being analyzed to determine the effect to the opto-isolator characteristic. Results from the laboratory works shows that the multiple lightning voltage impulse has significant effects on the collector emitter breakdown voltage  $V_{(BR)CEO}$  and emitter collector breakdown voltage  $V_{(BR)ECO}$  characteristics of the opto-isolator and no significant was observed for parameter of collector base breakdown voltage,  $V_{(BR)CBO}$ .

## ABSTRAK

Gaya laku dan kecekapan peranti pelindung kilat seperti *opto-isolator* di bawah kajian gelombang dedenyut berbilang adalah berbeza dengan gelombang dedenyut tunggal. Memandangkan penggunaan *opto-isolator* telah menjadi kebiasaan, lebih ekonomik dan suatu peranti yang boleh dipercayai untuk voltan rendah dan penggunaannya dalam peralatan penahan kilat, maka suatu kaedah ujian yang tepat harus diaplikasikan berdasarkan ciri-ciri panahan kilat untuk menentukan prestasi dan ketahanan peranti tersebut. Dalam kajian ini kerja-kerja makmal dilaksanakan terhadap *opto-isolator*, di mana ia telah dikenakan voltan dedenyut berbilang  $1/1000\mu\text{s}$ , 1kV dengan menggunakan penjana dedenyut berbilang MIGe. Ciri-ciri elektrik seperti *collector emitter breakdown voltage*,  $V_{(BR)CEO}$ ; *emitter collector breakdown voltage*,  $V_{(BR)ECO}$  dan *collector base breakdown voltage*,  $V_{(BR)CBO}$  akan dikaji kesannya terhadap gelombang dedenyut berbilang. Daripada kajian makmal menunjukkan bahawa gelombang dedenyut berbilang memberi kesan terhadap kuantiti *collector emitter breakdown voltage*  $V_{(BR)CEO}$  serta *emitter collector breakdown voltage*  $V_{(BR)ECO}$ , tetapi tidak memberi kesan terhadap kuantiti *collector base breakdown voltage*,  $V_{(BR)CBO}$

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**LIST OF SYMBOL**

A	-	Ampere
mA	-	miliampere
AC	-	Alternating Current
DC	-	Direct Current
R	-	Resistor
C	-	Capacitor
I	-	Current
V	-	Voltage
kV	-	kilo Volt
$\mu$ s	-	Micro second
$\mu$ F	-	Micro Farad
pF	-	Pico Farad
$\Omega$	-	Ohm
$V_{(BR)CEO}$	-	Collector emitter breakdown voltage
$V_{(BR)ECO}$	-	Emitter collector breakdown voltage
$V_{(BR)CBO}$	-	Collector base breakdown voltage

$t_f$  - Front time

$t_t$  - Tail time

## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Project Background**

Lightning is one of the major sources for electrical overstresses that can cause failure, permanent degradation or temporary malfunction of electrical and electronic devices. Lightning is a transient, high-current and high-voltage discharge which will propagate into the power line, data line, telecommunication systems and other low voltage system. 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 losses.

In order to achieve an optimum protection, it is necessary for the device to provide protection against lightning impulses. The most common, economical and reliable of suppressing surge or transient voltage is through the application of surge protective devices (SPDs) like metal oxide varistors (MOVs), opto-isolator and gas discharge tube (GDT) with its own characteristics and performance. This research is focusing on the effect of non standard multiple lightning impulses on the electric characteristic of opto-isolator as SPDs through the experimental approach.

## 1.2 Objective of The Research Project

There are three objectives of this project, which are stated as follows:

1. To generate a single and multiple lightning impulse voltage using Multiple Impulse Generator (MIGe).
2. To conduct an experiment on single and multiple impulses to opto-isolator.
3. To analyzes the effect of multiple lightning impulse on the electrical characteristic of opto-isolator as low voltage protective devices.

## 1.3 Scope of The Research Project

In order to achieve this project objective, the following scopes will be covered:

1. Generate a  $1/1000\mu$  single lightning impulse and multiple lightning impulse voltage using MIGe in the lab. The maximum voltage impulse is 1kV.
2. The electrical characteristic to be studied are Collector Emitter Breakdown Voltage,  $V_{(BR)CEO}$ ; Emitter Collector Breakdown Voltage,  $V_{(BR)ECO}$  and Collector Base Breakdown Voltage,  $V_{(BR)CBO}$ .
3. The Opto-isolator is to be subjected to single lightning impulse and multiple lightning impulse. Choose five different type of opto-isolator.
4. The types of opto-isolator as sample test has been used are NTE3040, NTE3041, NTE3042, 4N25 and 4N26.

## **1.4 Thesis Outlines**

This research project is presented in six chapters.

Chapter 1: Introduction

Chapter 2: Literature Review

Chapter 3: Research Methodology

Chapter 4: Experimental Works

Chapter 5: Results, Analysis and Discussion

Chapter 6: Conclusion and Recommendation

Chapter 1 is an overview of the whole research project where the problem statement, objectives and scope of research are defined.

Chapter 2 presents some background information on research project such as the issue of natural lightning and opto-isolator. This chapter explains the formation of lightning, lightning waveform, theory of opto-isolator and their parameter. Previous studies of multiple lightning impulses on protective device are also being reviewed.

Chapter 3 presents the methodologies for this research work. This method is present in flow chart and follow with brief explanation.

Chapter 4 presents the major parts of experiment work and functionality of multiple impulse generator (MIGe). Four major parts of MIGe are power supply unit, triggering units, lightning impulse waveshaping circuit and measurement unit explained in this chapter.



Chapter 5 presents the experiment result. Analysis are done to determine the effect of applying single and multiple lightning impulse voltage. Discussion on the effect of applying single and multiple lighting impulse voltage are also presented.

Chapter 6 presents the conclusion and suggestion for further studies that can be done in the related research area.

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