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

AHMAD BIN SIDIK @ MAT SIDEK

UNIVERSITI TEKNOLOGI MALAYSIA

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

AHMAD BIN SIDIK @ MAT SIDEK

A project report submitted in partial fulfillment of the
requirements for the award of the degree of
Master of Engineering (Electrical – Power)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

MAY 2008

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 1/1000μs, 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 1/1000μs, 1kV dengan menggunakan penjana dedenyut berbilang MIGe. Ciri-ciri elektrikal 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, $V_{(BR)CBO}$*

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURE

LIST OF SYMBOL

A	-	Ampere
mA	-	miliampere
AC	-	Alternating Current
DC	-	Direct Current
R	-	Resistor
C	-	Capacitor
I	-	Current
V	-	Voltage
kV	-	kilo Volt
μs	-	Micro second
μF	-	Micro Farad
pF	-	Pico Farad
Ω	-	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 propagates 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 looses.

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 1/1000μ 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.

REFERENCES

1. Martin A Uman, " *Natural Lightning*", IEEE Transaction on Industry Application, Vol. 30 No 3, May/June 1994.
2. M. Darveniza, S. Lester and Y. Zhou, "*Laboratory Studies Of The Effects of Multiple Lightning Currents on Low Voltage Zinc Oxide Varistors*", IEEE Region 10 Conference Tencon 92 11 – 13 November, 1992.
3. R. A Sargent, G. L. Dunlop and M. Darveniza, "*Effects of Multiple Impulse Currents on the Microstructure and Electrical Properties of Metal-Oxide Varistors*", IEEE Transcation on Electrical Insulation. 1992.
4. Mardira, K.P., Saha, T.K. and Sutton, R.A. "*The Effects of Electrical Degradation on the Microstructure of Metal Oxide Varistor*". 2001 IEEE/PES Transmission And Distribution Conference And Exposition. 28 Oct. – 2 November 2001. Atlanta, USA: IEEE. 2001.
5. M.M. Yaacob, R.A Ghani, "*Voltage-Current Characteristics of Metal Oxide Varistor for Low Voltage Telephone Lightning Protector Under the Application of Multiple Lightning Impulse*", Conference Record of the 1998 IEEE International Symposium on Electrical Insulation, Virginia USA, June 7-10, 1998.
6. MM Yaacob, AB Darus, ZB Salam, and HB Ahmad, "*A Multiple Impulse Generator (MIGe)*", Jurnal Elektrika, Universiti Teknologi Malaysia, Dec 2005.
7. Naidu, M.S. and Kamaraju, V. "*High Voltage Engineering Fundamentals*", 3rd Edition. Singapore: Pergamon Press. 1984.
8. M. A Uman, "*Natural and Artificially Initiated Lightning and Lightning Test Standard*", Proc. IEEE, Vol. 76 pp 1548-1563, Dec 1988.
9. Nam Hwang, Priya Sarapna Rajoo Naidu and Alastair Tigg, "*Failure Analysis of Plastic Package Light Emitting Diodes*", IEEE 2003

10. Pritindra Chowdori, "*Parameter of Lightning Stroke and Their Effect on Power Syatem*", IEEE 2001.
11. Optocouplers: "*When and how to use them*", Electrus Distribution Reference Data Sheet.
12. "*IEEE Guide for the Application of Surge-Protective Devices for Low-Voltage (1000V or Less) AC Power circuit*"
13. W.G. Hawley, "*Impulse- Voltage Testing*", Chapman & Hall Limited, London, 1959
14. M. Darveniza' , D. Roby' and L.R. Tumma', "*Laboratory And Analytical Studies Of The Effects Of Multipulse Lightning Current On Metal Oxide Arresters*", IEEE Transactions on Power Delivery, Vol. 9, No. 2, April 1994
15. P. Chowdhuri, A.K. Mishra, P.M. Martin, B.W. McConnell, "*The Effects Of Nonstandard Lightning Voltage Waveshapes On The Impulse Strength Of Short Air Gaps*", IEEE Transactions on Power Delivery, Vol. 9, No. 4, October 1994 1991
16. Shojiro Yoneda And Yutaka Pukui, "*A New Bilateral Optoisolator Circuit*", IEEE Transactionso N Componentsh, Ybrids, And Manufacturing Technology,V Ol. Chmt-3, No. 2, June 1980