IMPULSE VOLTAGE GENERATOR : TRIGGERING CIRCUIT

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Bachelor of Electrical Engineering
(Industrial Power)

MAY 2009

" I hereby declare that I have read through this report entitle "*impulse voltage generator : triggering circuit*" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power) "

Signature :……..

Name of supervisor : …….

Date : …….

IMPULSE VOLTAGE GENERATOR: TRIGGERING CIRCUIT

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

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May 2009

I declare that this report entitle "*impulse voltage generator : triggering circuit*" 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 : Khairul Ridzuan Bin Mohamad Zin

Date : ……..

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ABSTRACT

A surge is a transient electrical disturbance that is cause by lightning, switching operations of fault. Lightning may cause damage to equipment and electrical system. Lightning has their own characteristic such as strokes, speed and others. But nowadays, the research of lightning is focus on high voltage surge protective device. The project focus on single stage of High Voltage Impulse configuration which the voltage can be generated up to 2kV.By design and developing impulse voltage generator with triggering circuit, so that the electrical characteristic and performance of lightning in low voltage could be determine. This triggering circuit is purpose to create manually artificial lightning. By using this impulse generator equipment the low voltages study especially in lightning protection devices for building and electrical gadget could be done.

ABSTRAK

Pusuan adalah satu gangguan elektrik yang disebabkan oleh kilat, ganguan operasi pensuisan. Kilat mungkin menyebabkan kerosakan pada peralatan dan sistem elektrik. Kilat mempunyai ciri mereka sendiri seperti pukulan, kelajuan dan lain-lain. Pada masa sekarang ini, penyelidikan kilat hanya memfokus pada pusuan alat peranti pelindung bervoltan tinggi. Projek ini memfokuskan pada denyutan bervoltan tinggi dalam julat sehingga 2kV.Dengan membenuk dan membangunkan dedenyut bervoltan tinggi berserta alat pemicu,kajian mengenai cirri cirri dan prestasi kilat voltan rendah ini dapat dikaji.Unit pemicu ini bertujuan untuk membentuk kilat tiruan secara manual.Dengan mengunakan alat dedenyut voltan ini.maka dapatlah kajian mengenai voltan rendah terutama dalam sistem perlindungan kilat pada bangunan dan barangan elektrik yang lain dilakukan.

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LIST OF SYMBOLS

A	Ampere
mA	Miliampere
AC	Alternate current
DC	Direct current
R	Resistor
C	Capacitor
L	Inductor
I	Current
V	Voltage
kV	Kilovolt
µs	Microsecond
µF	Microfarad
pF	Pikofarad
Ω	Ohm
K	Kilo
Hz	Hertz
cm	Centimeter
mm	Milimeter
V_p	Peak voltage
T_1	Rise time

T_2	Tail time

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

1.1 Background

This project was proposed develop an impulse voltage generator triggering circuit in range of 2 kV. This project can be use for surge protector device (SPD) experiments that involving low voltage impulse because the existing impulse generator is not suitable for low voltage SPD testing cause of its voltage rating. Sensitivity also issues on conducting the test on low voltage SPDs in term of the sphere gap adjustments.

Breakdown characteristic of a material commonly study in high voltage engineering. As for this project, the study is about breakdown characteristic of a material for low voltage surge. The develop a low voltage impulse generator that can produce an artificial low voltage surge for the study purpose. The previous study of impulse voltage generator is for generating an impulse voltage at higher rating up to 20MV. There is less study in low voltage impulse compare to high voltage impulse. This project can be results a break through findings that can be beneficial to electrical and electronic technologies.

1.2 Problem Statement

The behavior of lightning consists of direct and indirect. In order to develop the artificial lightning, the impulse voltage generator is used besides adjusting the sphere gap. Besides that, triggering circuit must be built too as to easier to catch the flashover. Without this triggering circuit, flashover is producing itself automatically between two sphere gaps and some time continuously trigger. To catch the wave with this development of triggering circuit, difficulty could be overcome.

1.3 Objective

The objective of this project is been text as below:

1. To create an artificial lightning by using impulse voltage generator.
2. To develop a triggering circuit for in range of 2kV impulse voltage generator.
3. To determined impulse fine shape.

1.4 Scope of Project

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

1. The scope of this project is to generate flashover in range 2kV
2. Use a sphere gap as a triggering device.
3. Use an ignition coil or autotransformer to generate flashover.

1.5 Project report outline

For this project, its generally divide into 5 chapter which is consist;

Chapter 1: Introduction

Chapter 2: Literature Review

Chapter 3: Methodology

Chapter 4: Result of analysis

Chapter 5: Conclusion and Recommendation

For introduction, chapter 1 is a general overview of the research project, the problem statement, objective and scope of research project are defined. The research project that will be done are based on the objectives and scopes that been stated earlier.

In chapter 2, its presents the literature review and theory background. In this chapter the principle and phenomenon of lightning, studies related with the theoretical impulse voltage, waveshape of impulse, related circuit. The study also related with ignition coil or autotransformer where cover up general knowledge, operation of ignition coil. Studies on literature review helps in understanding the fundamental of voltage surge and the operation of impulse voltage.

Chapter 3 will explain about the methodology that available in this research such as planning progress, software design and hardware design. This methodology will be presented in flow chart and explanation about stage of this project till end of the project.

In chapter 4, the major parts of the experimental work and analysis were explained here. The general safety precaution, experimental works, experimental and result of analysis. In order to obtain the experimental data will be discussed in detail.

Chapter 5 will be discussed about conclusion and discussion. The overall objective analysis and recommendation.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This section will discuss about the previous study that related in project, impulse voltage generator with triggering circuit. In this section, the explanation about lightning phenomenon has been study also with related circuit and characteristic of impulse. For the experimental research about ignition coil or transformer is been cover too.

2.2 Lightning

Lightning as in Figure 2.1 is an atmospheric discharge of electricity, which typically occurs during thunderstorms, and sometimes during volcanic eruptions or dust storms. In the atmospheric electrical discharge, a leader of a bolt of lightning can travel at speeds of 60,000 m/s, and can reach temperatures approaching 30,000 °C (54,000 °F), hot enough to fuse silica sand into frightened lightning, known scientifically as glass channels or fulgurites which are normally hollow and can extend some distance into the ground. There are some 16 million lightning storms in the world every year. Lightning can also occur within the ash clouds from volcanic eruptions, or can be caused by violent forest fires which generate sufficient dust to create a static charge.

Figure 2.1: Lightning strike

M.A.Uman [1] has made a conclusion from his research of lightning and state that many “Cumulonimbus” cloud produces a light. Lightning is a discharge of electric static occur in cloud, it, s because in cloud already have negative and positive charges. Lightning that have been occurring is categorized as lightning between cloud and earth. Lightning cloud to earth can make harmful to human and others property. It parameter include amplitude voltage, current, time delay and others. Negative lightning can produce 3 or 4 impulse for every strike and delay time between impulse is 20 ms.For positive lightning, it does seldom occur.

2.2.1 Lightning Phenomenon

Lightning is a transient, a very large electric and high current discharge whose path length is measured in kilometers, produced by clouds. Lightning occurs when some region of at the atmosphere attain an electric charge sufficiently large that the electric field associated with the charge cause electrical breakdown of air. The most common producer of lightning is the thundercloud (cumulonimbus).However lightning also occur in snowstorm, sandstorm and in the cloud s over erupting volcano. According to Martin A.Uman, there are four characteristic of lightning discharges. They are intra cloud(IC), cloud to ground (CG), cloud to cloud (CC) and cloud to air. However cloud to ground (CG) lightning has been studied more extensively than others form of lightning because this type cause heavy casualties to human and animal, disturbance in power and telecommunication equipment and system, ignition of forest fire and other kinds of losses and damages. “As lightning is a major fault on overhead line and damage to or

malfunction of sensitivity electronic equipment, it‟s essential to evaluate the lightning electromagnetic environment in order to mitigate its effect and improve the power system quality”[2]

2.2.2 Type of Lightning

There are various ways by which lightning can disturb low voltage line [2.]Basically lightning consist direct and indirect lightning. Direct lightning occurs when there is a storm. Direct lightning is dangerous because it can kill a human. Indirect lightning occurs from the propagate wave of direct lightning. Its mean that it‟s less powerful than direct lightning. Indirect lightning commonly occur in communication line through induction [3].

2.3 Impulse Voltage Generator

A double exponential waveform may be simulated in the laboratory with a combination of a series R-L-C circuit under over damped conditions by the combination of two R-C circuits. Capacitor C_1 previously charged to a particular dc voltage is suddenly discharged into the wave-shaping network by the spark gap (G). The discharge voltage V_0 (t) across C_2 (test object) gives rise to the desired double exponential wave shape.

The simplified but more practical forms of impulse generator circuits are shown in figure 2.2 (b) & (c). The two circuits are widely used and differ only in the position of the wave tail control resistance R_2. When R_2. is on load side of R_1 in two resistance form a potential divider which reduce the output voltage, but when R_2 is on the generator side of R_1 this particular loss of output voltage is absent The impulse capacitor C_1 is charged through a charging resistance to a dc voltage V_0 and then discharged by flashing over the switching gap with a pulse of suitable value. The desired impulse voltage appears across

the load capacitance C_2. The value of the circuit elements determines the shape of the output impulse voltage.

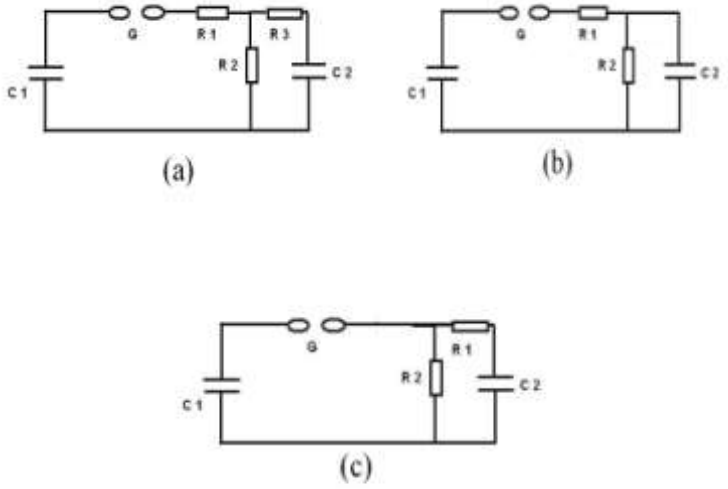

Figure 2.2: Type Circuits for producing impulse voltages

2.3.1 LIGHTNING IMPULSE WAVEFORM

A single, unipolar voltage pulse is term of an impulse voltage. The duration of the impulse voltage base upon the method of the generation. The various national and international standards define impulse voltages as a unidirectional voltage which rises more or less rapidly to a peak value and then decays relatively slowly to zero [3].

Impulse voltages with front durations varying from less than one up to a few tens of microseconds are defined as lightning impulse [4]. Three examples of lightning impulse are shown in Figure 2.3 below.

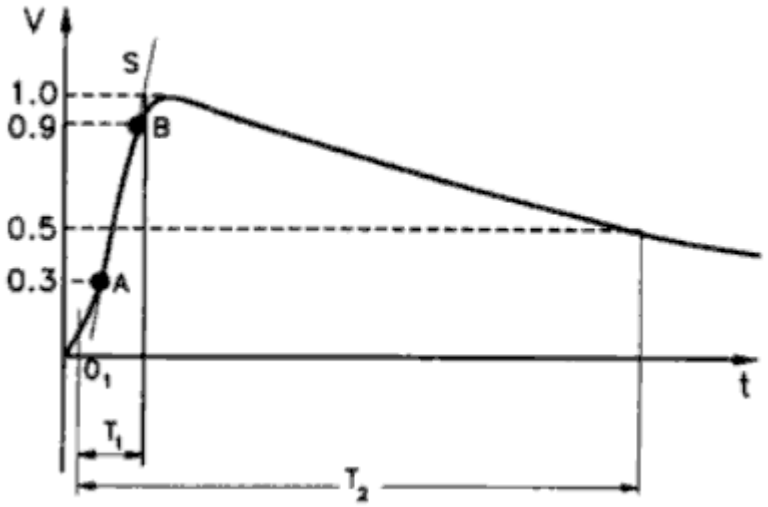

Figure 2.3: Full wave lightning impulse voltage

Referring to Figure 2.3, the point A and B on the impulse are marked corresponding to 30% and 90% of the peak voltage V_p . The virtual origin is defined as the point O_1 on the x-axis where the line O_1S drawn through the points A and B cuts the x-axis at $O_{1]}$. The virtual front time T_1 and the virtual time to half value T_2 are then defined as marked on the full lightning impulse wave[4] as shown in Figure 2.4 below. For those impulses chopped at the top or on the tail, T_c is defined as the time to chopping, Figure 2.4 (a). If the lightning is chopped in the front, the time to front is defined as indicated on Figure2.4 (b) by T_{fc}. [5]