

DESIGN AND SIMULATION OF MULTIPLE IMPULSE GENERATION

by

MASLINA BINTI MOHD ARIFFIN

Report submitted in partial fulfillment
of the requirements for the degree
of Industrial Electronic Engineering
Universiti Malaysia Perlis



JUN 2011

ACKNOWLEDGEMENT

I would like to express my gratitude to my major supervisor, En. Azralmukmin Bin Azmi, for trusting me with this challenging project and for his encouragement, enthusiastic spirit and guidance during my graduate studies.

I would also like to thank En Nasrul Helmei bin Halim and to all my friends for the technical information that shared with me. Furthermore, I would like to thank my parents for moral and financial support throughout my studies.

Last but not least I would like to thank to all for believing in me and morally supporting me.

“Without friends no one would choose to live, though he had all other goods.”

Aristotle (Greek Philosopher 384-322 B.C)



DECLARATION SHEET

I hereby declare that my Final Year Project Thesis is the result of my research work under supervision of supervisor(s) name. All literature sources used for the writing of this thesis have been adequately referenced.

Name (in capitals) : MASLINA BINTI MOHD ARIFFIN

Candidate number : 081070371

Supervisor : AZRALMUKMIN BIN AZMI

**Title of thesis (in capitals) : DESIGN AND SIMULATION OF MULTIPLE
IMPULSE GENERATION**

Candidate's signature: Supervisor signature:

Date:

Date:

APPROVAL AND DECLARATION

This project report titled Design and Simulation of Multiple Impulse Generation was prepared and submitted by Maslina Binti Mohd Ariffin (Matrix Number : 081070371) and has been found satisfactory in terms of scope, quality and presentation as partial fulfillment of the requirement for the Bachelor of Engineering (Industrial Electronic Engineering) in University Malaysia Perlis (UniMAP).

Checked and Approved by

(EN AZRALMUKMIN BIN AZMI)

Project Supervisor

School of Electrical System Engineering

University Malaysia Perlis

JUN 2011

REKAAN DAN SIMULASI GENERASI BERBILANG DEDENYUT

ABSTRAK

Kilat adalah sementara, mengeluarkan cas [1] arus yang tinggi yang menyebabkan peningkatan voltan. Kilat akan menghasilkan dedenyut, di mana ia mempunyai kesan pada sistem kuasa penghantaran dan peralatan. Voltan lebih dan arus lebih dihasilkan dari kejadian kilat yang bukan sahaja memberi kesan pada aliran kuasa tetapi juga pada voltan rendah seperti sistem telekomunikasi [2]. Projek ini menghasilkan gelombang dari kilat tunggal dan berbilang kilat menggunakan peranti perisian Pspice. Simulasi akan dibuat dengan menggunakan litar setara untuk dedenyut tunggal dan berbilang denyut. Untuk gelombang denyut tunggal, gelombang akan dijana mengikut cadangan standard voltan tinggi dedenyut (voltan dan arus dedenyut) IEC60060-1[3][6].

DESIGN AND SIMULATION OF MULTIPLE IMPULSE GENERATION

ABSTRACT

Lightning is a transient, high current discharge [1] that will cause steep build-up of voltage [7]. Lightning will generate impulses, which has a significant effect on power transmission system and equipment. The over-voltage or over-current resulting from a lightning incident will propagate not only into the power line but also into the low voltage line such as the telecommunication system [2]. This project presents the waveform of single and multiple impulse generation using PSpice software. The simulation will be performed by using an equivalent circuit of an impulse generator for single impulse generation and using a circuit of multiple impulses for multiple impulses generation. For single impulse waveform, the wave that will be generated follows the standard high voltage impulse (voltage and current impulse), IEC60060-1[3][6].

TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENT	ii
DECLARATION SHEET	iii
APPROVAL AND DECLARATION SHEET	iv
ABSTRAK	v
ABSTRACT	vi
TABLE OF CONTENTS	vii
LIST OF TABLES	x
LIST OF FIGURES	xi
LIST OF SYMBOLS, ABBREVIATIONS OR NOMENCLATURE	xiii
CHAPTER 1 INTRODUCTION	
1.1 Background	1
1.2 Problem Statement	2
1.3 Objective	2
1.4 Scope of Project	3
1.5 Report Layout	4

CHAPTER 2 LITERATURE REVIEW

2.1 Nature of Lightning	5
2.1.1 Lightning Characteristics	6
2.2 Generation of Impulse Current Generator	7
2.2.1 Standard Impulse Current Generator	7
2.3 Generation of Impulse Voltage Generator	8
2.3.1 Standard Impulse Voltage Generator	9
2.4 Multiple Lightning Strokes	10
2.5 PSpice Software	12

CHAPTER 3 METHODOLOGY

3.1 Introduction	14
3.2 Methodology Flow	15
3.3 Overview on Methodology	16
3.4 Basic Equivalent Circuit for the Simulation of Impulse Current and Voltage	16
3.4.1 Equivalent Circuit for the Simulation of Impulse Voltage	16
3.4.2 Equivalent Circuit for the Simulation of Impulse Current	19

CHAPTER 4 RESULT AND DISCUSSION

4.1 Simulation for Impulse Current Generator	22
4.1.1 Effect of impulse current waveform for different value of resistor, R	24
4.1.2 Effect of impulse current waveform for different value of inductor, L	25
4.2 Simulation for Impulse Voltage Generator	27
4.2.1 Effect of impulse voltage waveform for different value of damping resistor, R_2	29
4.2.2 Effect of impulse voltage waveform for different value of discharging resistor, R_1	31
4.3 Simulation for Multiple Impulse Generators	32
4.3.1 Simulation for Multiple Impulse Voltage Generator	33
4.3.2 Simulation for Multiple Impulse Current Generator	35
4.4 Discussion	36

CHAPTER 5 CONCLUSION

5.1 Conclusion	38
5.2 Recommendation for Future Project	39
5.3 Commercialization	39

REFERENCES

40

APPENDICES

42

© This item is protected by original copyright

LIST OF TABLES

Tables No.		Page
Table 2.1	IEC 60060-1 impulse current definition [9]	7
Table 2.2	IEC 60060-1 Impulse voltage definition [9]	9
Table 3.1	Parameter values for impulse voltage waveshape	19
Table 3.2	Parameter values for impulse current waveshape	21
Table 4.1	Simulation using actual value from calculation	23
Table 4.2	Simulation with with different value of resistor, R	25
Table 4.3	Simulation with different value of inductor, L	26
Table 4.4	Simulation using actual value from calculation	28
Table 4.5	Simulation with different value of damping resistor R_2	30
Table 4.6	Simulation with different value of discharging resistor, R_1	31

LIST OF FIGURES

Figures No.		Page
Figure 2.1	Multiple cloud-to-ground and cloud-to-cloud lightning Strokes are observed during a night-time thunderstorm [8]	6
Figure 2.2	Current in multiple negative lightning flashes [12]	6
Figure 2.3	Standard Impulse Current Waveform [9]	8
Figure 2.4	Standard impulse voltage waveform [3]	9
Figure 2.5	Total duration of multiple lightning strokes [5]	11
Figure 2.6	Time between discharges in multiple lightning strokes [5]	12
Figure 3.1	Methodology flows of this project	15
Figure 3.2	Equivalent circuit of impulse voltage generator [6]	16
Figure 3.3	Equivalent circuit of impulse current generator [13]	19
Figure 4.1	Simulation circuit of impulse current	23
Figure 4.2	Simulated $8/20\mu s$ Impulse Current Waveform	23
Figure 4.3	Effect of impulse current waveform for different value of resistor, R	24
Figure 4.4	Effect of impulse current waveform for different value of inductor, L	26
Figure 4.5	Simulation circuit of impulse voltage	28

Figure 4.6	Simulated 1.2/50 μ s impulse current waveform	28
Figure 4.7	Effect of impulse voltage waveform for different value of damping resistor, R_2	29
Figure 4.8	Effect of impulse voltage waveform for different value of discharging resistor, R_1	31
Figure 4.9	Simulation circuit of multiple impulse voltage generator	33
Figure 5.0	PSpice simulation for multiple impulse voltage generator	34
Figure 5.1	Simulation circuit of multiple impulse current generator	35
Figure 5.2	PSpice simulation for multiple impulse current generator	36

© This item is protected by original copyright

LIST OF SYMBOLS, ABBREVIATIONS OR NOMENCLATURE

IEC	International Electrotechnical Commission
μs	Micro seconds
L	Air cored high current inductor
R	Dynamic Resistor
C	Bank of Capacitor
G	Spark Gap
T_1	Front Time
T_2	Tail / fall time
DC	Direct Current
AC	Alternating Current
C_1	Stage Capacitor
C_2	Load Capacitor
R_1	Discharge Capacitor
R_2	Damping Resistor
S	Switching Gap
α	Front time
β	Fall time
i_2	Current through C_2
i_1	Current through C_1
Ω	Ohm
nF	Nano farad
pF	Pico farad
t_2	Duration for one half cycle of damped oscillatory wave
μH	Microhenry
μF	Microfarad
ms	Milliseconds
MOV	Metal Oxide Varistor