Lightning Warning System Based on Slow Field and Fast Transient Variations, Suitable for Oceanic Tropics

By

Kāhala Nimsiri Abhayasinghe

Thesis submitted in partial fulfillment of the requirements of the degree of Master in Science of the University of Moratuwa

August 2007

DECLARATION

"I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university and to the best of my knowledge and belief it does not contain any material previously published or written or orally communicated by another person except where due reference is made in the text or in the figure captions or in the table captions".

……..

Signature of the candidate

To the best of our knowledge the above particulars are true and accurate.

Name of Supervisor — Signature

Dr. E. C. Kulasekara, Department of Electronic and Telecommunication Engineering, University of Moratuwa, Moratuwa, Sri Lanka.

……

Dr. G. A. C. Gomes, Department of Physics, University of Colombo, Colombo, Sri Lanka.

……

ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to the Department of Electronic and Telecommunication Engineering, University of Moratuwa, Sri Lanka, where the work presented in this thesis has been conducted.

I am profoundly grateful to my former internal supervisor Dr. D. A. I. Munindradasa of the Department of Electronic and Telecommunications, University of Moratuwa for his sustained interest, guidance and encouragement throughout the course of this work as one of my supervisors and also as the head of the department.

I am particularly grateful to my external supervisor Dr. G. A. C. Gomes of the Department of Physics, University of Colombo for his sustained guidance and backup throughout the work.

A special word of thanks to Dr. E. C. Kulasekara who took the responsibility of supervision of my work and guided me to the destination after the demise of my internal supervisor.

I am most indebted to my dear father Mr. K. R. Abhayasinghe Bandara who built up my interest in this field and guided me to initiate the work and encouraged me all the time.

A special word of thanks to the head of the department Eng. A. T. L. K. Samarasinghe for his encouraging interest in my MSc work.

My special thanks to Mr. K. P. S. Sudashana, Mr. W. R. C. Nishantha, Mr. W. G. A. N. Jayantha, Mr. G. A. D. D. Senevirathne of the Electronic Workshop of the Department of Electronic & Telecommunication Engineering for there invaluable help in my work.

I acknowledge with gratitude the invaluable help given by Mr. S. A. Rajudeen and Mr. Kaluarachchi of the Electronic lab of the Department of Electronic and Telecommunication Engineering.

Thanks to all the others in the department of Electronic and Telecommunication Engineering, Mr. J. A. J. Perera, Mr. W. P. T. Fernando, Mrs. V. D. Dantasinghe, Mr. P. Watawala, Mr. A. L. V. T. Perera and the staff of the office of the department for the help they have done.

Special thanks to Mr. U. C. Jayathilaka for the help in doing the statistical analysis in this project.

Love and thanks to my dear wife Navoda for helping with my work and bearing with me during the completion of this work when I was unable to give her my full attention.

Love and thanks to dear mother and brother for there encouragement in my work.

Last, but not least, my warmest thanks to the Asian Development Bank for providing me with the scholarship bringing in the funds needed for my work without which this work would not have been possible.

APPRECIATION

One day, when I was very busy with my final year project work, Dr. Amith Munindradasa came to me to inform me that there are some ADB scholarships for M.Sc. research studies. I passed the message to my friends and I also prepared a small proposal. When I showed this proposal to Dr. Munindradasa, he agreed to accept that proposal and also to supervise me.

From this day onwards he took me on a journey filled with ideas and concepts toward the completion of the research. This process was initiated from a simple thing as correcting my proposal. He was indeed a guiding light every step of the way and was always behind me encouraging and enlightening me during my research.

He guided me through until his demise, as a supervisor, head of department, senior and friend. Without his presence this research would not have been such a success.

Dear Sir, I appreciate your kind guidance and I miss you a lot.

TABLE OF CONTENT

INDEX OF FIGURES

LIST OF TABLES

LIST OF ABBRIVIATIONS

Abbreviation	Description
ac	Alternating current
AM	Amplitude modulation
DSO	Digital storage oscilloscope
EM	Electromagnetic
GPS	Global positioning system
HF	High frequency
IMPATS	Improved accuracy using combined technology
LDS	Lightning detection systems
LED	Light emitting diode
LF	Low frequency
LPATS	Lightning position and tracking system
MDF	Method of direction finding
MF	Medium frequency
RMSE	Root mean square error
SAFIR	Systeme de surveillance et d'alerte foudre par interferometrie radioelectriqu
SSE	Sum of square error
TOA	Time of arrival
UHF	Ultra high frequency
ULF	Ultra low frequency
VHF	Very high frequency

ABSTRACT

Lightning causes a lot of property and human damage all over Sri Lanka. It has been a major requirement to develop a low cost lightning warning system.

The environmental vertical static electric field changes from 0.1 kVm^{-1} under fair weather conditions to extreme values like 10 kVm^{-1} under thunderstorm conditions. Also, lightning discharges generate electromagnetic radiation from ultra low frequency (ULF) through ultra high frequency (UHF) with peak energy emission at 10 kHz.

The work discussed in this thesis uses both the static field variation and the electromagnetic radiation emitted by lightning discharges to predict a thunderstorm. A portable transient detector using an envelope detector tuned to 1600 kHz is used to detect electromagnetic radiation emitted by lightning discharges. An operational amplifier circuit having a slow response with a horizontal plate antenna is used to detect the static field variation. Final decision is made by a third circuit and three levels of alarms are released accordingly.

Using the transient detector only, a warning can be released 25 minutes before the close by thunderstorm with 95% level of confidence. With the entire system, the confidence of the warning further increases.

The cost of the transient detector is about 2500 Sri Lankan rupees with a rechargeable battery bank. The entire system with a battery backup costs about 5000 Sri Lankan rupees.

According to the observations made by the transient detector the delay between cloud flashes and ground flashes shows a distribution of the form of a fractional function with a maximm at 27.52 minutes.

The newly designed lightning warning system shows an acceptable grade of performance with its low cost.