



**Faculty of Electronic and Computer Engineering**

**INITIAL ELECTRIC FIELD CHANGES OF LIGHTNING  
FLASHES IN TROPICAL THUNDERSTORMS**

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**INITIAL ELECTRIC FIELD CHANGES OF LIGHTNING FLASHES  
IN TROPICAL THUNDERSTORMS**

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## DECLARATION

I declare that this thesis entitled “Initial Electric Field Changes of Lightning Flashes in Tropical Thunderstorms” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : Muhammad Haziq bin Mohammad Sabri

Date : .....

## **APPROVAL**

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Electronic Engineering

Signature : .....

Supervisor Name : Dr. Mohd Riduan bin Ahmad

Date : .....

## **DEDICATION**

Dedicated to ALLAH Almighty,

My beloved parents Mr Mohammad Sabri and Mrs Haniza,

My loving family members for your infinite and unfading love, sacrifice, patience,  
encouragement and best wishes.

And to everyone.

## ABSTRACT

Lightning has been observed to be initiated by a series of electric field (E-field) bipolar pulses known as Initial Breakdown (IB) pulses. However, the main problem with this observation is how the first pulse of IB is initiated when the existing background electric field inside thundercloud is not enough to initiate the emission of the first pulse of IB. Recent study in 2017 based on Florida thunderstorms found Initial E-field Change (IEC) process initiated the first pulse of IB. The IEC is a slowly varying field represents the temporal change in cloud conductivity. So far, there are no other published results regarding IECs from other parts of the world. Therefore, this thesis is motivated to provide independent validation results based on tropical storms to the observations and analysis of IECs in Florida. The aims to design and develop measurement system to measure the IECs and VHF emissions from lightning flashes by using Fast E-field, Slow E-field and VHF E-field sensors. Then, the temporal characteristics of VHF emissions and IECs initiated the first IB pulse are analyzed. The key finding is that all the examined first classic IB pulses in 80 tropical flashes within the reversal distance were found to be initiated by an IECs. From this analysis, it is found that the durations of IECs are longer and the magnitude of E-change are smaller for both Negative Cloud-to-Ground (-CG) and Intra-cloud (IC) flashes in tropical storms. It shows that, the IEC process of lightning flashes in tropical regions took longer to increase the local electric field in order to produce the first IB pulse because of the smaller magnitude of E-change. Besides, in Florida storms, the IEC process took a shorter time to increase the local electric field to produce the first IB pulse because of the larger magnitude of E-change. It is found that the VHF pulses for tropical thunderstorms started earlier before the onset of the IECs between 12.69 and 251.60  $\mu\text{s}$  for the two normal IC flashes. Additional results show that, the VHF pulses for three IC flashes initiated by Positive Narrow Bipolar Events (+NBEs) were also detected before the onset of the IEC. The IEC started immediately after the detection of the +NBE and it is initiated by VHF pulses.

## ABSTRAK

Pemerhatian terhadap permulaan kejadian kilat dihasilkan oleh satu siri denyutan medan elektrik bipolar yang dikenali sebagai denyutan pemecahan awalan (IB). Walaubagaimanapun, masalah utama pemerhatian kajian adalah bagaimana nadi pertama IB tercetus apabila medan elektrik latar di dalam awan tidak mencukupi untuk memulakan pancaran nadi IB yang pertama. Kajian yang dijalankan pada tahun 2017 berdasarkan ribut petir di Florida mendapati proses Perubahan Medan-Elektrik Awalan (IEC) yang memulakan nadi IB yang pertama. IEC adalah medan perubahan yang berbeza berkadar perlahan bersifat sementara yang mewakili perubahan kekoduksian dalam awan. Sehingga kini, tiada lagi hasil kajian yang diterbitkan berhubung IEC selain kajian yang dijalankan di Florida. Justeru, ia mencetuskan motivasi kajian tesis ini dalam memberikan pengesahan kajian secara bebas berdasarkan ribut tropika sebagai perbandingan kepada pemerhatian dan analisis IEC di Florida. Objektif utama adalah untuk mereka bentuk dan membangunkan sistem pengukuran bagi mengukur pelepasan IEC dan VHF daripada percikan kilat dengan menggunakan sensor medan elektrik pantas, perlahan dan medan elektrik VHF. Seterusnya, ciri-ciri pelepasan VHF dan IEC yang memulakan denyutan IB pertama dianalisis. Penemuan utama adalah bahawa kesemua denyutan IB klasik pertama yang diperiksa dalam 80 kejadian kilat ribut tropika dalam jarak pembalikan songsang didapati dimulakan oleh IEC. Berdasarkan analisis yang dijalankan bahawa tempoh atau jangka masa IEC lebih panjang dan magnitud perubahan medan elektrik adalah lebih kecil bagi kedua-dua jenis kilat iaitu Awan-ke-Tanah (CG) dan Intra-Awan (IC) dalam ribut petir tropika. Ini menunjukkan bahawa, proses IEC di kawasan tropika mengambil tempoh masa yang lebih lama untuk meningkatkan medan elektrik tempatan bagi menghasilkan denyutan IB pertama disebabkan oleh magnitud medan elektrik yang lebih kecil. Selain itu, proses IEC di ribut petir Florida mengambil masa yang lebih singkat untuk meningkatkan medan elektrik tempatan bagi menghasilkan denyutan IB pertama kerana magnitud medan elektrik yang lebih besar. Di samping itu juga, denyutan pelepasan VHF bagi ribut petir di tropika bermula lebih awal iaitu sebelum bermulanya IEC di antara jarak 12.69 dan 251.60  $\mu\text{s}$  bagi kedua-dua kilat IC biasa. Analisis tambahan pula menunjukkan bahawa denyutan VHF bagi tiga kilauan IC yang dimulakan oleh Peristiwa Dwipolar Sempit Positif (+NBE) juga berlaku sebelum bermulanya IEC. IEC bermula dengan serta-merta selepas pengesanan +NBE dan dimulakan oleh denyutan VHF.

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