



**FACULTY OF ELECTRICAL ENGINEERING  
UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

# **LAPORAN PROJEK SARJANA MUDA**

**HIGH FREQUENCY RADIATION CHAOTIC LEADER  
VERSUS RETURN STROKE FROM CONVECTION  
AND FRONTAL THUNDERSTORM**

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June 2014**

“ I hereby declare that I have read through this report entitle “ High Frequency Radiation Chaotic Leader Versus Return Stroke From Convection And Frontal Thunderstorm ” and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)”

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**HIGH FREQUENCY RADIATION CHAOTIC LEADER VERSUS RETURN STROKE  
FROM CONVECTION AND FRONTAL THUNDERSTORM**

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

**Faculty of Electrical Engineering  
UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**JUNE 2014**

I declare that this report entitle “High Frequency Radiation Chaotic Leader Versus Return Stroke From Convection And Frontal Thunderstorm ” 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 : .....

Date : .....

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## ABSTRACT

Lightning flash is one of the oldest natural phenomenon. Many researcher found that it difficult to understand. During lightning flash, there are several process will happen to complete it. One of the process lightning flash is return stroke. Return stroke shows that its have consistently strongest sources of high frequency radiation. Its also the fastest impulse that transfer charge to the ground. However, chaotic leader is the process of lightning flash that controversial and poorly defined. This chaotic leader also can be appear after or before return stroke . This project more focused return stroke process and chaotic leader process in lightning flash include their characteristics and parameters from waveform display by oscilloscope. Then, it discuss which appeared first between these two type of lightning during lightning flash. For measurement high frequency radiation, the circuit 3MHz and 30MHz were used to determined return stroke and chaotic leader. The measurement for this project were used parallel plate antenna, circuit setup and oscilloscope. Antenna was used for detected the signal and oscilloscope was used for display the signal. High speed buffer LHM6609 was used in this circuit to isolated the high input impedance of the antenna and to delivered a stable signal to the filter circuit while operational amplifier LHM6599 was used to increased the weak input signal. After recorded data measurement, analyze the data and made discussion based on data measurement. Last but not least, making good conclusion and recomendation for improving the project for future work.

## ABSTRAK

Kilat adalah salah satu fenomena semula jadi yang paling lama. Ramai penyelidik mendapati bahawa ia sukar untuk difahami. Semasa berlakunya kilat, terdapat beberapa proses yang akan berlaku untuk menyempurnakan kejadian kilat. Salah satu proses kilat ialah 'Return Stroke'. 'Return Stroke' menunjukkan bahawa ia mempunyai sumber terkuat secara konsisten dalam radiasi frekuensi tinggi. Ia juga memindahkan cas ke tanah dengan paling cepat. Walau bagaimanapun, 'Chaotic Leader' adalah proses kilat yang kontroversi dan kurang jelas. 'Chaotic Leader' juga boleh muncul selepas atau sebelum 'Return Stroke'. Projek ini lebih fokus pada 'Return Stroke' dan 'Chaotic Leader' dalam kejadian kilat termasuk ciri-ciri dan parameter daripada gelombang osiloskop. Kemudian, ia membincangkan yang mana muncul dahulu antara dua proses kilat tersebut. Dalam pengukuran radiasi frekuensi tinggi, 3MHz dan 30MHz litar telah digunakan untuk mengenal pasti 'Return Stroke' dan 'Chaotic Leader'. Antena plat selari, persedian litar dan osiloskop telah digunakan untuk pengukuran dalam projek ini. Antena telah digunakan untuk mengesan isyarat dan osiloskop telah digunakan untuk memaparkan isyarat. Kelajuan tinggi penampakan LHM6609 telah digunakan dalam litar ini untuk diasingkan nilai kemasukan galangan yang tinggi dan menghantar isyarat yang stabil manakala penguat operasi LHM6599 telah digunakan untuk meningkatkan isyarat kemasukan yang lemah. Selepas mencatatkan ukuran data, analisis data dan perbincangan perlu dibuat berdasarkan pengukuran data. Akhir sekali, membuat satu kesimpulan yang baik dan mencadangkan untuk meningkatkan projek untuk kerja-kerja masa depan.

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## LIST OF ABBREVIATIONS

UTeM	-	University Teknikal Malaysia Melaka
FKE	-	Faculty of Electric
CGs	-	Cloud to Ground
ICs	-	Cloud flashes
VHF	-	Very High Frequency
PCB	-	Printed Circuit Board

## LIST OF SYMBOLS

MHz	-	Megahertz
m	-	Meter
K	-	Kelvin
H	-	Henry
$\Omega$	-	Ohm
V	-	Volt
s	-	Second
mV	-	Millivolt
ms	-	Millisecond
$\mu$ s	-	Microsecond

## CHAPTER 1

### INTRODUCTION

#### 1.1 Project Background

High frequency radiation of chaotic leader versus return stroke from convection and frontal thunderstorm was related the lightning phenomenon. During the lightning flash, there were several process happened include chaotic leader and return stroke. The first process was called preliminary breakdown process and it was followed by stepped leader process. After that, return strokes process had been appeared. There were several subsequent strokes after first return stroke. There were dart leaders, dart stepped leaders and chaotic leader. From all the process, return stroke shows that it have consistently strongest sources of high frequency radiation. It also the fastest impulse that transfer charge to the ground [1]. Return stroke happened after the stepped leader and the upward moving discharge. This high luminosity and also high current was move up the leader channel and out its branches at somewhere between one-half and one-tenth the speed of light. This movement of return stroke from ground to the cloud. However in the subsequent strokes, there is a controversial class that called as “chaotic leader”. There were more 30% of subsequent stroke in close lightning contain electric fields [3]. From the researched by Rakov and Uman, chaotic leader can appear before return stroke or after return stroke and they found that the chaotic leader was more strongest sources of high frequency radiation than return stroke [2]. This researched was cover the characteristic of chaotic leader and compared it with return stroke. There were some measurement devices had been used in this researched such as flat plate antenna, oscilloscope and electronic circuit.

## 1.2 Problem Statement

In lightning phenomenon, for the high frequency radiation there are several subsequent stroke not be clarify. One of the subsequent stroke is called chaotic leader. This chaotic leader was controversial and poorly defined [3]. This chaotic leader also can be appeared after or before return stroke. So, this project to analyse the chaotic leader characteristics. It also will define the duration of chaotic leader in lightning phenomenon which it will appear before or after return stroke. For chaotic leader, previously researched found that the direct measurement of narrowband is 10MHz high frequency radiation [3]. The researched for this project was used 3MHz and 30MHz circuit of high frequency radiation direct measurement of narrowband.

## 1.3 Objectives

- 1) To do comparative study between the characteristics of return stroke and chaotic leader.
- 2) To conduct electric field measurement in Universiti Teknikal Malaysia Melaka (UTeM) for data collection.
- 3) To investigate the radiation field of chaotic leader by analysing the frequency component at certain interests frequency range (3MHz and 30MHz,).

## 1.4 Project Scope

In order to achieve the project objectives, the project execution should be set parallel to the project objective. Specifically, these are the scopes for the project:

- 1) This project was measured the electromagnetic field that generated by lightning flashes in Malaysia.
- 2) This project focused on characteristics of return stroke process and chaotic leader process in lightning flash.
- 3) Location for measurement was conducted at Faculty of Electrical Engineering(FKE) in UTeM
- 4) Parallel plate antenna had been used for measured frequency radiation.



## **1.5 Motivation**

The lightning flash was the one phenomenon that difficult to understand. Many researchers found that the process of lightning difficult to clarified. Sometime the data collection of lightning from their research differently from previous. Chaotic leader was the one of the subsequent return stroke. From previous researched, they found that chaotic leader was controversial and poorly defined. The researched was analysed the characteristic of chaotic leader. The electromagnetic field measurement was so important in determined and identified the characteristics and parameter for the subsequent stroke.

## **1.6 Significant Study**

Lightning is a oldest natural phenomenon that difficult to understand until nowadays. Many researchers found that the process of the lightning have their sequence from beginning until it disappeared. One of the sequence it called chaotic leader. Chaotic leader can be classify as a controversial and poorly defined. Return stroke also the sequence of lightning process. This investigation was compared the characteristics of chaotic leader and return stroke from lightning process that happen in Malaysia by measurement electromagnetic field.

## CHAPTER 2

### LITERATURE REVIEW

In this chapter, it was about knowledge and previous researched of lightning that had been done by the researchers. The information about its can be in journal, paper, book and etc as the knowledge to conducted the project. The information also can be achieve and fulfill the requirement of the project.

#### 2.1 Introduction to lightning.

Lightning was one of the oldest observed natural phenomenon on earth. Many researcher found that process of lightning flashes were difficult to understand. Lightning can be defined as transient, which produce high current electric discharge whose path length is generally measured by kilometres. Usually it occur when atmosphere at some region attains an electric charge sufficiently large that associated the electric field with the charge cause electrical breakdown of the air. However, lightning also can happen during sandstorms and in the clouds over erupting volcanos [1]. The process of lightning are relate with the motion of charge and the motion of charge are relate with the measurement of electrostatic fields, radiation field and magnetic fields. There are two types in lightning. One is cloud to ground (CGs) and another one is cloud flashes (ICs). In the cloud, major part all negative cloud-to-ground flashes be determine by electromagnetic field measurements [2].

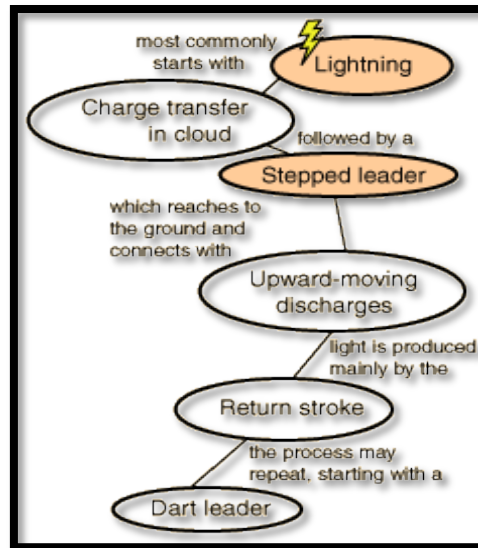


Figure 2.1: Lightning sequence [1]

## 2.2 The ground flash

In generally, a thundercloud consists two main charges centres which one positive and another one negative. The region for positive charge smaller than negative charge and it located at the base of the cloud. When positive charge downward to earth it called positive ground flash and when negative charge downward to earth it called negative ground flash. Ground flash will start with an electrical breakdown process in the cloud that called it preliminary breakdown by using electromagnetic field measurements. After that, column of charge will creation and travels from cloud to the ground in a stepped manner. This process called stepped leader. During its way to ground, a stepped leader will give rise to several branches. As the stepped leader arrive the ground the electric field at ground level increases instant. After the stepped leader reaches a height around few hundred or less metres from level ground, the electric field at the ground structures will increase to a level that electrical discharge are initiated from them. The discharge was called connecting leader will travel to down-coming stepped leader and become as a bridge of the gap between the ground and the down-coming stepped leader. The lightning will striking the connecting leader and it will be successfully connecting leader. When the connection between stepped leader and ground produce, a wave at ground potentials through the channel towards the cloud and associated luminosity event that travels upwards with a speed close to that of light is called the return stroke [1].

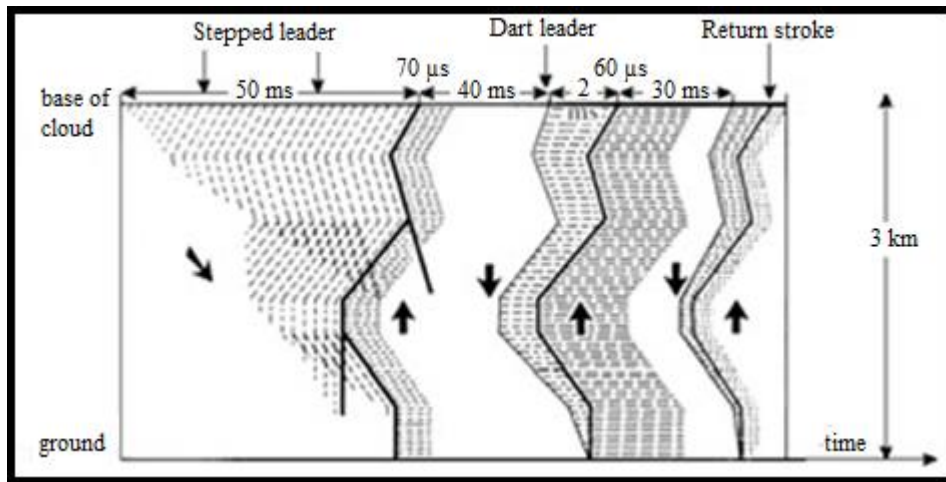


Figure 2.2: The ground flash process [1]

### 2.3 The cloud flash

Usually the cloud flash happen between main negative charge and upper positive charge of the cloud. The negative discharge from negative charge region through the positive centre in a more or less vertical direction. Then, charge will be moving from lower level to upper level along the vertical channel and make horizontal extension of the upper level channel. After that, there will be extension retrogressively at the lower channels. At the final stage, the conductivity of the vertical channel decreases and the upper level channels will be cut off from the low level channels [2].

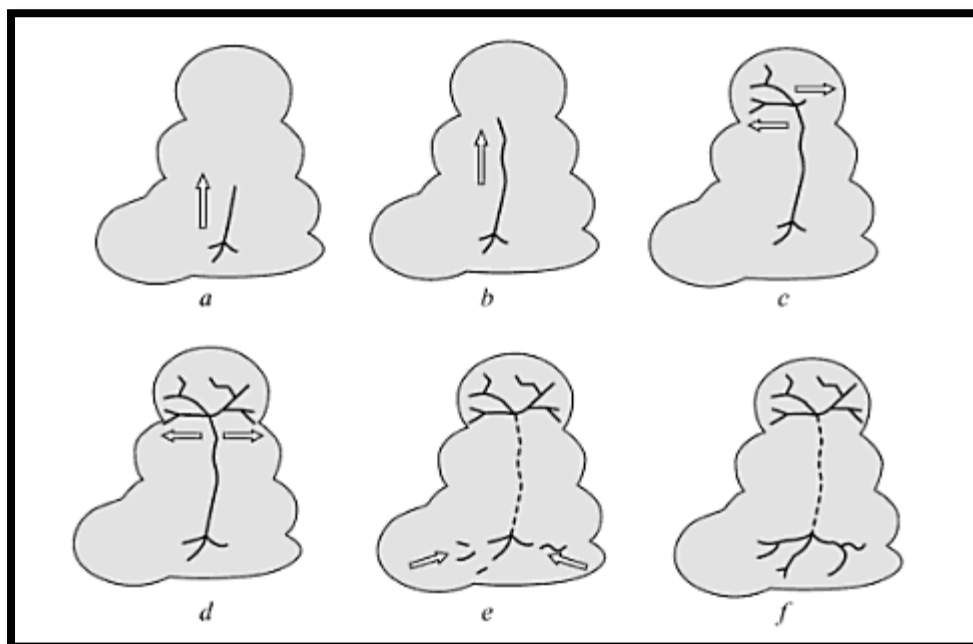


Figure 2.3: Process of the cloud flash [1]

## 2.4 Preliminary breakdown process

This preliminary breakdown process is the process before the stepped leader is launched. This process will generate electromagnetic fields at ground level. Preliminary breakdown process also generate slow electric fields and there are several steps to generate it. Firstly, the electrostatic field will increase slowly and increase constantly until some several tens to several hundreds of milliseconds. This called preliminary variation and it end with a burst of pulses. There are two names for pulse burst which are characteristics pulses or the preliminary breakdown pulse. The duration for pulse burst in millisecond. The total duration for preliminary breakdown process depend the time taken interval between first detectable static field change and the return stroke. There are three methods to determine the location of preliminary breakdown process in the cloud which are making multistation electric field measurement, based on single station measurement and based on the VHF radio imaging technique [1].

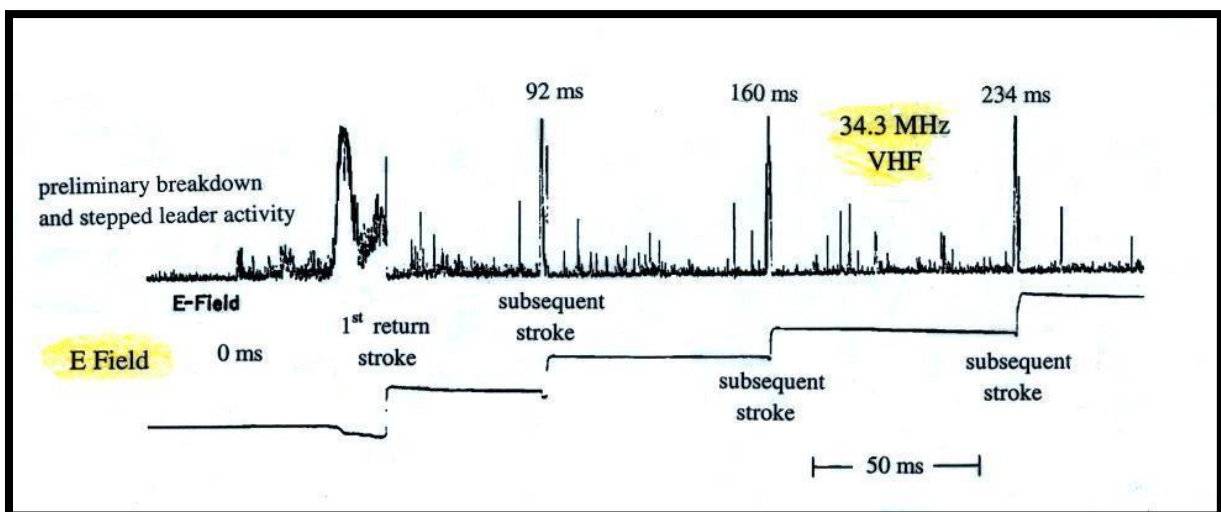


Figure 2.4: Example of lightning process [2]

## 2.5 Stepped Leader

Stepped leader is the process after preliminary breakdown process. In generally, stepped leader channel consists of a hot core surround by a cold, charged region called the corona sheath. The radius of the core between 0.1m and 0.5m. In initial, the channel remains dark until change to bright in between step formation. Leader also gives rise to several branches and the stepping process can be work simultaneously in several branches. Steps range are between 10 to 100m. The temperature of the leader can be raise until 30000 K. This measurement was measured by Orville. He also said the temperature of the leader cannot be lower than 15000 K. Stepped leader can generate the electric field at different distance. From that, the channel can describe as a uniform line charge with one end fixed at cloud height and uniform speed approaching the ground [1].

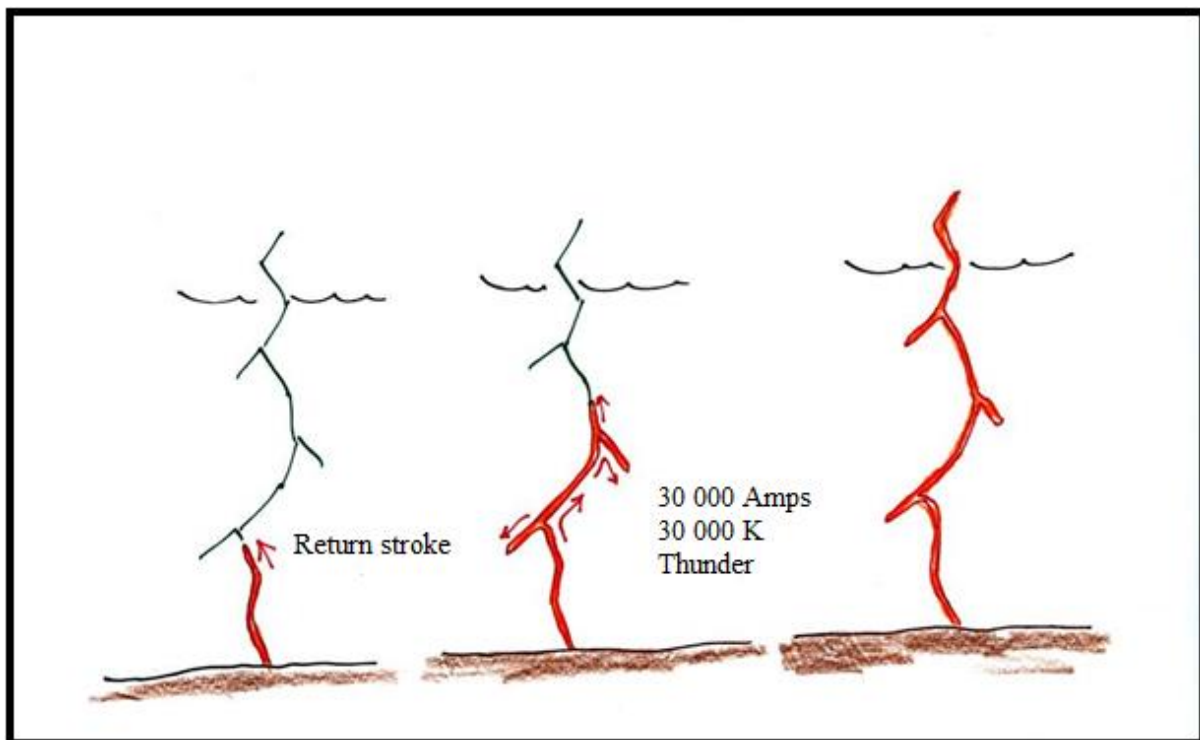


Figure 2.5: Process of stepped leader [2]

## 2.6 Return Stroke

Return stroke happen when streamer front makes a connection with a ground or with the streamer front of a connecting leader that rises to meet it. Stepped leader and the connecting leader will meet at one point. Therefore, the neutralisation process will progress with two different direction. One toward to the ground and another toward to cloud. When the stepped leader has lowered a charged column of high negative potential to near the ground, the resulting high electric field at the ground is sufficient to cause upward-moving discharges to be launched from the ground toward the leader tip. When one of these discharges contacts the leader, the bottom of the leader effectively connected to ground potential while the remainder of the leader is at negative potential and is negatively charged. Return stroke shows that it have consistently strongest sources of high frequency radiation. The return stroke wave front propagates at a velocity of typically one-third to one-tenth the speed of light. The return stroke is very visible bright and very fast so that the eye cannot capture the movement of the stroke. The movement of stroke can be obtained by using streak camera. The peak current of return stroke is very high around 100 000 amps or more. It also can be classify as high amplitude, long time duration of the continuing current and higher charge during transfer process.[1,3,5]

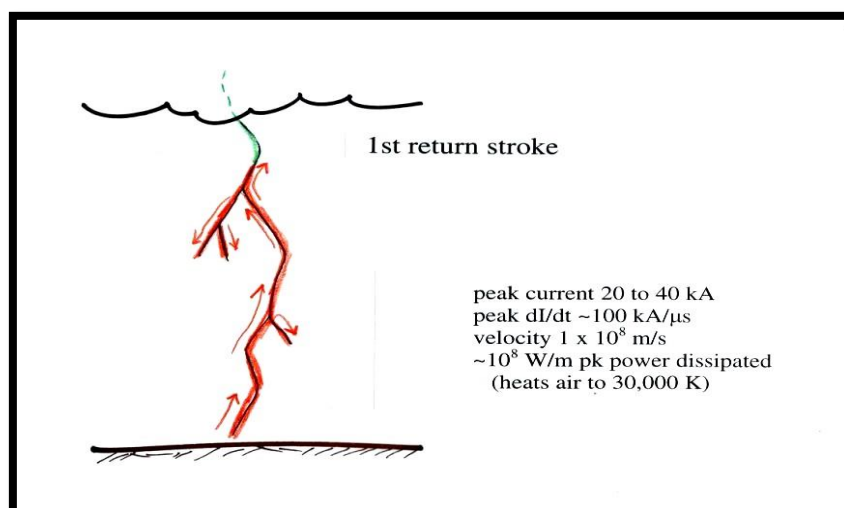


Figure 2.6: Example of first return stroke [3]

## 2.7 Chaotic Leader

After the return stroke, there are subsequent stroke occur in lightning. In subsequent stroke, it start with dart leader and followed by dart step leader. Then, chaotic leader produce after dart step leader process. Chaotic leader can be classify as a controversial and poorly defined. Chaotic leader got it name from the idea Weidman (1982) and it also got cited by Rakov and Uman (1990a). Chaotic leader can be found about 30% of subsequent strokes in close lightning flash from the researcher by Rakov and Uman (1990a). The direct measurement of narrowband of chaotic leader is 10MHz high frequency radiation. It also can be large subsequent strokes so that it can be strongest than return stroke. This process are related with “chaotic pulse” as defined by Gomes et al.(2004). Even two of these are irregular phenomena but it still same characteristics such as length and separation is 10 $\mu$ s range, duration for a few hundred microseconds and have noise level of the signal [1,2,3].