Different Measurement System of Lightning

Priti Bhakta Adhikari

Abstract — Lightning phenomena is the electrical discharging phenomena. The electromagnetic radiations due to lightning, having various frequencies with different wavelengths are produced. The measurement of lightning by different method like the photography method, current measurement method, electric and magnetic field measurements method and thunder measurement methods can be used. The lightning phenomena produced the waveforms of electric and magnetic field which are the basic parameters to understand the phenomena of lightning discharges. The pair of circular flat metallic plates, separated from each other by insulating material, and are used to capture the signature and measure the electromagnetic radiations produced due to lightning. The waveforms were recorded in the hilly and mountainous country, of Nepal. These types of waveforms are observed and recorded.

Keywords — Circular Metallic Plate, Lightning Phenomena, Measurement System, Vertical Electric Field.

I. INTRODUCTION

In cumulonimbus, when two different regions formed the two different charge centre then lightning occurs if they gets sufficiently large electric charge. On the process of lightning, the electric field produced between the positive and negative charge centre. The increased value of electric field may convert the air of insulating medium, into conducting medium. Lightning is a natural phenomenon of very fast process and complex discharging process released different forms of energy. Mainly, light energy, sound energy, heat energy, and so on produced due to it. There are various types of research in the research field. Among this research, mainly categorized into three types: theoretical, experimental and computational. Similarly in the field of thunderstorm lightning also, the research has been addressed by the same. In the process of lightning, the experimental research is very important. To do the experimental research about lightning, the various types of instruments were used. The electric and magnetic field measured by using antenna and electronic circuits, the photography method is used by camera and so on. By different methods the waveform of lightning signatures has been investigated. For the lightning signatures, it can be captured by two or more methods at a time gives the same types of waveforms is very important and achieved more success [1]. The first and pioneer scientist Benjamin Franklin did the two separate experiments in 1752. He did the two experiments, kite experiment and sentry box experiment, and proved that this phenomenon is a discharging phenomenon.

The first method of lightning experimental research is photography method which is easier after the invention of streak camera. The two scientists Hoffert in England, and Weber and Walter in Germany, in the year 1889, simultaneously used the same photography method. The second method was done by the scientist Pockels used the current measurement method in the research field of lightning in 1897. The third branch of research in 1916, Wilson in England measured the electric fields produced due to lightning. He was the first scientist used the electric field measurement method and won the Noble Prize. So many scientists and researcher explained about the lightning research, features of its electrical and magnetic properties [2]-[4], and many more. Adhikari et al. [5] reported that the transport of negative charge of the cloud to the ground gives rise to change of positive electric field change and directed downward. They also explain that transports a positive charge of the cloud to the ground, which gives rise to a negative electric field change and direction upward.

In 1897, Pockels used another method in which its magnetic field measured by using magnetizable materials. He also investigates the current during the lightning process in the channel. More investigator such as Norinider, Krider etc., used a various method of loop antenna and broadband antenna by estimating the current in the channel and determine the magnetic field later on [4], [6], [7].

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P. B. Adhikari, Tri-Chandra M. College, Tribhuvan University, Nepal. (corresponding e-mail: pbadhikari09@gmail.com)

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During lightning discharge phenomena, the sound produced due to lightning can be captured by the microphone and measured is called the method of Thunder Measurement. In this research, the measurement of lightning electric field and the wave signals captured by horizontal parallel plate.

II. METHODOLOGY AND INSTRUMENTATION

The instrument DSO, digital storage oscilloscope, which digitizes analogue voltage, and it can store the signal digitally. The Digital Storage Oscilloscope (DSO), which is same as oscilloscope, but it is used for advanced trigger, to store the data and its measurement. Here, 6404D pico-scope has been used as a DSO to store the data of the electric field digitally with the sampling rate of 5 Gs/S. The time window of captured wave signals is 500 ms. In the parallel plate antenna system, the upper circular metallic plate of the antenna is taken as positive and is connected with a buffer circuit, whereas the lower circular metallic plate of that antenna is connected as a negative, to the ground. Here, horizontal parallel circular plate antenna is used to measure the vertical electric field and the example of this antenna is shown in Fig. 1. Similarly, the circuit to measure the electric field inside the electronic box is shown in Fig. 2. Galvan and Fernando [8] described about these types of circular metallic plate antenna in horizontal to measure the vertical electric field and the vertical rod antenna is taken as the antenna system to measure the vertical electric field. Adhikari et al. [9] described about the horizontal parallel plate antenna to measure the vertical electric field in Kathmandu, Nepal. The altitude of Kathmandu is about 1300 m and this antenna which observed the vertical electric field produced by the lightning were recorded in the pico-scope. This lightning signal of vertical electric field in this case captured by the antenna and then passed through the RG-58 co-axial cable and finally captured by the pico-scope. This signature is analysed by using appropriate tools.

![Fig. 1. Horizontal circular plate antenna used to measure the vertical electric field in Kathmandu.](image1)

![Fig. 2. The electronic circuit inside the electronic box is used for the measurements.](image2)
III. RESULTS AND DISCUSSION

Lightning is a discharging process in which it radiates electromagnetic radiations of various wavelengths. It is a complex electrical discharge phenomenon. It is more intense due to high current and high temperature. Capturing the very intense electric field waveform produced due to lightning is very difficult. The horizontal parallel plate antenna with electronic circuit is connected as shown in Fig. 1. Electromagnetic radiations produced by lightning is captured by circular flat plate antenna installed in Kathmandu, Nepal. Some of the basic features of lightning electric fields of more than seven thousand signatures were measured by this device. Among them, mainly the positive CG lightning, cloud flashes radiation and newly found unusual lightning waveforms were observed. The waveform signature of positive cloud-to-ground (CG) lightning and their fine structures were studied. Different types of lightning signature were observed, and it is expressed in percentage is shown in Table I. The expression of the wave signature captured by this instrument also presented here in pie diagram of Fig. 3.

<table>
<thead>
<tr>
<th>S. N.</th>
<th>Different types of lightning flashes</th>
<th>Average in percentage</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cloud Activity of lightning</td>
<td>62.8%</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>+ve Cloud-to-Ground (CG) lightning</td>
<td>20.4%</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>Unusual lightning events</td>
<td>9.5%</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>IB/ PB Pulses of lightning</td>
<td>2.9%</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>Other Events of lightning</td>
<td>4.4%</td>
<td>-</td>
</tr>
</tbody>
</table>

![Pie Chart Diagram](image)

Fig. 3. The observed lightning wave signatures were expressed in the Pie-Chart diagram.

The main waveforms of lightning are cloud–to–cloud, cloud–to–ground (CG) positive and negative, and unusual events of lightning waveforms. The cloud–to–ground lightning waveform is 20.4 percent, the new unusual events of lightning waveforms are 9.5 percent, the cloud–to–cloud lightning waveform is 62.8 percent, and the remaining percentage are other events. The example of these lightning waveforms is presented in Fig. 4.

To understand the lightning, the combination of two or more than two methods of measurements are required. Among them, the measurements of lightning electric field and the lightning photography are the easier methods. The new development method in which lightning magnetic field measured by using magnetizable materials. The phenomena of measurement of magnetic fields by investigating the current during this process. Using various method by knowing the amplitude of the current in the channel of loop antenna and broadband antenna determine the magnetic field is also very interested. In the electric field measurement system, lightning electromagnetic radiations travel from discharge channel and the waveforms are captured by the antenna. The waveforms pass through cable with pico-scope and are recorded in the storage device PC. These electromagnetic waveforms are also shown in Fig. 4.
Fig. 4. Examples of (a) a Cloud-to-Ground (CG) waveform; (b) unusual lightning waveform; (c) Cloud-to-Cloud waveform; (d) breakdown events captured by the parallel flat-plate antenna stored in PC.

IV. CONCLUSION

Among the various methods of measurement, the lightning electric fields is measured by horizontal parallel-plate antenna with electronic circuit. Over the rugged terrain in a mountainous region in our scenario, the vertical lightning electric fields were captured by the circuit with antenna. Different types of lightning waveforms have been observed and recorded. Among the different types of lightning about two-third were cloud-to-cloud lightning waveform, about 20 percentage were CG lightning and 10 percentage were unusual lightning and rest were the breakdown events. A conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

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CONFLICT OF INTEREST

Authors declare that they do not have any conflict of interest.

REFERENCES

Pitri Bhakta Adhikari completed his PhD in the year 2019, recently from Tribhuvan University. He is an Assistant Professor of Physics at the Tribhuvan University, Nepal. He is Lifetime member of Nepal Physical Society since 2000. He has written several textbooks and reference books for university course related to Science and Technology. He has published research articles in the International Journal of Atmospheric and Solar-Terrestrial Physics, International Journal of Scientific & Engineering Research and so on. Also, he has published research articles in Journal of Nepal Physical Society, Bibechana, and so on. He has been serving as an editorial board member of some journals.