Distribution of Attempted Leader with Monsoon Seasons and Negative CG Flashes in Melaka, Malaysia

by Nur Asyiqin Isa

Submission date: 07-Jun-2021 01:18PM (UTC+0800)
Submission ID: 1601903303
File name: eader_with_Monsoon_Seasons_and_Negative_CG_Flashes_in_Melaka.pdf (680.3K)
Word count: 3568
Character count: 19751

Indonesian Journal of Electrical Engineering and Computer Science
Vol. 15, No. 3, September 2020, pp. xx~xx
ISSN: 2502-4752, DOI: 10.11591/ijeecs.v15.i3. ppxx-xx

Distribution of Attempted Leader with Monsoon Seasons and Negative CG Flashes in Melaka, Malaysia

Nur Asyiqin Isa[1], Zikri Abadi Baharudin*[2], Hidayat Zainuddin[3], Tole Sutikno[4], Maslan Zainon[5], Ahmad Aizan Zulkefle[6]

[1,3]Fakulti Kejuruteraan Elektrik, Universiti Teknikal Malaysia Melaka, Malaysia
[2,5,6] Fakulti Teknologi Kejuruteraan Elektrik & Elektronik, Universiti Teknikal Malaysia Melaka, Malaysia
[4]Department of Electrical Engineering, Universitas Ahmad Dahlan (UAD), Yogyakarta, Indonesia

Article Info

Article history:

Received , 2018
Revised Dec 10, 2018
Accepted Jan 25, 2019

Keywords:

Attempted Leader,
Correlation,
Tropical thunderstorm,
Pulse trains,
Initial breakdown,

ABSTRACT

Ninety (90) waveforms recognized as attempted leader were identified with both positive (84 event) and negative (6 event) initial polarity observed from four consecutive years of data (N=10,206). The positive attempted leader shows no correlation with the number of thunderstorm producing it during Monsoon. Meanwhile, the negative attempted leader during Monsoon and both polarity of attempted leader (positive and negative) during Inter-monsoon shows positive correlation with the number of thunderstorm producing it. In this study, the yearly statistical distribution of negative cloud-to-ground (CG) lightning flashes which were classified as positive preliminary breakdown pulses (214 events) and negative preliminary breakdown pulses (4982 events) in accordance of their preliminary polarity were also presented. The correlation percentage of occurrence between the preliminary breakdown pulse trains not followed by return stroke (attempted leader) with the preliminary breakdown pulse train followed by return stroke on both polarity shows negative correlation with each other.

Corresponding Author:

Zikri Abadi Baharudin,
Department of Electrical and Electronic Engineering, Technology
Universiti Teknikal Malaysia Melaka,
Fakulti Teknologi Kejuruteraan Elektrik dan Elektronik (FTKEE), Kampus Teknologi, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.
Email: zikri@utem.edu.my

1. INTRODUCTION

The basic needs for the formation of thunderstorm are sunlight, moist air and unstable atmosphere. The first stage of cloud formation called cumulus cloud formed when the moist air rises in the unstable atmosphere, and as the air rises higher, the condensation process also happen in faster rate. All thunderstorm formation start with air rising into the unstable atmosphere before forming a convective cell [1]. However, the air can be upraise in various ways by which where (land, oceanic, or mountain) or when (monsoons) they were

form [2]–[4]. All these type of condition will influence to different type and distribution of lightning discharge produced.

The first process of lightning discharge happen in cloud are called preliminary breakdown. This in-cloud process will initiates the earthward moving step leader preceding the first return stroke in CG lightning flashes. Negative CG flashes take place between the main negative charge center and ground [5]–[9] while positive CG flashes take place between the positive charge center and the ground [10]–[12].However, there are condition where the first step leader cannot propagate to the ground completely and this event was terminologically referred as 'attempted leader' [13]–[16]. Furthermore, the large current running in the return stroke of most lightning strikes causes damage, as does the heat generated by this and the continuing current [17]–[20]. If lightning strikes a person, the central nervous system, heart, lungs, and other vital organs might be injured by the stroke current; therefore, thorough analysis and monitoring are required to assure the safety of people and property [21]–[24].

Attempted leader is the potential cloud-to-ground lightning flash of first descending step leader in which its propagation may be discouraged by the excessive existence of LPCR [25], [26]. In other words, attempted leader is the potential cloud-to-ground lightning flash, however the downward moving step leaders die out before being attached with the progressing upward leaders as reported by previous researchers such as [27]–[30]. In this study we will present the novel information in large scale of data of attempted leader distribution activities with the correlation of number of thunderstorm producing it with the influence of climatology condition or Monsoon seasons at location of tropical region Melaka, Malaysia. The yearly distribution and correlation of attempted leader with negative cloud-to-ground lightning flashes are also presented in this study.

2. DATA

The attempted leader activities recorded for four consecutive years (2016 to 2019) are examined in this study. The data was examine from August to December 2016 (2259 data), January to July 2017 (1466 data), August to December 2018 (3692 data), and January to July 2019 (2789 data). From all these data gathered (10,206), ninety event were recognized as attempted leader. The measurement station was located in Melaka (2.1896° N, 102.2501° E). There were nineteen (19), thirty-three (33), fifteen (15) and twenty-three (23) of attempted leader waveform observed in 2016, 2017, 2018 and 2019 respectively from ten (10), eight (8), eight (8) and five (5) thunderstorms respectively.

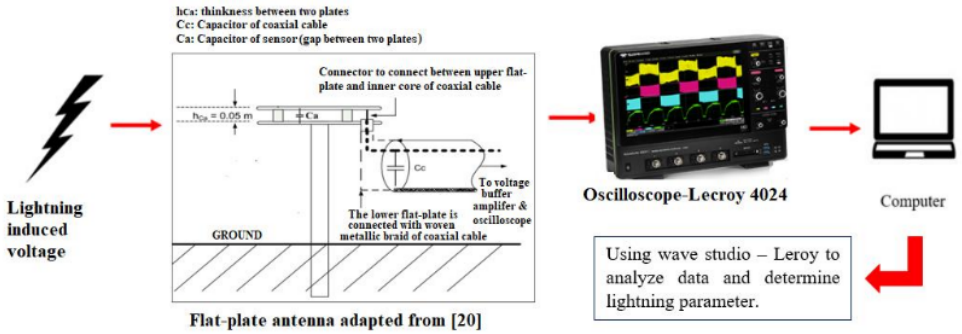
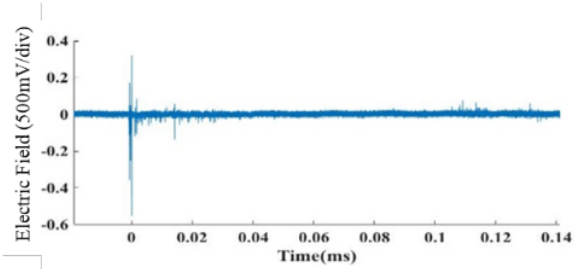


Figure 1. The arrangement of lightning measurement and followed by the recording and analyzing section.

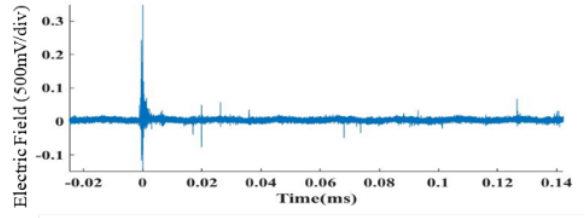
In this study, the vertical plate antenna, buffer circuit, coaxial cable, and transient recorder (Teledyne Lecroy HDO4024) has been implemented for measuring, recording and analyzing the electric radiation fields of lightning flashes. Figure 1 shows the arrangement as mentioned above where the measurement set up was similar to [23-25]. The antenna is used to detect the vertical electric fields and arranged perpendicularly to the electric field vector, parallel to the ground in order to prevent the horizontal electric field effect. Furthermore, the antenna's physical height is set to 1.5 metre with the effective height of 0.25 metre. The antenna is connected to electronic buffer circuit by using 60-centimetre-long coaxial cable (RG-58) and the signal is transmitted from the antenna to 12-bit digital high speed transient recorder (Teledyne Lecroy HDO4024) using 10-metre-long coaxial cable (RG-58). This high speed transient recorder is also equipped with 200 MHz High-Definition Oscilloscope and the transmission to digital transient recorder occur after passing through the electronic buffer circuit.

3. RESULTS AND DISCUSSION

The study presents the novel information on the statistical distribution of attempted leaders activities with number of thunderstorm during Monsoon and Inter-monsoon for four years (2016-2019) in tropical region Melaka, Malaysia. The author focused only on the microsecond scale of electric radiation field that that fails to propagate to the ground completely and not producing first return stroke. There were 84 positive polarity and 6 negative polarity of electric radiation field of attempted leader observed and the electric radiation field waveform sample are shown in Figure 2 (a) and (b).



(a)



(b)

Figure 2. (a) The attempted leader of the positive polarity on 7th December 2018 and (b) negative polarity on 30th September 2018.

This study presents the correlation between the attempted leader and thunderstorm under the influence of Northeast Monsoon (October – Mac), Southwest Monsoon (May – September), First Inter-monsoon (March), and Second Inter-monsoon (October), as depicted in Figure 3 (a), (b), (c) and (d), respectively. Result shows that the positive attempted leader activities during monsoon in Figure 2 (a) has negative correlation with thunderstorms. The highest positive attempted leader during monsoon occur in 2017 and 2019 in which twenty-nine (29) and twenty (20) positive attempted leader were observed in only five (5) and four (4) recorded thunderstorm respectively. While in 2016 and 2018, seventy (17) and twelve (12) of positive attempted leader activities were observed in only nine (9) and five (5) thunderstorm respectively. In other word, single thunderstorm during monsoon are capable of producing more than one attempted leader event.

However, the negative attempted leader activities during monsoon in Figure 3 (b) shows a positive correlation with the thunderstorm. The yearly distribution activities are also far less than that of positive attempted leader during the Monsoon season. Further, in Figure 3 (b), there was no attempted leader event in 2017 during the Monsoon season. Obviously, the thunderstorm produced during Monsoon seasons in tropical climate does not supporting the production of negative polarity of attempted leader since the activity of this profile appeared during this particular period (only three (3) activities recorded for four years).

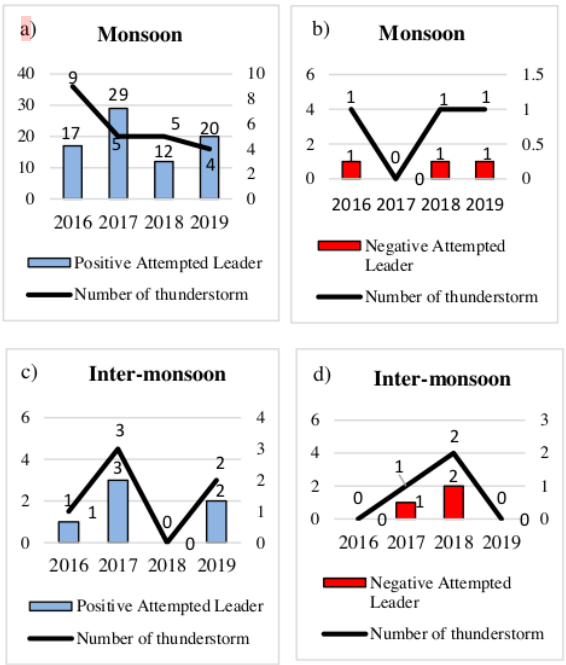


Figure 3. Variation of Monsoon thunderstorms for (a) positive attempted leader and (b) negative attempted leader and variation of Inter-monsoon thunderstorms for (a) positive attempted leader and (b) negative attempted in 2016 to 2019.

Next, the attempted leader for both positive and negative polarity during the Inter-monsoon in Figure 3 (c) and (d) also shows very positive correlation with thunderstorm. The yearly distribution activities were also not as frequent as can be seen during Monsoon for positive polarity of attempted leader activities. Specifically, single thunderstorm are seen producing not more than one positive and negative polarity during Inter-monsoon. The same scenario also seen during Monsoon for negative attempted leader.

On the other hand, the yearly distribution of attempted leader was also presented to perceive the correlation of attempted leader activities with the negative cloud-to-ground lightning flashes (same and opposite polarity of preliminary breakdown). The percentage of attempted leader on both polarity (positive and negative) in 2016, 2017, 2018 and 2019 were 0.84% 2.25%, 0.41% and 0.82% from the yearly data recorded respectively. Meanwhile, the percentage of negative cloud-to-ground lightning flashes on both preliminary breakdown polarity (positive and negative) in 2016, 2017, 2018 and 2019 were 77.51%, 59%, 66.66% and 45.39% from the yearly data recorded respectively. As depicted in figure 4, the highest activity of attempted leader occurred in year 2017 (N= 33). However, the least activity of negative cloud-to-ground lightning flashes (N=865) were seen in the same year. On the other hand, the lowest activity of attempted leader (N=15) portrayed in year 2018 shows the highest activity of negative cloud to-ground lightning flash (N=2461). Overall, the summary of the correlation between the total attempted leader and negative cloud-to-ground lightning flashes, is presented as shown in Figure 4.

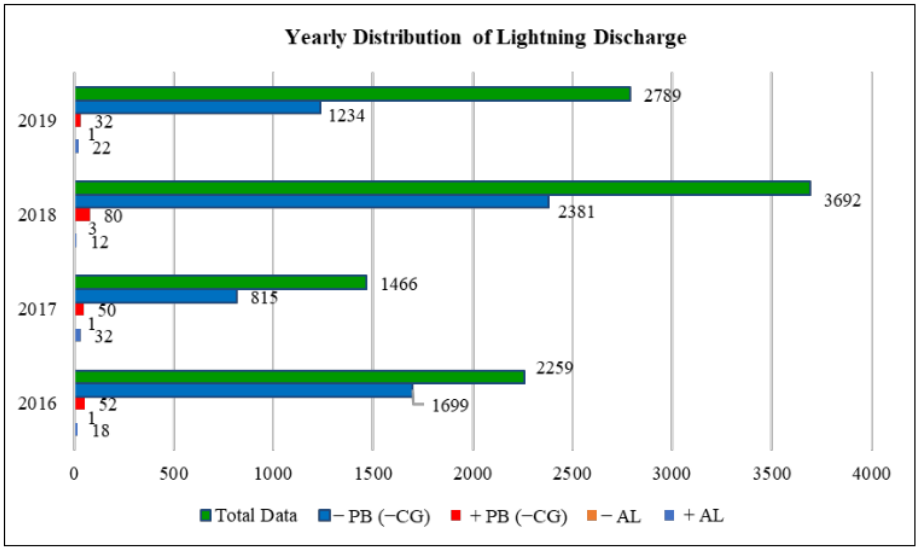


Figure 4. The yearly variation of positive attempted leader, negative attempted leader, positive preliminary breakdown and negative preliminary breakdown of negative CG flashes of 2016 (August to December), 2017 (January to July), 2018 (August to December) and 2019 (January to July) from total of 10,206 electric radiation field of lightning flashes.

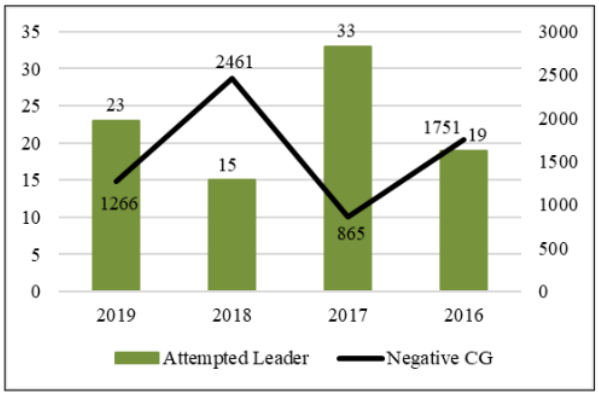


Figure 5. Variation of yearly distribution of both polarity (positive and negative) of attempted leader and both polarity of preliminary breakdown (same and opposite) of negative cloud-to-ground lightning flashes in 2016 to 2019.

Figure 5 depicts the attempted leader indicated the negative correlation with the negative cloud-to-ground lightning flashes. It seems like the attempted leader activities are decreases with the increases of cloud-to-ground lightning flashes occurrences. In other words, the more succeeding return stroke of lightning flash activity observed, the less not succeeding return stroke lightning flashes will be observed (attempted leader occurrences). These phenomena agree with the explanation in [28]and [34] where mostly the LPCR in tropical countries are either weak or without any PBP signature possibly due to an insignificant LPCR magnitude. In this situation, initial breakdown processes happened to be in the cloud with a low energy level between the negative charge region and the LPCR, do not need to struggle to break the "blocking" agent in LPCR. Although,

the profile of overall attempted leaders in tropical countries were found to have weak compared to negative cloud-to-ground lightning flashes. However, the attempted leaders are commonly existing during the Monsoon season and uniquely the majority exhibit as positive attempted leader.

4. CONCLUSION

From amount of 10,206 data of lightning flashes for four years (August to December 2016, January to July 2017, August to December 2018, and January to July 2019) recorded in Melaka (tropical region), only 90 (0.88%) attempted leader activities which comprises of positive (N=84, 0.82%) and negative (N=6, 0.06%) polarity were observed. The occurrence of positive attempted leader were more common compared to negative polarity especially with thunderstorm during Monsoon seasons. In fact, there were negative correlation between the thunderstorm producing attempted leader and the attempted leader observed. In other word, single thunderstorm during Monsoon were seen sufficient of producing more than one positive attempted leader activities.

However, the negative polarity during Monsoon and both polarity of attempted leader activities during Inter-monsoon were seen significantly less than the positive attempted leader recorded during Monsoon. Also, they shows very positive correlation with the thunderstorm producing it. In other word, during these period, single thunderstorm were seen only producing single event of attempted leader. Next, the attempted leader activities shows negative correlation with the negative cloud-to-ground flashes. The more attempted leader recorded, the less negative cloud-to-ground observed.

ACKNOWLEDGEMENTS

Nur Asyiqin Isa would like to thank to Zamalah Scheme under Universiti Teknikal Malaysia Melaka for fully funding her PhD study. Moreover, we would also like to thank to the Minister of Education (MOE), Malaysia and the Center for Research and Management (CRIM) of UTeM for equipment and measurement facilities, moral support and co-operation during our measurement campaign. The equipment of this research was earlier purchased from the funding by MOE under Exploration Research Grant Scheme (ERGS/2013/FKE/TK02/UTEM/03/01).

REFERENCES

[1] V. Cooray, *Interaction of lightning flashes with the Earth's atmosphere. In An Introduction to Lightning*. Springer, Dordrecht., 2015.

[2] E. R. Williams, M. E. Weber, and R. E. Orville, "The relationship between lightning type and convective state of thunderclouds," *J. Geophys. Res.*, vol. 94, no. D11, pp. 213–220, 1989, doi: 10.1029/jd094id11p13213.

[3] E. Williams and S. Stanfill, "The physical origin of the land-ocean contrast in lightning activity," *Comptes Rendus Phys.*, vol. 3.10, pp. 1277-1292., 2002.

[4] P. Ramesh Kumar and A. K. Kamra, "Land-sea contrast in lightning activity over the sea and peninsular regions of South/Southeast Asia," *Atmos. Res.*, vol. 118, pp. 52–67, 2012, doi: 10.1016/j.atmosres.2012.05.027.

[5] V. A. Rakov, "Initiation of Lightning in Thunderclouds," *Top. Probl. Nonlinear Wave Physics. Int. Soc. Opt. Photonics*, vol. 5975, no. p. 597512., pp. 1–12, 2006, doi: 10.1117/12.675583.

[6] Z. A. Baharudin, M. Fernando, N. . Ahmad, J. . Mäkelä, and V. Rahman, M. Cooray, "Electric field changes generated by the preliminary breakdown for the negative cloud-to-ground lightning flashes in Malaysia and Sweden," *J. Atmos. Solar-Terrestrial Phys.*, vol. 84–85, pp. 15–24, 2012, doi: 10.1016/j.jastp.2012.04.009.

[7] V. A. Rakov and M. A. Uman, *Downward negative lightning discharges to ground*. 2013.

[8] A. Hazmi, P. Emeraldi, M. I. Hamid, and N. Takagi, "Some characteristics of multiple stroke negative cloud to ground lightning flashes in Padang," *Int. J. Electr. Eng. Informatics*, vol. 8, no. 2, pp. 438–450, 2016, doi: 10.15676/ijeei.2016.8.2.14.

[9] C. Wooi, Z. Abdul-malek, N. Ahmad, and A. I. El Gayar, "Physics Statistical analysis of electric fi eld parameters for negative lightning in Malaysia," *J. Atmos. Solar-Terrestrial Phys.*, vol. 146, pp. 69–80,

2016, doi: 10.1016/j.jastp.2016.05.007.
[10] T. . Ushio, Z. . Kawasaki, K. Matsu-ura, and D. Wang, "Electric fields of initial breakdown in positive ground flash," *J. Geophys. Res. Atmos.*, vol. 103, no. 97, pp. 135–139, 1998.
[11] X. Qie, Y. Yu, and D. Wang, "Characteristics of Cloud-to-Ground Lightning in Chinese Inland Plateau," *J. Meteorol. Soc. Japan.*, vol. 80, no. 4, pp. 745–754, 2002.
[12] C. Gomes and V. Cooray, "Radiation field pulses associated with the initiation of positive cloud to ground lightning flashes," *J. Atmos. Solar-Terrestrial Phys.*, vol. 66, no. 12, pp. 1047–1055, 2004, doi: 10.1016/j.jastp.2004.03.015.
[13] M. M. F. Saba *et al.*, "High-speed video observations of positive lightning flashes to ground," *J. Geophys. Res. Atmos.*, vol. 115, no. 24, pp. 1–9, 2010, doi: 10.1029/2010JD014330.
[14] T. Wu, Y. Takayanagi, T. Funaki, S. Yoshida, and T. Ushio, "Preliminary breakdown pulses of cloud-to-ground lightning in winter thunderstorms in Japan," *J. Atmos. Solar-Terrestrial Phys.*, vol. 102, pp. 91–98, 2013, doi: 10.1016/j.jastp.2013.05.014.
[15] Y. Zhang, Y. Zhang, W. Lu, and D. Zheng, "Analysis and comparison of initial breakdown pulses for positive cloud-to-ground fl ashes observed in Beijing and Guangzhou," *Atmos. Res.*, vol. 129–130, pp. 34–41, 2013, doi: 10.1016/j.atmosres.2013.03.006.
[16] D. Johari, V. Cooray, M. Rahman, P. Hettiarachchi, and M. M. Ismail, "Characteristics of preliminary breakdown pulses in positive ground flashes during summer thunderstorms in Sweden," *Atmosphere (Basel).*, vol. 7, no. 3, pp. 1–18, 2016, doi: 10.3390/atmos7030039.
[17] M. F. Habban, M. Manap, M. H. Jopri, and A. R. Abdullah, "An Evaluation of linear time frequency distribution Analysis for VSI switch faults identification," *Int. J. Power Electron. Drive Syst.*, vol. 8, no. 1, p. 1, 2017.
[18] A. R. Abdullah, M. Manap, M. R. Yusoff, and M. F. Habban, "An improved detection and classification technique of harmonic signals in power distribution by utilizing spectrogram," *Int. J. Electr. Comput. Eng.*, vol. 7, no. 1, p. 12, 2017.
[19] A. F. N. Azam, A. Jidin, N. A. Ngatiman, M. Manap, A. L. Herlino, and N. F. Alias, "Current control of BLDC drives for EV application," in *2013 IEEE 7th International Power Engineering and Optimization Conference (PEOCO)*, 2013, pp. 411–416.
[20] N. . Abidullah, "Analysis of Power Quality Disturbances Using Spectrogram and S-transform," *Int. Rev. Electr. Eng.*, vol. 3, no. June, pp. 611–619, 2014.
[21] A. R. Abdullah, N. S. Ahmad, N. Bahari, and M. Manap, "Short-circuit switches fault analysis of voltage source inverter using spectrogram," in *2013 International Conference on Electrical Machines and Systems, ICEMS 2013*, 2013, doi: 10.1109/ICEMS.2013.6713294.
[22] L. R. L. Victor, A. Jidin, K. A. Karim, and R. Sundram, "Improved torque control performance of direct torque control for 5-phase induction machine," *Int. J. Power Electron. Drive Syst.*, vol. 3, no. 4, p. 391, 2013.
[23] M. R. Ab Ghani, M. H. Jopri, and M. R. Yusoff, "A Critical Review of Time-frequency Distribution Analysis for Detection and Classification of Harmonic Signal in Power Distribution System.," *Int. J. Electr. Comput. Eng.*, vol. 8, no. 6, 2018.
[24] N. M. Kassim, M. Manap, N. A. Ngatiman, and M. R. Yusoff, "Localization of Multiple Harmonic Sources for Inverter Loads Utilizing Periodogram," *J. Teknol.*, vol. 8, no. 2, pp. 87–91, 2016.
[25] A. Nag and V. A. Rakov, "Pulse trains that are characteristic of preliminary breakdown in cloud-to-ground lightning but are not followed by return stroke pulses," *J. Geophys. Res. Atmos.*, vol. 113, no. 1, pp. 1–12, 2008, doi: 10.1029/2007JD008489.
[26] S. R. Sharma, V. Cooray, and M. Fernando, "Isolated breakdown activity in Swedish lightning," *J. Atmos. Solar-Terrestrial Phys.*, vol. 70, p. pp.1213-1221., 2008, doi: 10.1016/j.jastp.2008.03.003.
[27] S. R. Sharma, V. Cooray, and M. Fernando, "Unique lightning activities pertinent to tropical and temperate thunderstorms," *J. Atmos. Solar-Terrestrial Phys.*, vol. 73, no. 4, pp. 483–487, 2011, doi: 10.1016/j.jastp.2010.11.006.
[28] Z. A. Baharudin, *Characterizations of ground flashes from tropic to northern region*. (Doctoral dissertation, Acta Universitatis Upsaliensis)., 2014.
[29] M. R. Ahmad, M. R. M. Esa, V. Cooray, Z. A. Baharudin, and P. Hettiarachchi, "Latitude dependence of narrow bipolar pulse emissions," *J. Atmos. Solar-Terrestrial Phys.*, vol. 128, pp. 40–45, 2015, doi: 10.1016/j.jastp.2015.03.005.
[30] N. Asyiqin *et al.*, "On the Existence of Attempted Leader in Tropical Thunderstorm," vol. 8, pp. 153–157, 2020.
[31] V. Cooray and S. Lundquist, "On the characteristics of some radiation fields from lightning and their possible origin in positive ground flashes," *J. Geophys. Res.*, vol. 87, no. C13, p. 11203, 1982, doi: 10.1029/jc087ic13p11203.

[32] A. Galvan and M. Fernando, "Operative characteristics of a parallel-plate antenna to measure vertical electric fields from lightning flashes," 2000.
[33] Z. A. Baharudin, N. A. Ahmad, J. S. Mäkelä, M. Fernando, and V. Cooray, "Negative cloud-to-ground lightning flashes in Malaysia," *J. Atmos. Solar-Terrestrial Phys.*, vol. 108, pp. 61–67, 2014, doi: 10.1016/j.jastp.2013.12.001.
[34] Z. A. Baharudin *et al.*, "Retracted: Relationship between the low positive charge region and multiplicity of return stroke in negative ground flash," *J. Fundam. Appl. Sci.*, vol. 10, no. 5S, 2018.

Distribution of Attempted Leader with Monsoon Seasons and Negative CG Flashes in Melaka, Malaysia

ORIGINALITY REPORT

15%	11%	13%	7%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Binus University International Student Paper	3%
2	An Introduction to Lightning, 2015. Publication	1%
3	Submitted to Tikrit University Student Paper	1%
4	iaescore.com Internet Source	1%
5	Baharudin, Z.A., Noor Azlinda Ahmad, M. Fernando, V. Cooray, and J.S. MÃ¤kelÃ¤. "Comparative study on preliminary breakdown pulse trains observed in Johor, Malaysia and Florida, USA", Atmospheric Research, 2012. Publication	1%
6	E. Krider, Martin Uman. "Cloud-to-Ground Lightning: Mechanisms of Damage and Methods of Protection", Seminars in Neurology, 2008 Publication	1%

7	ijeei.org Internet Source	1 %
8	ftkee.utem.edu.my Internet Source	1 %
9	ijece.iaescore.com Internet Source	1 %
10	www.slideshare.net Internet Source	1 %
11	moam.info Internet Source	1 %
12	E. N. C. Perera, D. T. Jayawardana, Pathmakumara Jayasinghe. "A Rainfall Intensity-Duration Threshold for Mass Movement in Badulla, Sri Lanka", Journal of Geoscience and Environment Protection, 2017 Publication	1 %
13	Submitted to Universiti Putra Malaysia Student Paper	1 %
14	Weihown Tee, M. R. Yusoff, M. Faizal Yaakub, A. R. Abdullah. "Voltage variations identification using gabor transform and rule-based classification method", International Journal of Electrical and Computer Engineering (IJECE), 2020 Publication	1 %

Exclude quotes	Off	Exclude matches	< 1%
Exclude bibliography	On		