CHARACTERIZE THE MOST SIGNIFICANT PULSE OF PRELIMINARY BREAKDOWN PULSE TRAIN OF NEGATIVE CLOUD-TO-GROUND FLASH IN MELAKA, MALAYSIA

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ABSTRACT: This study presents a comprehensive statistical information of the most significant pulse in Preliminary Breakdown Pulse (PBP) train of negative cloud to ground flash (-CG). Therefore, the electric fields generated by lightning -CG in Malaysia were measured and analysed (nanosecond resolution) using broadband radiation electric field buffer and high-speed recorder (HDO 4000 LeCroy). The 2992 electric field samples were recorded from 21 thunderstorm events which occurred between 2018 and 2019. From the recorded data, only 39 samples (Southwest Monsoon—SM), 72 samples (Northeast Monsoon—NM), 40 samples (Monsoon transition of April—T-April), and 41 samples (Monsoon transition of October—T-October) are suitable for characterising. The arithmetic means of the total pulse duration (individual pulse) during SM, NM, T-April, T-October was 37.45 μs, 23.23 μs, 34.06 μs, and 26.88 μs, respectively.

Keywords: *Preliminary Breakdown Pulse; PBP; Seasonal Monsoon*

INTRODUCTION

As reported in [1], typically either negative or positive cloud-to-ground lightning flashes (or ground lightning flash) produces a train of pulses in the Initial Breakdown process which characterised as large microsecond-scale electric field pulses. The main objective of this research is to characterize the significant pulse or the highest pulse in the Preliminary Breakdown Pulse Train lightning flashes data collected between 2018 and 2019 at Paya Rumput and Fakulti Teknologi Kejuruteraan Elektrik & Elektronik, UTeM, respectively. Figure 1 shows the example of a typical profile for the case of the most significant pulse in PBP. This study presents the results of lightning parameters such as the Rising Time of 10-90%, Individual Duration Pulse (μs), Zero Crossing Time (ZCT(μs)), and Full Width Half maximum (FWHM(μs)).

METHODOLOGY

The methodology used in this research is according to the methodology presented in [1-3]. However, the observatory station is differed whereby it is located at two different places; Fakulti Teknologi Kejuruteraan Elektrik dan Elektronik (UTeM) and Paya Rumput (Alor Gajah), respectively. In addition, the frequency range used in this research is between 33 and 50 MHz. Figure 2 shows the example of analysing the lightning parameters. In addition, 39 samples of Southwest Monsoon (SM), 72 samples of Northeast Monsoon (NM), 40 samples of Monsoon transition in April (T-April), and 41 samples of Monsoon transition in October (T-October) were analyzed separately.

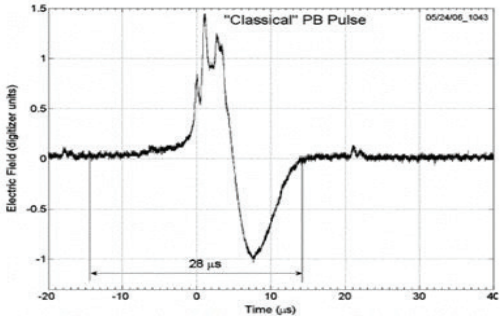

Figure 1 Example of the most significant (highest) pulse in PBP train.

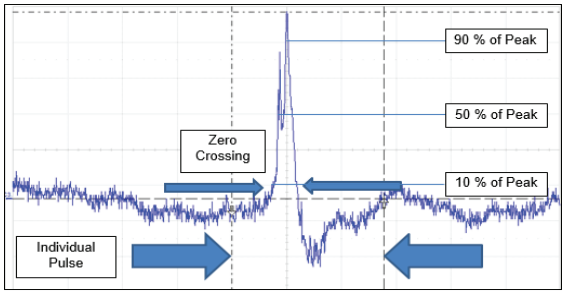

Figure 2 Determination of lightning parameters for the most significant pulse in PBP train

RESULTS AND DISCUSSIONS

Table 1 shows the summary of individual pulse duration for all monsoons. The arithmetic means of individual pulse for SM, NM, T-April and T-October are 36.63 μs, 23.53 μs, 34.06 μs and 26.88 us, respectively. The arithmetic mean of NM is slightly different compared to SM under a factor of 1.56. Next, Table 2 shows the summary of ZCT for all monsoons. The arithmetic means of ZCT for SM, NM, T-April and T-October are 16.75 μs, 9.97 μs, 15.12 μs and 10.44 us, respectively. In this case, the value of NM is slightly different compared to SM and T-April under a factor of 1.68 and 1.52, respectively.

Table 1 Individual pulse duration for all monsoons.

Parameter	SM	NM	T-April	T-October
Min	3.52	1.3	13.04	3.6
Max	89.2	45.68	54.32	56.08
Arith Mean	36.63	23.53	34.06	26.88
Geo Mean	32.97	20.31	32.3	22.74
Std. Dev	15.79	10.01	10.38	14.12

Table 2 ZCT for all monsoons.

Parameter	SM	NM	T-April	T-October
Min	2.4	1.70	7.44	1.2
Max	50.08	23.40	30.24	44.16
Arith Mean	16.75	9.97	15.12	10.44
Geo Mean	14.03	8.85	14.14	8.43
Std. Dev	10.63	4.60	5.65	7.44

It is important to perform the HFWM analysis for estimating the energy distribution of the pulse. We performed HFWM analysis and summarised in Table 3. The arithmetic means of ZCT for SM, NM, T-April and T-October are 5.56 µs, 2.8 µs, 4.56 µs and 3.19 us, respectively. The value of NM is different compared to SM under a factor of 2 while slightly different than the value of T-April under a factor of 1.63.

Table 3 HFWM duration for all monsoons

Parameter	SM	NM	T-April	T-October
Min	0.63	0.27	0.64	0.35
Max	38.6	7.96	15.12	16.42
Arith Mean	5.56	2.80	4.56	3.19
Geo Mean	3.68	2.01	3.4	1.81
Std. Dev	6.98	2.08	3.63	3.87

The histogram for all parameters under different monsoon is shown in Figure 3. In this extended abstract, we only provided an example of the histogram for the case of Northeast Monsoon. In Figure 3 (a) and (b) presented the normal distribution trend which indicated that the duration of individual pulse and ZCT lies between 20 to 24 µs and 8 to 10 µs, respectively. Dominantly, the HFWM of the pulse vary between 1 to 2 µs. Rising peak of lightning return stroke in -CG become high consideration for lightning and protection scheme because it introduces high frequency component that can harm the sensitive devices [4]. Therefore, in this analysis also brought out the profile of high frequency component in the most significant pulse. Figure 3 (d) presents the histogram skewed to the left side which indicated that majority of the rising peaks are less than 1 µs. This feature is comparable with the lightning return stroke that potentially can affect the sensitive devices [5].

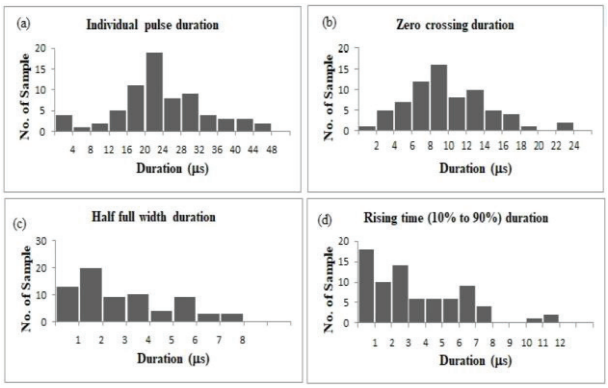

Figure 3 Histogram of lightning parameters under the case of Northeast Monsoon (a) Individual Pulse; ((b) Zero Crossing; (c) half full width; (d) time rise (10% to 90 %)

CONCLUSION

This report performs a comprehensive information regarding of the most significant pulse in Preliminary Breakdown Pulse train of negative cloud-to-ground flashes. In conclusion, the Northwest Monsoon exhibited different properties as compared to the other types of monsoons. We suggest that the difference may be due to a different property of the thunderclouds among types of monsoons. Due to this reason, further investigations which required sufficient data related to the properties of the thunderclouds are crucial to be carried out in order to prove this hypothesis.

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