

**ANALISIS KARAKTERISTIK SINYAL PETIR AWAN KE TANAH
NEGATIF PADA RENTANG *VERY HIGH FREQUENCY*
MENGUNAKAN *CONTINUOUS WAVELET TRANSFORM***

TUGAS AKHIR

Karya Ilmiah sebagai salah satu syarat untuk menyelesaikan jenjang strata satu
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Judul	ANALISIS KARAKTERISTIK SINYAL PETIR AWAN KE TANAH NEGATIF (CG NEGATIF) PADA RENTANG <i>VERY HIGH FREQUENCY</i> (VHF) MENGUNAKAN <i>CONTINUOUS WAVELET TRANSFORM</i> (CWT)	Arif Habibillah
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Abstrak Petir awan ke tanah bermuatan negatif (<i>negative cloud-to-ground, -CG</i>) merupakan fenomena pelepasan muatan listrik di atmosfer yang memancarkan radiasi elektromagnetik pada rentang <i>Very High Frequency</i> (VHF), berlangsung melalui beberapa fase utama yaitu <i>Preliminary Breakdown</i> (PB), <i>Stepped Leader</i> (SL), <i>Return Stroke</i> (RS), dan <i>Continuing Current</i> (CC), yang masing-masing memiliki karakteristik temporal dan spektral berbeda. Karena sinyal VHF petir bersifat <i>non-stasioner</i>, penelitian ini menggunakan metode <i>Continuous Wavelet Transform</i> (CWT) berbasis <i>wavelet</i> Morlet untuk menganalisis karakteristik waktu–frekuensi, distribusi energi, dan <i>Instantaneous Frequency</i> sinyal VHF pada setiap fase pelepasan muatan, menggunakan antenna <i>discone</i> untuk VHF dan <i>slow antenna</i> untuk LF, dengan akuisisi data melalui PicoScope pada <i>sampling rate</i> 250 MS/s dan pengolahan menggunakan MATLAB. Hasil analisis terhadap kejadian petir -CG menunjukkan frekuensi minimum 30,0 MHz, maksimum 119,2 MHz, dan rata-rata 55,8 MHz, dengan karakteristik per-fase: PB pada 30,56–58,88 MHz (<i>mean</i> 37,09 MHz), SL pada 30,28–75,50 MHz (<i>mean</i> 45,27 MHz), RS pada 30–31,70 MHz (<i>mean</i> 30,52 MHz), dan CC pada 31,97–61,62 MHz (<i>mean</i> 44,25 MHz). Sebagai data pelengkap, 9 data <i>Compact Intracloud Discharge</i> (CID) turut dianalisis dan menunjukkan frekuensi minimum konsisten 30,0 MHz, dengan nilai maksimum tertinggi mencapai 115,33 MHz, dan rata-rata 54,64 MHz (data 01-05-2025), tanpa pemisahan fase karena mekanisme pembentukannya yang berbeda dari petir -CG. Hasil ini menunjukkan bahwa CWT berbasis <i>wavelet</i> Morlet mampu mengidentifikasi dinamika spektral setiap fase secara lebih rinci dibandingkan analisis domain waktu maupun frekuensi secara terpisah, sehingga diharapkan mendukung pengembangan sistem deteksi dan analisis petir berbasis pendekatan waktu–frekuensi. Kata Kunci : Petir CG negatif, <i>Very High Frequency</i> (VHF), <i>Continuous Wavelet Transform</i> (CWT), analisis waktu–frekuensi, <i>scalogram</i>, <i>Instantaneous Frequency</i>.		

<i>Title</i>	<i>ANALYSIS OF THE CHARACTERISTICS OF NEGATIVE CLOUD-TO-GROUND (CG) LIGHTNING SIGNALS IN THE VERY HIGH FREQUENCY (VHF) RANGE USING CONTINUOUS WAVELET TRANSFORM (CWT)</i>	Arif Habibillah
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<i>Abstract</i> <i>Negative cloud-to-ground (-CG) lightning is a natural phenomenon involving the discharge of electrical charges in the atmosphere that emits electromagnetic radiation in the Very High Frequency (VHF) range, occurring through several main phases, namely Preliminary Breakdown (PB), Stepped Leader (SL), Return Stroke (RS), and Continuing Current (CC), each exhibiting distinct temporal and spectral characteristics. Because VHF lightning signals are non-stationary, this study applies the Continuous Wavelet Transform (CWT) method based on the Morlet wavelet to analyze the time–frequency characteristics, energy distribution, and Instantaneous Frequency of VHF signals at each discharge phase, using a discone antenna for VHF and a slow antenna for LF, with data acquisition performed via PicoScope at a sampling rate of 250 MS/s and processing carried out using MATLAB. Analysis of the -CG lightning event showed a minimum frequency of 30.0 MHz, a maximum of 119.2 MHz, and a mean of 55.8 MHz, with distinct phase characteristics: PB ranged from 30.56–58.88 MHz (mean 37.09 MHz), SL from 30.28–75.50 MHz (mean 45.27 MHz), RS from 30.00–31.70 MHz (mean 30.52 MHz), and CC from 31.97–61.62 MHz (mean 44.25 MHz). As supplementary data, 9 Compact Intracloud Discharge (CID) events were also analyzed, showing a consistent minimum frequency of 30.0 MHz, with the highest maximum frequency reaching 115.33 MHz, and a mean of 54,64 MHz, without phase separation due to their different discharge mechanism compared to -CG lightning. These results show that the Morlet wavelet-based CWT method is capable of identifying spectral dynamics at each phase in greater detail than time-domain or frequency-domain analysis alone, and is expected to support the development of time–frequency-based lightning detection and analysis systems.</i> <i>Keywords :</i> <i>Negative CG lightning, Very High Frequency (VHF), Continuous Wavelet Transform (CWT), time–frequency analysis, scalogram, Instantaneous Frequency.</i>		