# KARAKTERISTIK SPEKTRUM VHF DARI RADIASI MEDAN LISTRIK PETIR NEGATIF AWAN KE TANAH

**TUGAS AKHIR**

Karya Ilmiah sebagai salah satu syarat untuk menyelesaikan jenjang strata satu (S-1) di Departemen Teknik Elektro, Fakultas Teknik, Universitas Andalas


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## Abstrak

Petir negatif awan ke tanah (-CG) merupakan fenomena alam yang menghasilkan radiasi elektromagnetik kuat pada rentang *Very High Frequency* (VHF). Dengan mengamati spektrum frekuensi sinyal medan listrik selama fase petir diantaranya *Preliminary Breakdown* (PB), *Stepped Leader* (SL), *Return Stroke* (RS), dan *Continuing Current* (CC) dapat diperoleh informasi tentang distribusi energi dan karakteristik frekuensi tiap fase. Pengukuran dilakukan menggunakan sensor *discone* dan *slow antenna*, dengan analisis sinyal menggunakan metode *Short-Time Fourier Transform* (STFT) melalui perangkat lunak Picoscope dan MATLAB. Hasil menunjukkan bahwa setiap fase memiliki karakteristik frekuensi yang berbeda. Fase PB secara umum menunjukkan rentang 20–44 MHz (rata-rata 30,11 MHz, *window* 100 ms), sementara pada pulsa awal PB rentangnya meningkat menjadi 20–49 MHz (rata-rata 36 MHz, *window* 100 µs), dan pada pulsa terbesar mencapai 20–54 MHz (rata-rata 38,99 MHz). Fase SL berada pada rentang 25–63 MHz (rata-rata 39,59 MHz, *window* 100 µs) dan menurun menjadi maksimum 43 MHz serta rata-rata 35,85 MHz saat *window* diperlebar (*window* 100 ms). Fase RS menunjukkan aktivitas tertinggi pada 36–65 MHz (rata-rata 46,1 MHz, *window* 100 µs), diikuti oleh *Subsequent* RS (40–52 MHz, rata-rata 43,46 MHz, *window* 100 µs). Fase CC mencakup 30–68 MHz (rata-rata 39,47 MHz *window* 100 µs) dan menurun menjadi 30–43 MHz (rata-rata 38,29 MHz) dengan *window* 100 ms. Penggunaan *window* waktu kecil memberikan resolusi frekuensi yang lebih tinggi. Selain itu, fenomena *time delay* antar pulsa teramati pada fase RS, yang menunjukkan perbedaan jarak sambaran terhadap sensor. Didapatkan juga perbandingan frekuensi maksimum dan minimum pada setiap fase petir dari penelitian lain. Dari perbandingan tersebut, dapat disimpulkan bahwa karakteristik sinyal petir dapat dipengaruhi oleh spesifikasi sensor yang digunakan, metode yang diterapkan serta penggunaan *window* dan kondisi lingkungan saat pengukuran.



Kata Kunci*:* Petir awan ke tanah negatif, frekuensi VHF, analisis spektrum, *Short-Time Fourier Transform* (STFT)

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## *Abstract*

*Negative cloud-to-ground lightning (-CG) is a natural phenomenon that generates strong electromagnetic radiation in the Very High Frequency (VHF) range. By observing the frequency spectrum of electric field signals during lightning phases—namely Preliminary Breakdown (PB), Stepped Leader (SL), Return Stroke (RS), and Continuing Current (CC)—information can be obtained regarding the energy distribution and frequency characteristics of each phase. Measurements were conducted using discone and slow antennas, with signal analysis performed using the Short-Time Fourier Transform (STFT) method through Picoscope and MATLAB software. The results show that each phase exhibits distinct frequency characteristics. In general, the PB phase ranges from 20–44 MHz (average 30.11 MHz, 100 ms window), while the initial PB pulse increases to a range of 20–49 MHz (average 36 MHz, 100 µs window), and the strongest PB pulse reaches 20–54 MHz (average 38.99 MHz). The SL phase lies within 25–63 MHz (average 39.59 MHz, 100 µs window) and decreases to a maximum of 43 MHz with an average of 35.85 MHz when the window is widened to 100 ms. The RS phase shows the highest activity within 36–65 MHz (average 46.1 MHz, 100 µs window), followed by the Subsequent RS at 40–52 MHz (average 43.46 MHz, 100 µs window). The CC phase spans 30–68 MHz (average 39.47 MHz, 100 µs window) and decreases to 30–43 MHz (average 38.29 MHz with a 100 ms window). Using a smaller time window provides higher frequency resolution. Additionally, a time delay between pulses was observed during the RS phase, indicating differences in strike distance relative to the sensor. A comparison with other studies also revealed variations in the maximum and minimum frequencies for each lightning phase. These findings suggest that lightning signal characteristics are influenced by the specifications of the sensors used, the methods applied, the choice of window size, and the environmental conditions during measurement.*



*Keywords: Negative cloud-to-ground lightning, VHF frequency, spectrum analysis, Short-Time Fourier Transform (STFT)*