



INTISARI

Fenomena sambaran petir berpotensi menimbulkan *ground potential rise* (GPR) yang tinggi serta menciptakan bahaya berupa *touch voltage* dan *step voltage* pada area terbuka seperti lapangan upacara. Untuk memastikan keselamatan manusia dan menilai efektivitas sistem *grounding*, penelitian ini bertujuan menganalisis kinerja sistem *grounding* lapangan upacara terhadap tiga jenis arus petir menggunakan pemodelan berbasis *frequency domain* pada perangkat lunak *XGSLab*. Sistem *grounding* dimodelkan dalam konfigurasi *grid*, *ring conductor*, dan *ground rod*, sedangkan karakteristik tanah direpresentasikan melalui pendekatan *multilayer* dan *multizone*. Tiga bentuk gelombang arus petir yang dianalisis meliputi *first positive stroke* (10/350 μ s), *first negative stroke* (1/200 μ s), dan *subsequent negative stroke* (0.25/100 μ s), dengan parameter evaluasi berupa GPR, *touch voltage*, dan *step voltage* yang dibandingkan terhadap batas aman IEC 60479-1/2. Hasil simulasi pada model *multilayer* menunjukkan bahwa *first positive stroke* menghasilkan sebaran GPR terluas dan membentuk area tidak aman *touch voltage* terbesar, sehingga menjadi kondisi paling berbahaya terhadap keselamatan manusia. Sementara itu, *first negative stroke* menghasilkan nilai puncak GPR tertinggi. Seluruh variasi arus petir menghasilkan *step voltage* yang berada dalam batas aman. Pada model *multizone*, distribusi GPR, *touch voltage*, dan *step voltage* memperlihatkan pola persebaran yang tidak merata antar zona, dengan perbedaan tegangan yang nyata antara sisi kiri dan kanan grid. Variasi resistivitas lateral menyebabkan gradien tegangan tidak simetris dan menghasilkan konsentrasi tegangan yang lebih tinggi pada zona berresistivitas besar. Selain itu, model *multizone* menghasilkan area tidak aman yang lebih luas dibandingkan model *multilayer*, sehingga memberikan representasi yang lebih realistis untuk kondisi tanah heterogen. Penelitian ini menegaskan bahwa bentuk gelombang arus petir dan heterogenitas tanah berpengaruh signifikan terhadap performa sistem *grounding*, sehingga perlu dipertimbangkan secara cermat dalam perancangan sistem *grounding* pada area terbuka dengan tingkat paparan petir tinggi.

Kata kunci: *Grounding, Ground Potential Rise, Touch Voltage, Step Voltage, XGSLab.*



ABSTRACT

Lightning strikes can generate significant ground potential rise (GPR) and create hazards in the form of touch voltage and step voltage, particularly in open areas such as ceremonial fields. To ensure human safety and assess the effectiveness of the grounding system, this study analyzes the performance of the existing grounding system under three types of lightning currents using a frequency-domain modeling approach in XGS-Lab. The grounding system is modeled with a grid configuration incorporating horizontal conductors, a ring conductor, and ground rods, while soil characteristics are represented using both multilayer and multizone models. The lightning currents examined include the first positive stroke (10/350 μ s), first negative stroke (1/200 μ s), and subsequent negative stroke (0.25/100 μ s). The evaluated parameters consist of GPR, touch voltage, and step voltage, referenced against the safety limits defined in IEC 60479-1/2. Simulation results for the multilayer model indicate that the first positive stroke produces the widest GPR distribution and the largest unsafe touch voltage area, making it the most hazardous condition for personnel safety. Meanwhile, the first negative stroke yields the highest peak GPR value. All lightning variations produce step voltage levels that remain within safe limits. The multizone model exhibits non-uniform voltage distribution across zones, with clear differences between the left and right sides of the grid. Lateral variations in soil resistivity lead to asymmetric potential gradients and higher voltage concentrations in zones with greater resistivity. Additionally, the multizone model produces a wider unsafe area compared to the multilayer model, providing a more realistic representation for heterogeneous soil conditions. This study concludes that lightning current waveform characteristics and soil heterogeneity significantly influence grounding system performance. These factors must be carefully considered in the design of grounding systems for open-field environments with high lightning exposure.

Keywords: *grounding, ground potential rise, touch voltage, step voltage, XGSLab.*