INTISARI

Interkoneksi antara Sistem Khatulistiwa dan Sistem Sarawak berperan penting dalam meningkatkan keandalan penyediaan tenaga listrik di Kalimantan Barat melalui dukungan transfer daya antar sistem, namun rencana penerapan skema *load reduction* pada interkoneksi berpotensi menyebabkan Sistem Khatulistiwa beroperasi secara terpisah, sehingga diperlukan evaluasi ketahanan frekuensi sistem, khususnya apabila setelah pelepasan interkoneksi terjadi gangguan kehilangan pembangkit terbesar (N-1). Penelitian ini bertujuan menganalisis karakteristik respons frekuensi Sistem Khatulistiwa pada kondisi interkoneksi normal, setelah pelepasan interkoneksi, setelah penerapan UFLS, serta mengevaluasi pengaruh penguatan sistem berdasarkan skenario RUPTL 2025–2034 terhadap peningkatan ketahanan frekuensi. Pemodelan sistem dilakukan berdasarkan data operasi aktual Sistem Khatulistiwa, dengan simulasi dilakukan pada kondisi beban puncak melalui empat skenario operasi, yaitu interkoneksi terhubung, interkoneksi terlepas, interkoneksi terlepas dengan penerapan UFLS empat tahap (49,0–48,7 Hz) dengan pelepasan beban 7% tiap tahap (total 28%), serta skenario penguatan sistem berdasarkan RUPTL 2029. Parameter evaluasi meliputi RoCoF, frekuensi nadir, frekuensi keadaan *steady-state*, dan kesesuaiannya terhadap ketentuan *Grid Code* Jaringan Sistem Kalimantan. Hasil penelitian menunjukkan bahwa pada kondisi interkoneksi terhubung sistem tetap stabil dengan frekuensi nadir 49,201 Hz dan frekuensi keadaan tunak 50 Hz, sedangkan setelah interkoneksi dilepas frekuensi nadir turun menjadi 47,097 Hz dan frekuensi keadaan tunak menjadi 46,773 Hz sehingga tidak memenuhi batas operasi *Grid Code*. Penerapan UFLS meningkatkan frekuensi nadir menjadi 48,578 Hz dan frekuensi keadaan tunak menjadi 49,028 Hz sehingga sistem kembali memenuhi batas operasi minimum, sedangkan pada skenario RUPTL 2029 penguatan sistem menunjukkan perbaikan RoCoF dari sekitar -1,495 Hz/s menjadi -0,646 Hz/s, frekuensi nadir menjadi 48,797 Hz, serta frekuensi keadaan tunak menjadi 49,385 Hz. Hasil ini menunjukkan bahwa penguatan sistem melalui penambahan kapasitas pembangkit disertai evaluasi berkala skema UFLS merupakan strategi efektif untuk meningkatkan ketahanan frekuensi Sistem Khatulistiwa apabila terpisah dengan Sistem Sarawak.

Kata kunci— *Sistem Khatulistiwa, Sistem Sarawak, decoupling, stabilitas frekuensi, Under Frequency Load Shedding (UFLS), RUPTL, Rate of Change of Frequency (RoCoF), DIgSILENT PowerFactory.*

ABSTRACT

The interconnection between the Khatulistiwa System and the Sarawak System plays an important role in improving the reliability of electricity supply in West Kalimantan through inter-system power transfer support; however, the planned implementation of a load reduction scheme on the interconnection may cause the Khatulistiwa System to operate in an islanded condition, thereby requiring an evaluation of the system's frequency stability, particularly when the interconnection release is followed by an N-1 contingency involving the loss of the largest generating unit. This study aims to analyze the frequency response characteristics of the Khatulistiwa System under normal interconnection conditions, after interconnection release, after the implementation of UFLS, and to evaluate the effect of system reinforcement based on the 2025–2034 RUPTL scenario on improving frequency stability. The system was modeled based on actual operational data of the Khatulistiwa System, with simulations performed under peak-load conditions across four operating scenarios: interconnection connected, interconnection disconnected, interconnection disconnected with four-stage UFLS implementation (49.0–48.7 Hz) shedding 7% of load at each stage (28% in total), and a system reinforcement scenario based on RUPTL 2029. The evaluation parameters included the RoCoF, frequency nadir, steady-state frequency, and compliance with the Kalimantan System Grid Code. The results show that under connected interconnection conditions, the system remained stable with a frequency nadir of 49.201 Hz and a steady-state frequency of 50 Hz, whereas after interconnection release the frequency nadir dropped to 47.097 Hz and the steady-state frequency to 46.773 Hz, failing to meet the Grid Code operating limits. The application of UFLS improved the frequency nadir to 48.578 Hz and the steady-state frequency to 49.028 Hz, restoring compliance with the minimum operating limits, while the RUPTL 2029 reinforcement scenario showed an improved RoCoF from approximately -1.495 Hz/s to -0.646 Hz/s, a frequency nadir of 48.797 Hz, and a steady-state frequency of 49.385 Hz. These results indicate that system reinforcement through additional generation capacity, combined with periodic evaluation of the UFLS scheme, is an effective strategy for improving the frequency stability of the Khatulistiwa System when decoupled from the Sarawak System interconnection.

Keywords— Khatulistiwa Power System, Sarawak Power System, decoupling, frequency stability, Under Frequency Load Shedding (UFLS), Rate of Change of Frequency (RoCoF), Grid Code, DIgSILENT PowerFactory.