INTISARI

Stabilitas sistem tenaga listrik menjadi prioritas utama bagi utilitas sistem untuk memenuhi *Sustainable Development Goals* (SDGs) poin tujuan nomor tujuh yang mencakup penyediaan energi listrik bersih dan terjangkau secara kontinu. Salah satu klasifikasi stabilitas sistem adalah respons frekuensi yang harus dipertahankan dalam rentang operasi kontinu (49,8 - 50,2 Hz) dengan memperhatikan keseimbangan antara daya pembangkitan dan beban sesuai aturan operasi jaringan. Salah satu kasus nyata gangguan stabilitas adalah Sistem Interkoneksi Kalimantan yang mengalami gangguan pada tahun 2023 sehingga menyebabkan stabilitas frekuensi sistem menurun hingga titik nadir. Gangguan tersebut berdampak pada Subsistem Barito (Kalimantan Tengah dan Selatan) dan Subsistem Mahakam (Kalimantan Timur dan Utara) terpisah dengan pemadaman listrik sebesar 60% dari total beban Sistem Interkoneksi Kalimantan.

Berdasarkan permasalahan gangguan Sistem Interkoneksi Kalimantan pada tahun 2023, dilakukan penelitian pada Sistem Interkoneksi Kalimantan tahun operasi 2024 untuk mengkaji desain *defense scheme* yang optimal dalam menjaga keseimbangan suplai daya dan melindungi sistem dari gangguan. Metodologi penelitian melibatkan evaluasi performa desain *existing* pada Subsistem Barito dan Mahakam dengan lima level *defense scheme* dan tahap pelepasan beban oleh *under frequency relay* (UFR) melalui skenario *worst credible contingency* (WCC) pembangkitan sistem. Analisis penelitian terdiri atas proses evaluasi dan penyusunan usulan desain *defense scheme* yang diuji menggunakan simulasi stabilitas respons frekuensi RMS *balanced* menggunakan perangkat lunak DIgSILENT PowerFactory.

Hasil penelitian desain usulan *defense scheme* Sistem Interkoneksi Kalimantan tahun operasi 2024 lebih optimal dibandingkan desain *defense scheme existing* berdasarkan pengujian skenario WCC yang berfokus pada aspek respons frekuensi dan tahapan pelepasan beban. Performa kinerja desain *defense scheme existing* dinilai tidak optimal berdasarkan hasil respons frekuensi yang di bawah rentang operasi kontinu dan pelepasan beban yang tidak merata secara bertahap. Setelah dilakukan proses usulan desain *defense scheme*, hasil performa kinerja menunjukkan bahwa desain usulan dapat memberikan peningkatan performa kinerja yang lebih optimal dengan stabilitas respons frekuensi dalam rentang 49,9 - 50,1 Hz dan kelima tahap pelepasan beban oleh UFR lebih merata secara bertahap.

Kata kunci : *defense scheme*, stabilitas sistem tenaga listrik, stabilitas frekuensi, *under frequency relay* (UFR), pelepasan beban

ABSTRACT

Power system stability is a main priority for system utilities to fulfill the Sustainable Development Goals (SDGs) seventh goal point which includes the continuous provision of safe and reliable electric energy. One classification of system stability is the frequency response that must be maintained within the continuous operating range (49.8 - 50.2 Hz) by taking into consideration the stability between generation power and load according to the grid operating rules. One of the real cases of stability disturbance is the Kalimantan Interconnection System which was disturbed in 2023, causing the system frequency stability to decrease to the nadir point. The disturbance affected the Barito Subsystem (Central and South Kalimantan) and the Mahakam Subsystem (East and North Kalimantan) separately with a power outage of 60% of the total load of the Kalimantan Interconnection System.

Based on the problem of the Kalimantan Interconnection System disturbance in 2023, research was conducted on the Kalimantan Interconnection System in the 2024 operating year to assess the optimal defense scheme design in maintaining the balance of power supply and protecting the system from disturbances. The research methodology involves evaluating the performance of the existing design in the Barito and Mahakam Subsystems with five levels of defense scheme and the load shedding stage by the under frequency relay (UFR) through the worst credible contingency (WCC) scenario of system generation. The research analysis consists of the evaluation process and the preparation of the proposed defense scheme design which is tested using RMS balanced frequency response stability simulation using DIgSILENT PowerFactory software.

The results of the research design of the proposed defense scheme for the Kalimantan Interconnection System in the 2024 operating year are more optimal than the existing defense scheme design based on WCC scenario testing which focuses on the aspects of frequency response and load shedding stages. The performance of the existing defense scheme design is considered not optimal based on the results of the frequency response which is below the continuous operating range and uneven load shedding in stages. After the defense scheme design proposed process, the performance results show that the proposed design can provide a more optimal performance improvement with frequency response stability in the range of 49.9 - 50.1 Hz and the five stages of load shedding by UFR are more evenly distributed in stages.

Keywords : *defense scheme*, *power system stability*, *frequency stability*, *under frequency relay* (UFR), *load shedding*