EVALUASI KINERJA *DROOP CONTROL* DAN *VIRTUAL SYNCHRONOUS MACHINE* PADA *GRID-FORMING INVERTER* UNTUK NANOGRID PESISIR BERBASIS ENERGI GELOMBANG LAUT

Mahmudin Dimas Hamdani

ABSTRAK

Pemanfaatan *Wave Energy Converter* (WEC) pada nanogrid *islanded* memerlukan inverter *grid-forming* yang mampu mempertahankan kestabilan tegangan dan frekuensi ketika terjadi fluktuasi daya sumber dan perubahan beban. Penelitian ini membandingkan kinerja *Droop Control* dan *Virtual Synchronous Machine* (VSM) melalui pemodelan MATLAB/Simulink. Profil daya WEC ekuivalen dibentuk berdasarkan *matriks daya* listrik NREL RM5 dan variasi temporal spektrum Bretschneider. Sebanyak 18 simulasi dilakukan pada skenario variasi daya WEC, perubahan beban, dan gangguan kombinasi. Evaluasi mencakup deviasi frekuensi maksimum, *Rate of Change of Frequency* (RoCoF), waktu *settling*, deviasi tegangan RMS, deviasi tegangan *DC-link*, THDv, dan kompleksitas struktur kontrol. Hasil menunjukkan bahwa VSM secara umum lebih baik dalam membatasi perubahan frekuensi dan tegangan. Pada gangguan *load step*, VSM menghasilkan deviasi frekuensi maksimum sekitar 0.242 Hz dengan waktu *settling* 26 s, sedangkan *Droop Control* menghasilkan sekitar 0.355 Hz dengan waktu *settling* 31 s. Seluruh nilai THD_v berada di bawah batas 8%. Meskipun VSM memberikan respons dinamis yang lebih baik, *Droop Control* memiliki struktur dan proses penalaan yang lebih sederhana. Dengan demikian, pemilihan metode kontrol perlu disesuaikan dengan prioritas kestabilan dinamis, kualitas daya, dan kompleksitas implementasi.

Kata kunci: *Droop Control, Grid-Forming Inverter, Virtual Synchronous Machine, Wave Energy Converter.*

PERFORMANCE EVALUATION OF DROOP CONTROL AND VIRTUAL SYNCHRONOUS MACHINE IN A GRID-FORMING INVERTER FOR AN OCEAN-WAVE-ENERGY-BASED COASTAL NANOGRID

Mahmudin Dimas Hamdani

ABSTRACT

The utilization of a Wave Energy Converter (WEC) in an islanded nanogrid requires a grid-forming inverter capable of maintaining voltage and frequency stability under source-power fluctuations and load changes. This study compares the performance of Droop Control and a Virtual Synchronous Machine (VSM) through MATLAB/Simulink modeling. The equivalent WEC power profiles were developed based on the NREL RM5 electrical power matrix, with temporal variations generated using the Bretschneider spectrum. A total of 18 simulations were conducted under WEC power variation, load-change, and combined-disturbance scenarios. The evaluation covered maximum frequency deviation, maximum Rate of Change of Frequency (RoCoF), frequency settling time, maximum RMS voltage deviation, maximum DC-link voltage deviation, Total Harmonic Distortion of Voltage (THDv), and control-structure complexity. The results indicate that VSM generally performs better in limiting frequency and voltage variations. During the load-step disturbance, VSM produced a maximum frequency deviation of approximately 0.242 Hz with a settling time of 26 s, whereas Droop Control produced approximately 0.355 Hz with a settling time of 31 s. All THD_v values remained below the 8% limit. Although VSM provides better dynamic performance, Droop Control has a simpler structure and tuning process. Therefore, the selection of the control method should be based on the priorities of dynamic stability, power quality, and implementation complexity.

Keywords: *Droop Control, Grid-Forming Inverter, Virtual Synchronous Machine, Wave Energy Converter.*