RINGKASAN

PERANCANGAN DAN ANALISIS KONTROL ARUS PROPORTIONAL-INTEGRAL PADA INVERTER *H-BRIDGE* VSI PWM TERHUBUNG JALA-JALA LISTRIK

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Inverter satu fasa berbasis *Voltage Source* Inverter (VSI) merupakan elemen penting dalam sistem konversi daya modern yang berfungsi mengubah energi listrik arus searah (DC) menjadi arus bolak-balik (AC). Pada inverter yang dirancang untuk aplikasi *grid-connected*, pengendalian arus yang stabil dan responsif menjadi aspek krusial guna menjamin kualitas daya serta keamanan operasi sistem. Penelitian ini membahas perancangan dan analisis kontrol arus *Proportional-Integral* (PI) pada inverter satu *fasa* tipe *H-Bridge* berbasis VSI dengan teknik modulasi *Sinusoidal Pulse Width Modulation* (SPWM).

Metode penelitian meliputi pemodelan dan simulasi sistem inverter terhubung jala-jala listrik menggunakan perangkat lunak PSIM dan MATLAB/Simulink, serta validasi melalui pengujian prototipe dengan beban resistif sebesar 8 Ω. Kontrol arus PI diterapkan dengan parameter k_P= 0,5, k_i = 15, dan periode sampling Ts= 0,0333 s, sedangkan modulasi inverter menggunakan SPWM unipolar dengan frekuensi carrier 22 kHz dan *dead time* sebesar 1,10 µs. Sinkronisasi fasa terhadap tegangan grid direalisasikan menggunakan metode Zero Crossing Detection (ZCD) sebagai referensi fasa sistem. Hasil simulasi menunjukkan bahwa arus inverter mampu mengikuti arus referensi secara stabil dan sefasa dengan tegangan grid, dengan nilai *Total Harmonic Distortion* (THD) arus *grid* sebesar 0,90% pada arus referensi 0,1 A, 1,20% pada 0,5 A, dan 2,09% pada 1 A, serta faktor daya mendekati satu. Namun, pada pengujian prototipe, sistem menunjukkan keterlambatan fasa arus sekitar 34° yang menghasilkan faktor daya sebesar 0,83 *lagging*. Arus inverter terukur berada pada kisaran 0,38 A hingga 1,38 A RMS, dengan nilai THD arus inverter yang relatif tinggi terutama pada kondisi arus referensi rendah, sehingga menunjukkan bahwa meskipun sistem pensaklaran, sinkronisasi ZCD, dan algoritma kontrol PI telah berfungsi, performa inverter *grid-connected* pada prototipe masih memerlukan optimasi lebih lanjut, khususnya pada aspek sinkronisasi fasa, penalaan parameter kontrol PI, dan penyempurnaan desain filter untuk meningkatkan kualitas daya dan efisiensi injeksi daya ke jaringan listrik.

Kata Kunci: Kontrol PI, SPWM unipolar, inverter sumber tegangan, sinkronisasi fasa, respons dinamis

SUMMARY

DESIGN AND ANALYSIS OF PROPORTIONAL-INTEGRAL CURRENT CONTROL FOR A GRID-CONNECTED PWM VSI H-BRIDGE INVERTER

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A single-phase inverter based on a voltage source inverter (VSI) is a key component in modern power conversion systems, functioning to convert direct current (DC) into alternating current (AC). In grid-connected inverter applications, stable and responsive current control with proper phase synchronization to the grid voltage is essential to ensure power quality and operational safety. This research presents the design and analysis of a proportional–integral (PI) current control strategy applied to a single-phase h-bridge vsi inverter using unipolar sinusoidal pulse width modulation (SPWM).

The research methodology includes system modeling and simulation under grid-connected conditions using psim and MATLAB/Simulink, followed by experimental validation through prototype testing with an 8 ω resistive load. The pi current controller was implemented with parameters k_P = 0,5, k_i =15, *and a sampling period of* Ts = 0,0333 *s, while the inverter modulation employed unipolar spwm with a carrier frequency of 22 khz and a dead time of 1.10 µs. Phase synchronization with the grid voltage was achieved using a Zero Crossing Detection (ZCD) method as the phase reference. Simulation results demonstrate that the inverter current is able to accurately track the reference current and remain in phase with the grid voltage, achieving low grid current total harmonic distortion (thd) values of 0.90% at a reference current of 0.1 a, 1.20% at 0.5 a, and 2.09% at 1 a, with the power factor approaching unity. However, experimental prototype testing reveals a phase delay of approximately 34° between the inverter current and grid voltage, resulting in a lagging power factor of 0.83. The measured inverter current ranges from 0.38 a to 1.38 a rms, with relatively high inverter current THD, particularly at low reference current levels. These results indicate that although the switching scheme, zcd-based synchronization, and pi current control algorithm operate as intended, further optimization is required, particularly in phase synchronization accuracy, pi controller tuning, and filter design, to improve power quality and injection efficiency in grid-connected inverter operation.*

Keywords: *PI current control, unipolar SPWM, voltage source* inverter*, phase synchronization, dynamic response*