

**ANALISIS KESTABILAN DAYA DAN MANAJEMEN ENERGI
PEMBANGKIT LISTRIK TENAGA PIKOHIDRO MENGGUNAKAN
KENDALI PID DAN *PARTICLE SWARM OPTIMIZATION***

TUGAS AKHIR

Karya Ilmiah sebagai salah satu syarat untuk menyelesaikan jenjang Strata Satu
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Judul	Analisis Kestabilan Daya dan Manajemen Energi Pembangkit Listrik Tenaga Pikohidro Menggunakan Kendali PID dan <i>Particle Swarm Optimization</i>	Muhammad Huseini
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Abstrak Pembangkit Listrik Tenaga Pikohidro (PLTPh) berbasis <i>Self-Excited Induction Generator</i> rentan mengalami instabilitas frekuensi akibat fluktuasi beban konsumen pada kondisi <i>standalone</i>. Penelitian ini bertujuan merancang sistem kendali frekuensi dan manajemen energi berbasis <i>Electronic Load Controller</i> pada PLTPh 1 kW (380 V, 50 Hz). Kombinasi pengendali <i>Proportional-Integral-Derivative</i> (PID) dan algoritma <i>Particle Swarm Optimization</i> (PSO) diimplementasikan pada MATLAB/Simulink untuk mengoptimalkan penalaan parameter K_p, K_i, dan K_d dengan meminimalkan fungsi objektif <i>Integral Time Absolute Error</i> (ITAE). Hasil simulasi menunjukkan pengendali PID-PSO berhasil mereduksi nilai ITAE sebesar 82,73% (dari 9,1793 menjadi 1,5851) dibandingkan metode <i>trial-and-error</i>. Sistem mampu mengunci frekuensi <i>steady-state</i> pada nilai nominal 50,00 Hz, meredam fluktuasi daya generator pada kisaran 980 W–1000 W. Selain itu, strategi manajemen energi terbukti bekerja presisi. Ketika nilai <i>State of Charge</i> turun hingga 79,956%, sistem secara otomatis mengalihkan surplus daya generator untuk pengisian ulang hingga mencapai dan bertahan konstan tepat pada batas referensi 80,00% pada detik ke-24. Kata Kunci: Pikohidro, <i>Self-Excited Induction Generator</i>, PID-PSO, Manajemen Energi, Kestabilan Frekuensi		

<i>Title</i>	<i>Analysis of Power Stability and Energy Management in Pico-Hydropower Plants Using PID Control and Particle Swarm Optimization</i>	Muhammad Huseini
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<i>Abstract</i> <i>Picohydro power plants based on Self-Excited Induction Generators are vulnerable to frequency instability caused by consumer load fluctuations in standalone operation. This study aims to design and simulate a frequency control and energy management system based on an Electronic Load Controller for a 1 kW (380 V, 50 Hz) picohydro power plant. A combination of a Proportional-Integral-Derivative (PID) controller and the Particle Swarm Optimization (PSO) algorithm is implemented in MATLAB/Simulink to optimize the tuning of K_p, K_i, and K_d parameters by minimizing the Integral Time Absolute Error (ITAE) objective function. The simulation results demonstrate that the PSO-tuned PID controller successfully reduces the ITAE value by 82.73% (from 9.1793 to 1.5851) compared to the conventional trial-and-error method. The system is capable of locking the steady-state frequency precisely at the nominal value of 50.00 Hz, dampening generator power fluctuations within the range of 980 W–1000 W. Furthermore, the energy management strategy works with high precision. When the State of Charge value drops to 79.956%, the system automatically diverts excess generator power for recharging until it reaches and maintains a constant target reference of exactly 80.00% at the 24th second.</i> <i>Keywords: Pico-Hydropower, Self-Excited Induction Generator, PID-PSO, Energy Management, Frequency Stability</i>		