ANALISIS DAN SIMULASI INVERTER MULTILEVEL CHB 13-LEVEL MENGGUNAKAN METODE *SELECTIVE HARMONIC ELIMINATION* PWM BERBASIS OPTIMASI *MOTH-FLAME OPTIMIZATION*

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ABSTRAK

Inverter multilevel *Cascaded H-Bridge* (CHB) banyak digunakan dalam aplikasi konversi energi karena mampu menghasilkan tegangan keluaran mendekati sinusoidal dengan jumlah komponen yang efisien. Namun, proses pensaklaran pada inverter ini masih menghasilkan distorsi harmonisa yang dapat menurunkan kualitas daya listrik. Penelitian ini bertujuan menganalisis dan mensimulasikan inverter CHB 13-Level menggunakan metode *Selective Harmonic Elimination Pulse Width Modulation* (SHEPWM) yang dioptimasi dengan algoritma *Moth-Flame Optimization* (MFO) untuk menentukan sudut pensaklaran optimal guna mengeliminasi harmonisa orde rendah. Simulasi dilakukan pada MATLAB/Simulink dengan variasi *Modulation Index* (MI) sebesar 0.55 hingga 1.00 pada beban Resistor (R) dan Induktor-Kapasitor (LC). Hasil pengujian karakteristik tegangan menunjukkan gelombang keluaran berbentuk *staircase* 13-tingkat dengan rasio Vrms terhadap Vpp/2 konsisten sebesar 0.707 pada beban Resistor, mendekati gelombang sinusoidal ideal, sedangkan pada beban LC bentuk *staircase* tetap terbentuk baik meski terdapat sedikit pergeseran fasa dan penghalusan transisi akibat komponen reaktif, dengan nilai Vpp dan Vrms yang hanya berbeda tipis (kurang dari 3 V) dibandingkan beban Resistor. Hasil penelitian menunjukkan bahwa algoritma MFO berhasil menentukan sudut pensaklaran optimal dengan nilai fitness terkecil sebesar 0.00027 pada MI = 0.80. Nilai *Total Harmonic Distortion* (THD) terendah diperoleh sebesar 5.09% pada beban R pada MI = 0.85 dan 5.22% pada beban LC pada MI = 0.60. THD tertinggi terjadi pada MI = 0.95, yaitu 10.03% di beban R dan 9.79% di beban LC, berkorelasi dengan kenaikan nilai fitness tajam mendekati kondisi overmodulation. Penelitian ini membuktikan bahwa metode SHEPWM berbasis MFO efektif meningkatkan kualitas tegangan keluaran inverter CHB 13-Level.

Kata kunci: *Inverter Multilevel, Cascaded H-Bridge, SHEPWM, Moth-Flame Optimization, Total Harmonic Distortion.*

ANALYSIS AND SIMULATION OF 13-LEVEL CASCADED H-BRIDGE MULTILEVEL INVERTER USING SELECTIVE HARMONIC ELIMINATION PWM METHOD BASED ON MOTH-FLAME OPTIMIZATION

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ABSTRACT

Cascaded H-Bridge (CHB) multilevel inverters are widely used in energy conversion applications because they can produce output voltages that closely approximate a sinusoidal waveform with an efficient number of components. However, the switching process in this inverter still produces harmonic distortion that can degrade power quality. This research aims to analyze and simulate a CHB 13-Level inverter using the Selective Harmonic Elimination Pulse Width Modulation (SHEPWM) method optimized with the Moth-Flame Optimization (MFO) algorithm to determine the optimal switching angles for eliminating low-order harmonics. Simulations were conducted in MATLAB/Simulink with a Modulation Index (MI) ranging from 0.55 to 1.00, tested on Resistor (R) and Inductor-Capacitor (LC) loads. The voltage characteristic test results show that the output waveform forms a 13-level staircase with a consistent Vrms-to-Vpp/2 ratio of 0.707 on the Resistor load, closely approximating an ideal sinusoidal waveform, while on the LC load the staircase waveform is still formed properly despite a slight phase shift and smoothing at the voltage-level transitions caused by the reactive components, with Vpp and Vrms values differing only slightly (less than 3 V) from the Resistor load. The results show that the MFO algorithm successfully determined the optimal switching angles with the smallest fitness value of 0.00027 at MI = 0.80. The lowest Total Harmonic Distortion (THD) was 5.09% on the R load at MI = 0.85 and 5.22% on the LC load at MI = 0.60. The highest THD occurred at MI = 0.95, reaching 10.03% on the R load and 9.79% on the LC load, correlating with a sharp increase in the fitness value near the overmodulation condition. This research demonstrates that the MFO-based SHEPWM method effectively improves the output voltage quality of the CHB 13-Level inverter.

***Keywords**: Multilevel Inverter, Cascaded H-Bridge, SHEPWM, Moth-Flame Optimization, Total Harmonic Distortion*