

ABSTRAK

IMPLEMENTASI METODE *FUZZY LOGIC* UNTUK OPTIMASI ENERGI SISTEM LAMPU JALAN TENAGA SURYA BERBASIS ESP32 DENGAN MENGUNAKAN SENSOR PIR

(2026: xiii + 74 Halaman + 31 Gambar + 19 Tabel + Daftar Pustaka + Lampiran)

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Penerangan jalan konvensional menyala dengan intensitas tetap sepanjang malam tanpa mempertimbangkan kondisi lingkungan maupun aktivitas pengguna jalan, sehingga menyebabkan pemborosan energi. Penelitian ini merancang sistem lampu jalan tenaga surya berbasis ESP32 menggunakan metode Fuzzy Logic Sugeno, dengan sensor LDR untuk mendeteksi intensitas cahaya dan sensor PIR HC-SR501 untuk mendeteksi aktivitas pengguna jalan. Kedua data sensor diproses melalui fuzzifikasi, evaluasi rule base, dan defuzzifikasi metode rata-rata berbobot untuk menentukan kecerahan lampu (Terang, Redup, atau Mati), dikendalikan melalui empat modul relay. Mekanisme timer hold 10 detik ditambahkan untuk mengatasi keterbatasan sensor PIR dalam mendeteksi objek diam. Pengujian pada lima sesi lapangan merekam 17.249 sampel data selama $\pm 310,5$ menit. Sensor PIR mendeteksi 936 kali gerakan secara real-time, timer hold bekerja sesuai rancangan, dan algoritma Fuzzy Logic konsisten sesuai rule base pada seluruh sampel. Berdasarkan proporsi status lampu (Terang 49,4%, Redup 13,5%, Mati 37,1%), sistem menghasilkan penghematan energi $\pm 43,8\%$ dibandingkan sistem konvensional yang menyala penuh secara konstan. Hasil ini menunjukkan integrasi sensor LDR, sensor PIR, dan Fuzzy Logic pada ESP32 efektif menghasilkan sistem penerangan jalan tenaga surya yang adaptif dan hemat energi.

Kata Kunci : Fuzzy Logic Sugeno, ESP32, sensor PIR, sensor LDR, lampu jalan tenaga surya, optimasi energi.

ABSTRACT

IMPLEMENTATION OF FUZZY LOGIC METHOD FOR ENERGY OPTIMIZATION OF SOLAR STREET LIGHT SYSTEM BASED ON ESP32 USING PIR SENSOR

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Conventional street lighting systems operate at a fixed intensity throughout the night regardless of environmental conditions or road user activity, causing energy waste. This research designs a solar-powered street light system based on the ESP32 microcontroller using the Sugeno Fuzzy Logic method, with an LDR sensor to detect ambient light and a PIR HC-SR501 sensor to detect road user activity. Both readings are processed through fuzzification, rule base evaluation, and weighted-average defuzzification to determine the lamp brightness (Bright, Dim, or Off), controlled via four relay modules. A 10-second timer hold mechanism is added to overcome the PIR sensor's limitation in detecting stationary objects. Testing across five field sessions recorded 17,249 data samples over ± 310.5 minutes. The PIR sensor detected motion 936 times in real time, the timer hold worked as designed, and the Fuzzy Logic algorithm consistently matched the rule base across all samples. Based on the lamp status proportions (Bright 49.4%, Dim 13.5%, Off 37.1%), the system achieved an energy saving of approximately 43.8% compared to a conventional, continuously full-brightness system. These results show that integrating LDR sensors, PIR sensors, and Fuzzy Logic on ESP32 effectively produces an adaptive, energy-efficient solar street lighting system.

Keyword : *Sugeno Fuzzy Logic, ESP32, PIR sensor, LDR sensor, solar street light, energy optimization.*