

ABSTRAK

RUDI YANWAR.

Rancang Bangun Sistem Pendeteksi Suhu dan Kelembapan Untuk Proteksi Kubikel Yang Dilengkapi Dengan Heater Hybrid

Keandalan sistem distribusi tenaga listrik sangat dipengaruhi oleh kondisi kubikel 20 kV, terutama pada bagian terminasi kabel yang rentan terhadap kelembapan dan kondensasi. Pada kondisi padam PLN, *heater* kubikel ikut tidak beroperasi sehingga kelembapan meningkat dan berpotensi memicu *partial discharge*, *tracking*, hingga *flashover* saat tegangan kembali diberikan. Tugas akhir ini merancang dan membangun sistem pendeteksi suhu dan kelembapan untuk proteksi kubikel yang dilengkapi dengan *heater hybrid* berbasis dua sumber listrik, yaitu listrik PLN (JTR) sebagai sumber utama dan PLTS dengan penyimpanan AKI sebagai sumber cadangan, dengan *Automatic Transfer Switch (ATS)* berbasis ESP32 WROOM, sensor DHT22, sensor tegangan ZMPT101B, *solid state relay (SSR)*, serta *platform monitoring IoT* berbasis *web* dan *Blynk*. Pengujian meliputi akurasi sensor DHT22 terhadap alat ukur referensi, akurasi pembacaan tegangan ZMPT101B, kinerja pengisian dan pengosongan aki PLTS, waktu perpindahan sumber oleh *ATS*, serta pengujian keseluruhan sistem dalam mengendalikan kelembapan kubikel. Hasil pengujian menunjukkan sensor DHT22 memiliki galat pembacaan suhu sebesar 3,93% dan kelembapan dalam sebesar 5,36% terhadap alat ukur referensi, sedangkan sensor ZMPT101B memiliki galat pembacaan tegangan sebesar 0,58% setelah proses kalibrasi. Sistem *ATS* mampu melakukan perpindahan sumber dari PLN ke PLTS maupun sebaliknya dengan waktu jeda sekitar 10 detik tanpa terjadi kondisi paralel sumber dan tanpa gejala *chattering*, sehingga suplai *heater* tetap berkelanjutan. Pada pengujian keseluruhan, ketika kelembapan kubikel mencapai atau melebihi ambang 80% RH, *heater* aktif dan mampu menurunkan kelembapan hingga di bawah ambang batas tersebut sesuai rekomendasi SPLN D3.020 1:2019, sementara suhu tetap berada dalam rentang operasi aman. Dengan demikian, sistem pendeteksi suhu dan kelembapan dengan *heater hybrid* PLN–PLTS yang dirancang terbukti mampu menjaga kondisi lingkungan kubikel lebih stabil dan meningkatkan keandalan proteksi kubikel 20 kV.

Kata Kunci : Kubikel 20 kV, *Heater*, *Energi Hybrid*, *Panel Surya*, *Automatic Transfer Switch*, *Internet of Things*

ABSTRACT

RUDI YANWAR.

*Design and Implementation of a Temperature and Humidity Detection System for Cubicle Protection Equipped with a Hybrid Heater
Supervised by Ir. Hendrianto Husada, M.T.*

The reliability of electrical power distribution systems is strongly influenced by the condition of 20 kV cubicles, particularly at cable terminations that are highly susceptible to moisture and condensation. During PLN outages, the cubicle heater becomes inoperative, causing humidity levels to rise and potentially triggering partial discharge, surface tracking, and flashover when voltage is re-energized. This final project designs and implements a temperature and humidity detection system for cubicle protection equipped with a hybrid heater powered by two energy sources: PLN low-voltage supply (JTR) as the primary source and a photovoltaic (PV) system with battery storage as the backup source. The system utilizes an Automatic Transfer Switch (ATS) based on the ESP32-WROOM microcontroller, a DHT22 temperature and humidity sensor, a ZMPT101B voltage sensor, solid state relays (SSR), and a web-based IoT monitoring platform integrated with Blynk. Testing procedures include evaluating the accuracy of the DHT22 sensor against a reference instrument, voltage measurement accuracy of the ZMPT101B sensor, battery charging and discharging performance of the PV system, source transfer time of the ATS, and overall system performance in controlling cubicle humidity. The test results indicate that the DHT22 sensor exhibits a temperature measurement error of 3.93% and an internal humidity measurement error of 5.36% compared to the reference instrument, while the ZMPT101B sensor shows a voltage measurement error of 0.58% after calibration. The ATS system successfully performs source transfer from PLN to the PV system and vice versa with an approximate delay of 10 seconds, without source paralleling and without chattering phenomena, ensuring continuous heater supply. In overall system testing, when cubicle humidity reaches or exceeds the 80% RH threshold, the heater is activated and effectively reduces humidity below the specified limit in accordance with SPLN D3.020-1:2019 recommendations, while maintaining temperature within a safe operating range. Therefore, the designed temperature and humidity detection system with a hybrid PLN–PV heater has been proven capable of maintaining more stable cubicle environmental conditions and enhancing the reliability of 20 kV cubicle protection systems.

Keywords: 20kV Cubicle, Heater, Hybrid Energy, Solar Panel, Automatic Transfer Switch, Internet of Things