ABSTRAK

Ahmad Khairul Umam : Analisis Keandalan Relay Diferensial Menggunakan ETAP Pada Trafo Daya di Gardu Induk Denai

Transformator daya memiliki peran vital dalam sistem tenaga listrik sebagai peralatan untuk menaikkan dan menurunkan tegangan sehingga memerlukan sistem proteksi yang handal. Salah satu proteksi utama adalah *relay* diferensial yang bekerja dengan membandingkan arus masuk dan keluar trafo untuk mendeteksi gangguan internal. Namun, di Gardu Induk Denai pernah terjadi keterlambatan respon *relay* diferensial saat pengujian. Penelitian ini bertujuan untuk menganalisis faktor-faktor penyebab keterlambatan tersebut, termasuk kondisi *wiring*, kualitas sinyal arus, dan faktor teknis lainnya, serta mengevaluasi keandalan *relay* diferensial melalui simulasi gangguan internal menggunakan *software ETAP*.

Penelitian ini dilakukan dengan populasi seluruh komponen proteksi pada transformator daya di Gardu Induk Denai 150 kV dan sampel berupa data arus CT, *konfigurasi relay*, serta hasil pengujian relay diferensial. Instrumen penelitian meliputi data primer dari gardu induk, hasil perhitungan manual, dan perangkat lunak *ETAP* sebagai alat simulasi. Analisis data mencakup perhitungan rasio CT, *error mismatch*, arus sekunder, arus diferensial, arus *restrain*, *slope*, serta arus setting, kemudian diinterpretasikan untuk menentukan penyebab keterlambatan respon *relay*. Simulasi *ETAP* digunakan sebagai pembanding untuk melihat kemampuan *relay* dalam mendeteksi gangguan internal.

Hasil penelitian menunjukkan rasio CT pada sisi primer sebesar 300:1 A dan sisi sekunder 2000:1 A dengan *error mismatch* masing-masing 0,89% dan 1,125%. Arus sekunder pada sisi primer sebesar 0,7698 A dan sisi sekunder 0,8660255 A, menghasilkan arus diferensial 0,0962255 A dan arus *restrain* 0,81791275 A dengan *slope* 1 sebesar 11,76% dan *slope* 2 sebesar 23,53%. Arus setting *relay* dihitung sebesar 0,0961865 A. Melalui simulasi *ETAP*, *relay* diferensial bekerja instan (0 ms) ketika terjadi gangguan internal dan menginstruksikan CB1 serta CB2 untuk trip masing-masing pada 80 ms dan 100 ms. Hasil ini menunjukkan bahwa *relay* diferensial memiliki kemampuan deteksi yang baik, dan keterlambatan pada pengujian kemungkinan dipengaruhi oleh faktor eksternal seperti *wiring* atau kualitas sinyal arus.

Kata Kunci: Relay diferensial, transformator daya, proteksi sistem tenaga, ETAP, arus diferensial, arus restrain, rasio CT, error mismatch, pemutus sirkuit (CB).

ABSTRACT

Ahmad Khairul Umam: ***Differential Relay Reliability Analysis Using ETAP on Power Transformers at the Denai Substation***

Power transformers play a vital role in the electric power system as devices for stepping up and stepping down voltage, requiring a reliable protection system. One of the primary protection devices is the differential relay, which works by comparing the transformer's incoming and outgoing currents to detect internal faults. However, at the Denai Substation, differential relay response delays occurred during testing. This study aimed to analyze the factors causing these delays, including wiring conditions, current signal quality, and other technical factors. It also evaluated the reliability of the differential relay through internal fault simulations using ETAP software.

This study was conducted using a population of all protection components on the 150 kV power transformer at the Denai Substation, with samples consisting of CT current data, relay configurations, and differential relay test results. The research instruments included primary data from the substation, manual calculations, and ETAP software as a simulation tool. Data analysis included calculations of the CT ratio, error mismatch, secondary current, differential current, restraint current, slope, and setting current, which were then interpreted to determine the cause of the relay response delay. ETAP simulation was used as a comparison to assess the relay's ability to detect internal faults.

The results showed a CT ratio of 300:1 A on the primary side and 2000:1 A on the secondary side, with mismatch errors of 0.89% and 1.125%, respectively. The secondary current on the primary side was 0.7698 A and 0.8660255 A on the secondary side, resulting in a differential current of 0.0962255 A and a restraint current of 0.81791275 A, with slope 1 of 11.76% and slope 2 of 23.53%. The relay setting current was calculated to be 0.0961865 A. Through the ETAP simulation, the differential relay operated instantly (0 ms) when an internal fault occurred, instructing CB1 and CB2 to trip at 80 ms and 100 ms, respectively. These results indicate that the differential relay has good detection capabilities, and delays in testing are likely influenced by external factors such as wiring or current signal quality.

Keywords: *Differential relay, power transformer, power system protection, ETAP, differential current, restrain current, CT ratio, error mismatch, circuit breaker (CB).*