ABSTRACT

Frequency stability is one of the key factors in maintaining the reliability of power systems. Direct testing on real systems is costly and risky, therefore this study adopts the Hardware in the Loop Simulation (HILS) method based on Arduino Uno R3 microcontroller as a safer and more economical alternative. The objective of this research is to design and implement a Proportional-Integral (PI) controller in the form of an analog circuit to minimize frequency deviation using the HILS method, within the scope of a two-area power system modeled in MATLAB/Simulink.

The research steps include the design of a PI controller in MATLAB two-area power system, determining Kp and Ki parameters through tuning, and implementing the controller in the form of an analog circuit using OP-AMP LM358 integrated with Arduino. The integration is tested with HILS to evaluate the frequency control performance in real-time against load disturbances.

Simulation results show that the controller achieved a rise time of 2 seconds in both areas, a settling time of 18 seconds in area 1 and 25 seconds in area 2, with a maximum overshoot of +0.15 Hz, minimum undershoot of –0.75 Hz, and steady-state error of 0 Hz. In the HILS implementation, the results obtained were a rise time of 2 seconds in both areas, a settling time of 20 seconds, maximum overshoot of +0.15 Hz in area 1 and +0.65 Hz in area 2, minimum undershoot of –1.15 Hz in area 1 and –0.85 Hz in area 2, and steady-state error of 0.8 Hz. These results demonstrate that the HILS-based PI controller can improve frequency stability, although steady-state deviation remains and requires further optimization.

Keywords: frequency, HILS, power system, PI controller, stability