INTISARI

Penelitian ini bertujuan mengembangkan sistem kendali yang mampu melakukan reference tracking dan disturbance rejection pada kendaraan listrik. Dua strategi kendali klasik diterapkan, yaitu Proportional-Integral-Derivative (PID) dan lead-lag compensator. Kedua kendali tersebut dirancang berdasarkan model linier dari dinamika longitudinal kendaraan listrik. Pada pengendali lead-lag compensator, dilakukan augmentasi integrator untuk meningkatkan kemampuan pelacakan referensi secara presisi dan menghilangkan SSE. Hasil simulasi menunjukkan bahwa masing-masing pendekatan mampu menjaga performa pelacakan secara stabil serta tangguh terhadap gangguan eksternal. Analisis komparatif berdasarkan karakteristik domain waktu dan indeks kinerja kesalahan mengindikasikan bahwa PID memiliki keunggulan dalam respons transien. Secara khusus, untuk model kendaraan listrik (EV plant), pengendali PID menghasilkan nilai kesalahan yang jauh lebih kecil, yaitu ISE sebesar 0,0017, ITAE sebesar 19,04, IAE sebesar 0,3631, dan ITSE sebesar 0,0670, dibandingkan dengan lead-lag compensator.

Selain itu, dari segi kenyamanan dan efisiensi energi, simulasi gaya traksi menunjukkan bahwa meskipun kontroler PID lebih boros energi dibandingkan LLC, ia memberikan gaya traksi yang lebih halus dan nyaman bagi pengendara. Sebaliknya, LLC lebih hemat energi namun menghasilkan respons yang tajam dan kurang nyaman secara dinamis. Temuan ini menegaskan bahwa sistem cruise control yang efektif pada kendaraan listrik dapat dicapai dengan metode kendali klasik tanpa harus bergantung pada algoritma modern yang kompleks.

Keywords: PID controller, lead-lag compensator, cruise control, electric vehicle, disturbance rejection

ABSTRACT

This study aims to develop a control system capable of performing reference tracking and disturbance rejection for electric vehicles (EVs). Two classical control strategies are employed: a Proportional-Integral-Derivative (PID) controller and a lead-lag compensator. Both controllers are designed based on a linear model of the EV's longitudinal dynamics. To enhance steady-state performance, the lead-lag compensator is augmented with an integrator, ensuring zero steady-state error in reference tracking tasks. Simulation results demonstrate that each approach effectively ensures stable tracking performance and robustness to external disturbances. Comparative analysis using time-domain characteristics and error performance indices indicates that the PID controller exhibits superior transient response. In particular, for the EV plant, the PID controller yields significantly lower error metrics—ISE of 0.0017, ITAE of 19.04, IAE of 0.3631, and ITSE of 0.0670—compared to the lead-lag compensator. In addition to error-based performance, traction force profiles were evaluated to assess rider comfort and energy efficiency. The PID controller, while consuming more energy (7.13 MJ), produces smoother and more comfortable traction responses. In contrast, the LLC (lead-lag compensator) is more energy efficient (0.461 MJ) but generates sharper and less comfortable force changes due to its impulsive behavior. These findings confirm that effective and practical cruise control in electric vehicles can be achieved using classical control methods, with a trade-off consideration between energy consumption and ride comfort.

Keywords: *PID controller, lead-lag compensator, cruise control, electric vehicle, disturbance rejection*