Advances in Automobile Engineering

Extended Abstract

CONTROL OF DPPS IN VEHICLE USING FEED-FORWARD DECOUPLING

Hao Chen, Chao Wang[1], Xi Chen and Xiaomin Lian

Abstract

To solve the contradiction between interior space and demand for electricity of vehicle, this paper brings forward the dual-generator parallel power system (DPPS). However, it is difficult to control the voltage and balance output power between two different types of generators simultaneously. Thus, feed-forward control has been developed to accomplish decoupling the target current of two generators, and proportional-integral-differential (PID) controllers, with its stability being discussed, are also designed to track desired values. Based on structural analysis of DDPS, the simulation model is built in MATLAB/Simulink to prove the preliminary feasibility of the scheme and provide a reference for the real system. Finally, bench tests have been performed involving the dynamic change in the reference voltage, engine rotating speed, and load, to verify the effectiveness of the proposed method. The results show that it can achieve synchronous control of the output voltage and current ratio of two generators in DPPS. The generator, as an important source in the vehicle power supply system, is also the main component that can be controlled initiatively (Denton, 2013; Athani et al., 2016; Ayaz and Erkan, 2016). Since the rotor of the generator is driven by engine, the performance of generators affects vehicle's economy significantly (Adhikari et al., 2010; Ji et al., 2016). In recent years, the demand of vehicle's electrical power has been much greater than before. To improve the power of individual generator only, it will meet some tough issues, such as cost increasing. Besides, there is a contradiction between the limitation of the inner space of vehicle and the improvement of generator power because the rated/maximum power is always proportional to its volume, i.e. the greater the power is, the larger the size is. The multi-generators parallel power system has been considered as a valid solution (Cao, 2016). It can not only expand capacity of power supply, but also reduce the volume compared with the single generator with the same rated/maximum power. Actually, the multi-generators parallel power system has been applied to aerospace and shipping industry successfully for its flexibility and redundancy. In the automotive industry, BOSCH has put forward the coordinated operation method of multigenerators in vehicular power grid based on chief- part structure. Its basic idea is to adopt high-performance generators and a regulator with LIN communication function. The output power is calculated by a central controller to achieve balancing goal via detecting the power load of each generator (Bosch, Inc., 2014). BMW has also developed a regulator that has the similar function. This research work has developed the dual-generator parallel power system (DPPS), which utilizes two different small volume generators to supply power in parallel way. In fact, there are two control targets for DPPS: the output voltage and the current ratio between two generators. The traditional control method for vehicular generator takes effect mainly through regulators (Unutulmaz and Lale, 2013; Blaga and Norbert, 2014; Scacchioli et al., 2014). Once the generator begins to generate electricity, it will enter the self-excitation stage with fixed output voltage. As a result, the adjustment of the output voltage cannot be done within dynamic way (Hwu and Yu, 2016). Furthermore, even the same generators still have inconsistencies in the internal parameters during the manufacturing procedure, which perhaps cause unbalancing output power. Thus, it is hard to control and balance the output simultaneously in most cases. There are substantial methods for this problem (Balogh, 2002). Zhang et al. (2015), Irving and Jovanovic (2000) and Zhang et al. (2013) used the output impedance method (the droop method), which is the simplest current sharing way. However, it fails to balance as for parallel modules with non-identical rated power. Wang et al. (2012) and Liu et al. (2016) applied master slave current method. This is suitable for double closed-loop systems with voltage and current control. One of the modules is designated as the main module and the other is the slave. The slave module adjusts itself according to feedback information of the main module, but if there has some breaks down of the master one, the whole system will be out of control completely. Panov and Jovanovic (2008) and Wu et al. (2014) adopted average current sharing method. It introduces a load share bus as reference. The error is obtained by comparison of each module with load share bus. Similarly, when a short circuit happens to the bus, the voltage droops, resulting in failure in the parallel power system.

Chao Wang
Tsinghua University, Beijing, China Email: c.wang@mail.tsinghua.edu.cn