Robust predictive speed control for surface-mounted permanent magnet synchronous motor systems

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Permanent magnet synchronous motor (PMSM) systems have been widely used due to their high power density and high efficiency. Digital control systems have been applied to improve the performance of PMSM systems. Proportional integral control, as a straightforward and effective control method, has been implemented on the microprocessors to manipulate PMSM systems.

However, PMSM is a nonlinear system with variable parameters, which means that the linear proportional integral (PI) controller is unable to give full play to the performance of a PMSM system. Therefore, a number of modern control strategies, including model-based predictive control, sliding mode control, and internal model control, have been proposed for PMSM systems.

In a study published in *IEEE Transactions on Energy Conversion*, Dr. Wang Fengxiang's group from Fujian Institute of Research on the Structure of Matter of the Chinese Academy of Sciences has proposed a sliding mode gradient descent disturbance observer-based adaptive reaching law sliding mode predictive speed control (GD-SMPC+ARL) to prompt the robustness and tracking performance of surface-mounted permanent magnet synchronous motor (SPMSM) systems.

The researchers found that continuous control set model-based predictive control (CCS-MPC) has an advantage over finite control set MPC (FCS-MPC) by reducing the velocity and current ripple, and it is more sensitive against parameter uncertainties and external disturbances. Sliding mode control (SMC) is one of the well-known variable-structure systems and has been extensively applied owing to its robustness against parameter mismatches and external disturbances.

By introducing the predefined sliding mode reaching law into the cost function of CCS-MPC, the dynamic property of the MPC system can be controlled. However, the chattering phenomenon is drawn into CCS-MPC due to the discontinuous signum function.

The researchers proposed an SPMSM model with disturbance by representing the lumped disturbance as the q-axis current's coefficient.

Additionally, they devised a sliding mode gradient descent disturbance observer (SM-GDDO) by introducing a sliding mode term into the gradient descent disturbance observer (GDDO). The SPMSM model uncertainties were compensated by SM-GDDO at each sampling period. An adaptive reaching law was designed to accelerate the convergence rate and reduce the chattering level simultaneously.

On the basis of the proposed predictive model and estimated disturbance term, the researchers defined the cost function of GD-SMPC+ARL by employing the adaptive reaching law and a linear predictive sliding surface. The current constraint is considered when applying the optimized control input for each control period.

The researchers carried out experiments on a Zynq-based hardware prototype, and the experimental results validated that the proposed method is superior to sliding mode predictive speed control (SMPSC) and extended state sliding mode observer based sliding mode control (SMC+ESMDO) in tracking performance, load disturbance performance, and parameter robustness.

More information: Fengxiang Wang et al, A Robust Predictive Speed Control for SPMSM Systems Using a Sliding Mode Gradient Descent

Disturbance Observer, *IEEE Transactions on Energy Conversion* (2022).
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