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RESEARCH ARTICLE

Adaptive predictive control of flywheel storage for transient stability enhancement of a wind penetrated power system

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Summary

Flywheel energy storage system (FESS) needs to be operated within its allowable speed range because it will be shut down outside this range. Furthermore, the power supplied/absorbed by FESS is constrained by the associated power electronic interface. This article proposes supervisory adaptive predictive control (APC) scheme for flywheel energy storage system to enhance power system transient stability while addressing the constraints mentioned earlier. The supervisory adaptive predictive controller gives a reference power command signal to the inner control loop of FESS while ensuring the operation of FESS within its regime of operation. The gains of the inner control loop are optimized by employing Genetic Algorithm (GA). The constraints on the state of charge of FESS and power rating of the associated converter are explicitly included in the adaptive predictive controller formulation, which is usually done in an ad hoc manner. The performance of the proposed control strategy is evaluated under four scenarios: a step wind disturbance, realistic wind profile, doubly fed induction generator (DFIG) outage, and a severe symmetrical fault condition on modified New York/New England 16 machine 68-bus power system. The validity of the adaptive predictive control based flywheel energy storage system (APC based FESS) in improving transient stability of power system is verified by the simulation studies carried out in MATLAB/Simulink environment.

KEYWORDS

adaptive predictive control, critical clearing time, flywheel energy storage system, frequency control, transient stability

1 | INTRODUCTION

As the human population increases, greenhouse gas emission reduction techniques are explored. A massive deployment of renewable energy sources (RESs) has become an obligatory aim in order to minimize carbon intensity. DFIG-based Wind Energy Conversion Systems (WECS) offer one of the most promising technological and economic possibilities among the different renewable energy resources.[1,2] Significant study effort has been

Abbreviations: AGPC, adaptive generalized predictive control; APC, adaptive predictive control; AVR, automatic voltage regulator; CCT, critical clearing time; DFIG, doubly fed induction generator; DSTATCOM, distribution STATic COMpensator; ESSs, energy storage systems; FCT, fault clearing time; FESS, flywheel energy storage system; GA, genetic algorithm; GPC, generalized predictive control; MPC, model predictive control; NETS, New England Test System; NYPS, New York Power System; PMSG, permanent magnet synchronous generator; PSS, power system stabilizer; RESs, renewable energy sources; RLS, recursive least square; SOC, state of charge; WECS, wind energy conversion system; ZOH, zero order hold.

