論　文　の　要　旨

題　目　A Model Predictive-Based Robust Load Frequency Control Considering Renewable Energy Uncertainties
（再生可能エネルギーの不確定性を考慮したモデル予測型ロバスト負荷周波数制御）

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The installation of uncertain renewable energy sources (RESs) in power systems greatly impacts the stability and reliability of the system, especially the frequency stability. The dissertation focuses on the load frequency control (LFC) schemes using adaptive model predictive control (AMPC). In the following paragraphs, the contributions of this dissertation to the frequency control in the power systems are highlighted.

A novel LFC method using AMPC is proposed in this thesis to solve the frequency problems under high penetration of RESs. The main objective of the proposed method is to develop a highly accurate and robust LFC method. The proposed AMPC method can predict the future performance of target system based on the internal prediction model. A simplified internal prediction model is also proposed for AMPC. The parameters of the internal prediction model are estimated and updated by an unscented Kalman filter (UKF) online. The simulation results show that the proposed method can effectively solve the frequency problem for low inertia power system. Furthermore, the results have determined that the proposed AMPC method has the better performance than the conventional proportional integral (PI) control.

The proposed AMPC method is applied to large-scale thermal plants. A second-order lag system as an internal prediction model is proposed for AMPC to approximate the system performance. An UKF also is applied to the proposed AMPC for estimating the parameters of the internal prediction model. Simulation studies have been conducted using the large-scale thermal plant, considering the large disturbance. The simulation results show that the proposed method can address the frequency problem effectively, which has the better performance than the conventional PI control.

Case studies on a small-scale MG system with uncertain RESs are carried out to demonstrate the effectiveness of the proposed AMPC method. In this circumstance, the LFC controller must have high response speed and robustness to cope with the uncertainties of RESs and disturbances. The RESs, such as photovoltaic (PV), wind turbine (WT) power and various step change are considered to the disturbance. At the same time, a battery energy storage system (BESS) as supplemental power is considered to compensate for rapid load fluctuations. The simulation results confirm that the proposed AMPC method can successfully deal with the frequency problem, and has better performance than the conventional PI control.

The thesis consists of six chapters. The research topics are mainly distributing among the chapters as follows:

Chapter 1: presents the introduction to the research objectives, scope of the research, and organization of the thesis.

Chapter 2: provides a comprehensive review of load frequency control, impact of renewable energy resources on frequency regulation, load frequency control techniques, and current world frequency technologies.

Chapter 3: presents a novel load frequency control method using adaptive model predictive control. The proposed AMPC method combine with unscented Kalman filter for capturing the optimal control operation. Meanwhile, some estimation methods are described in this chapter.

Chapter 4: presents a novel load frequency control method using adaptive model predictive control. The proposed method can cope with the frequency problem caused by disturbance. In this chapter, large-scale power systems with large disturbance are used to confirm the effectiveness of the proposed method. The numerical results show that the proposed method is effective to mitigate the frequency problem.

Chapter 5: develops a load frequency control method for small-scale microgrid (MG) using adaptive model predictive control. Large amount of renewable energy resources, such as wind turbine (WT) power, photovoltaic (PV) are installed in MG system, which can affect the MG system stability, especially the frequency stability. The developed method can address the MG system frequency problem effectively. The numerical simulation results demonstrate that the developed method is effective to mitigate the MG system frequency problem caused by PV, WT, and types of disturbance.

Chapter 6: provides a conclusion part, where contributions of the study are discussed. In addition, some recommendations for further research in the future are presented.