再生可能エネルギー電源の導入による電力系統負荷周波数制御手法

Abstract of Dissertation

Tittle: Power System Load Frequency Control Approach by introducing Renewable Energy Sources

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In most remote and isolated areas, electric power is often supplied by diesel generators. However, diesel generators cause serious impacts on the environment as every liter of diesel releases about three kilograms of CO_2 . Also, diesel is expensive because transportation to remote area adds extra cost. Moreover, diesel generators are inherently inefficient when operating at a low load factor (below 40%-50% of their rated capacity). Due to these environmental and economic influences of the diesel generator, the environment pollution had been attracted most researcher attention recently, and it is consider to be solved by renewable energy sources (RESs) as an alternative to nonrenewable sources. Among them, Wind, solar, sea, biomass, and geothermal powers are sustainable and clean sources. Wind and solar attracted a lot of attention nowadays and became the most widely utilized renewable energy sources in power systems. Also, fuel cell (FC) has the ability to be considered as one of the green power sources of the future. However, the sharp fluctuations in the generated power of RESs devices caused by conditions of weather, temperature and season leads to the deterioration of the supply-demand balance, which may also affect the systems stability and reliability, especially in isolated systems with renewable energy sources such as WTG and PV, faces some stability problems because the power supplied by these sources is not constant, diverges quickly and cannot be easily predicted. So, these oscillations in the renewable power sources can produce instantaneous mismatch in the vital balance between generation and demand. Consequently, continuous variations in frequency and voltage levels usually appear which negatively affect the electric power system stability. Therefore, a continuous control for the supplied power by these renewable sources is required to ensure robust performance of the power system.

One of the most serious problems in power system is frequency deviation. In small-scale and isolated power system like isolated islands power system or remote areas power system, the output power fluctuation of RESs causes a huge frequency fluctuation. The fluctuation in system frequency causes the supply unstable and large scale blackout in the worst case. To eradicate the frequency fluctuation phenomenon, power deviation needs to be controlled. A large number of research efforts have been conducted based on the load frequency control methods using battery technology. However, it is hard to compensate the supply-demand balance by using batteries, since the implementation cost of the battery is high. In order

to increase the penetration of RESs in the future power system, a system frequency control method is necessary.

Nowadays, energy storage systems (ESS) are integrated with the renewable sources to maintain the safe operation of the power system and balance the supply and demand sides. These serve as backup devices and store excess power when the generation is more than demand and release power to the system when the demand is more than generation. This action helps in maintaining a steady flow of power irrespective of the load and generation power levels fluctuations. As a result, it guarantees acceptable levels of systems frequency deviations.

In this thesis, first approach presents a novel output power fluctuate compensation scheme in the small-scale power system with verifying the effect of output power control using storage battery, demand-response and RESs. Four scenarios are considered in the proposed approach: real-time pricing demand-response employment, RESs output control use and both of demand-response and RESs output control implementation. The performance of the proposed control technique is investigated using the real 10-bus power system model of Okinawa island, Japan. Moreover, the system stability is checked using the pole-zero maps for all of the control loops associated with the proposed scheme.