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Key Consideration for Ensuring Effect of Proposed Control Method using RoCoF Relay

Summary of This Contribution

- **The proposed control method using the RoCoF relay can perform high-speed load shedding as the same amount of RES self-disconnection that has caused frequency stability deterioration**. The following are important considerations to ensure sufficient effect of the proposed control method.
- **It is important to use the RoCoF calculation method equivalent to the anti-islanding RES protection relay for the RoCoF relay to ensure both accuracy and fast-response of the RoCoF relay that detects RES self-disconnection.** Although the difference in the characteristics of anti-islanding relay among manufacturers is significant, each characteristic can be expressed approximately using a standard RoCoF calculation method with appropriate parameters, respectively.
- **It is also important to adjust the RoCoF relay setting appropriately according to the system status, to maintain the accurate amount of the load shedding for RES self-disconnection.** For this purpose, it is important to thoroughly keep track of or share information on the characteristics of each RES anti-islanding relay.

Aims and Objectives of Proposed Control Method using RoCoF Relay

- In recent years, **RES self-disconnection following the loss of large-scale generation, characterized primarily by anti-islanding protection relay, has caused frequency stability deterioration**. In the future, further increases in RESs could decrease system inertia, eventually increasing the RoCoF following the loss of generation, causing significant **large-scale self-disconnection of RESs** and **the risk of large-scale power outages** due to frequency drops.
- In the case of the large-scale self-disconnection of RESs or the loss of generation exceeding the scale of contingencies, **under-frequency load shedding (UFLS) schemes as a backup become important to ensuring frequency stability.**
- **In Japan, the RoCoF relays are expected to contribute to faster load shedding as one of the countermeasures for enhancing UFLS. Therefore, the authors have developed a new control method using the RoCoF relay to cope with RES self-disconnection**. In the proposed control method, a load shedding function based on RoCoF considering the characteristics of the anti-islanding protection relay of RESs is added to UFLS. Furthermore, the amount of load shedding is adjusted by changing the RoCoF relay settings in real-time according to the RES output, estimated self-disconnection, etc..

Logic of Anti-islanding RES Protection Relay that should be Considered for Ensuring Sufficient Effect of Proposed Control Method (slide 2)

- **In the logic of the anti-islanding protection relay, the RoCoF is calculated as df/dt at a certain measuring time window**. Here, the main elements and parameters that characterize the characteristics of the anti-islanding protection relay are as follows.
  - Frequency detection method (Zero-crossing, etc.)
  - **Measuring time window of frequency (How many cycle averages are used)**
  - **Measuring time window of RoCoF calculation**
  - Operating condition (Operate with a single logic, or under the OR condition of multiple logics, etc.)
- It is important to use the above elements and parameters as the logic of the RoCoF relay. Therefore, in the proposed load shedding system prototype, the logic of the anti-islanding RES protection relay is accurately emulated using the PC and 81R elements of a commercial IED, respectively.

Current Performance of RoCoF Relay with Built-in Commercial IEDs (slide 3)

- It is preferable to be able to use the RoCoF relays with built-in commercial IEDs of various manufacturers to utilize these relays efficiently and effectively to construct the proposed load shedding system easily. However, information on the logic and characteristics of the RoCoF relays with built-in IEDs is limited, and the actual characteristics are unclear. Therefore, the authors investigated the current performance of the RoCoF relays with built-in IEDs of each manufacturer through the experiments. The results showed **the performance (mainly operate time) of the RoCoF relays with the same setting with built-in IEDs varies significantly among different manufacturers.**
- In addition, the reason for the significant difference in operate time among the RoCoF relays was investigated by estimating the main parameters (The measuring time window of the frequency and calculation). It was

inferred that **the differences in operate time in the RoCoF relay were due to differences in the Measuring time window of frequency calculation**. **However, the frequency calculation method of the RoCoF relay is manufacturer-specific, and the main parameters cannot also be changed.**

- Although it is possible to obtain characteristics similar to anti-islanding protection by combining multiple RoCoF relays in a trial-and-error manner, **it is preferable to use the RoCoF calculation method equivalent to the anti-islanding protection relay for the RoCoF relay to ensure accuracy**.

Adjustment of RoCoF Relay Setting Appropriately According to System Status for Maintaining Accurate Amount of Load Shedding for RES Self-Disconnection (slide 4)

In the proposed control method, adjustment of the relay setting is conducted in the following flow.

1) Estimate the output of RESs.

2) Estimate the amount of RES self-disconnection vs. RoCoF. It should be noted that the characteristics of RES self-disconnection are characterized by that of anti-islanding protection relay. Therefore, it is important to thoroughly keep track of or share information on the characteristics of each RES anti-islanding protection relay.

3) Adjust the settings of each RoCoF relay (use or non-use, threshold level, and time delay as necessary).

4) Send setting change command to each RoCoF relay.

Thus, to build a system that can actively change the RoCoF relay setting, it is important not only to use SV and GOOSE, which are considered in this paper, but also to make the RoCoF relay IEC 61850 compliant (to be able to change logic and key parameters using IEC 61850).

Conclusion

- The proposed control method using the RoCoF relay can perform high-speed load shedding as the same amount of RES self-disconnection that has caused frequency stability deterioration.
- To ensure sufficient effect of the proposed control method, **it is important to ensure both accuracy and fast-response of the RoCoF relay that detects RES self-disconnection (to avoid malfunction) and to maintain the accurate amount of the load shedding for RES self-disconnection (to avoid excess/deficiency amount of load shedding).**