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Application of active power sensitivity to frequency and voltage variations on load shedding

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ABSTRACT

The occurrence of a large disturbance in a power system can lead to a decline in the system frequency and bus voltages due to a real and reactive power deficiency or due to the formation of islands with generation–load imbalance. Load shedding is an emergency control action that can prevent a blackout in the power system by relieving the overload in some parts of the system. This paper shows that rate of change of frequency can be utilized to determine the magnitude of generation–load imbalance, while the rate of change of voltage with respect to active power can be utilized to identify the sensitive bus for load shedding. The frequency, voltages and their rate of change can be obtained by means of measurements in real-time from various devices such as digital recorders or phasor measurement units or these parameters can be estimated from the voltage data by other means such as an optimal estimation method like Kalman filtering. The rate of change of system frequency, along with the equivalent system inertia may be used to estimate the magnitude of the disturbance prior to each load shedding step. The buses with a higher rate of change of voltage may be identified as the critical ones for load shedding and load can be first shed at these buses, depending on the change in the power flow at each bus. This application is tested on the IEEE 30 bus system and the preliminary results demonstrate that it is feasible to be used in load shedding to restore system voltage and frequency.

1. Introduction

Present day power systems transfer large amounts of energy over an extensive area and are being operated closer to the stability limit, thereby making them more vulnerable to disturbances. There are some areas rich in generation and some areas rich in load in these stresses systems, but their interconnection may be weak due to bottlenecks on the transmission network. Also generation reserves are minimal and reactive power is often in short supply where it is needed. A triggering event like a fault on an important facility can lead to a wide area disturbance and subsequently certain quantities such as voltage, frequency and power flows may leave the secure range. Load shedding is one of the most effective measures for averting a power system blackout. When the power system is approaching a catastrophic failure, shedding some amount of load at certain locations relieves the overload on the system, limits the extent of the disturbance and helps in retaining power supply to the important loads. The main objectives of this paper are: (i) to test the application of frequency variation to estimate the generation/load imbalance; (ii) to test the application of voltage variation in identifying appropriate locations for load shedding.

Various types of load shedding schemes have been formulated and implemented by utilities in the past. Most of the earlier schemes were traditional schemes that relied heavily on local measurements for inputs and shed a preset amount of load when frequency or voltages reached a certain level. The traditional schemes were later replaced by semi-adaptive and adaptive under frequency load shedding schemes [1–8] that tried to overcome the problem of under shedding or over shedding of load by utilizing the rate of change of frequency along with the frequency value to make decisions about shedding load. Under voltage load shedding schemes [9–21] started making an appearance a few years ago as they proved to be an economical and effective technique to maintain voltage stability as against expensive and time consuming methods like shunt compensation, new additions to the main circuit, etc. With the advent of advanced metering and communication systems, centralized load shedding schemes [22] that used frequency and voltage values from different parts of the system as inputs became widespread. Some load shedding schemes were based on optimization procedures [23–26] that aimed at reducing

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