Estimation of Frequency Deviations in Power Network with Primary Frequency Control

Oleg O. Khamisov

Skolkovo Institute of Science and Technology, Moscow, Russia
oleg.khamisov@skolkovotech.ru

Behavior of power system with generators failures under droop control is considered. It is assumed, that there is no congestion management or inter-area constraints and at the pre-failure state frequencies are at the nominal values.

The model of power transmission network [1] is described by a connected oriented graph. It is assumed, that bus voltage magnitudes are constant, line flows are approximated by DC linear power flows, all loads are assumed to be constant loads. Additionally it is assumed that the system was already Kron reduced in order to eliminate load buses. Reduced graph is denoted $G = (V, E)$, where V is the set of n generator buses, E is the set of m lines. Dynamics of the transmission network is specified by the set of differential equations given below

$$M_i\dot{\omega}_i = -d_i\omega_i + \sum_{j:(j,i)\in E} p_{ji} - \sum_{j:(i,j)\in E} p_{ij} + \\ - p_i^M + g_i,\ \omega_i(0) = 0,\ i = \overline{1,n}, \tag{1a}$$

$$\dot{p}_{ij} = b_{ij}(\omega_i - \omega_j),\ p_{ij}(0) = 0,\ (i,j) \in E, \tag{1b}$$

$$T^M\dot{p}_i^M = -p_i^M + \alpha_i,\ p_i^M(0) = 0,\ i = \overline{1,n}, \tag{1c}$$

$$T^B\dot{\alpha}_i = -r_i\omega_i - \alpha_i,\ \alpha_i(0) = 0,\ i = \overline{1,n}, \tag{1d}$$

here variables have the following meanings: $\omega_i,\ i = \overline{1,n}$ are deviations of bus frequencies from their nominal values, $p_{ij},\ (i \to j) \in E$ are active power flows, $p_i^M,\ i = \overline{1,n}$ are mechanic power injections at generators, $\alpha_i,\ i = \overline{1,n}$ are positions of valves.

The purpose of the paper is to obtain estimations for convergence rate and maximal frequency deviations. Mathematical description of methodology is given. Preliminary numerical results are presented.

References

1. A. R. Bergen and V. Vittal, Power Systems Analysis, 2nd ed. Prentice, 819 p. Hall, 2000.