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Estimation of Inertia Constant of Iran Power Grid Using the Largest Simulation Model and PMU Data

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Abstract— Inertia constant is an effective parameter for power system analysis such as the load frequency control, dynamic behavior study and it is necessary for system operators to do decision making during contingency conditions. This paper uses the largest simulation model of Iran power grid (containing integrated transmission and sub-transmission network model) and Phasor Measurement Unit (PMU) data to analysis the generator outage of Bushehr power plant as a very effective event to estimate the inertia constant of Iran power system. The approximate matching between simulation and measurement based calculation results supports the validity of resulted value.

Keywords- Inertia constant; Phasor Measurement Unit (PMU); The Largest Simulation model of Iran Grid.

I. INTRODUCTION

Some parameters are very important for power system evaluation and control such as inertia constant which is especially used for load frequency control and dynamic behavior analysis of power network. On the Other hand, the inertia is a very effective parameter for system operators to do decision making during contingency conditions. Therefore, some papers such as [1]–[4] have presented discussions and methods for calculation and using this parameter in various issues.

In this paper, we use the largest simulation model of Iran containing transmission and sub-transmission network (with about 60000 busbar/terminal, detailed model of 500 generators, 4400 lines and 4000 transformers, etc.) which is developed and updated by workgroups of regional electric companies (RECs) with cooperation of Iran Grid Management Company(IGMC)[5]. Simulations are done using DIgSILENT PowerFactory[6].

On the other hand Wide Area Measurement System (WAMS) has been installed and operated in Iran network and used for system analysis and validation of simulation models[7], [8]. One of the main goals of WAMS is monitoring of system parameters in order to estimate the power system state such as stability margin and enhancement of system control. The main property of WAMS is synchronized measurement in Phasor Measurement Units (PMUs) which normally installed in some power system substations. In this paper, we use the PMU data at a very effective event in Iran network for estimation of Iran Grid inertia constant. Comparing the results of measurement and simulation based method show the validity of the calculations.

II. INERTIA OF POWER SYSTEM

Immediately following a disturbance, the missing/excess power is delivered from the kinetic energy stored in the rotating mass of the turbines. This leads to a deceleration/acceleration and thus to a decrease/increase in the system frequency. The contribution of each generator towards the total additional power required is proportional to its inertia. Individual contributions to the balance are proportional to the inertia/acceleration time constant of each generator. This relation can be mathematically described as follows:

$$\Delta P_i \triangleq P_i - P_i^{disp} = K_i.\Delta f \tag{1}$$

where,

P_i is the modified active power of generator i, P_i^{disp} is the initial active power dispatch of generator i and ΔP_i is the active power change in generator i. Δf is the total frequency deviation and K_i is the inertia gain parameter of generator i, which can be calculated as:

$$K_i = J_i.\omega_n.2\pi \tag{2}$$

Where ω_n is the rated angular velocity of generator i and J_i as the moment of inertia of the generator can be calculated as:

$$J_i = P_{n_i}.\frac{Ta_i}{\omega n^2} = \frac{2H_i P_{n_i}}{\omega n^2} \tag{3}$$

Where H_i is inertia time constant of generator i and $T_{a_i} = 2H$ is the acceleration time constant of the generator rated to its nominal active power (P_{n_i}). Where, having nominal apparent power (S_{n_i}) and nominal power factor ($\cos\theta_n$) of the generator, it is clear that:

$$P_{n_i} = S_{n_i}.\cos\theta_n \tag{4}$$

On the other hand, for all power network, swing equation states that[3]:

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