Abstract:

The power system inertia immediately following small and large system disturbances was investigated. By understanding factors affecting the system inertia and primary frequency response behaviour, an online inertia model was developed. Historical data was extracted from the Eskom Energy Management System (EMS) and Wide Area Monitoring System (WAMS). The developed model using Multivariate Analysis (MVA) includes measured and estimated data from Eskom generators, Renewable Energy Sources (RESs) and the interconnected Southern African Power Pool (SAPP). Inertia plus Fast Primary (Frequency) Response (FPR) (as determined by the load behaviour) and system inertia models were developed from June 2015-December 2016 and validated with past frequency disturbance events (June 2014-March 2017). From the comparison between the measured and model results for 355 actual disturbances, 225 disturbances resulted in errors within ±5% and 51 events resulted in errors between ±5% and ±10%. Eight disturbances caused errors greater than ±10%, which were largely from trips at particular large power stations and HVDC. During a large disturbance, the multivariate coefficients for Renewable Energy Sources, HVDC and interconnectors were very small for the pure inertia model (excluding the load frequency behaviour and the generator damping). In contrast, the spinning reserve provides significant contribution and is location based. The location of a disturbance affects the FPR behaviour and the system inertia but not the Rate of Change of Frequency (RoCoF) with reference to the central power station. The strong and weak areas with respect of the stiffness of the system (extent of frequency nadir for particular disturbances) were identified. This can contribute to future grid planning and real-time operations in managing the system inertia and primary frequency response. The model is expected to improve with time, as the accuracy of a statistical approach requires large amounts of data. The model can be used to determine and monitor the maximum level of RES in real-time.

Key words – Correlation, Frequency Stability, Inertia, Multivariate Analysis (MVA), Renewable Energy Sources (RES), System Operator (SO), Swing Equation, Situational Awareness (SA), Spinning reserve