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PS 2 Modelling of the future grid based on lessons learned from system events

Defining the power system load frequency static response slope based on transient synchrophasor data

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Frequency and active power changes in bulk power systems are characterized by a power system or a power region active power frequency static response. Resulting power system response depends upon the corresponding response of the generation and the loads.
Different from the nodes load voltage static response for a power system or a power region, load frequency static response might be derived only as an aggregate of the nodes responses. It is due to the fact that load nodes voltage is a locally controlled parameter while the frequency might be assumed similar or close to similar for all power region nodes at any time.
Power region aggregate load is defined as the sum of the region generation and net external power flow.
However, not all generation sources provide frequency and power measurements, that is generally applicable to low-capacity generation, mostly distributed (DER). Hence, due to the impossibility to measure overall generation and evaluate the actual influence of the nodes voltage on their consumption, the aggregate power region static response is to be considered, being characterized by the load value.
What should be noted here is the importance of the frequency static response slope. Frequency static response is an inherent parameter of a power system computational model along with other parameters. Utilizing the power system computational model enables the calculation of power system operation conditions, which serve as the basis for solving the power system dispatch control tasks, such as defining the admissible power flow over the power system sections, required minimum generation capacity margins, effectiveness of automatic control actions etc. In case the actual frequency static response is unknown, the computational model parameters are defined based on rated values with the most undesirable values being considered in order to ensure the results account for the heaviest power system operation conditions. If the frequency static response is better than the assumed, this leads to excessive power system operation restrictions, which, in turn, reduces the overall power system efficiency.
In 1970s-1980s frequency and voltage static response as well as frequency static response slope for the load nodes with different consumption mix were defined

experimentally involving actual power systems in operation. To date conducting these experiments is difficult and expensive, moreover, their consequences are unpredictable. Hence, the existing frequency static responses have become obsolete due to significant changes in consumption structure and steadily widening variety of load components (storage systems, electric vehicles, etc.).
The introduction of the new generation measurement devices, providing the possibility to obtain the time-synchronized high-accuracy measurements of power and frequency corresponding to the external power flows and high-capacity generators, allows to define the external power flows and generators frequency static response based on the transient recordings during regular operation (i.e. conduct passive experiments) under random disturbances conditions in power system.
Current research proposes the investigation of the possibility to define a power region or a load node frequency static response slope based on the transient recording corresponding to the predefined short periods of time.
The method is proposed for defining the power system load frequency static response based on synchrophasor measurements during transients accompanied by frequency deviations. Linear and square models are compared for modelling the response slope. The method was validated involving 13 events resulting in frequency deviations in the Northern part of Tyumen region of up to 0.06 Hz magnitude and recorded by means of the System operator of Russia’s WAMS.