Effects of Increasing Power Electronics based Technology on Power System Stability: Performance and Operations

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Effects of Increasing Power Electronics based Technology on Power System Stability	PDF	2MB

The decarbonisation of electricity production through the increasing deployment of renewable energy sources (RES) is mainly achieved by power electronic (PE) converters which offer fundamentally different performance characteristics when compared to synchronous machines. Hence the traditionally synchronous generation rich power systems are transitioned towards being PE dominated. The expectation is that the dynamic behaviour of power systems will change with impact on the stability characteristics in terms of performance and operation.

Voltage and frequency stability

Voltage stability due to lack of reactive power provision or demand could be the first to be impacted (provision issue during large disturbances as power electronics interfaced generation has no or limited capability and demand issue as it can be supplied via distributed generation at medium or low voltage level resulting in a surplus of reactive power and an increase in network voltages).
On the frequency stability side, the lack of “natural” inertia and hence the response has been observed to increase the rate of change of frequency (RoCoF) following a contingency. Different geographies already resolving this as the needs of the power system require (e.g. in Manitoba, Canada all generators must be able to ride through a RoCoF of 4 Hz/sec). A further issue is the recovery of active power when in some systems the priority is given to reactive power following a voltage dip.

Reduced system strength and loads

Reduction in the fault current (i.e. reduced system strength) is likely to be another impacted characteristic which may bring multiple issues. Lack of sufficient fault current may result in mis-operation of protection systems, operation of phase locked loop controllers may face stability issues and line commutated converters may experience increased commutation failures due to the increased chance of voltage depression. Furthermore, in a weak system an increased possibility of interaction between different PE interfaced devices is likely to be higher when two or more devices are trying to regulate the same or electrically close bus voltage.
Power electronics interfaced loads exhibiting constant power characteristics, which require high quality and reliability of power supply, will draw an increased current from the system when the network voltage is reduced.

Real time operability

On the operational side, the variability of RES generation between none and full, will require accurate forecasting algorithms for both wind and solar generation to reduce uncertainty. Another aspect is the increased cross-zonal or inter-regional power flows due to the inherent location of wind based RES (offshore and at the edges of the system remote from load centres). This brings further complexity in the form of congestion and an increased need for remedial actions.
Operationally, it is expected that the power system of the future with increased PE penetration will exhibit more frequent, faster and less damped dynamic phenomena. Larger frequency fluctuations are likely to be commonplace in the absence of conventional generation. The availability of power reserves is expected to be more volatile and likely to be driven by the market.

Developments

Strategies are being developed to overcome the challenges mentioned. Requirements embodied within system codes are being clarified on the synthetic inertia, prioritisation of active or reactive power, need for enhanced frequency control capabilities, mandatory provision of

ramp rate and others are being discussed and introduced by various regulatory bodies. Enhanced security assessment tools continue to be developed for use within all operational timeframes, including real-time, to monitor system dynamics.
Extended investigation on the use of or conversion of decommissioned synchronous generators into synchronous condensers is being looked. In parts of the world, actual implementation of synchronous condenser is well underway due to the benefits in providing short circuit current, inertia and dynamic reactive power.

Concluding remarks

The technological change that is taking place from traditional rotating machines to PE converter based generation and load and, from pure AC systems to hybrid AC/DC systems brings major challenges. Although the complexity is increasing, so is the controllability, bringing new possibilities.
The identified challenges focus around voltage and frequency stability, decreased system strength, and increased probability of unwanted PE interactions. System Operators, with support from other stakeholders, are developing different strategies and solutions to cope with such challenges. One primary area is the use of the available controllability and flexibility to enhance system security and stability by providing congestion management and ancillary services.
Fundamental research in various platforms is driving innovative technologies such as energy storage systems to support new ancillary services that will aid recovery and response when required.

Further reading

This Reference Paper is a very short summary of a longer and wider paper prepared by a small task force made up of members from two system oriented Study Committees; SC C2 - System Operations and Control and SC C4 - System Technical Performance. The original paper considers two aspects of power system stability, that from a technical performance and the operations side. Due to the multidimensional technical complexity the paper is written in a slightly more technical format with emphasis given to areas deemed to require some explanation.
Readers are encouraged to reach out and read the full paper in the flagship CIGRE Science & Engineering Journal’s Volume No 11, June 2018 issue.