Considerations for Low Inertia and Short Circuit Level Improvement

Contribution in response to Question 1.4,
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The need for additional inertia and short circuit current is the main driving force for the current trend of installing synchronous condensers in power systems. A synchronous condenser provides reactive power support, short circuit current and inertia to the power system. . However, a synchronous condenser's inherent frequency support has a number of limitations:

1. The frequency variation and RoCoF during a frequency event is normally small, typically less than one Hz and 2.5 Hz/s. Therefore, only a small portion of the machine's stored energy is exchanged with the power system.
2. A machine's stored kinetic energy cannot be utilized to restore the system frequency when the system frequency drops below the nominal level. Similarly, its capacity to absorb extra energy cannot be utilized in an over-frequency event. The machine inertia only opposes the variation of the frequency.
3. After an under-frequency or over-frequency event, the machine inertia opposes the fast restoration of the frequency to the normal level.
4. A synchronous condenser (SC) normally experiences electromechanical oscillations or swings after a frequency or voltage event. The active and reactive power output of the SC also vary during these swings. This has an undesirable impact on the system voltage and frequency.

This contribution introduces a novel solution that substantially improves the synchronous condenser's performance in all areas mentioned above, while maintaining its capability to provide large short circuit current during a voltage event. The proposed solution utilizes a combination of a synchronous condenser and a pair of Back-to-Back (BtB) converters and offers the following features:

1. In steady state, it provides reactive power support to the system considerably higher than a standalone SC.
2. During a voltage event, it provides substantial short circuit current, more than a stand-alone SC.
3. During a frequency event, it can supply (or absorb) active power proportional to df/dt (inertia). The active power can be several times larger than a standalone synchronous condenser with the same rating.
4. During an under or over-frequency, it can provide or absorb power according to the power system requirement (e.g. in proportion to Δf).
5. It does not oppose the frequency change during the frequency restoration. In fact, it can provide active power support during the frequency restoration if required.
6. It's output is not oscillatory. In fact it can even provide power oscillation damping.
7. Provides better dynamic performance in case of a voltage disturbance event