VIRTUAL SYNCHRONOUS MACHINE CONTROL FOR LOW-INERTIA POWER SYSTEM CONSIDERING ENERGY STORAGE LIMITATION

Renewable energy integration leads to low-inertia power systems. Reducing inertia leads to high rate of change of frequency (ROCOF). Low frequencies will occur after disconnection of a large generation unit or step load change, and worsens fluctuation leading to greater effort and wear and tear on conventional units. To improve freq performance we use synthetic inertia which comes in three forms:

* Event Based
* Frequency Deviation
* Virtual Synchronous Machine

The first two are based on the renewable resource and the load making it uncertain and limited in speed response + stability so this paper focuses on VSM. Grid forming VSM adjusts frequency based on local power measurement to improve frequence regulation.

Concerns include the energy source on the DC side of the VSM. Energy Storage Systems are a promising candidate for VSM application. However there are two drawbacks

* ESS has limited power and energy capacity for both short and long term versions
* Synthetic inertia due to VSM is based on the response speed of ESS
  + Fast Acting ESS (super cap and flywheels), large power density but low energy density
  + Slow Acting ESS (hydrogen storage, electrochem batteries), high energy density, limited response speed
* Super caps for fast varying power with battery storage for long term fluctuations in power.
* Improved VSM on type IV wind turbines FAESS whose SoC is controlled by PI control.
* FAESS integrated with sync gen where droop control and SoC info so that ESS can maintain both frequency and SoC, but this is for droop control while most VSM are grid forming control

Emulate the inertia damping and governor control of a sync gen with FAESS and SAESS respectively. Using the following network, this studies active power and frequency control, reactive power ref for WTG and SG is set at zero. This corresponds to small islanded microgrid, small isolated system, or large area power system. Synch gen and governor are a combination of grid forming and grid following control.