



Synchronous Condenser and Controller

A *synchronous condenser* (sometimes called *synchronous compensator*) is a synchronous generator that is not attached to a prime mover. There is typically a small pony motor attached to the synchronous machine input shaft, but it is used only to accelerate it to synchronous speed. Once the synchronous machine is on-line, the pony motor is de-energized and spins freely.

The synchronous machine field current is controlled by a voltage regulator as needed to control the system voltage or to furnish/absorb a specified amount of reactive power. Increasing the device's field excitation increases its reactive

power (kVAR) output. The synchronous condenser is thus a continuous variable source/sink of reactive power.

A synchronous condenser performs several key functions in a renewable energy microgrid. When in running in parallel with one or more diesel generators, it shares the reactive power load with the diesel generator(s), which improves the system voltage regulation and often allows for the net load to be met with a smaller genset than would otherwise be required. Also, the inertia of the rotating machine resists rapid changes in speed and thereby assists the diesel



generator(s) with frequency regulation. This improved voltage and frequency regulation counteracts the destabilizing influence of the solar arrays and wind turbines, which can be significant in gusty winds or on partly cloudy days, when wind and solar power fluctuations can be rapid and large.

In high renewable penetration microgrids, which typically are designed to support diesel-off operation in islanded mode (such that the renewable generation resources carry 100% of the load), the bus voltage and frequency voltage is typically controlled by an energy storage system inverter. Even where there is a battery/inverter or flywheel/inverter system that regulates grid voltage, a synchronous condenser is often necessary to ensure an adequate supply of fault clearing current and low voltage ride-through capability, which inverters often cannot provide unassisted.

Machine Standard Features

- Synchronous machine and pony motor pre-assembled and aligned on a rugged structural steel skid.
- Pony motor connected via high torsional stiffness flexible disk shaft coupling for smooth quiet operation.
- Class H Insulation System utilizes an unsaturated polyester varnish for optimal insulation life and superior moisture protection.
- Permanent magnet generator ensures 300% short circuit current during fault conditions and provides the regulator with input power isolated from load distortions.
- Digital voltage regulator is encapsulated for reliable performance in all environments.
- Fully guarded for operator safety and generator protection, no rotating or electrically energized parts are exposed. All openings are covered by louvers or screens.

Controller Standard Features

- User friendly front panel color touch screen enables operator to view system operation in real time, identify faults and view fault history, and change operating parameter settings.
- Available control modes: 1) Voltage control, 2) Droop voltage control, 3) Reactive power control
- Built-in protective relaying for the synchronous machine:
 - Over-/undervoltage (59/27)
 - Over-/underfrequency (81O/U)
 - Voltage asymmetry (47)
 - Overload (32)
 - Reverse power (32R)
 - Reduced power (32F)
 - Unbalanced load (46)
 - Loss of excitation (40Q)
 - Time-overcurrent (50)
- Rapid restart: synchronous condenser may be re-enabled immediately following a disconnect event, i.e. without waiting for the machine to spin down.
- Web-enabled PLC controller. Parameters may be changed and operation monitored via the Internet.

Specifications

Line Voltage	3-phase 208, 400, 415, 480, 600, or 4160 VAC
Line Frequency	50 or 60 Hz.
Reactive Power Rating	150 – 1,500 kVAR
Steady State Voltage Regulation	Within 0.25%