ORNL Establishes Reactive Power Laboratory

Distributed Resources and Controls are Implemented to Supply Cost-Effective Reactive Power

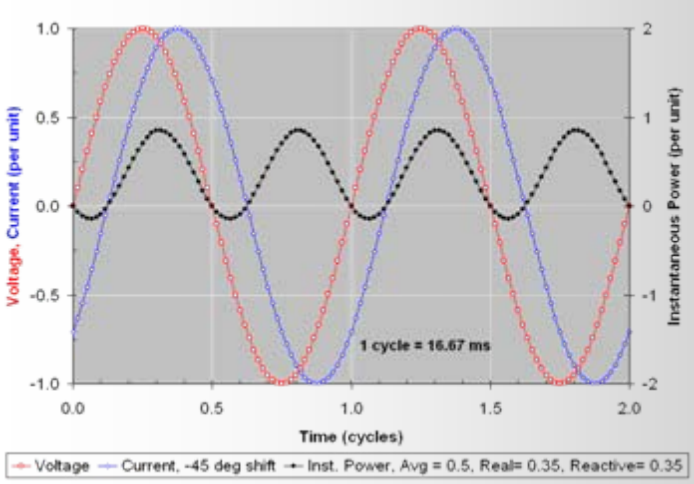
Background

Reactive power is a complex phenomenon that plays a key role in the operation of the electric power grid. Reactive power is that portion of electricity that establishes and sustains the electric and magnetic fields of alternating current (AC) equipment. It is created by capacitors and inductors as they stabilize voltage and current respectively, and it must be supplied to most types of magnetic equipment (such as motors and transformers) for proper operation. Inadequate reactive power reserves can contribute to voltage collapse and wide-scale power outages, so it is necessary to effectively manage reactive power levels.

Reactive power is best applied locally since its transmission from remote sources can cause power lines to experience voltage drops and decreased capacity to carry active power.

Objective

The Reactive Power Lab has been established to demonstrate that distributed resources (DR) can provide reactive power locally for power factor correction and voltage regulation through low-cost controls and minimal communications using either inverters or synchronous machines.

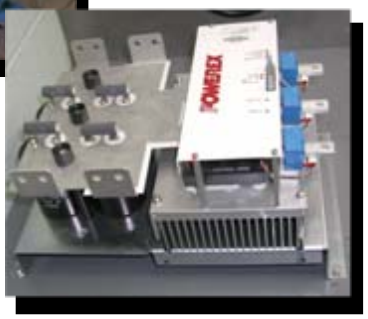


Reactive Power Basics

Current and voltage fluctuate with each AC cycle. When current and voltage are fluctuating together in phase, active power is produced for tangible use; however, when voltage and current are out of phase, reactive power is produced. Although reactive power is not available for end-use consumption, it is required by some electrical equipment for operation.

Technology

DR with power electronic interfaces can be controlled to produce and absorb reactive power in order to stabilize voltage on transmission networks. Some DR devices, such as reciprocating engines, contain synchronous generators, which can be directly connected to the local power system. Others, such as photovoltaics or microturbines, produce direct current (DC) and therefore must be converted to AC through an inverter. The ORNL Reactive Power Lab has been established to develop the controls allowing both types of device to produce reactive power locally.



250 kVar synchronous motor & 75, 150 & 300 kVar 3-phase inverters

For example, in the synchronous condenser testing area, a 250 hp synchronous motor is overexcited (by DC power provided by a 6.6 kW power supply) and operated unloaded in order to produce reactive power. In the inverter portion of the Lab, three different sizes of programmable inverters are also tested to supply reactive power and can also provide overall non-active power compensation (such as harmonics, unbalance, and flicker).

The test equipment of the Reactive Power Laboratory connects with the ORNL distribution system (owned and operated by ORNL and supplied by TVA) at different electrical locations. This interface allows testing to occur under various scenarios, such as motor starts, relaxation of capacitor compensation and reconfiguration.

Milestones & Future Work

Milestone
April 27, 2005

The 300 kVar synchronous condenser was operated for the first time to inject reactive power into the ORNL distribution system. The device has been operated to its full reactive power rating since that time.

Milestone
February 23, 2006

The 62kVar (75A) rated inverter was first operated to produce 10% of its rated output. In March, the same inverter operated at 58% of its rated output.

Spring 2006

Feedback control algorithms for both the synchronous condenser and inverter operating independently have been developed and tested for maintaining a local voltage schedule.

By September 2006…

Researchers plan to simultaneously control a 300kVar (volt-ampere reactive) synchronous condenser and a 125kVar (150A) inverter which are connected to two different distribution circuits.

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