



## *Intelligent Capacitor Bank Control*

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### **INTRODUCTION**

Many renewable energy resources, such as solar and wind, utilize dc to ac converters for electrical grid interconnections. During the dc to ac conversion, an inverter produces harmonics due to switching and nonideal power factor. Typically, a utility installs a capacitor bank on a distribution system for voltage and VAR support, but these capacitors also provide harmonic isolation and power factor correction that are perfect for interconnecting renewable energy resources.

### **PROBLEM**

Many capacitor bank controllers are configured solely for monitoring voltage magnitude, phase angle, and reactive power flow. This means existing controllers are not well suited for dc to ac interconnection applications that require switching capacitors when the power factor drops 0.90 or the total harmonic distortion (THD) exceeds 5 percent of the fundamental voltage. Both of these factors can significantly reduce the operating efficiency of motors, transformers, and electronics while creating problems for neighboring electrical customers. Retrofitting a new capacitor bank with advanced control, protection, and metering can be an expensive proposition, and a utility may not have the time for the retrofit.

### **SEL SOLUTION**

In addition to revenue and power quality metering, the SEL-734 Advanced Metering System provides advanced logic and control functions ideal for the control and protection of capacitor banks. This single low-cost meter provides advanced capacitor bank control and protection while reporting instantaneous data to SCADA (supervisory control and data acquisition) and collecting billing information in the load profile recorder. Many substations already have an SEL-734, so simply adding control logic to the settings provides the utility with a free capacitor bank controller.

Figure 1 is an illustration of the capacitor bank control philosophy. The SEL-734 continuously monitors the bus voltage and load current to provide automatic control of two capacitor banks. When the bus voltage is above the voltage inhibit threshold and automatic control is enabled, the capacitor bank control logic is active. The SEL-734 begins timing to close capacitor banks when any phase of the bus voltage is below the low-voltage override threshold. Conversely, the control logic begins timing to trip energized capacitor banks when any phase of the bus voltage is above the high-voltage override threshold. Low- and high-voltage dead bands are provided to reduce the likelihood of hunting. When the bus voltage is in the high-voltage dead band, the control logic prevents the energization of capacitor banks on power factor and kVAR control. When the bus voltage is in the low-voltage dead band, capacitor bank tripping is prevented on low kW load, power factor, and kVAR control. When the bus voltage is healthy and the kW load is significant (above the power factor and kVAR control inhibit thresholds), the control logic will automatically trip and close capacitor bank stages as needed to maintain the power factor and kVAR loading within the preset limits. If the kW loading drops below the kW trip threshold, the control logic will de-energize both capacitor banks as long as the bus voltage remains above the low-voltage dead-band threshold.

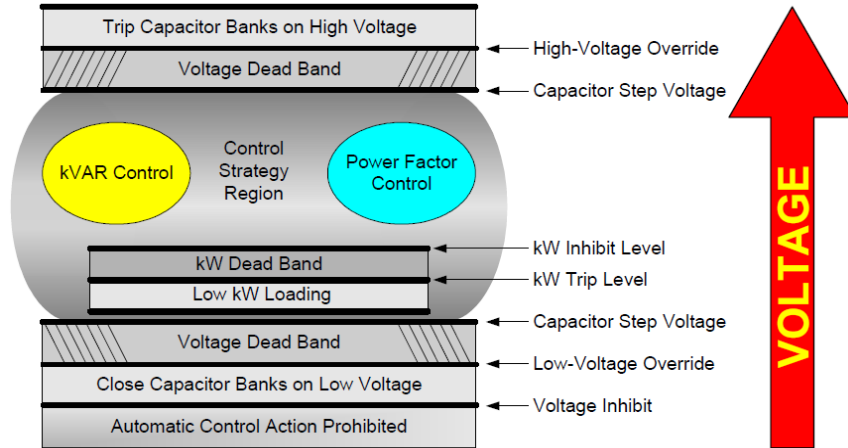


Figure 1 SEL-734 Two-Stage Capacitor Bank Control

## FEATURES OF A CAPACITOR BANK CONTROL USING THE SEL-734 METER

The SEL-734 control logic offers the following methods for energizing and de-energizing capacitor banks:

- Automatic control operation modes
  - Three-phase average power factor control
  - Three-phase average kVAR control
  - Bus voltage override control
- Other features
  - Voltage inhibitor to prevent automatic control actions with blown secondary PT (potential transformer) fuses
  - Voltage dead-band settings to prevent the tripping of capacitor banks on power factor and kVAR control when the voltage override thresholds are exceeded
  - Load profile, harmonic metering, Sequential Events Recorder (SER), and 8 kHz oscillographic waveform capture
  - Separate close and trip delay timers for each of the three automatic control functions
  - kW trip and automatic control inhibit thresholds to de-energize capacitor banks and prevent power factor and kVAR control actions during periods of low kW load
  - Hunting logic to detect unstable operation and disable automatic control
  - Capacitor discharge timing to prevent re-energization of capacitor banks too quickly
  - DNP3 communications for remote control and monitoring of capacitor bank control
  - Local independent control of the capacitor banks
  - Intuitive front-panel displays and programmable LEDs (light-emitting diodes) that indicate all pending control actions of the capacitor bank control scheme
  - Stage rotation logic that can be enabled to equalize capacitor bank usage