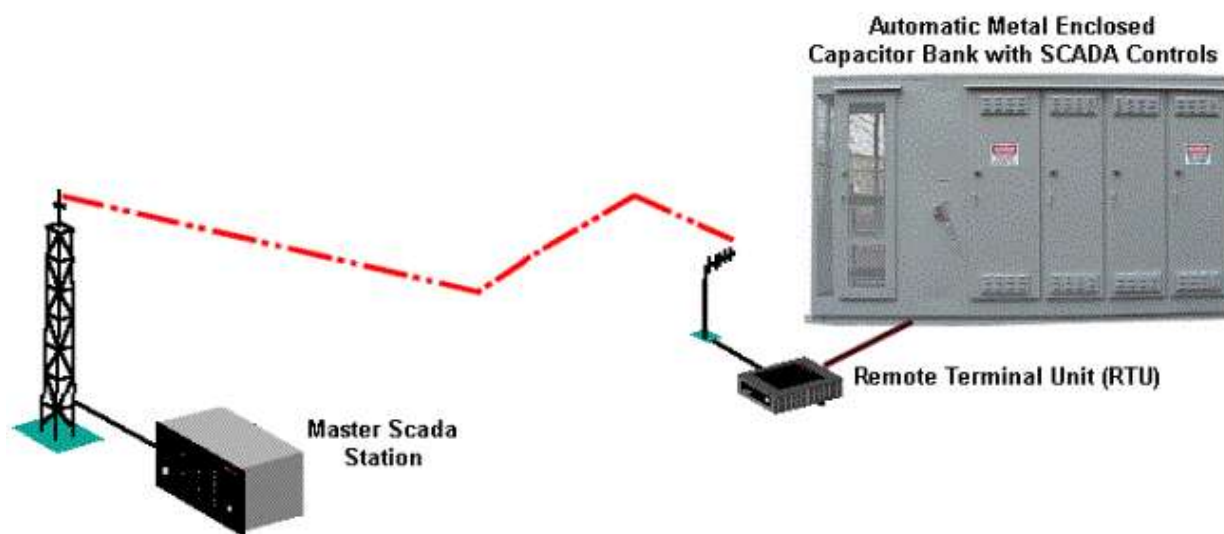


# SCADA Controlled Multi-Step Automatic Controlled Capacitor Banks & Filter Banks

## Introduction

SCADA (Supervisory Controlled and Data Acquisition) controlled multi-step metal-enclosed automatic capacitor banks and harmonic filter banks can provide many benefits that are not available in standard metal-enclosed capacitor banks. A SCADA controlled automatic capacitor bank provides local and remote control, failure prediction and detection, reduced operating cost, and an ability to boost distribution and transmission system performance with supervisory control. This Technical Note provides information on the benefits of SCADA controlled multi-step capacitor banks as well as a common SCADA control package provided by Northeast Power Systems, Inc. (NEPSI).

Detailed specifications on SCADA controlled multi-step metal-enclosed capacitor banks and harmonic filter banks are available from NEPSI by email. You may request a copy at: [Sales@nepsi.com](mailto:Sales@nepsi.com)



*Figure 1 – SCADA Controlled Automatic Capacitor Banks Offer Many Benefits Over Conventional Metal-Enclosed Capacitor Banks*

## Background

Conventional multi-step automatic capacitor banks consist of 2 to 5 steps of shunt capacitors with total bank kvar ratings to 10,000 kvar. The capacitor steps are automatically energized and de-energized with vacuum switches to regulate voltage, power factor, or VARs on distribution substations ranging in voltages from 4.16kV to 34.5kV. The banks are shipped fully assembled and ready for interconnection. All switching devices (including air-disconnect switches), protection and control features

are neatly packaged into a single unit to allow for direct connection to the main bus of a distribution substation. A concrete pad, external current transformer signal, three power cables, and a ground wire is all that is required to connect these banks to your system.

A SCADA controlled bank offers the same benefits as conventional metal enclosed banks, but goes one step further and allows for connection to a SCADA system. These SCADA controlled banks provide the following key benefits:

- SCADA controls offer the ability to over-ride automatic controls of the bank to provide voltage or var support to the distribution, sub-transmission, and transmission systems.
- SCADA controls can alert utility personnel of capacitor and fuse failures. This will increase capacitor bank reliability and minimize downtime.
- SCADA controls reduce operating cost by reducing crew trips to the substation.
- SCADA provides for remote monitoring of the status of all protection and control devices within the bank.
- SCADA controls provide remote monitoring of all power system parameters (i.e. harmonic distortion, voltage, power factor, etc.) associated with the capacitor bank. This provides for a key diagnostic tool when power quality concerns arise.

## **SCADA Control**

Figure 1 shows a typical block diagram of a SCADA controlled metal-enclosed automatic capacitor bank. Key elements shown in the diagram are as follows:

- **SUPERVISORY CONTROL SWITCH** – This switch is typically located on the control panel of the metal enclosed automatic capacitor bank. When the supervisory control switch is in the "DISABLED" position, all SCADA controls are disabled and the bank can only be operated from the control panel. When the Supervisory Control Switch is in the "DISABLED" mode, the SCADA system will continue to receive indication of the capacitor bank's status, but SCADA controls received by the bank will be ignored.
- When the Supervisory control switch is in the "ENABLED" position, the bank can be controlled by the SCADA system, but will remain in the automatic control mode until an over-ride command is sent. Once in over-ride command is sent (i.e. SCADA command to turn stage 3 on), automatic mode is disabled and complete capacitor bank control is based upon commands received by the SCADA system. Automatic control can be re-initiated by SCADA with a "Return to Automatic Control" signal.
- **MAN/OFF/AUTO SWITCH** – These switches are only functional when the bank is not being controlled by the SCADA system (i.e. when the Supervisory Control

Switch is in the "DISABLED" or when the bank is in automatic control mode). These switches are 3-Position. When in the "ON" Position, the stage associated with the MAN/OFF/AUTO switch is forced on. When in the "OFF" position, the associated stage is forced off. When in the "AUTO" position the bank is controlled by the Power Factor Controller. Re-energization of a stage in less than 5-minutes is prevented by the controls.

- MODICON PLC – The Modicon PLC controls many of the functional requirements of the SCADA control system.
- PROTECTION SYSTEM – This system is composed of the neutral unbalance protection system, over-current relay(s), and over-voltage relay(s) (Note: over-voltage and over-current relays are not always installed in multi-step capacitor banks. Requirements for these relays are system dependent).
- SENSORS – The PT's, CT's and other devices required to provide SCADA and automatic control signals as outlined in Table 1 of this specification.
- STAGE VACUUM SWITCH – These switches are part of the capacitor bank and are responsible for energizing and de-energizing the capacitor bank.
- NEUTRAL SENSOR(S) – These sensors are typically located in the neutral of most capacitor banks and will be either a current transformer or voltage transformer. Their purpose is to provide a voltage or current signal to the unbalance relay on the loss of a capacitor fuse.
- METERING – This meter shall monitor the power system parameters as listed in Table 1. The power system parameters shall be available to the PLC for detection of alarm and fault conditions as well as to the RTU for the SCADA System. A common communication protocol (RTU or DNP 3 needs to exist between the RTU, Metering device(s), and the PLC.
- AUTO CONTROLLER – The auto controller, controls the capacitor bank stages based upon system power factor, voltage, or vars. The auto controller is only allowed to control the bank when it is not being controlled by the SCADA system.

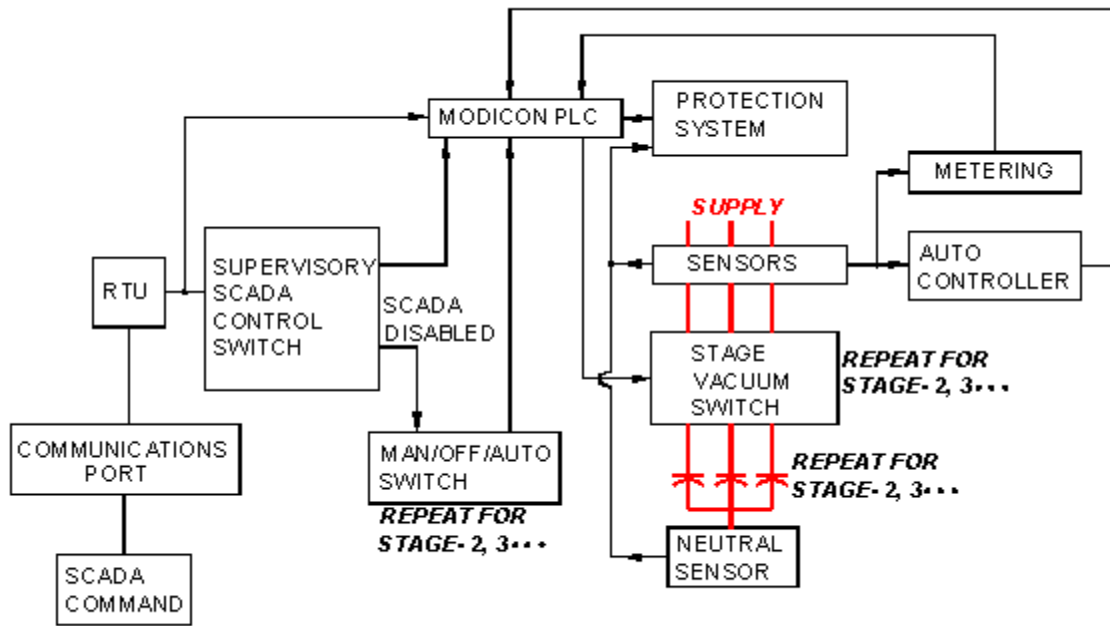


Figure 1 – Block Diagram of SCADA System

### SCADA Input/Output Requirements

Table 1 below shows the typical I/O requirements of the RTU. NEPSI can install and pre-wire the RTU and communication devices at the factory or can leave space in the automatic metal-enclosed control cabinet for installation by the customer.

| Table 1 - SCADA Controlled Capacitor Bank |                  |  |
|---|------------------|--|
| I/O Requirements                          |                  |  |
| Name                                      | Type             | Functional Description   |
| Supervisory Control Enabled               | Indicator/Output | Provides indication if Automatic Capacitor Bank can be supervisory controlled.   |
| Supervisory Control Disabled              | Indicator/Output | Provides indication that supervisory controls are disabled. This mode of operation can only be performed by throwing a switch on the capacitor bank control panel and is primarily used for testing. |
| Return to Automatic Control               | Control/Input    | Returns control back to the capacitor banks automatic power factor correction control system.  |
| Stage 1 On                                | Control/Input    | Turns Stage 1 on when supervisory control is enabled - Automatic Power Factor Control System gets disabled.  |
| Stage 1 Off                               | Control/Input    | Turns Stage 1 off when supervisory control is enabled - Automatic Power Factor Control System gets disabled.   |
| Stage 2 On                                | Control/Input    | Turns Stage 2 on when supervisory control is enabled - Automatic Power Factor Control System gets disabled.  |

|                             |  |  |
|-----------------------------|--|--|
| Stage 2 Off                 | Control/Input  | Turns Stage 2 off when supervisory control is enabled<br>- Automatic Power Factor Control System gets disabled   |
| Stage 3 On                  | Control/Input  | Turns Stage 3 on when supervisory control is enabled<br>- Automatic Power Factor Control System gets disabled.   |
| Stage 3 Off                 | Control/Input  | Turns Stage 3 off when supervisory control is enabled<br>- Automatic Power Factor Control System gets disabled   |
| Stage 1 On                  | Indicator/Output   | Indicates if Stage 1 is on   |
| Stage 1 Off                 | Indicator/Output   | Indicates if Stage 1 is off  |
| Stage 2 On                  | Indicator/Output   | Indicates if Stage 2 is on   |
| Stage 2 Off                 | Indicator/Output   | Indicates if Stage 2 is off  |
| Stage 3 On                  | Indicator/Output   | Indicates if Stage 3 is on   |
| Stage 3 Off                 | Indicator/Output   | Indicates if Stage 3 is off<br><i>(Repeat above Stage indicators for each stage)</i>   |
| Data Acquisition Parameters | Output Via DNP/Modbus Protocol to RTU<br><br><i>(Specify communication requirement of RTU)</i> | Three Phase Voltage, Average Voltage, L-L Voltage, Phase Currents, Voltage Unbalance, Current Unbalance, Line Frequency, Phase KW, Total KW, Phase Kvar, Total Kvar, Phase KVA, Total KVA, Phase Power Factor, KW Thermal Demand, KVAR Thermal Demand, KVA Thermal Demand, Maximum KW Demand, Maximum Kvar Thermal Demand, Maximum KVA Thermal Demand, Maximum Total kW, Maximum Total Kvar, Maximum Total KVA, Minimum Average Current, Total kVARh, Net kVARh, Total kVARh, Max Phase Voltage THD, Maximum Phase Current THD |
| Neutral Unbalance Alarm     | Indicator/Output   | Provides warning against a blown capacitor fuse condition.   |
| Neutral Unbalance Trip      | Indicator/Output   | Provides indication that bank tripped on a blown capacitor fuse condition.   |
| Over-Voltage Alarm          | Indicator/Output   | Provides indication of an over-voltage alarm<br><i>(Only required when bank is equipped with an over-voltage relay)</i>  |
| Over-Voltage Trip           | Indicator/Output   | Provides indication that the capacitor bank tripped an over-voltage.<br><i>(Only required when bank is equipped with an over-voltage relay)</i>  |
| Over-Current Trip           | Indicator/Output   | Provides indication that the capacitor bank tripped on over-current.<br><i>(Only required when the bank is equipped with an over-current relay)</i>  |

## Conclusion

This Technical Note presented the benefits of SCADA controlled automatic capacitor banks. It also presented a SCADA control scheme and the input and output requirements of the scheme. It is important that the customer properly specifies the requirements of the SCADA system and anticipates the I/O requirements of the RTU. It is

in the customer's best interest to specify an RTU and communication device that is compatible with the Master SCADA system. To ensure a fully functional automatic capacitor bank SCADA control system, the manufacturer should be requested to install and test the SCADA control system with the desired RTU.

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