Installation and Operation Manual
Automatic Capacitor Bank Equipment

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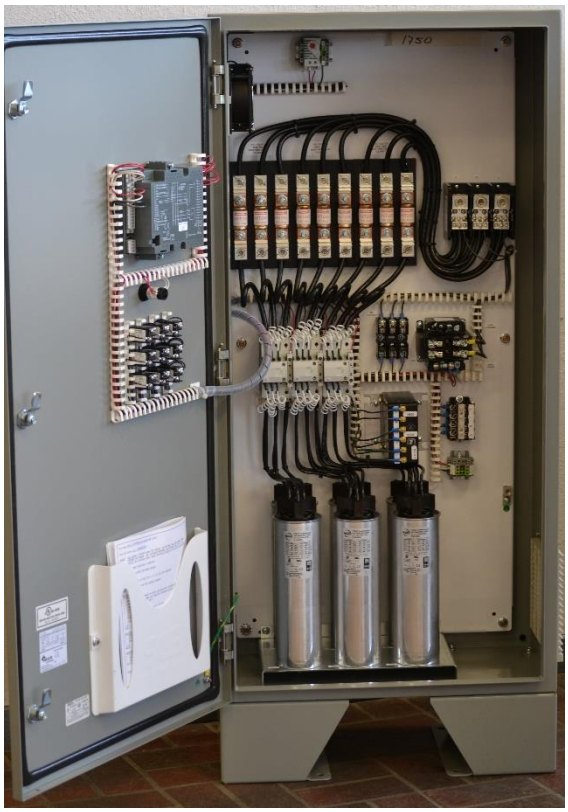
1 Introduction



The operation and installation manual is intended for qualified electricians that are involved in integrating, installing, operating and/or maintaining NUCO's automatic capacitor bank equipment. Electricians are expected to be aware of general electrical wiring practices, electronic components and electrical schematic symbols.

The present manual applies to all automatic capacitor banks.

2 Safety instructions

These safety instructions are intended for all work on capacitor equipment.

Neglecting these instructions can cause physical injuries and death.

All electrical installation and maintenance work on automatic capacitor banks should be carried out by qualified electricians.

Do not attempt to work on a powered capacitor equipment.

After switching off the power supply to the capacitor equipment, always wait at least 5 minutes before working on the unit (i.e. time for the power capacitors to be discharged). Always verify that capacitors are discharged.

Note: AC capacitors may be charged at a higher voltage than network nominal value.

Before installing the current transformer(s) (CT), make sure that the secondary is short-circuited. Never open the secondary connections of a loaded CT.

You shall always wear insulating gloves and eye-protection when working on electrical installations. Make sure that all local safety regulations are followed.

DANGER:

To ensure safe working conditions, all circuits (power and auxiliary) of each individual enclosure should be opened before entry / opening the capacitor bank.

This equipment contains capacitors. Check for residual voltage before working inside the equipment.

3 Upon reception

The capacitors are normally delivered in a wooden crate bolted or strapped on a pallet.

Make sure that the packing has not been damaged.

After removing the packaging, perform a visual check of the exterior and interior of your capacitor bank.

Immediately notify your representative if there is any damage to the equipment.

The following documentation is supplied with the equipment:

- Wiring diagram
- RVT manual (softcopy)

3.1 Lifting and transportation guidelines

Please note that the equipment can weigh up to several thousand pounds. Care should be taken to ensure the equipment is handled properly.

During handling and transportation, do not ‘shock’ the equipment (i.e., sudden jolts).

- The capacitor equipment should be moved and positioned using the shipping pallet.

- After unpacking, if the equipment was supplied with lifting eyes, lift the equipment using the lifting eyes supplied.

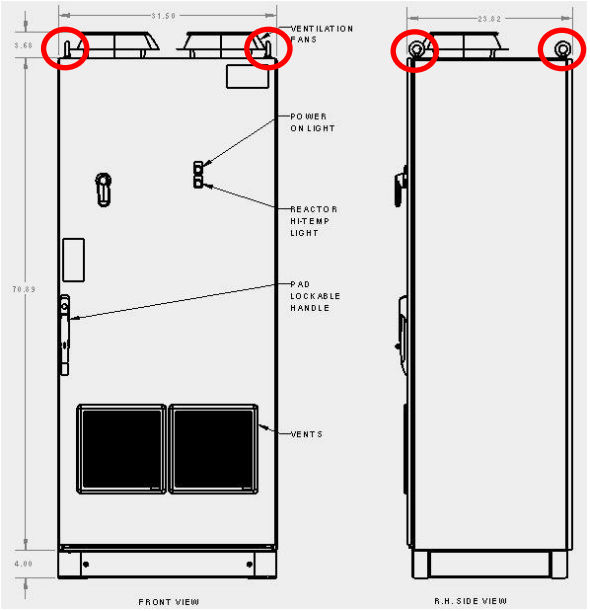


Figure 1: Lifting eyes

3.2 Identification tag

The electrical nameplate is located on the front door, on the inside.

The nameplate information should always remain readable to ensure proper identification during the life of the capacitor bank. The bank nameplate includes key data such as the nominal voltage, frequency, KVAR, and part number.

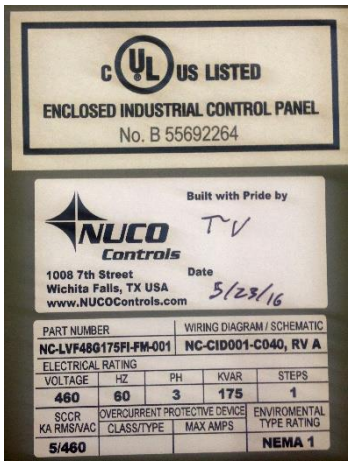


Figure 2: UL certification sticker on top and nameplate on bottom

3.3 Storage

The capacitor bank must be stored indoors, in a dry, dust free, non-corrosive atmosphere and protected from vibrations or shocks.

The storage temperature must be between -20°C (or -4°F) and +60°C (or +140°F).

3.4 Packing & unpacking

To unpack:

- Remove the nails, screws or bolts from the crate.
- Use the unit lifting bolts if supplied and secure the unit.
- The unit may be bolted to the pallet. Remove any hardware that may be securing the equipment to the pallet. Take extra caution when handling the unpacked unit as it can weigh hundreds or thousands of pounds.

4 Products overview and description

4.1 Capacitor Bank Types

- Free floor-standing cubicles without reactor
- Free floor-standing cubicles with reactors

All automatic capacitor banks are supplied with an ABB RVT controller as standard

4.2 Power Factor Controllers

- RVT (provided as standard)

Note: A softcopy of the manual of the power factor controller is provided within the capacitor bank.

Figure 3: RVT Power Factor controller

4.3 Ventilation system

Most automatic capacitor banks are air forced ventilated.

Important note: All fans use 120V, 60Hz power unless specified otherwise. Control power is supplied with all capacitor bank equipment.

4.4 Temperature Monitoring

The capacitor equipment may include a thermostat that cuts the power to the RVT controller (i.e., the RVT controller will be off) when the temperature exceeds 60°C (or 140°F) inside the enclosure. In such an event, all the capacitors are switched off and the fan(s) continue to operate. A thermal cutoff switch automatically closes when temperature returns to normal conditions.

DANGER

When the thermal protection switches off, the RVT controller is off but the capacitor bank is still connected to the main power supply.

Figure 4: Thermostat

5 Installation

5.1 Working conditions: dust, moisture and temperature

The capacitor banks can be installed indoor or outdoor depending on your order options. Place the equipment in a well-ventilated area where the ambient temperature doesn't exceed the following values:

- 40°C (or 104°F) maximum.

5.2 Harmonics

The installation of a capacitor bank on networks with harmonics requires special precautions to avoid any risk of resonance.

In such cases, consult your representative for details.

Capacitor banks supplied with detuning reactors enable the capacitor bank to operate in a polluted network up to a THDV of 8% with following spectrum:

- V3 = 0.5% V5 = 6.0%
- V7 = 5.0% V11 = 3.5%
- V13 = 3.0%

5.3 Mechanical installation

5.3.1 General

- The capacitor equipment should be installed according to local standards and requirements. It is the sole the responsibility of the installation personnel to follow local code requirements.
- Free floor standing cubicles - minimum clearance distance at the back: 2 in.
- Can be placed immediately side by side with other cubicles when fans or ventilation vents are not mounted on the side.
- Incoming power cables shall be sized according to local and NEC electrical codes.
- Refer to the equipment mechanical drawings to locate the incoming connection location.
- The depth of the capacitor equipment may vary based on the KVAR rating. Refer to the equipment drawings for specific dimensional information.
- The equipment should be secured to the installation location using the mounting holes provided in the enclosure or on mounting feet.
- Installation personnel shall take all the necessary precautions to ensure the equipment certification is not compromised.

5.4 Electrical installation

5.4.1 Electrical insulation test

All capacitor equipment are hi-potted as follows: V_{sys}*2 + 1000V for 1 sec.

Example: For a 600V capacitor bank, a 2200V (600V*2 + 1000V) insulation test will be applied between each phase and ground.

5.4.2 Electrical connections overview

Each capacitor bank requires:

- Power connections
- Current transformer (CT) connections
- RVT automatic or manual commissioning

5.4.3 Ground connection

Grounding lugs are provided in all enclosed capacitor equipment. Grounding lugs can be identified by locating the ground sticker next to the grounding lug.

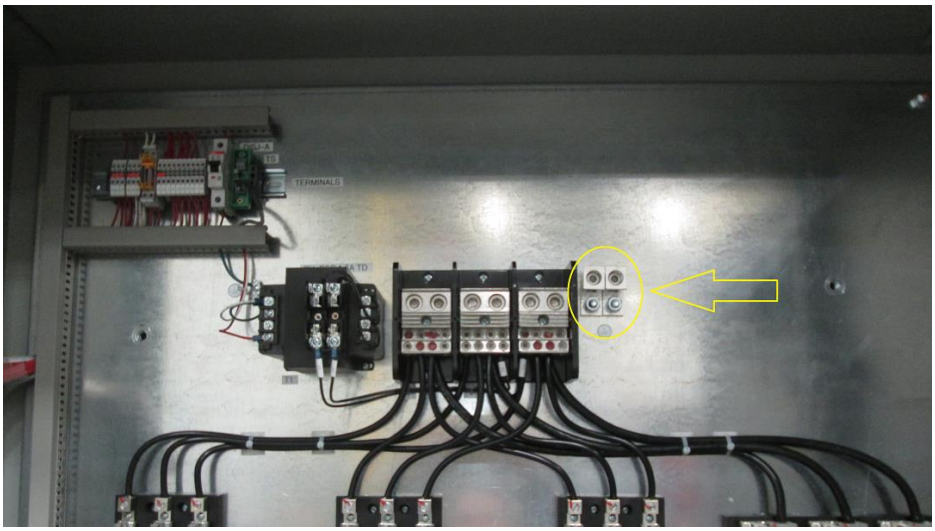


Figure 5: Ground connection

5.4.4 Power cables selection

Power cables should be sized by following local code and NEC requirements. Refer to NEC 460-8 for additional information regarding capacitor equipment. All NEC code requirements must be followed.

Note: When selecting the appropriate cable size, please consider possible future expansion of the equipment (i.e. additional power modules) if ordered with this option.

Main switch, fuses and/or circuit breaker

At the location of the bank installation, the network short-circuit current shall be taken into consideration to determine the main incoming fuses, or rating of the circuit breaker.

To disconnect the unit from the network, a circuit breaker is recommended or may be required based on local and international code requirements.

A non-fused or fused disconnect may also be used. Follow local and international standards to ensure proper application.

It is recommended that the circuit breaker be sized a minimum of 1.5 times the nominal current rating of the capacitor bank to minimize chances of nuisance tripping.

Fuse should be sized based on the type of fuse used. Time delay J fuses should be sized 1.65 times the capacitor bank nominal current rating and non-time delay fuses should be rated 3 times the capacitor bank nominal current rating to minimize chances of nuisance blowing.

5.4.5 Electrical connections – Top or side entry

- The capacitor banks are top or side cable entry by default.
- Connect the ground.
- Connect the power cables to the incoming power distribution block, breaker, or disconnect switch

*The incoming lugs accept various cable gauges based on the capacitor bank rating. Refer to the capacitor equipment documentation for details.

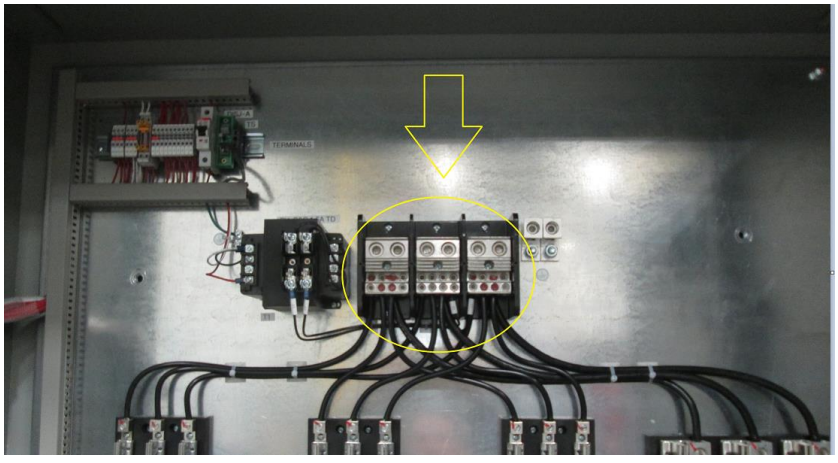


Figure 6: Capacitor bank power cables connection to distribution block

- Connect the CT cables

5.4.6 Current transformer selection

The current transformer (CT) is not included with automatic power factor correction equipment. The CT must be ordered separately.

CT connections must be installed in a closed loop configuration. This means that the CT should monitor the total current (i.e. both the load current and capacitor current).

CT specification:

- 1 or 5 A secondary current rating.
- 15 VA burden for up to 30 meters with 2.5 mm^2 cable. For longer cables lengths, refer to Figure 7. If the CT is shared with other loads, the proper VA burden should be used accordingly.
- Class 1 resolution or better.
- Primary side current rating should be sufficient to monitor the total line current.

The capacitor equipment is provided with an ABB RVT controller with the ability to automatically change the phase-rotation to ensure proper monitoring.

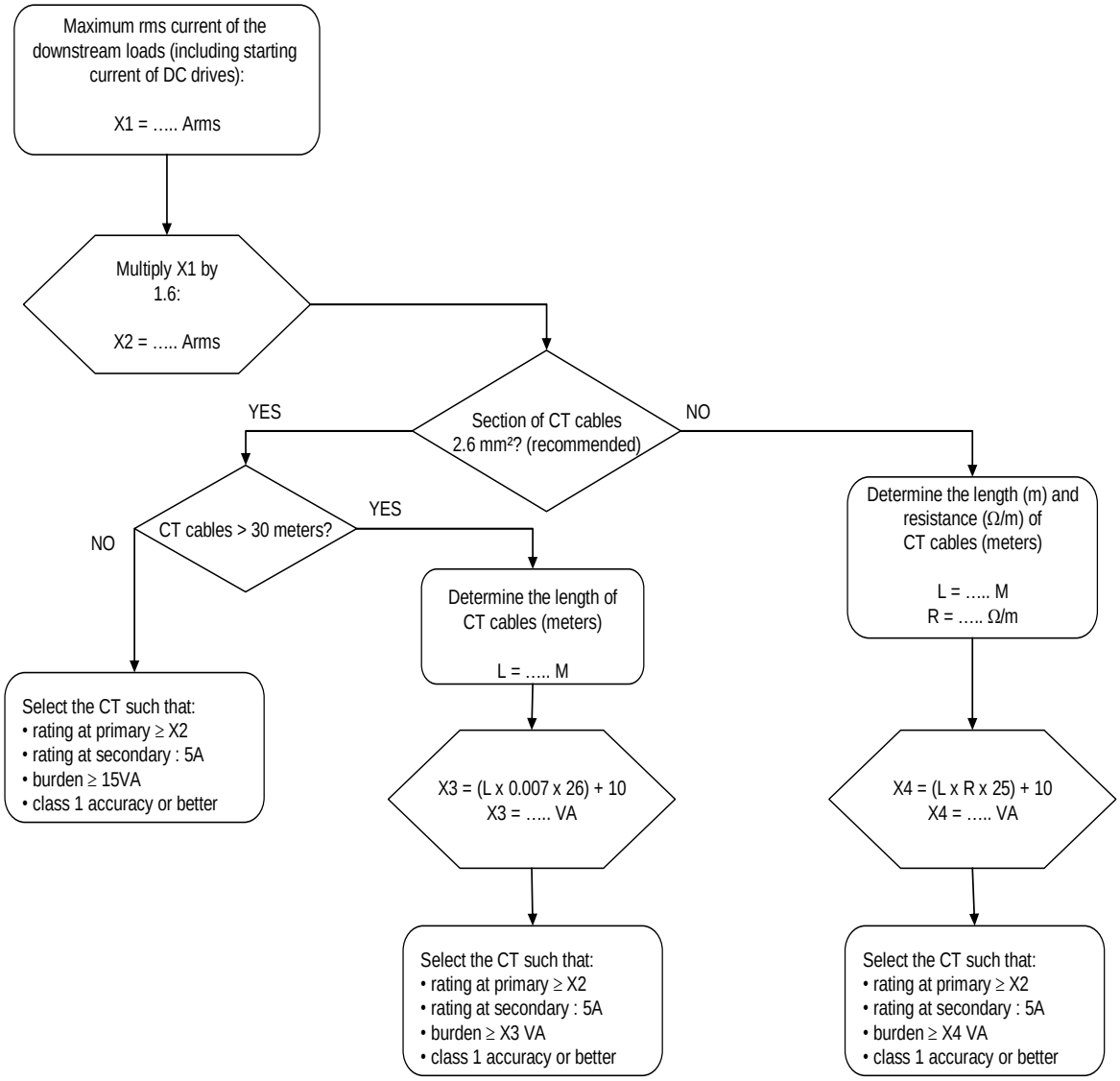


Figure 7: Flow chart for CT determination

5.4.7 Current transformer connection

WARNING: When connecting the CT(s), the secondary terminals of each CT must be shorted. Failure to do so may result in CT damage and damage to the installation. Once the CT connections to the capacitor banks have been made, remove the short circuit.

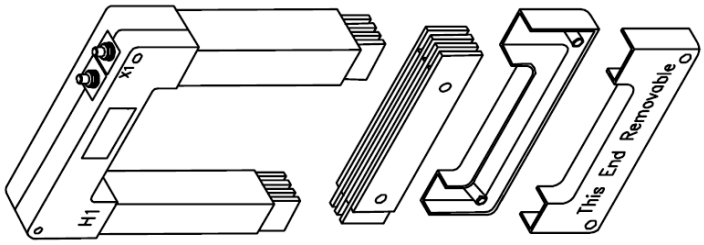


Figure 8: CT representation

WARNING: A CT can be connected to several pieces of equipment. The CT must be connected in series.

The CT shall be connected to CT's terminals as per the electrical layout provided in each unit.

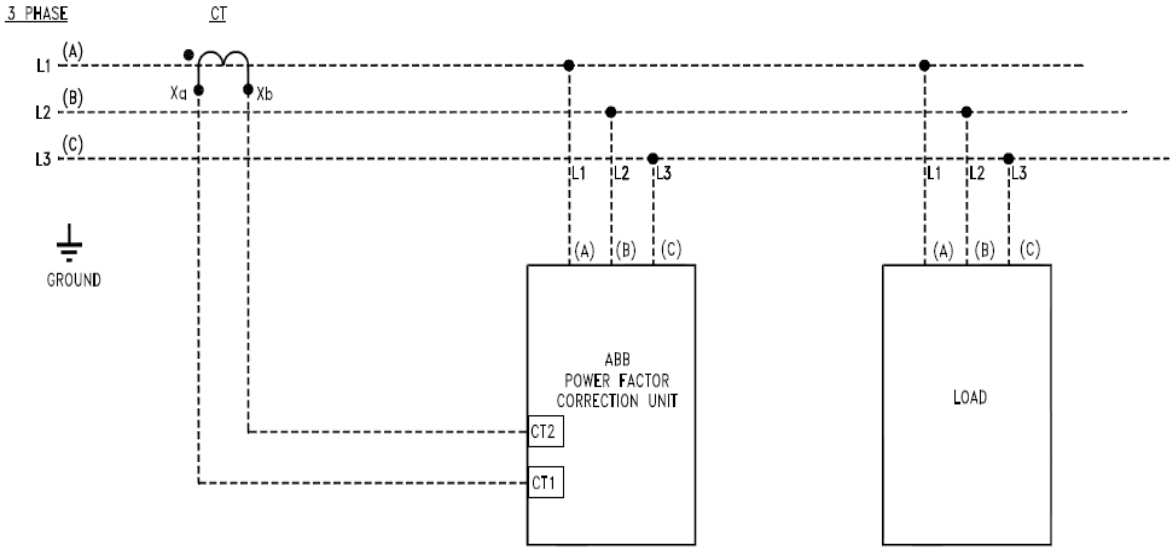


Figure 9: Single CT connection example

The CT terminal block can handle control cable wiring with cross sections from 0.5 mm² to 10 mm² (24 to 6 AWG).

Run CT cables inside the cubicle. The cables can be installed in the cable duct (if supplied) used for other control wires.

The CT connections should be terminated on the connection points labelled k and l.

5.4.8 Multi ratio CT and summation transformer

When a multi ratio split core CT is used, the appropriate ratio is selected by connecting either X1 to X5 to the terminal marked l. The CT ratio should be selected as close as possible to the requested CT specification.

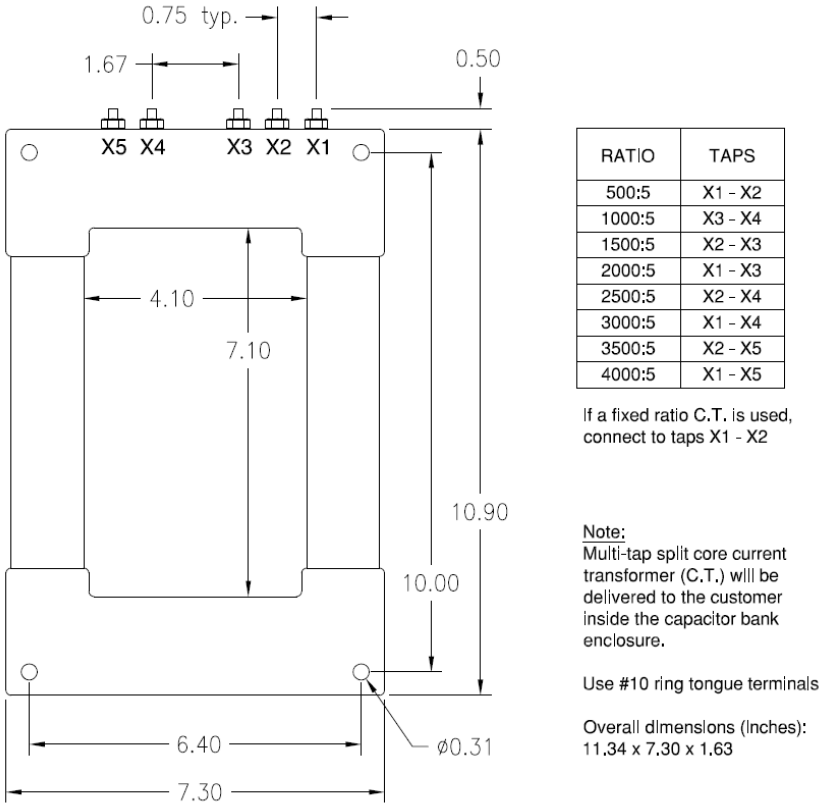


Figure 9: Multi ratio CT

Summation transformer

For more complex situations (i.e.: two or more power source connections), the current has to be measured at different locations in order to monitor the total load current.

This situation requires a summing CT to totalize the load and generate a single 1A or 5A output to represent the total load.

When a summing CT is used, the terminal markings will usually be H1, H2 and X1, X2. The secondary connections X1 and X2 should be connected to k and l, respectively.

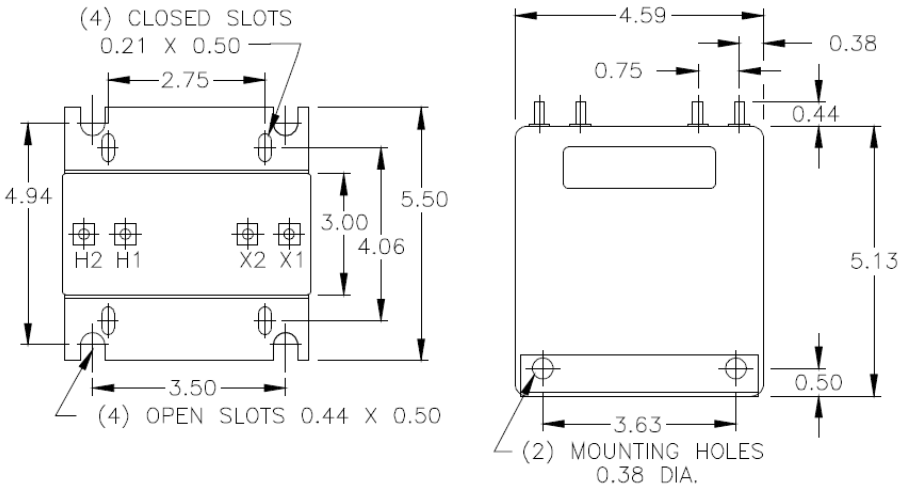


Figure 10: Summation CT 5+5:5

The first CT should be connected to H1 and X1 while the second CT should be connected to H2 and X2 on the summation CT.

It is important that all CT's monitor current in the same direction.

5.4.9 Connection of several banks in parallel

Several automatic capacitor banks can be connected in parallel.

All capacitor banks are master units (i.e. fitted with a RVT controller). If two units or more are connected, they must be connected as shown in Figure 11.

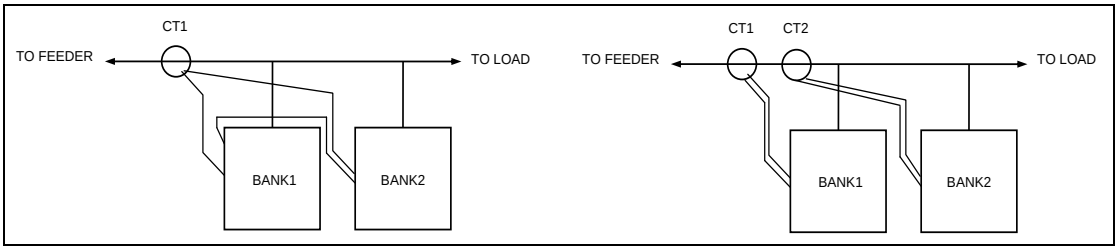


Figure 11: Connection of several capacitor banks in parallel

The "switching delay" parameter of each RVT Controller must be set differently.

If the RVT controllers are set to normal mode, we recommend using a switching time delay difference of 1 sec. (e.g. 40s, 41s, 42s …).

If the controllers are set to integral mode, we recommend using a switching time delay difference of at least 21 sec. (e.g. 120s, 141s, 162s …).

6 Quick commissioning steps

1. General check of the capacitor bank: tightness of all connections, ground, fuses, contactors, etc.
2. Check incoming power cables, circuit breaker, and/or fuses to ensure they are sized correctly and according to local and international code requirements.
3. Check that the CT (s) is (are) properly installed (closed loop) and connected.
4. Remove the CT short circuit jumper.

Note: Your capacitor bank is equipped with a RVT controller, refer to the RVT instruction manual for more details.

7 Troubleshooting

Most of the capacitor bank operating problems may be identified with the help of error messages or icons displayed on the RVT controller.

Refer to the troubleshooting paragraph in the RVT controller instruction manual.

If the RVT controller is properly connected but nothing appears on its display, this may be due to one of the following reasons (by order of precedence):

- No power supply (check the wiring, fuses, etc…).
- Thermostat fails or opens due to too high temperature (> 60°C or 140°F) in the cubicle. If temperature related, it may be due to an ambient temperature (i.e. outside the bank enclosure) above the maximum allowed temperature. (> 40°C or 104°F).
- Failure of both fans and thermostat. This could cause a very high temperature and cause the internal protection of the RVT controller to activate (about 85°C or 185°F).
- Faulty RVT controller.

8 Maintenance

All maintenance operations must be completed by a qualified electrician.

The interval between two maintenance procedures depends on site conditions but should not be longer than one year.

Regular maintenance procedure:

- Check ambient temperature and equipment ventilation (should be within specification)
- Isolate the capacitor bank from the power source
- Open the front door panel
- Clear air inlet and outlet
- Clean all parts from dust and dirt
- Check fuses
- Re-torque all power connections (i.e., breakers, power distribution blocks, fuse blocks, contactors, capacitors, etc)

Re-energize the capacitor bank:

- Switch on each capacitor step manually with RVT controller
- Check contactors for proper operation – replace them if necessary
- Check operation of the RVT Controller
- Measure capacitor currents (in all three phases) for every capacitor step and record the measurements

Note: current measurements should be compared to expected nominal current ratings of the capacitors. If current is 10% lower than the expected nominal current, the capacitors should be replaced.

Nominal current is normally given by: $I_n = \frac{Q_x}{U_n\sqrt{3}}$

Where:

- I_n = current in one phase
- Q_x = Reactive power (kvar) of the capacitor step
- $\sqrt{3} =$ = square root of three
- U_n = RMS phase to phase voltage

Fan replacement:

Fan replacement is subject to environmental and installation conditions. As a result, the service life will vary site to site.

9 Technical Specifications

Voltage range	208V to 600V, 3PH, 60Hz For other voltages, please consult us.
Working ambient temperature	-5°C (23°F)/+40°C (104°F)
Installation	- Free floor standing, top or side cable entry. Back clearance: 2”
Connection	Three-phase, balanced network.
Protection	- NEMA 1, 12 (optional) and 3R (optional)
Execution	Indoor up to NEMA 12 (optional) and Outdoor for NEMA 3R (optional)
Color	ANSI 61 Gray or Beige
Ventilation	Forced air cooling
Power factor setting	From 0.7 inductive to 0.7 capacitive
Starting current setting (C/k)	From 0.01A to 5A for the RVT controller
Operation	During operation, RVT controller displays: - number of active outputs - inductive or capacitive power factor - alarm conditions: target cos φ, over/under voltage, THDV, over temperature - demand for switching on/off a capacitor step
Losses at 600V 60Hz	- Without reactors: less than 1.5 Watt/kvar - With reactors: less than 5.5 Watt/kvar
Reactors (detuned units only)	- Dry type resin - Maximum harmonic pollution: 8% THDV with specific spectrum: V3 = 0.5% V5 = 6% V7 = 5.0% V11 = 3.5% V13 = 3.0%
Standard(s)	UL508A
Options	RVT controller Circuit breaker/ Fused and Non-fused disconnect switch Blown fuse indicators