LV Capacitor Bank APC

Installation, operation and maintenance instructions

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1. Read this first

1.1. About this instruction manual

This instruction manual is intended to help you install and operate, quickly and efficiently, your APC automatic capacitor bank, with the guarantee of optimum operation.

1.2. Safety

Before installation and operation of the APC automatic capacitor bank, read this instruction manual carefully. Keep it at the disposal of the people in charge of the installation, operation and maintenance.

Do not introduce or store any extraneous body in the automatic capacitor bank.
Take care not to obstruct the ventilation grids.

Power capacitors operate continuously at full load. Please respect the points below:

- Installation and maintenance must only be carried out by authorized and qualified personnel, in accordance with current local regulations.
- Isolate the equipment from the power supply before attempting to gain access.
- Wait five minutes to allow the capacitor to discharge through the discharge resistors. As an additional precaution before starting work, short-circuit the capacitor terminals with a piece of insulated cable (bare at the ends) to confirm discharge.
- Check that the secondary winding of the current transformer is short-circuited or connected to another parallel load (with a sufficiently low impedance) while connecting or disconnecting measuring instruments or relays. An open secondary winding of a loaded current transformer may cause dangerous overvoltages.
- The APC automatic capacitor bank must be installed according to EN 61921 and local specifications.

1.3. APC types

The APC exists in five different types:

- 2 types of boxes: APCL1 and APCL2
- 3 types of cubicles: APCM1, APCM2 and APCR

Note that APCL2, APCM2 and APCR types exist in slave execution. Slave units are not equipped with PF controller but with an interconnection cable (factory wired).

1.4. Inspection on reception

Make sure that the packaging has not been damaged in transit.

Any loss or damage should be notified immediately to your closest local ABB agent.

The small boxes (APCL1) are delivered upright.
The big boxes (APCL2) are delivered on their side and 2 units maximum can be stacked one on top of the other for transit and storage.
The cubicles (APCM1 and APCM2) are also delivered on their side and 2 units maximum can be stacked one on top of the other for transit and storage.
No stacking allowed for APCR.

1.5. Guarantee

Prior to dispatch, all our equipment is tested in compliance with the requirements of EN 60831-1 & 2 (for AC capacitors up to 1000V) and EN 61921 (Power capacitors - Low voltage power factor correction banks) and it is guaranteed in accordance with our standard sales conditions.

1.6. Storage

The APC 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 and + 60°C.

1.7. Handling

After having carefully unpacked the equipment, check that
- the characteristics noted on the nameplates correspond to the ones specified in your purchase order.
- the material does not appear to be damaged and particularly the central frame, the rear and top panels.

Any damage should be notified immediately to your closest local ABB agent.

Be very careful to avoid personal injury and damage to the equipment while setting upright the boxes and cubicles.

Suitable equipment for handling the cubicles such as a hoist is highly recommended. Use the lifting lugs that are provided for this purpose.
Avoid shocks and bumps.
Take care not to damage the plinth of the cubicles while setting upright them.

Figure 1.1. APCM and APCR setting upright

1.8. Electric insulation test

Before applying voltage, make an electric insulation test of 2.5 kV between the earth and the short-circuited phases.
Any damage resulting of this test should be notified immediately to your closest local ABB agent.

WARNING: End this test by removing the short circuit of the phases.

2. APC description

Figure 2.1. APC types

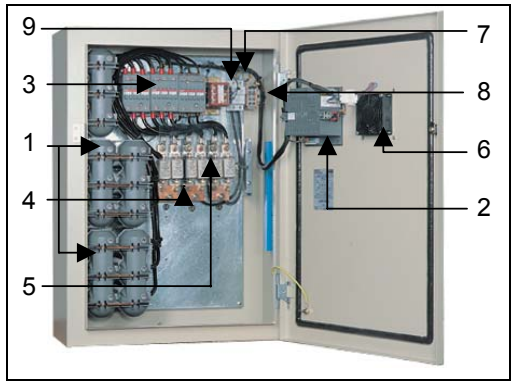

Figure 2.2. APCL2 of 125kvar/400V

1	LVCS capacitors
2	RVC controller *
3	UA type contactors
4	Power cables connections
5	HRC fuses
6	Fan(s)
7	Control circuit fuses
8	Current transformer connection *
9	Fan supply **
10	Reactors modules

Remarks:
*: in master cubicle only.
**: not for slave APCL2.

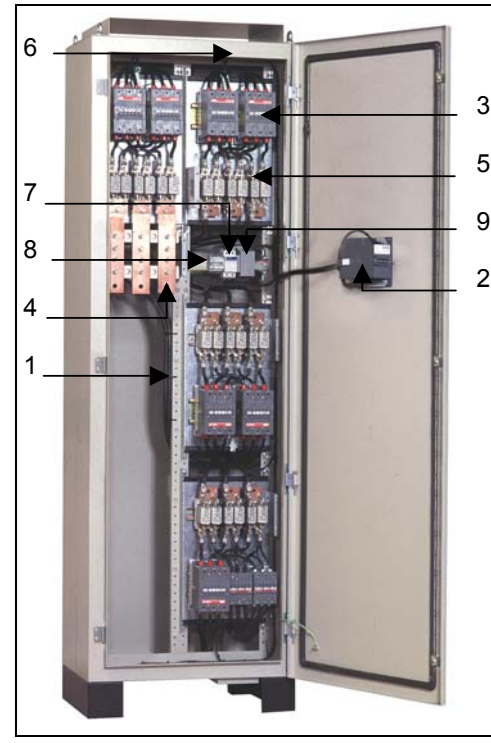

Figure 2.3. APCM2 of 400kvar/400V

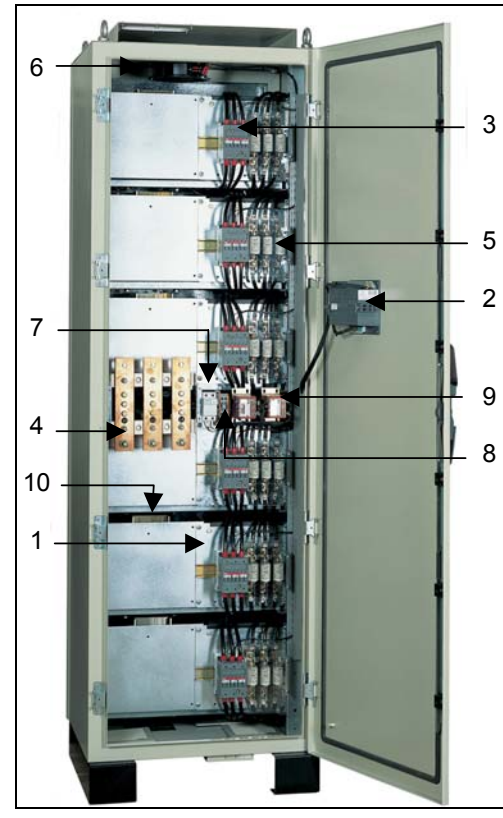

Figure 2.4. APCR of 300kvar/400V

2.1. Power modules

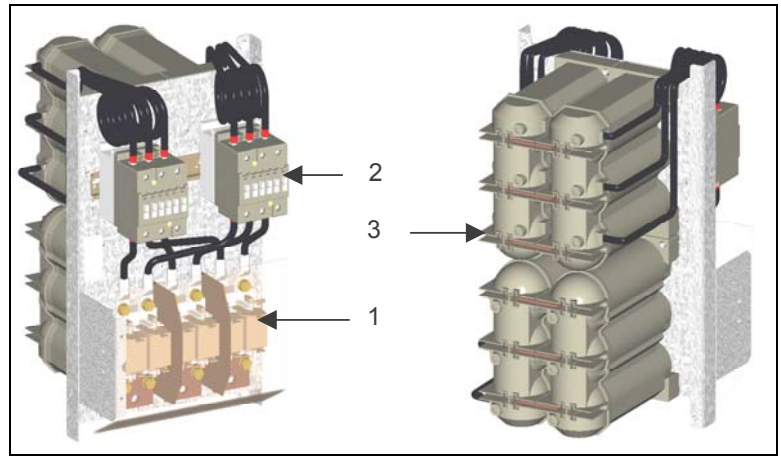

Figure 2.5. Example of a front face and rear face (APCM module)

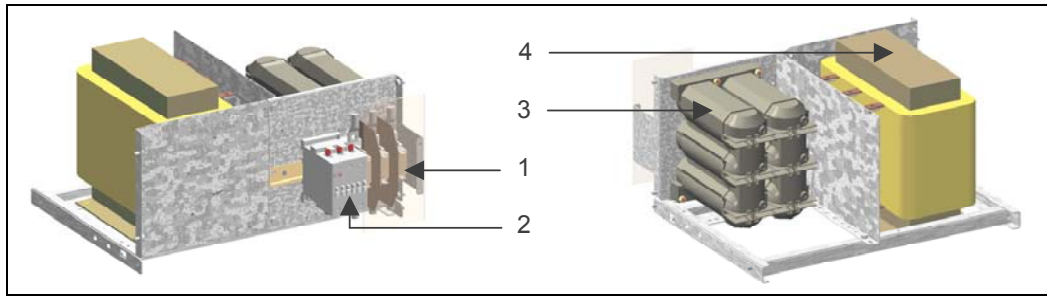

Figure 2.6. Example of a front face and rear face (APCR module)

1	Fuses
2	Contactors
3	Capacitors
4	Reactors

2.2. Ventilation system

APCL2, APCM1, APCM2 and APCR are provided with one or several fans.
APCL1 is provided with air grids allowing natural ventilation.

	APCL1	APCL2	APCM1	APCM2	APCR
Fan(s) quantity	0	1	2	1	2
Fan(s) position	/	door	top	top	top

2.2.1. Thermistor

Each fan is of DC type and is equipped with its own thermistor.
This thermistor will adapt the speed of the fan (“variofan” type) to the APC internal temperature.
This fan operates from a 30°C temperature and delivers a maximum airflow for a 50°C temperature.

2.2.2. Temperature probe

Each APC cubicle is also equipped with a temperature probe in order to switch off the controller power supply. In case of overtemperature around 60°C, the whole APC bank is automatically disconnected.

Figure 2.7. Temperature probe

3. Installation

3.1. Location

The APC are suitable for indoor installation, on appropriate surfaces. Shelter the equipment from dust and moisture and place it in a well-ventilated area where the ambient temperature doesn't exceed the following values:

40°C maximum;
35°C over 24h;
25°C over one year.

Appropriate action must be taken for ambient temperature down to -5°C or above 40°C.

3.2. Harmonics

The installation of capacitors on networks disturbed by harmonics may require special precautions especially when there is a risk of resonance.
Consult your closest local ABB agent if it is the case.

3.3. Fixation

3.3.1. APCL1 and APCL2 boxes

Fix the boxes on the wall by means of the fixation kit provided for this purpose.
The ground clearance must be of 10 cm minimum.
It's advised to keep a distance of 10 cm between the boxes.

3.3.2. APCM1, APCM2 and APCR cubicles

The cubicles must be placed on the ground.
Their backside must be positioned at a minimum distance of 5 cm from the wall.

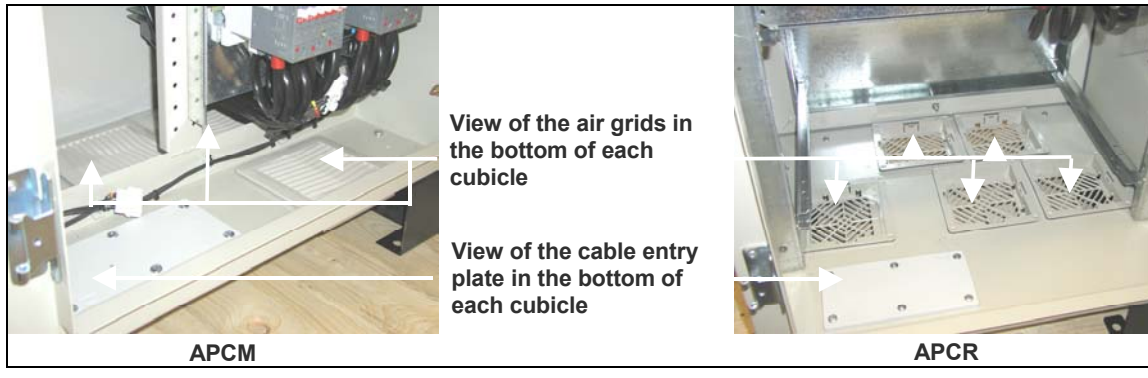

Figure 3.1. Air grids and cable entry in APCM and APCR

3.4. Connection

Cabling of equipment requires three main power connection (no neutral required) to each unit, two control wires from the current transformer to the master unit and, in case of master unit + slave unit configuration, the wiring of the interconnection cable from the slave unit to the master unit. The interconnection cable is factory wired in the slave unit.

3.4.1. Electrical diagram

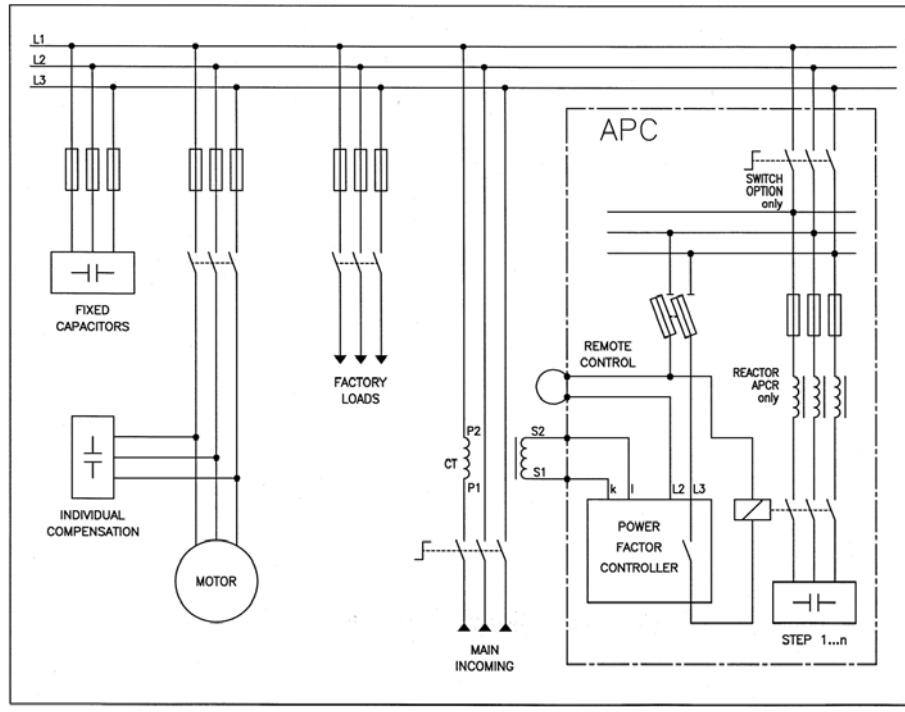

Figure 3.2. Electrical diagram

Regarding the standard wiring of the ABB controllers, the voltage reference for the controllers is taken from L2 and L3 phases and the current transformer is sited on the L1 phase.

If the current transformer is sited on another phase, it's useless to modify the voltage and current connections since the APC bank is provided with an ABB controller with automatic adaptation to network phase-rotation and CT terminals.

Master units are fitted with a power release contact which allows to remotely switch on and off the whole APC bank. Before installing this feature, disconnect the whole APC bank from the power supply. In the master unit, remove the connection wire (jumper) situated next to the gray CT jumper (see Figure 3.6.) in order to switch off the power supply phase L2 of the PF controller. Connect the cable for remote control in place of the considered jumper. Only when the contact is closed the PF controller is fed and the bank is switched on.

WARNING:	**hazard of electrical shock: be sure that the APC isolating switchgear is open before every manipulation. All units (master and slave) must be disconnected.**

3.4.2. Connection of several banks in parallel (master units or master unit + slave unit configuration)

Several banks can be connected in parallel. Each bank may consist of a single master unit or a master unit + slave unit configuration. Please note that to obtain higher ratings (kvar) we recommend a master unit + slave unit configuration.

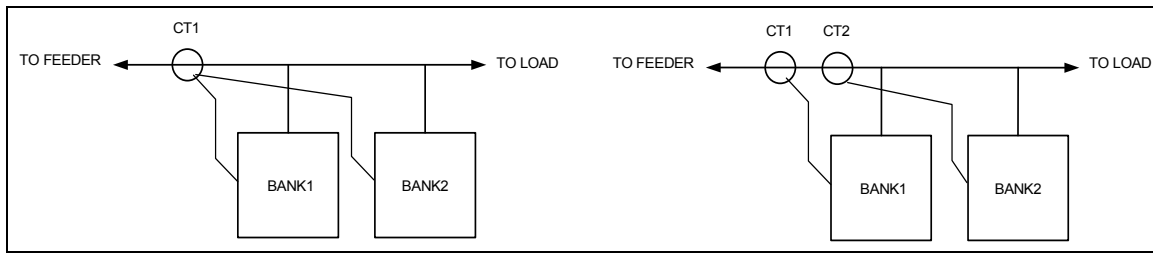

Figure 3.3. Connection of several banks in parallel

The switching delay time of each master unit must slightly differ from the other ones.
If the 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, …)
Note that each bank may include either a single master unit or a master unit plus a slave unit.

3.4.3. Power cables connection

When selecting the appropriate cable size due consideration should be given to possible future extension of the equipment. Cables and isolating switchgear should be rated at 1.5 times the nominal capacitor current of the total capacitor bank and should always be coordinated with the current rating of the back up fuses.

Cross section of supply cables

The different parameters like localization, temperature, etc… and other factors which may exist, do not allow to cover all the possible cases of installation and simple rules. The standards in force in the concerned country have to be taken into consideration keeping in mind that the current must be considered as a minimum 1.5 times the nominal current.

Master switch and fuses

At the location of the bank installation, the power of the network short-circuit must be taken into consideration to define the main connection fuses, or rating of the circuit breaker.

To disconnect the unit from the network, we suggest preferably a circuit breaker. A 3-phase disconnecting fuse or a 3-phase switch with fuses may nevertheless be used.

The apparatus should be chosen with a nominal current rating of minimum 1.5 times the rating of the capacitor bank.

It is to be noted however that the fuses, if any, must be calibrated to protect the cables and at least at 1.6 times the rating current of the capacitor bank.

3.4.3.1. APCL1 and APCL2 boxes

APCL1 and APCL2 are factory mounted with a bottom cable entry.
A knock out is provided for this purpose.

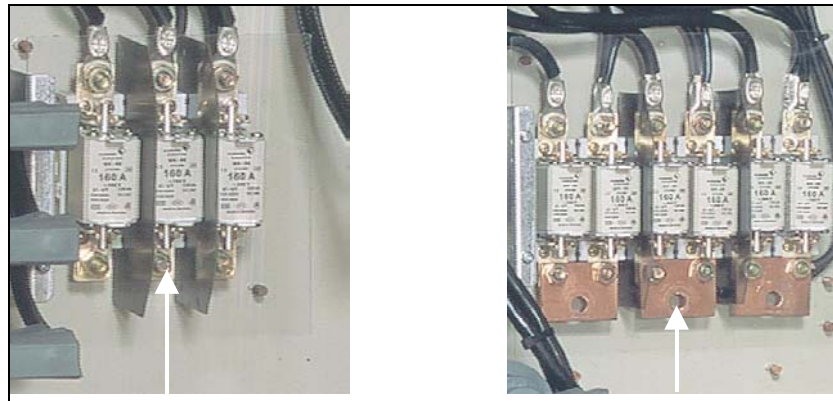

***Figure 3.4. P**ower cables connection to the incoming power terminals for boxes*

3.4.3.2. APCM1, APCM2 and APCR cubicles

The APCM and APCR cubicles are available in bottom or top cable entry. By default, the bottom cable entry is applied.
The plate at the bottom left of the cubicle is provided to allow cable entry (see Figure 3.1.) In case of top cable entry, use the two other plates at the top of the cubicle.
Run the power cable through a gland of a suitable diameter in order to keep the protection level of the cubicle.

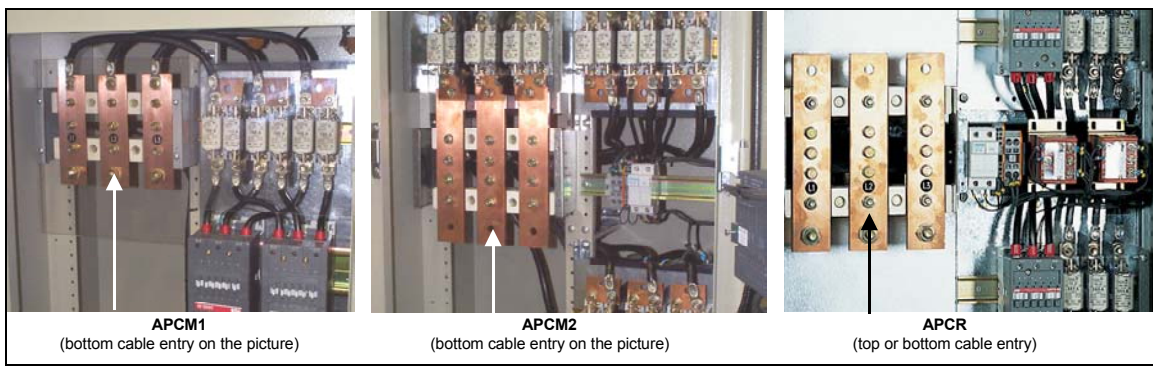

Figure 3.5. Power cables connection to the incoming power terminals for cubicles

3.4.4. Current transformer connection

Current transformers of Class 1 accuracy and appropriate burden with secondary current 5A will normally be used. In case CT and the automatic capacitors are close to each other a 5VA burden is sufficient if no other loads are connected to the CT.

- The current transformer must be sited in a position to monitor the total load (i.e. inductive load and capacitive load). This will normally be close to the incoming supply metering position. A range of ring and split core CTs exists on the market to ease installation.

- Current transformers are normally marked P1/P2 and S1/S2 and should be positioned so that P1 faces the incoming supply while P2 faces the load side.

- **Control wires from S1 terminal go to terminal marked k on the circuit diagram and from S2 to terminal marked l on the diagram. Once the connection is made, the shorting link (gray jumper) must be removed for proper operation.**

To easy guide control wires, a cable profile is fixed in each box.
Each cubicle has several base supports on its central frame to receive cable ties.

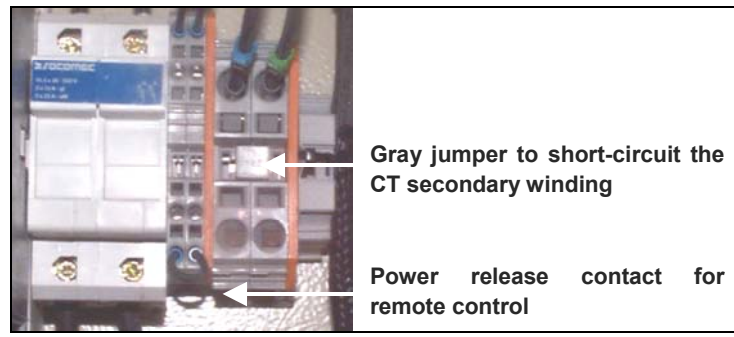

Figure 3.6. CT connection and release contact

- When a multi ratio split core C.T. is used the appropriate ratio is selected by connecting either S2 or S3 or S4 to terminal marked **l**. The C.T. ratio should be selected as near as possible to suit the supply loading.

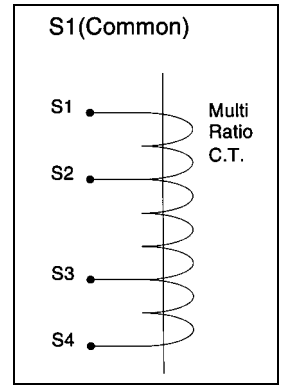

Figure 3.7. Multi ratio CT

- When a summation current transformer is used the terminal markings will usually be P1, P2, P3, P4 and S1, S2. The secondary connections S1 and S2 should be made to **k** and **l** respectively as before.

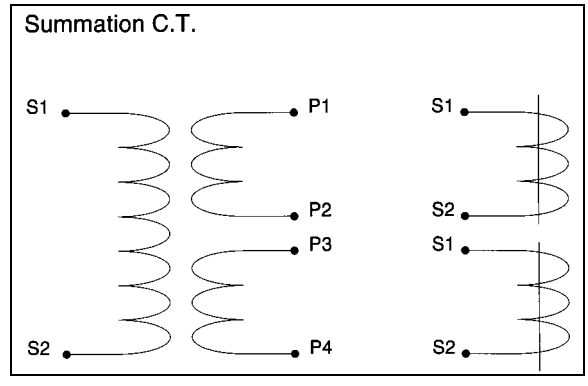

Figure 3.8. Summation CT

The first C.T. should be connected with S1 and S2 to P1 and P2 on the summation C.T. while the second C.T. should be connected with S1 and S2 to P3 and P4 on the summation C.T. It is important that all CTs monitor current in the same direction.

- When a summation C.T. is used or the CT monitors only part load (i.e. two cables per phase with the C.T. on one cable only) the total system current that gives 5A in the relay current coil is used to calculate relay setting.

3.4.5. Slave (AUX) to master (PIL) unit connection (for master unit + slave unit configuration)

In a master unit + slave unit configuration an interconnection cable must be installed between the units. This cable is factory wired in the slave unit and allows a full control of the slave unit from the master unit. Note that only one slave unit can be added to each master unit and the slave unit must be of the same type (APCL2 with APCL2, APCM2 with APCM2 and APCR with APCR).

Please follow the below instruction carefully for proper connection:

- Free and unwind the interconnection cable that is temporally arranged in the bottom part of the slave unit. Take away the black grommet from the bottom plate of the enclosure. Beware the grommet shape is not symmetrical hence look at its orientation (and even tag it). Please refer to Step 1 and Step 2 on the figure below.

- Put the interconnection cable through the grommet then through the hole from which the grommet has been taken away. Refer to Step 3 on the figure below.

- Once the whole cable length is out of the units, replace the grommet to its initial position. Refer to Step 4 on the figure below.

- Depending on the installation and the type of capacitor bank, pass the cable below the enclosure or behind the plinth. Always follow good practice of electrical installation when installing the interconnection cable.

- In the master unit, take away the black grommet from the bottom plate. You will need again to put it back hence look at its orientation (and even tag it).

- Put the interconnection cable through the hole from which the grommet has been taken away then through the grommet.

- Once the whole cable length is inside the enclosure, put the grommet back to its initial position.

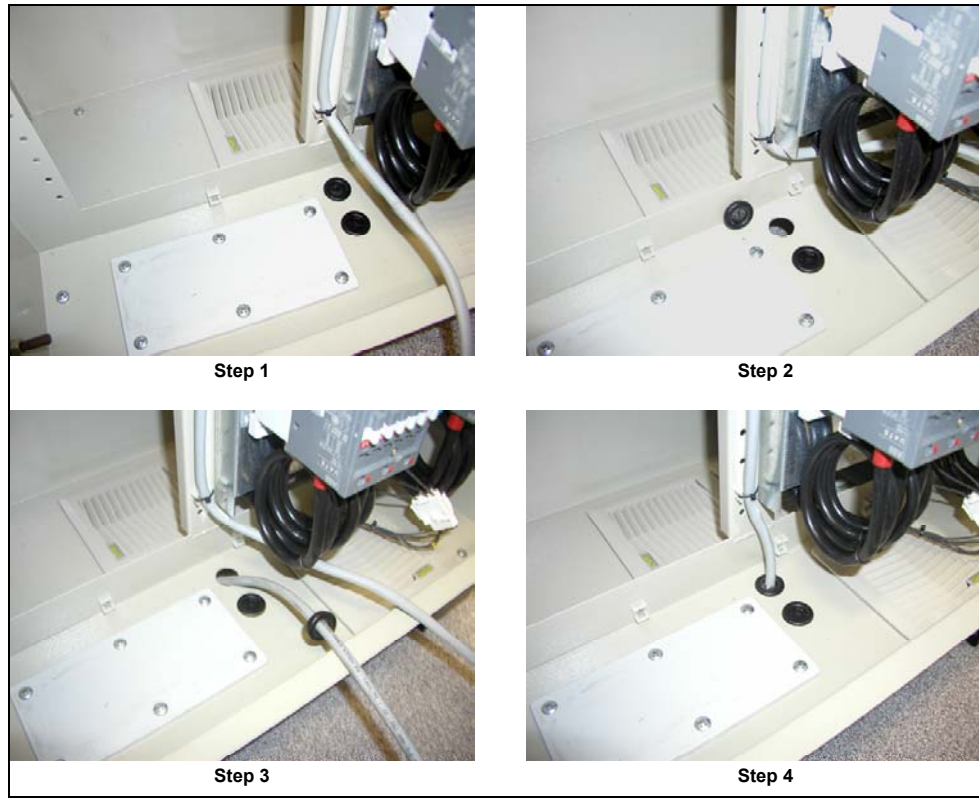

Figure 3.9. Slave to master unit connection

Depending on the type of the bank, pass the cable inside the right hand side raceway (APCL2 and APCR) or fix it along the central plate (APCM2). Please refer to Figure 3.10.

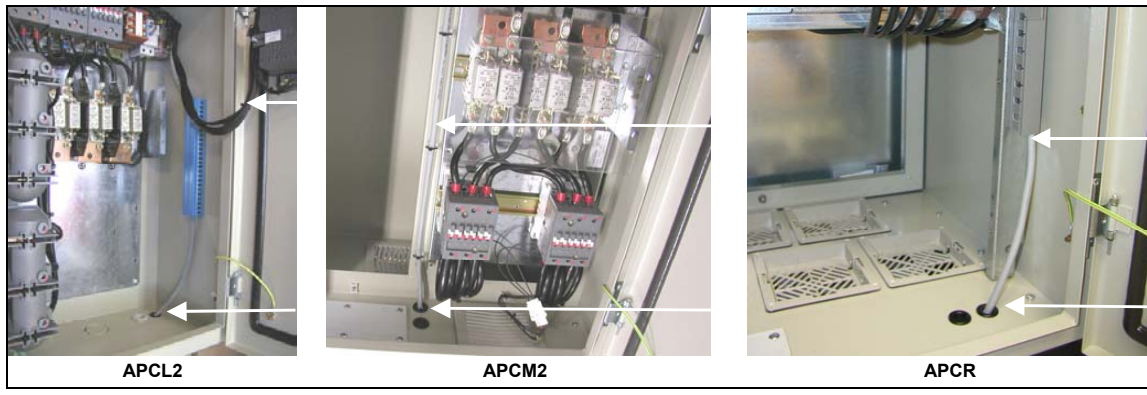

Figure 3.10. Interconnection cable location

3.4.5.1. Master (PIL) APCL2 wiring

The cable is divided in three main parts: the DC supply for the fan (to DC supply unit), the step control (to the PF controller) and special features (to a dedicated terminal).

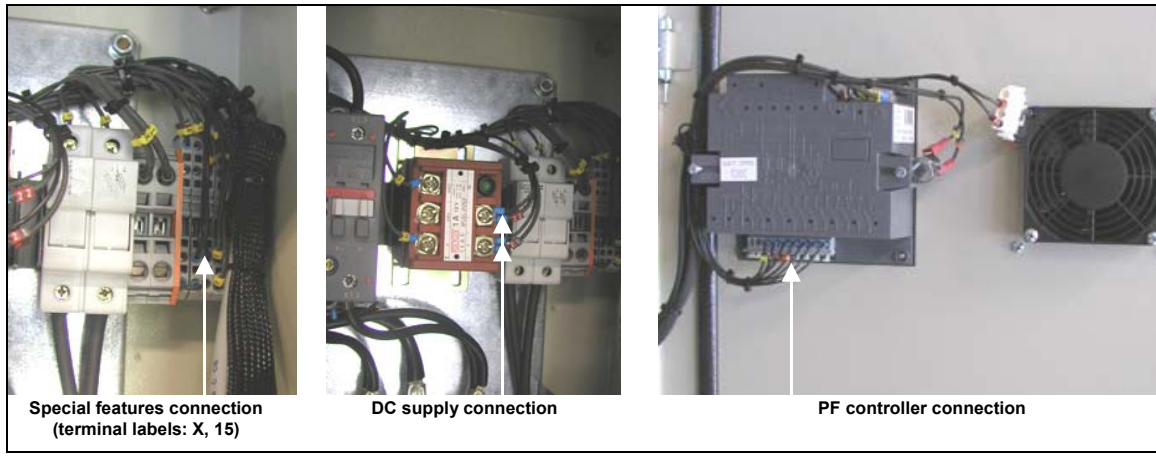

Figure 3.11. Master APCL2 wiring

Please revert to the schematic diagrams fitted with the bank for exact label of the wires.

3.4.5.2. Master (PIL) APCM2 wiring

The cable is divided in two main parts: the step control (to the PF controller) and special features (to a dedicated terminal).

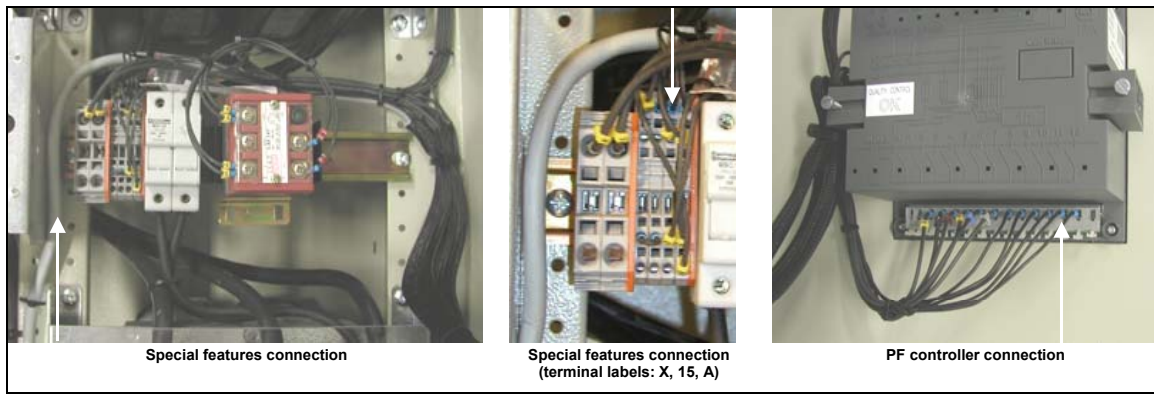

Figure 3.12. Master APCM2 wiring

Please revert to the schematic diagrams fitted with the bank for exact label of the wires.

3.4.5.3. Master (PIL) APCR wiring

The cable is divided in two main parts: the step control (to the PF controller) and special features (to a dedicated terminal).

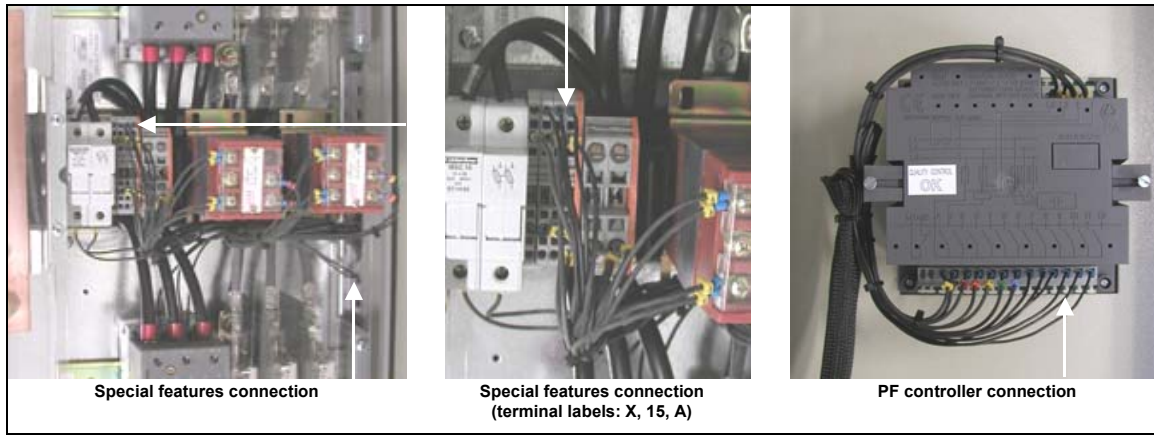

Figure 3.13. Master APCR wiring

Please revert to the schematic diagrams fitted with the bank for exact labels of the wires.
After wiring, please check that the cable is properly fixed in the bank.

3.4.6. Earth connection

The APCL earth connections are made by means of a stud (∅ M6). This one is welded inside the APCL in the lower right corner. The door is already connected to this stud. It only remains to connect the earth wire if the power cable is fitted with it. For the APCM and APCR, the earth connection can be made by means of one of the two stud (∅ M8) located in the upper and lower left corners.

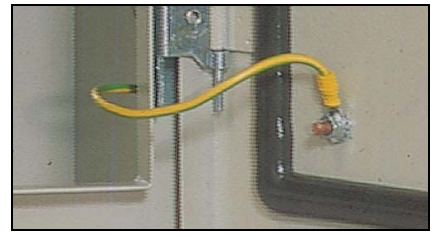

Figure 3.14. Earth connection

4. Easy commissioning

1. With the equipment isolated from the supply check tightness of all connections, earth bonding, fuses, free movement of contactors.

2. Check that the requirements for the cable cross section and the fuses are respected with regard to the total bank power.

3. Check that the C.T. is properly located on line L1 i.e. the only line where the PF Controller voltage is not taken (The PF Controller should be connected between L2 and L3).

4. Remove the C.T. short circuit by opening or removing the bridge of the C.T. wire connector (inside the bank).

Note: The APC is normally equipped with an RVC controller. To carry on with this commissioning, follow the points below. If your APC is equipped with an optional RVT, refer to RVT instruction manual and don't follow the points below.

5. Switch the voltage on.
   After a power outage, the reset delay time is 40 seconds. During this delay time, the alarm icon blinks and the alarm contact remains closed.

Check that all the fans are in good working order.
If it's not working properly, refer to the Chapter 5. Troubleshooting.

6. **RVC Power Factor Controller auto setting.**

WARNING: if several units are connected in parallel, please refer to 3.4.2.

WARNING: for automatic capacitor banks with a switching delay time greater than 40s., set delay time before starting Autoset.

In this case, refer to RVC Instruction Manual chapter 11.

Activate the AUTO SET Mode by pressing twice the Mode button. "AU" appears on the LCD display.

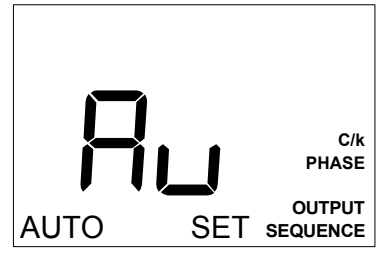

Figure 4.1. View of the Autoset mode in RVC

Press the + button once in order to make only appear C/k and phase parameters, output and sequence have been already set in factory.

Press the + and – buttons simultaneously to start the automatic setting.
"AU" starts flashing. C/k and phase parameters are automatically set.

If an error is detected, the Autoset procedure is stopped and an error message is displayed.
In this case, refer to the RVC Instruction Manual chapter 13 for a complete description of error messages and solutions.

7. Setting of the target cos φ

Press the Mode button once to activate the manual setting of the target cos φ.
The already programmed value is displayed. If the RVC has never been programmed before, *1.00* appears on the LCD display.

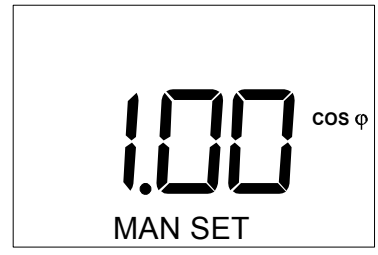

Figure 4.2. View of the target cos φ setting

Set your target cos φ by pressing either the – or + button.

indicates an inductive PF and indicates a capacitive PF.

8. Reactivate the AUTO Mode by pressing the mode button repeatedly.

During this procedure, the values of the parameters automatically set in the previous step will be displayed.
Once in AUTO Mode, the RVC automatically switches on the necessary steps to reach the programmed target cos φ.

The actual cos φ appears on the LCD display.

Note: a negative cos φ indicates that the load is re-injecting reactive power on the network. The RVC continues to work normally.

Important notice
The minimum value of the switching delay time between the APC steps is 40sec.
If this delay time has been manually modified and is lower than 40 sec., there is a hazard of equipment damage. This will void the guaranty.

4.1. Front view

A. LCD display

1. Activated outputs
2. Inductive PF
3. Capacitive PF
4. Undercompensation alarm
5. Overtemperature indication
6. Demand for switching on or off capacitor steps
7. Numerical display
8. Programmable parameters
9. Modes
10. Special features icons

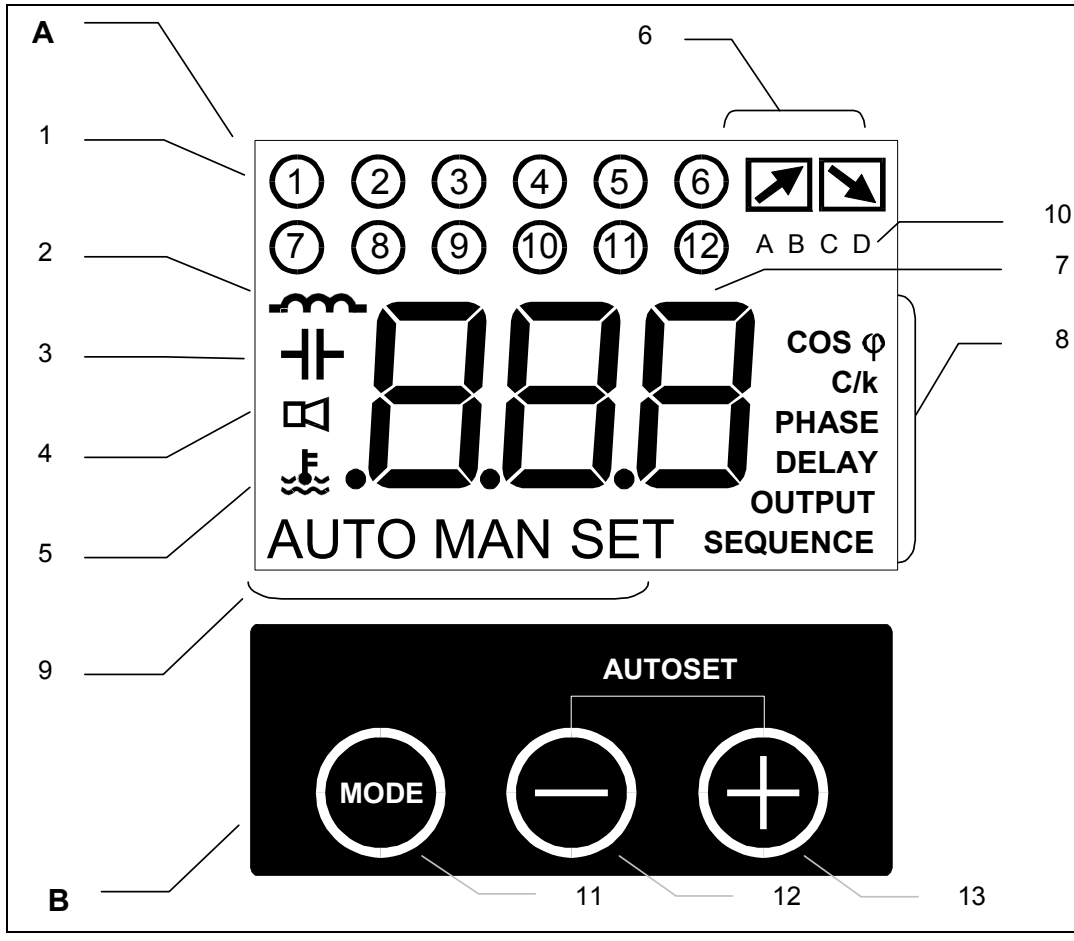

Figure 4.3. LCD display of the RVC

B. Keypad

11. Mode button
12. – button
13. + button

4.2. Rear view

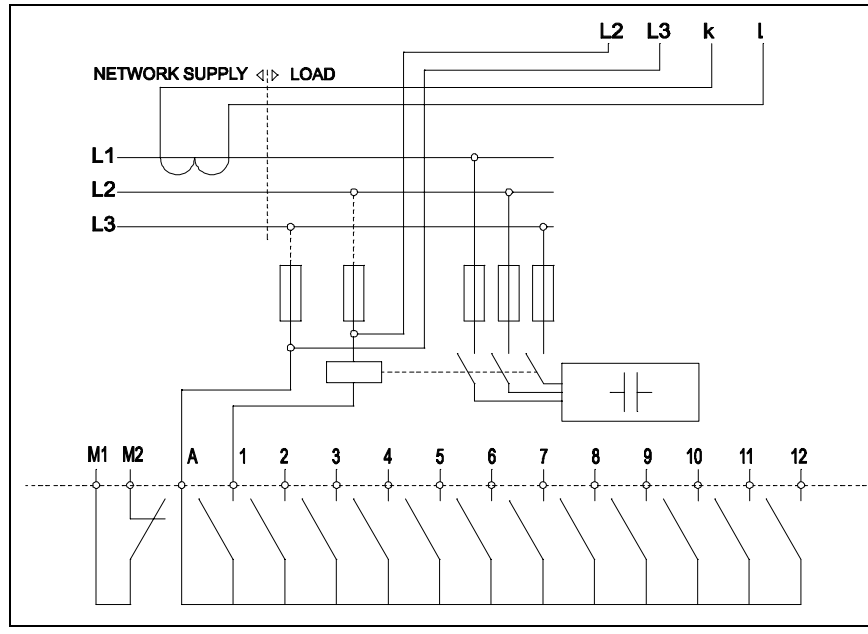

Figure 4.4. Rear view of the RVC

k, l:	leads of the current transformer
L2, L3:	2 of the 3 phases (not monitored by the CT)
M1, M2:	leads of the normally closed contact
A:	output relay common source
1-12:	outputs

5. Troubleshooting

Most of the APC operating problems may be detected thanks to the controller.
Refer to the troubleshooting paragraph of the controller instruction manual.

If the controller is connected but doesn't display anything, check the voltage presence to its leads.
If there is no voltage, this may be explained by:

- a discontinuity of the circuit (check the wiring, fuses, etc…)
- an overtemperature of 60°C having caused the opening of the temperature probe and thus the power supply cut off. This overtemperature may be due to an ambient temperature upper to the maximum allowed temperature.
- a ventilation system as well as a defective temperature probe causing the RVC power supply cut off at 85°C.
- a defective temperature probe opening without overtemperature.

6. Maintenance

Ensure safety procedures are completed as earlier stated.

6.1. APC maintenance

Your capacitors are an investment, protect them by regular maintenance.

Annual maintenance should include:
- Remove dust deposits, clean all parts, paint metalwork as required;
- Check fuse condition;
- Check contactor condition and operation – replace as necessary;
- Check isolator connections and operation;
- Check operation of PF Controller;
- Check ambient temperature and equipment ventilation;
- The cleaning of the entry grid is to be checked regularly, the frequency of controls are under end-user's responsibility.

Check that ventilation grids are obstructed by neither dust, nor any extraneous body.

6.2. APCR capacitors module replacement

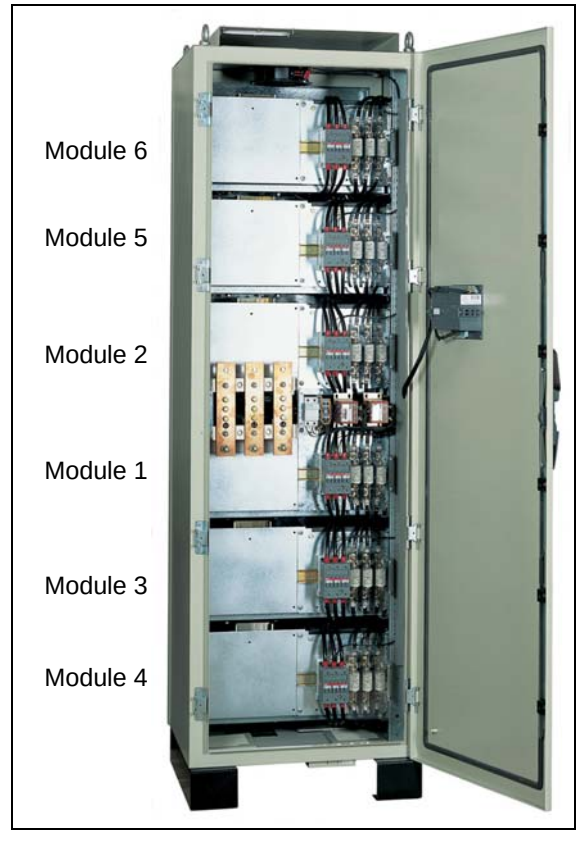

Figure 6.1. APCR 300kvar module 4 replacement

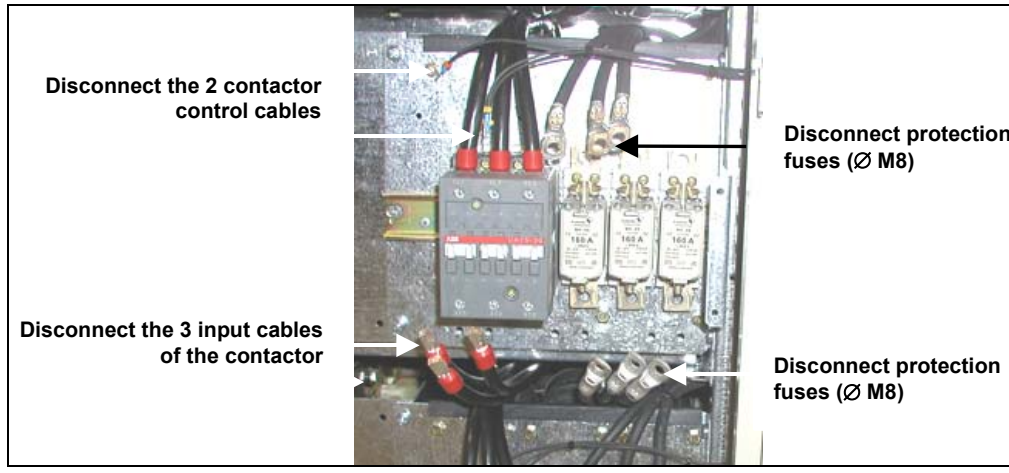

Figure 6.2. Disconnection of the contactor and the protection fuses

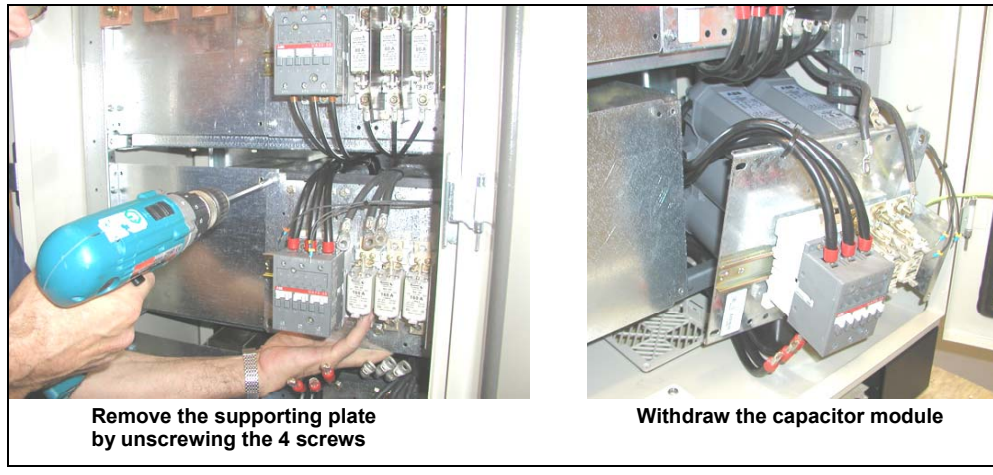

Figure 6.3. Removal of the capacitor module

6.3. Access to reactors

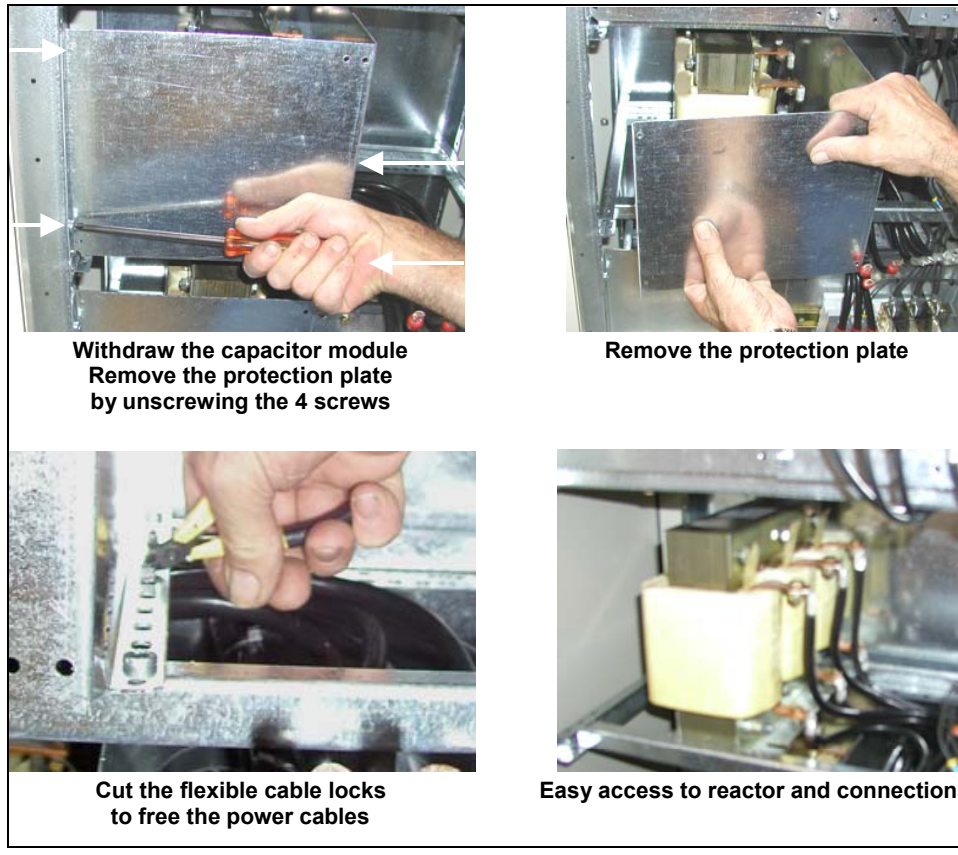

Figure 6.4. Access to reactors

7. Appendices

7.1. Technical specifications

Nominal voltage and frequency:
230, 400V – 50Hz (standard range),
240, 480V – 60Hz (standard range),
400V – 50Hz (reinforced range rated at 474 V),
400, 415, 525, 690V – 50Hz (de-tuned capacitor bank),
240, 380, 480, 600V – 60Hz (de-tuned capacitor bank).

Connection:
Three phase.

Configuration:
APCL1 & APCM1: master unit only.
APCL2, APCM2 & APCR: master and slave units.
Slave units are not equipped with PF controller but are fitted with an interconnection cable.

Power factor setting:
From 0.7 inductive to 0.7 capacitive.

Starting current setting (C/k):
From 0.05 A to 1 A for the RVC controller.
From 0.01 A to 5 A for the RVT controller (optional for the APCM1, APCM2 and APCR).

Operation:
Automatic or manual setting of the controller with indication of:
- The number of active outputs.
- The inductive or capacitive power factor.
- Alarm conditions.
- Overtemperature.
- Demand for switching on/off a capacitor step.
- Overvoltage and undervoltage protection.

Losses:
Dielectric losses: less than 0.2 Watt/kvar.
Capacitor total losses: less than 0.5 Watt/kvar (discharge resistors included).
Automatic bank total losses at 400 V 50 Hz:
- without reactors: less than 1.5 Watt/kvar (including accessories losses),
- with reactors: less than 5.5 Watt/kvar (including accessories losses).

Capacitors:
Dry type self-healing according to EN 60831-1&2.
Voltage test: 2.15 * Un between terminals during 10 s. at rated frequency (above EN 60831-1&2).
Acceptable overloads:
- Overvoltage tolerance: 10% max. intermittently.
- Overcurrent tolerance: 30% permanently.

Temperature range: -25°C / class D according to IEC 60831-1&2.

Reactors:
- Type: dry type resin embedded according to IEC 289, IEC 76
- Maximal harmonic voltage distortion:
  U_3/U_1 = 0.5 % U_5/U_1 = 6.0 %
  U_7/U_1 = 5.0 % U_{11}/U_1 = 3.5 %
  U_{13}/U_1 = 3.0 % (not exceeding a THDU of 8 %).

The automatic capacitor bank complies with EN 61921.

Automatic capacitor bank tests:
- Insulation test
- Functional test

CE Marked

Protection:
IP23D (closed door).
Protected against direct and accidental contacts (open door).

Execution:
Indoor.

Colour:
Beige RAL 7032.

Ambient temperature:
-5°C/+40°C according to EN 61921.

Ventilation:
- Natural for the APCL1.
- Forced for the APCL2, APCM1, APCM2 and APCR. (temperature-dependent speed controlled fans).

Installation:
Box:
- Wall mounting (fixation brackets included).
- Bottom cable entry.

Cubicle:
- Floor fixation.
- Equipped with a plinth.
- Lifting lugs provided.
- Top or bottom cable entry.

Slave units have to be connected to the master unit.

Important notice:
The installation of capacitors on networks disturbed by harmonics may require special precautions especially when there is a risk of resonance.

7.2. Dimensions and weights

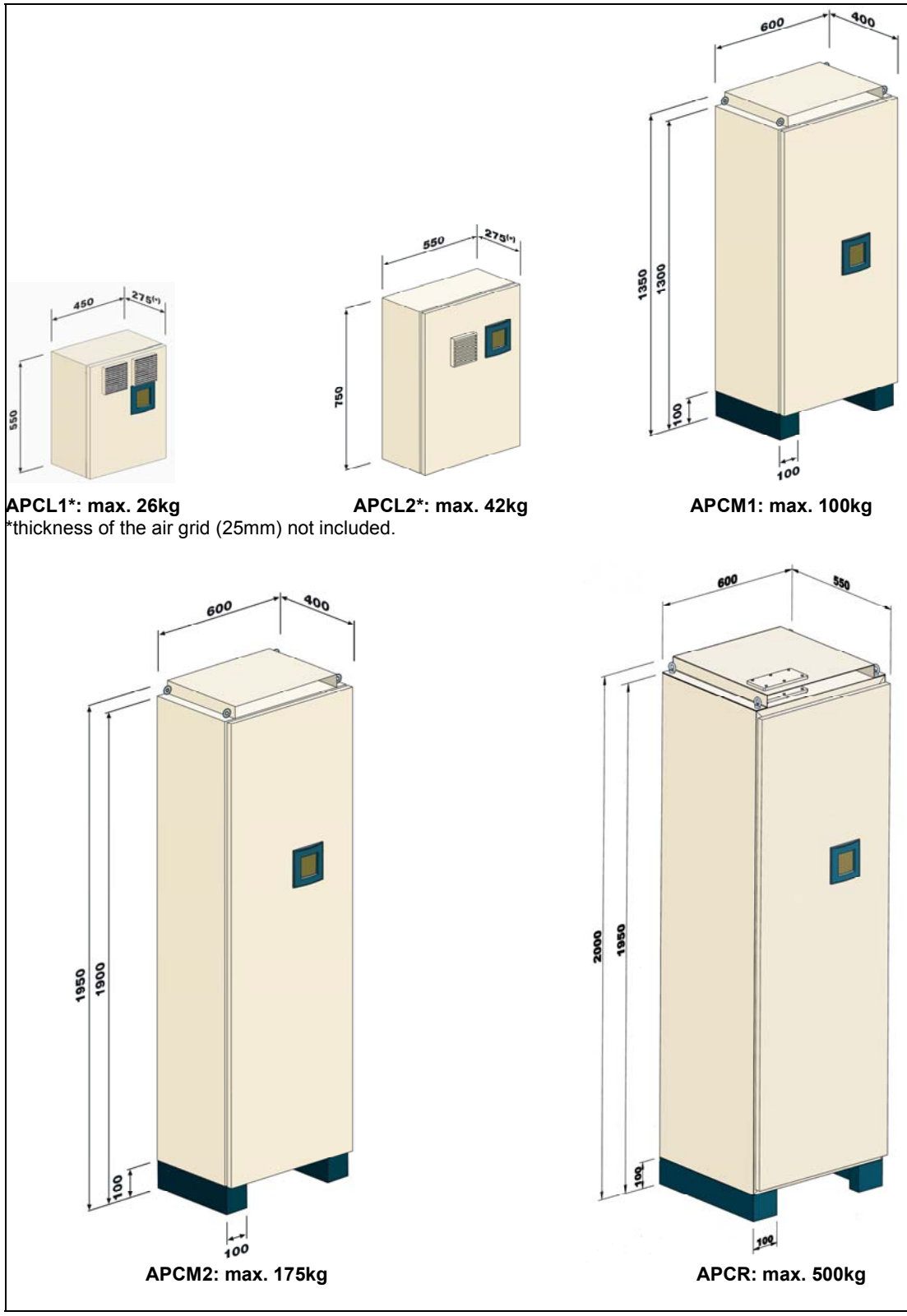

Figure 7.1. APC dimensions and weights

Asea Brown Boveri Jumet S.A.
Zoning Industriel de Jumet
B-6040 Charleroi, Belgium
Phone: +32 71 250 811
Fax: +32 71 344 007

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