# Panelbuilder

Power Factor Correction products

a brand of Schneider Electric

Merlin Gerin

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# Specialists in power factor correction

## Applying power factor capacitors in switchboards is relatively straight forward, provided some simple guidelines are followed. In order to provide reliable, cost-effective solutions, the following design issues must be considered:

**Types of automatic power factor correction:**

Automatic Power Factor correction equipment is divided into three major categories:

- **Standard** = Capacitor + Fuse + Contactor + Controller
- **Detuned** = Capacitor + Detuning Reactor + Fuse + Contactor + Controller
- **Filtered** = Capacitor + Filter Reactor + Fuse + Contactor + Controller

The choice of equipment is dependent upon the nature of the loads on the same network as the power factor correction equipment. Specifically, if there are harmonic generating (i.e. non-linear or 'electronic') loads on the network on which the PFC equipment is applied, then detuned or filtered equipment will be required.

**Effect of Harmonics on power factor capacitors**

Harmonics are a natural by-product of the manner in which modern-day electronic loads draw current. Harmonic currents effect capacitors in several ways:

- Capacitors naturally absorb harmonic currents, leading to premature failure
- Harmonic voltage distortion can exceed the capacitor dielectric rating
- Capacitors without detuning reactors form a 'tank circuit' with the distribution network impedance that can cause harmonic amplification (i.e. resonance) which can lead to nuisance fuse operation, breaker tripping and/or capacitor failure

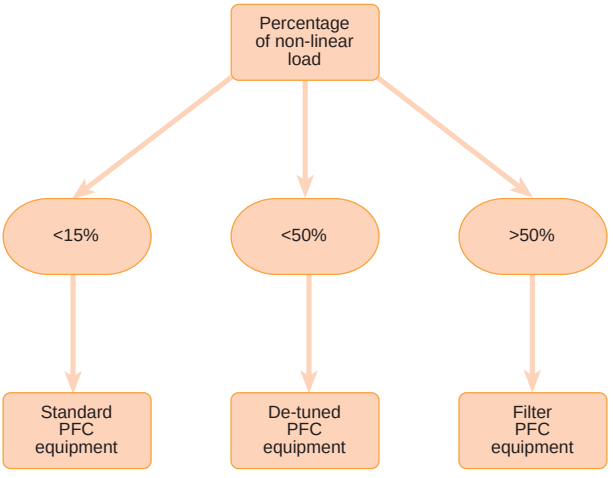
As a general rule of thumb, if the amount of non-linear load compared to the total connected load exceeds 15%, detuning reactors must be used. E.g. If the distribution transformer is rated 1500kVA, and there are 1000kVA of connected load of which 200kVA is variable speed drives, then there is 20% non-linear load and detuned power factor correction is required.

The panel builder however, does not always know what percentage of non-linear loads is on the customer's network. In such cases, it is always safest to apply detuning reactors ahead of capacitors to avoid potential problems now, or in the future, caused by harmonic currents. The inclusion of detuning reactors, even if they were not technically required, will not harm the network. Unfortunately, the opposite is not true.

**Specifying the correct dielectric voltage rating**

The longevity of a capacitor element is dependent upon two factors:

- Dielectric voltage rating
- Operating temperature class for the dielectric




The dielectric is the insulating medium between the two capacitor plates. The thickness of the film gives the capacitor its voltage withstand rating as well as its operating temperature class and is the essential specification to ensure capacitor longevity.

Despite European voltage regulation, the operating voltage common to the UK is predominantly 415V (rather than 400V) for low voltage connection. The minimum capacitor dielectric rating should therefore be 415V plus allowance for fluctuation in voltage. This means that a capacitor must have a dielectric voltage rating (i.e. it's maximum voltage rating) no less than 440V (415V + 6%) for the UK market.

Harmonic currents impose stress upon the capacitor dielectric that must be allowed for. If the amount of harmonic pollution is very low (less than 5%), then standard 440V dielectric rated capacitors can be used. Most electrical networks today do however contain levels of harmonic generating load that exceed 5%. In cases where the level of harmonic generating load exceeds 5% but is less than 15%, Merlin Gerin recommends a 470V dielectric if detuning reactors are not used. If the levels of harmonic generating load exceed 15%, detuning reactors must be used.

Detuning reactors impose a voltage rise across the capacitor generally between 4-7%. This voltage is added above the 440V maximum allowable for the network. Therefore, in applications in which detuning reactors are used, and the amount of non-linear load is less than 50%, 470V dielectric must be specified.

Finally, the longevity of a capacitor will depend upon maintaining its temperature class specification. IEC831 specifies temperature classifications for capacitors that relate to the temperature that the capacitor is operated within. While it is called 'ambient temperature', the term ambient applies to the temperature within the cubicle, not room temperature. The designer must take into account cooling considerations within the enclosure to ensure that ambient limits for the capacitors are not exceeded.

**Minimum dielectric voltage rating**

| | % Non-linear load | | |
|---|---|---|---|
| **Application** | **<5%** | **<15%** | **<50%** |
| **Standard** | 440V | 470V | - |
| **Detuned** | - | 470V | 470V |

**Note:** For applications with >50% non-linear load, filters will be required. In such cases consult Merlin Gerin for specific technical application support.

**Ambient air temperature (°C)**

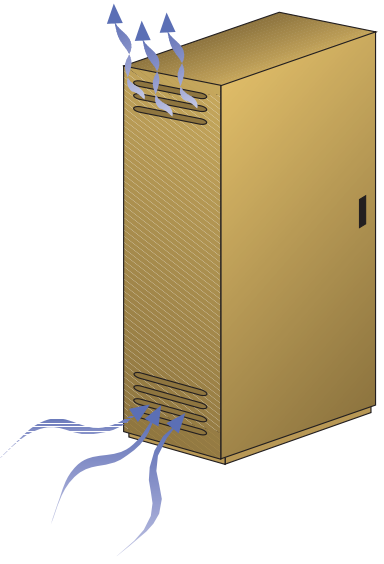
| Symbol | Maximum | Highest average over 24 hrs | Highest average over 1 year |
|---|---|---|---|
| **B** | 45 | 35 | 25 |
| **C** | 50 | 40 | 30 |
| **D** | 55 | 45 | 35 |

**Note:** Ambient temperature - temperature around the capacitor inside the bank, not the room temperature.

# Installing capacitors in a cubicle

## Cooling considerations

The longevity of a capacitor bank is dependent upon the maintenance of the maximum allowable temperature of the components. Capacitors, reactors, fuses and cables all generate heat that will result in a temperature rise within the cubicle above the ambient of the room. Capacitors are particularly susceptible to the effects of elevated temperature and should be maintained within IEC831 limits for their temperature class. See page 5.



Maintaining the required ambient temperature within the cubicle will entail calculating the heat rise from the component losses. There are generic software programs available that can calculate internal heat rise given variables for component watts loss, cubicle volume and maximum room ambient. In many cases, particularly when detuning reactors are employed, it will be necessary to add fans to force heat from the cubicle.

**In the absence of such software, the following guidelines apply if the following limits are respected:**

- Maximum room temperature 40°C (1 hour)
- Average maximum room temperature over 24 hrs: 35°C
- Average maximum room temperature over 1 year: 25°C
- For cubicles less than or equal to: H=2000mm, W=600/700/800mm, D=400/500mm
- Power is less than or equal to 400 kVAr per section

**Guidelines for standard PFC:**

- Assume 2.5W/kVAr for losses (includes capacitor, fuses, cables, contactors, etc)
- Air must be able to flow from bottom to top through cubicle
- Cross section of the outlet grill must exceed 1.1 x Inlet grill cross sectional area

**For IP ratings less than IP3X**

| Reactive power (Kvar at 400V - 50Hz) | Type of ventilation | Air inlet | Minimum air flow ($m^3$/hour) |
|---|---|---|---|
| **Power ≤100Kvar** | Natural | 200$cm^2$ | - |
| **Power from 100-200 Kvar** | Natural | 400$cm^2$ | - |
| **Power >200 Kvar** | Forced | - | 0.75 times power in Kvar |

**Note:** For IP ratings greater than IP3X, forced air cooling equal to 0.75 x kVAr rating is required for any power rating.

**Guidelines for detuned PFC:**

- Assume 8W/kVAr for losses (includes capacitor, reactors, fuses, cables, contactors, etc)
- Forced air cooling is always required
- Air must be able to flow from bottom to top through cubicle
- It is preferable that air be extracted from the top of the cubicle rather than injected at the bottom
- Cross section of the inlet grill must exceed 1.1 x outlet grill cross sectional area
- The REAL air flow ($m^3/h$) rating of the fan must include inlet and outlet grill pressure losses (consult fan manufacturer) and should be equal to at least 2 times the kVAr rating. For example,a 200kVAr bank will require >/= 400 $m^3/h$

**A note about fans**

Fan manufacturers usually rate their fans in $m^3/h$ in open air or at best, with only one inlet grill. The effective air movement (in $m^3/h$) is directly dependant upon the back pressure presented by fan inlet and outlet grills and possibly also internal component layout. All of these items present losses thus increasing the back pressure to the fan to reduce its effective air flow. Furthermore, as fan filters get dirty, their losses increase, thus decreasing the effective airflow. It is almost always necessary to specify a fan rating that will be larger than the calculated rating to account for input and output losses not accounted for in the manufacturers fan rating. It is recommended that the fan manufacturer be consulted for fan flow vs pressure curves.

## Component placement

- For functional plates placed in the horizontal plane, allow a minimum 50mm between plates to avoid mutual heating. Plates in the vertical plane can touch on all sides
- ALWAYS place detuning reactors above or to the side of capacitor plates. NEVER place detuning reactors below capacitors in order to avoid excessive heating of the capacitor

**Cable sizing**

In addition to carrying current to components, cables also carry heat away from components. Proper cable rating is essential to avoid problems. Cables must be de-rated for grouping (touching) of conductors and ambient temperature (temperature within the bank). In addition, capacitor banks will absorb harmonic currents that cause additional heating in the cables above and beyond the normal fundamental (50hz) component. Taking all these factors into account, Merlin Gerin recommends as a minimum, the cable sizes shown below.

**Cable size $mm^2$**

Based on 105°C tri-rated cable

| | kVAr rating | | |
|---|---|---|---|
| **Application** | **25** | **50** | **100** |
| **Standard** | 25 | 35 | 50 |
| **Detuned** | 35 | 50 | 70 |

**Note:** Based upon 3 conductors touching in 55°C ambient.

# Optimising equipment designs

## Economic sizing

Most specifiers stipulate a total power for the capacitor bank and a minimum step size. For example, they will specify 250 kVAr in 50 kVAr stages. Most panel builders will interpret this to mean that 5 x 50 kVAr stages are required.

The essence of the specification is to achieve the final maximum output power using a finite minimum step resolution that can track changes in the customers' loads. There are a number of ways in which these two constraints can be achieved, with one being more economical to build than the others.

All modern power factor controllers allow for switching combinations other than 1:1:1:1… (i.e 5 x 50 kVAr stages uses linear 1:1… switching). By employing the controller's features, the same switching can be achieved using fewer components. For example, using a binary 1:2:2 step function in the example above would require only 1 x 50 kVAr + 2 x 100 kVAr stages resulting in fewer components, less construction and wiring time and frequently, less cost all with no degradation in performance.

**1:1:1:1:1**
All the steps have the same power

**1:1:2:2:2**
The first two stages have the same power, from stage 3 the power is doubled

**1:1:2:3:3**
The first two stages have the same power, stage 3 has double the power and from stage 4 the power is tripled

**250 kVAr using binary switching (e.g. 1:2:2)**

| Bank step | kVAr output | Stage 1 50kVAr | Stage 2 100kVAr | Stage 3 100kVAr |
|---|---|---|---|---|
| 1 | 50 | ■ | □ | □ |
| 2 | 100 | □ | ■ | □ |
| 3 | 150 | ■ | ■ | □ |
| 4 | 200 | □ | ■ | ■ |
| 5 | 250 | ■ | ■ | ■ |

**250 kVAr not using binary switching (e.g. 1:1:1:1:1)**

| Bank step | kVAr output | Stage 1 50kVAr | Stage 2 50kVAr | Stage 3 50kVAr | Stage 4 50kVAr | Stage 5 50kVAr |
|---|---|---|---|---|---|---|
| 1 | 50 | ■ | □ | □ | □ | □ |
| 2 | 100 | □ | ■ | □ | □ | □ |
| 3 | 150 | ■ | ■ | □ | □ | □ |
| 4 | 200 | □ | ■ | ■ | ■ | □ |
| 5 | 250 | ■ | ■ | ■ | ■ | ■ |

■ = Contactor closed □ = Contactor open

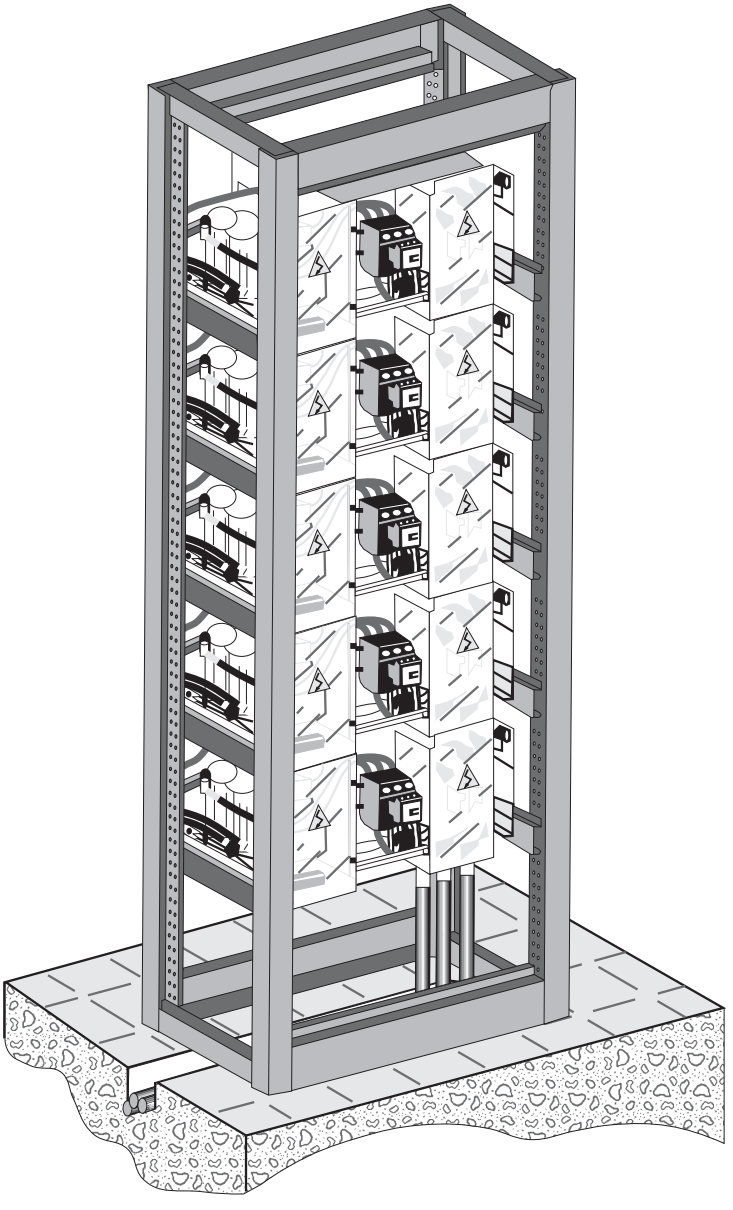
Utilising the binary switching option on modern PFC controllers allows the same stage resolution with fewer contacts, fuses and less manufacturing time.

# Functional plates for building complete banks

## P400DR

Example of the new P400DR functional plate.

The modular P400DR installs simply and easily into 700mm and 800mm wide, 400D panels.



# Functional plates for detuned power factor correction banks

## For use in applications with up to 50% non-linear loads

### 470V rated dielectric, IP2X

P400 DR power factor correction module

The new P400DR detuned functional plate is a breakthrough in panel builder power factor correction offers. This functional offer is a complete 470V detuned functional plate and includes a 470V rated capacitor, Telemecanique LC1D.K capacitor rated contactor with 230V coil and DIN fuse on a 570mm width functional plate, complete with overtemperature protection, busbars and IP2X shielding. This plate is suitable for use in enclosures at least 700W x 400D.

This plate is specifically designed to save valuable time and component cost while providing the best possible protection for its components. Each plate includes its own busbar assembly. Connection between plates is accomplished with a simple bus bar clamping splice kit (included). Plates are assembled on a tray with integral mounting channels. The panel builder mounts the channels into the panel board frame and the entire assembly simply slides in after. Assembly time is dramatically reduced. Each stage contains uncompromised protection features: In addition to the patented HQ capacitor protection system associated with every Varplus capacitor, each reactor includes a temperature sensor which opens the contactor on its stage if that stage should overheat.

**Technical Data**

- Capacitor rated voltage: 470V, three phase 50Hz
- Tuning order: 3.8 - 4.2 (190Hz - 210Hz)
- Maximum permissible current: 1.27 In (400V)
- Maximum permissible voltage (8 hours over 24 hours as IEC 831): 517V
- Degree of protection: IP20 front face
- Standard: IEC 439-1, EN 60439-1

**Installation**

- Horizontal mounting:
  - In 700 and 800mm wide cubicles depth: 400mm
- Fastened to cubicle columns using fastening cross members
- Vertical distance between plates: 55mm minimum
- Control circuit power supply: 230V, 50Hz
- Ventilation compulsory see ‘guide for P400 DR power factor correction modules’
- Maximum of 250 kVAr per vertical stack

**Note:** Each module is delivered with 2 fastening cross-members for mounting in 400 and 500mm deep cubicles and fishplates for parallel connection modules.

**470V detuned switched functional plate (IP2X)**

More than 15%, but less than 50% non-linear load

| 400/415V 50Hz kVAr | Style | Tuning frequency | In (A) | Reference |
|---|---|---|---|---|
| 25 | DR | 190 | 36 | **52786** |
| 50 | DR | 190 | 72 | **52787** |
| **400/415V 50Hz kVAr** | **Style** | **Tuning frequency** | **In (A)** | **Reference** |
| **4.2 tuning (210Hz)** | | | | |
| 25 | DR | 210 | 36 | **52789** |
| 50 | DR | 210 | 72 | **52790** |

Coil voltage = 230V, fuses = DIN.

## Bank kit selection guide

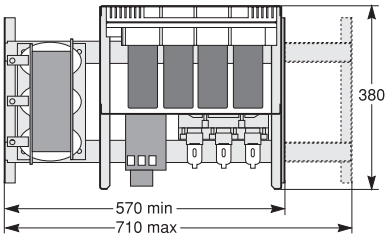
Merlin Gerin has constructed an easy method to order a complete kit of major components to construct an entire detuned power factor correction bank. A kit would comprise of the required number of detuned capacitor plates and a Varlogic controller to construct a bank in the total power shown.

**Recommended components to construct an entire detuned capacitor bank***

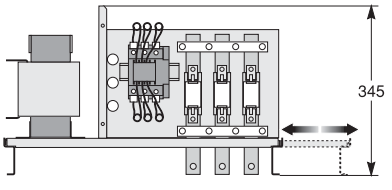
190Hz detuned functional plates plus a relay for applications <50% non-linear load

| Bank (step) kVAr rating | Functional plate reference and number of plates required | | Controller reference |
|---|---|---|---|
| | 52786 | 52787 | 52448 |
| 50 (25) | 2 | | ■ |
| 75 (25) | 1 | 1 | ■ |
| 100 (25) | 2 | 1 | ■ |
| 125 (25) | 1 | 2 | ■ |
| 150 (25) | 2 | 2 | ■ |
| 175 (25) | 1 | 3 | ■ |
| 200 (25) | | 4 | ■ |
| 250 (50) | | 5 | ■ |
| 300 (50) | | 6 | ■ |
| 350 (50) | | 7 | ■ |
| 400 (50) | | 8 | ■ |
| 500 (50) | | 10 | ■ |

**Note:** * Requires 400D panel (minimum), maximum 250kVAr per column.
(1) 50kVAr stages cascaded to give 100kVAr steps.




P400 DR module dimensions
(Cubicle depth, 400 or 500mm)



# Functional plates for standard power factor correction banks

## For use in applications with up to 15% non-linear loads

### 470V rated dielectric, IP2X

For applications in which there is up to 15% harmonic generating load, Merlin Gerin offers the style 'D' P400 functional plate. This functional plate is a complete 470V rated capacitor, Telemecanique LC1D.K capacitor rated contactor with 230V coil and DIN fuse on a 575 width functional plate, suitable for use in enclosures 600W x 400D (minimum).

**470V dielectric delta switched functional plate (IP2X)**

For use in applications with less than 15% non-linear load

| 400/415V 50Hz kVAr | Style | Number of stages | In (A) | Reference |
|---|---|---|---|---|
| 25 | D | 1 | 36 | **52779** |
| 25+25 | D | 2 | 72 | **52777** |
| 50 | D | 1 | 72 | **52780** |
| 25+50 | D | 2 | 104 | **52778** |
| 75 | D | 1 | 104 | **52781** |

Coil voltage = 230V, fuses = DIN.

**Technical Data**

- Capacitor rated voltage: 470V +10%, three phase, 50 Hz
- Capacitor tolerance: 0, +10
- Insulation level: 660V
- Withstand 50 Hz: 1 min: 2.5 kV
- Maximum permissible current: 1.5 In (400V)
- Maximum permissible voltage (8 hours over 24 hours as in IEC 831): 517V
- Temperature class (-25/D):
  - Maximum temperature: 55°C
  - Maximum average temperature over 24hrs: 45°C
  - Maximum average annual temperature: 35°C
- Degree of protection: IP2X front face
- Colour: (front face) RAL 9002

**Installation**

- Vertical mounting: 600mm wide cubicle
- Support short edge of plate on suitable cross rails
- Vertical distance between plate: 0 mm (may be touching). Note: for horizontal mounting, allow 55mm (min) between plates to allow for proper heat dissipation
- Control circuit power supply: 230V/50 Hz
- Connection via cable

## Bank kit selection guide

Merlin Gerin has constructed an easy method to order a complete kit of major components to construct an entire detuned power factor correction bank. A kit would comprise of the required number of detuned capacitor plates and a Varlogic controller to construct a bank in the total power shown.

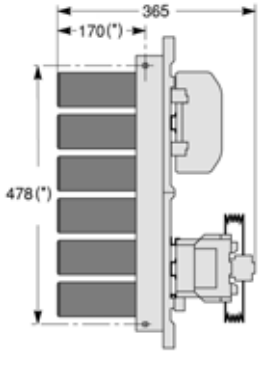
**Recommended components to construct an entire detuned capacitor bank***

190Hz dielectric delta switch functional plates plus a relay for applications <15% non-linear load

| Bank (step) Kvar rating | Functional plate reference and number of plates required | | | Controller reference | |
|---|---|---|---|---|---|
| | 52777 | 52778 | 52781 | 52448 | 52449 |
| 50 (25) | 1 | | | ■ | |
| 75 (25) | | | 1 | ■ | |
| 100 (25) | 1 | 1 | | ■ | |
| 125 (25) | | 1 | 1 | ■ | |
| 150 (25) | | 3 | | ■ | |
| 175 (25) | | 2 | 1 | ■ | |
| 200 (25) | | 4 | | ■ | |
| 250 (50) | | 5 | | ■ | |
| 300 (50) | | 6 | | ■ | |
| 350 (50) | | 7 | | | ■ |
| 400 (100)[1] | | 8 | | ■ | □ |
| 500 (100)[1] | | 10 | | ■ | □ |

**Note:** * Requires 400D panel (minimum), maximum 250kVAr per column.
(1) 50kVAr stages cascaded to give 100kVAr steps.

■ Offered as standard
□ Optional (please consult Schneider Electric)




(*) Fixing point

P400 power factor correction modules

# Functional plates for standard or detuned power factor correction banks

## For use in standard PFC applications with up to 15% non-linear loads, or for use with detuning reactors in applications up to 50% non-linear loads.

### 470V rated dielectric, IP00

For applications in which the panel builder chooses to combine separate functional plates and reactors, the style 'A' plate is the solution. This functional plate is a complete 470V detuned-rated capacitor, Telemecanique LC1D.K capacitor rated contactor with 415V coil and DIN fuse on a 575 width functional plate, suitable for use in enclosures:

- 600W x 400D (style 'A' plate minimum)

**470V dielectric line switched functional plate (IP00)**

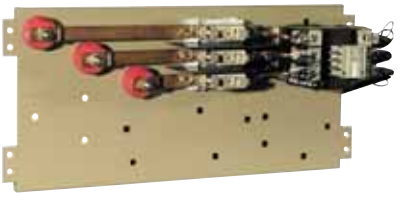
For use in applications with less than 15% non-linear load (<50% with detuning reactors

| 400/415V 50Hz kVAr | Style | Number of stages | In (A) | Reference |
|---|---|---|---|---|
| 25 | A | 1 | 36 | **51586** |
| 25+25 | A | 2 | 72 | **51589** |
| 50 | A | 1 | 72 | **51587** |

Coil voltage = 230V, fuses = DIN.

**Technical Data**

- Capacitor rated voltage: 470V +10%, three phase, 50 Hz
- Capacitor tolerance: 0, +10
- Insulation level: 660V
- Withstand 50 Hz: 1 min: 2.5 kV
- Maximum permissible current: 1.5 In (400V) (1.27 In with detuning reactors)
- Maximum permissible voltage (8 hours over 24 hours as in IEC 831): 517V
- Temperature class (-25/D):
  - Maximum temperature: 55ºC
  - Maximum average temperature over 24hrs: 45ºC
  - Maximum average annual temperature: 35ºC
- Degree of protection: IP00 front face
- Colour: painted sheet metal: RAL 7032



**Installation**

- Vertical mounting: 600mm wide cubicle
- Connection via vertical bus or cable
- Vertical distance between plate: 50mm
- Control circuit power supply: 415V/50 Hz

## Bank kit selection guide

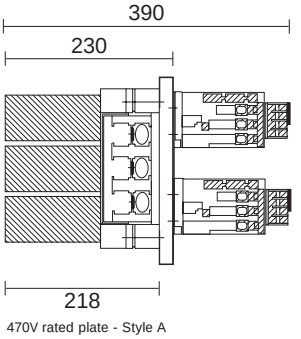
Merlin Gerin has constructed an easy method to order a complete kit of major components to construct an entire detuned power factor correction bank. A kit would comprise of the required number of detuned capacitor plates and a Varlogic controller to construct a bank in the total power shown.

**Recommended components to construct an entire detuned capacitor bank***

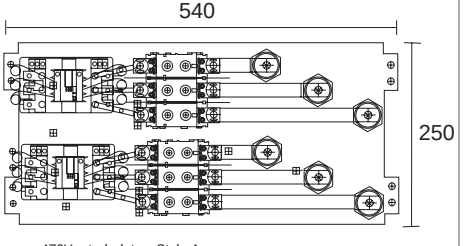
190Hz dielectric line switch functional plates plus a relay for applications <15% non-linear load

| Bank (step) Kvar rating | Functional plate reference and number of plates required | | | Controller reference |
|---|---|---|---|---|
| | 51586 | 51589 | 51587 | 52448 |
| 50 (25)[1] | | 1 | | ■ |
| 75 (25)[1] | 1 | | 1 | ■ |
| 100 (25)[1] | | 1 | 1 | ■ |
| 125 (25)[1] | 1 | | 2 | ■ |

**Note:** (1) Installs in 600W x 400D panel (minimum).




470V rated plate - Style A




470V rated plate - Style A

# Components for building complete banks

## Power factor relays

## Varplus M capacitors

## Contactors

## Detuning reactors

Varlogic NR6

Varlogic NR12

Varlogic RC12

# Varlogic power factor relays

The Varlogic power factor relay constantly measures the reactive power of the installation and energises dry contacts to connect or disconnect capacitor steps in order to reach the user-selected target power factor. Varlogic controllers simplify design, commissioning, monitoring and maintenance of automatic power factor equipment.

**Ordering references**

| Type | Number of step output contacts | Supply voltage (V) | Reference |
|---|---|---|---|
| **NR6** | 6 | 220/240 - 380/415 | **52448** |
| **NR12** | 12 | 220/240 | **52449** |
| **RC12** | 12 | 220/240 | **52403** |

**General data**

| | | |
|---|---|---|
| Accuracy: 2.5% | | |
| Operating temperature: 0...50°C | | |
| Standards: | EMC: | EM50082-2, EN5008-2, |
| | Electrical: | CEI664, VDE0110, IEC1010-1, EN61010-1 |
| Mounting: panel or 35mm DIN rail | | |
| Protection class: IP40 | | |
| Display: R6 type: 7 segment, R12 and RC12: 16 character | | |
| Alarm contact | | |
| Alarm message and reset | | |
| Phase to phase or phase to neutral voltage reference | | |
| Insensitive to Ct polarity | | |
| Insensitive to phase rotation | | |
| Current input: 5A class 1 | | |
| Minimum current input: R6 and R12 type: 0.18A, RC12 type: 0.036A | | |
| Potential free output contacts: 2A 400V AC, 2A 250V AC, 2A 120V AC | | |
| Automatic or manual C/K setting facility | | |
| Circular or linear switching | | |
| Step combinations: | 1:1:1:1:1, 1:2:2:2:2, 1:2:3:4:4, 1:1:2:2:2, 1:2:3:3:3, 1:2:4:4:4, 1:1:2:3:3 | |
| Generator application available on RC12 type | | |

**Display information**

| | | | NR6 | NR12 | RC12 |
|---|---|---|---|---|---|
| Cos ø | | | ■ | ■ | ■ |
| Connected steps | | | ■ | ■ | ■ |
| Period before switching | | | ■ | ■ | ■ |
| Step output contact configuration | | | | | ■ |
| Step output status (capacitance loss monitoring) | | | | | ■ |
| Load and reactive currents | | | | | ■ |
| Total harmonic distortion | | | | | ■ |
| Voltage, temperature, kW, kVA, kVAr, Irms/In (“expert” level) | | | | | ■ |
| Voltage harmonic spectrum (3rd, 5th, 7th. 11th and 13th orders) | | | | | ■ |
| **Alarms** | | | | | |
| Low power factor | | | ■ | ■ | ■ |
| Hunting | Unstable operation | | ■ | ■ | ■ |
| Abnormal Cos ø | <0.5 ind or 0.8 cap | | ■ | ■ | ■ |
| Overcompensation | | | ■ | ■ | ■ |
| Frequency not detected | +/- 1Hz | Correction stopped | ■ | | |
| during startup | +/- 2Hz | Correction stopped | | ■ | ■ |
| Overcurrent | >6A within 180s | | ■ | ■ | ■ |
| Voltage low | <0.8 input V within 1s | Disconnection (2) | ■ | ■ | ■ |
| Voltage high | > 1.2 input V within 60s | | ■ | ■ | |
| Overvoltage | > 1.2 input V within 60s | Disconnection (2) | | | ■ |
| | > 1.1 input V within 30s | Disconnection (2) | | | ■ |
| Over temperature | >35°C (1) | Fan contact | | | ■ |
| | >50°C (1) | Disconnection (2) | | | ■ |
| Total harmonic distortion | >7% within 120s (1) | | | | ■ |
| Current overload | >1.5 within 120s (1) | Disconnection (2) | | | ■ |
| Capacitor output low | High capacitance loss | | | | ■ |

**Note:** (1) Adjustable threshold.
(2) Capacitor steps are automatically re-connected after fault clearance and safety delay.

# Components for building functional plates

## Varplus M capacitors:

Varplus M capacitors cover a wide range of voltages (230V - 690V) and a wide range of power ratings, all from a limited number of references. Their technology relies on a self-healing metallised polypropylene film requiring no gas or liquid impregnation. The HQ (high quality) protection system built into each capacitor element guarantees operating safety. With its unique, patented design it has been used for more than a decade on several million elements.

- The HQ system provides protection against two types of faults encountered as capacitors approach the end of their services life. High current fault protection is provided by a fuse with a high breaking capacity, whereas low current fault protection is provided by the combination of an over pressure protection device with the HRC cartridge fuse
- Whatever the fault, pressure inside the capacitor element is always limited to a value far lower than the maximum admissible pressure
- In both cases, a standard HRC fuse is used to break the electrical circuit

**Technical Data**

- Capacitor Rated Voltage (Dielectric strength): 470V
- Capacitor tolerance: 0, +10%
- Insulation level:
  - 660V
  - Withstand 50Hz, 1 min: 6 kV
  - Impulse test withstand: 1.2/50uS: 25kV
- Maximum permissible current: 1.5 In (400V)
- Maximum permissible voltage (per IEC 831): 517V (470V dielectric, other ratings available)
- Internal discharge resistors: 50V 1 min per IEC 831
- Temperature class: -25 / D
- Degree of protection: IP00
- Losses: </= 0.5W/kVAr
- Standards: IEC 831 1/2, NF C 54-104, VDE 0560, Teil 41, CSA 22-2 No190, UL 810

**Installation**

- Mount in vertical plane as shown; never flat on its base

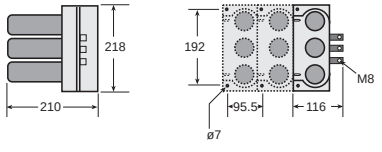
**Varplus capacitors - non-enclosed 470V dielectric**

| Rating (kVAr) | Consists of | Reference |
|---|---|---|
| **4** | (1) M1 | **52424** |
| **5** | (1) M1 | **52425** |
| **7.5** | (1) M1 | **52426** |
| **11** | (1) M1 | **52427** |
| **12.5** | (1) M1 | **52428** |
| **45** | (1) M4 | **52429** |
| **50** | (1) M4 | **52430** |

**Note:** kVAr rating at 415V 50Hz, other voltages available.

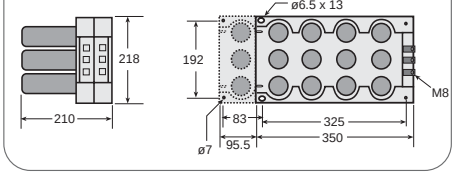
### Varplus M1

Varplus M1 capacitors can be configured as from one to four blocks connected together.




### Varplus M4

Varplus M4 capacitors can accept up to three additional M1 blocks to form a single block of capacitance.



## Telemecanique capacitor rated contactors

Telemecanique LC1D.K contactors were designed specifically for the demands of capacitor switching. Standard contactors must be de-rated for capacitive switching. In addition to proven durability, the LC1D.K contactor provides safety and reliability for the entire bank.

**Unique technology**
A patented resistive pre-charge circuit operates from an auxiliary set of contacts to pre-charge the capacitor element just prior to main contact closure. This circuit reduces damaging switching transients more effectively than air core inductors. Reducing switching transients lessens the chance of disrupting sensitive equipment such as variable frequency drives. Furthermore, the reduced inrush current helps to extend the life of the capacitor elements.

**Durability**
The LC1D.K contactor was specifically designed for the purpose of capacitor switching. As such, their durability is in excess of 300,000 operations at 400V.

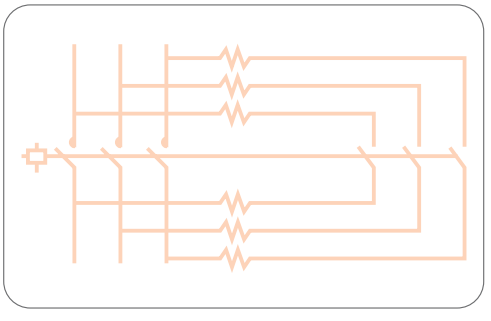
**Safety of personnel**
The LC1D.K contactors cannot be operated manually and are equipped with terminal covers to prevent accidental finger contact.

**Ordering references**

| Power rating at 415V 50Hz ø <50°C (kVAr) | Instantaneous auxiliary contacts NO | NC | Tightening torque on cable end (Nm) | Reference 415V coil | Reference 240V coil |
|---|---|---|---|---|---|
| 25 | 1 | 1 | 2.5 | **LC1DMK11N7** | **LCDMK11U7** |
| 50 | 1 | 2 | 9 | **LC1DMK12N7** | **LCDMK12U7** |
| 100 | 1 | 1 | 12 | **LC1D11N7** | **LCD115U7** |

**Technical data**

| | | |
|---|---|---|
| **Power ratings in the table below are given under the following conditions:** | | |
| **Switching peak current** | LC1-D.K | 200 In |
| **Maximum switching rate** | LC1-DMK | 240 operations per hour |
| | LC1-DWK, LC1-D115 | 100 operations per hour |
| **Electrical durability** | | 300,000 operations |
| **At normal load** | | 200,000 operations |



# Reactors for building detuned power factor correction banks

## Detuned reactors for use with 470V rated Style A plates

### 190Hz (3.8 tuning) & 210Hz (4.2 tuning) detuning reactors

For applications in which the panel builder chooses to combine separate functional plates and reactors, the reactors shown below are ideal. The reactors shown are suitable for most general applications in which the percent non-linear load is below 50%.

**Technical Data**

- Tolerance per phase: +/- 5%
- Phase-to-phase tolerance: Lmax/Lmin < 1.07
- Withstand 50 Hz: 1 min: 2.5 kV
- Maximum permissible current: 1.3 In (400V)
- Maximum permissible voltage: 660V
- Maximum operating temperature: 135°C
- Temperature class:
  - Maximum temperature: 55°C
  - Average temperature over 24hrs: 45°C
  - Average annual temperature: 35°C
- Degree of protection: IP00 front face

**Installation**

- Always mount reactors above or to the side of capacitor plates. NEVER place reactors below the capacitors to avoid overheating the capacitor plates
- Observe the recommended cable sizes shown above
- Ensure adequate ventilation: 2 x kVAr rating in $m^3/h$ EFFECTIVE air flow, see page 7
- It is more effective to extract heat from the top with fans as opposed to forcing air in at the bottom
- Cabling between capacitors and reactors is necessary

**3.8 tuning (190Hz)**

| Stage kVAr | L(mH) | In (A) | Maximum losses @ 115°C (W) | Fixing centre distance (mm) | Maximum dimensions (mm) H | W | D | Reference |
|---|---|---|---|---|---|---|---|---|
| 25 | 1.5 | 36 | 200 | 205 x 110 | 230 | 240 | 140 | **52353** |
| 50 | 0.75 | 73 | 300 | 205 x 110 | 270 | 260 | 160 | **52354** |
| 100 | 0.37 | 146 | 450 | 205 x 110 | 360 | 370 | 230 | **51569** |

**4.2 tuning (210Hz)**

| Stage kVAr | L(mH) | In (A) | Maximum losses @ 115°C (W) | Fixing centre distance (mm) | Maximum dimensions (mm) H | W | D | Reference |
|---|---|---|---|---|---|---|---|---|
| 25 | 1.5 | 36 | 200 | 205 x 110 | 230 | 240 | 140 | **51565** |
| 50 | 0.592 | 72 | 320 | 205 x 110 | 270 | 260 | 160 | **51566** |
| 100 | 0.296 | 143 | 480 | 205 x 110 | 360 | 370 | 230 | **51567** |

**Cable size ($mm^2$)**

Based on 105°C tri-rated cable

| Application | kVAr rating 25 | 50 | 100 |
|---|---|---|---|
| Detuned | 35 | 50 | 70 |

**Note:** Based upon 3 cables touching in 55°C ambient.

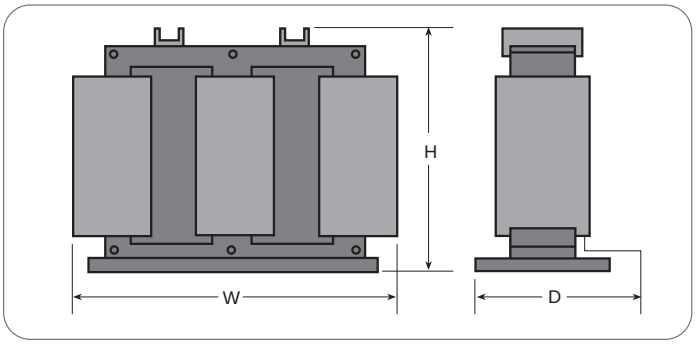
## Bank kit selection guide

Merlin Gerin has constructed an easy method to order a complete kit of major components to construct an entire detuned power factor correction bank. A kit would comprise of the required number of detuned capacitor plates and a Varlogic controller to construct a bank in the total power shown.

**Recommended components to construct an entire detuned capacitor bank**
470V dielectric line switched functional plates plus reactors
plus a relay for applications with <50% non-linear load

| Bank (step) kVAr rating | Functional plate reference and number of plates required | | | reactor reference and number of plates required | | Controller reference |
|---|---|---|---|---|---|---|
| | 51586 | 51589 | 51587 | 52353 | 52354 | 52448 |
| 50 (25) [1] | | 1 | | 2 | | ■ |
| 75 (25) [1] | 1 | | 1 | 1 | 1 | ■ |
| 100 (25) [1] | | 1 | 1 | 2 | 1 | ■ |
| 125 (25) [1] | 1 | | 2 | 1 | 2 | ■ |

■ Stocked
**Note:** (1) = installs in 600W x 400D panel (minimum).




**Dimensions (mm)**

| Stage kVAr | Maximum H | W | D |
|---|---|---|---|
| 25 | 236 | 240 | 140 |
| 50 | 270 | 260 | 160 |
| 100 | 330 | 380 | 220 |

Example of detuning reactor

# Notes

# Notes

## Nationwide support on one number - call the Customer Information Centre on

# 0870 608 8 608

Fax 0870 608 8 606

## Schneider Electric's local support

Schneider Electric is committed to supporting its customers at every stage of a project. Our 180 sales engineers, the largest dedicated sales force in the UK electrical industry, operate from 4 customer support centres.

Our sales engineers are skilled at assessing individual requirements and combined with the expert support of our product specialists, will develop the most effective and economical answer taking relevant regulations and standards fully into account.

To access the expertise of the Schneider Electric group, please call 0870 608 8 608. Each customer support centre includes facilities for demonstrations and training, and presentation rooms fully equipped with audio visual and video, providing excellent meeting facilities.

Merlin Gerin

**Merlin Gerin** is a world leader in the manufacture and supply of high, medium and low voltage products for the distribution, protection, control and management of electrical systems and is focused on the needs of both the commercial and industrial sectors. The newly launched VDI Network Solutions offer provides flexible, configurable Ethernet systems for all communication needs.

Square D

**Square D** is a total quality organisation and its business is to put electricity to work productively and effectively, protecting people, buildings and equipment. Its low voltage electrical distribution equipment, systems and services are used extensively in residential and commercial applications.

Telemecanique

**Telemecanique** is a UK market leader and world expert in automation and control. It provides complete solutions, with its range of components, Modicon range of high technology programmable controllers (PLCs), multiple fieldbus and Ethernet communication networks, HMI, motion control systems, variable speed drives and communications software. In addition, it offers power distribution through prefabricated busbar trunking.

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