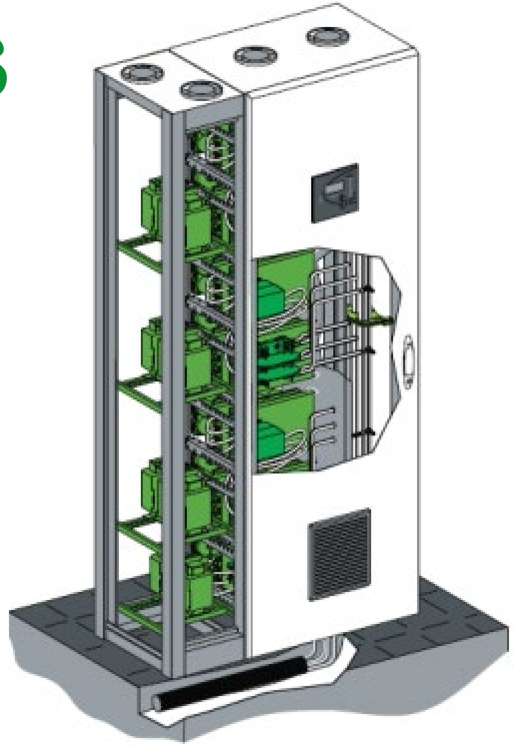
Panel Building recommendations
for Low Voltage Power Factor Correction panels

Version 2



PQ Offer Marketing
Jan 2015

Capacitors offer transition 2004 - 2014

LV Capacitors Offer Evolution

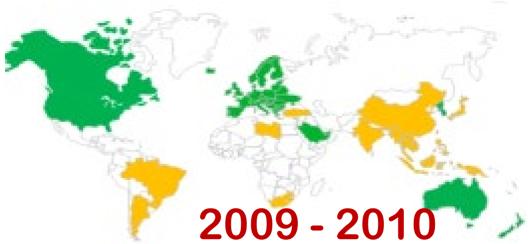
Up to 2009

Varplus²

230V – 690V
1-20kvar

Annual Sales :

70k Pcs



2009 - 2010

Varplus²

230V – 690V
1-20kvar

VarplusCan

230V – 690V
1-30kvar

Annual Sales :

120k Pcs

2011 - 2013

VarplusCan HDY

230V – 830V
1-50kvar

VarplusCan SDY

230V – 525V
1-30kvar

Annual Sales :

270k Pcs

2014 onwards

VarPlus

230V – 830V
1-50kvar

EasyCan

230V – 525V
1-30kvar

Annual Sales :

410k Pcs

The LV capacitor offer story

2004 2006 2009 2010 2011 2012 2013

Varplus M

SpArrow

Varplus 2

VarplusBox Compact

Installed base of 1Million units across the globe in Schneider brand

100% Acquisition of a brand which has 15 years market experience in 2009

VarPlus Can / EasyCan / VarPlus Box

Varplus 2 Capacitors are discontinued in 2012 after the successful launch of VarPlus Can and EasyCan range of capacitors

Technical differentiation between VarPlus and EasyCan

Electrical parameters

Parameter	EasyCan	VarPlus
Over Current Handling Capacity	1.5 X I_N	1.8 X I_N
Life Expectancy	100,000 Hrs	130,000 Hrs
Number of Operations / year	5000	7000

Offer Selection Criteria

Selection of Detuned reactors

Selection of detuning reactors

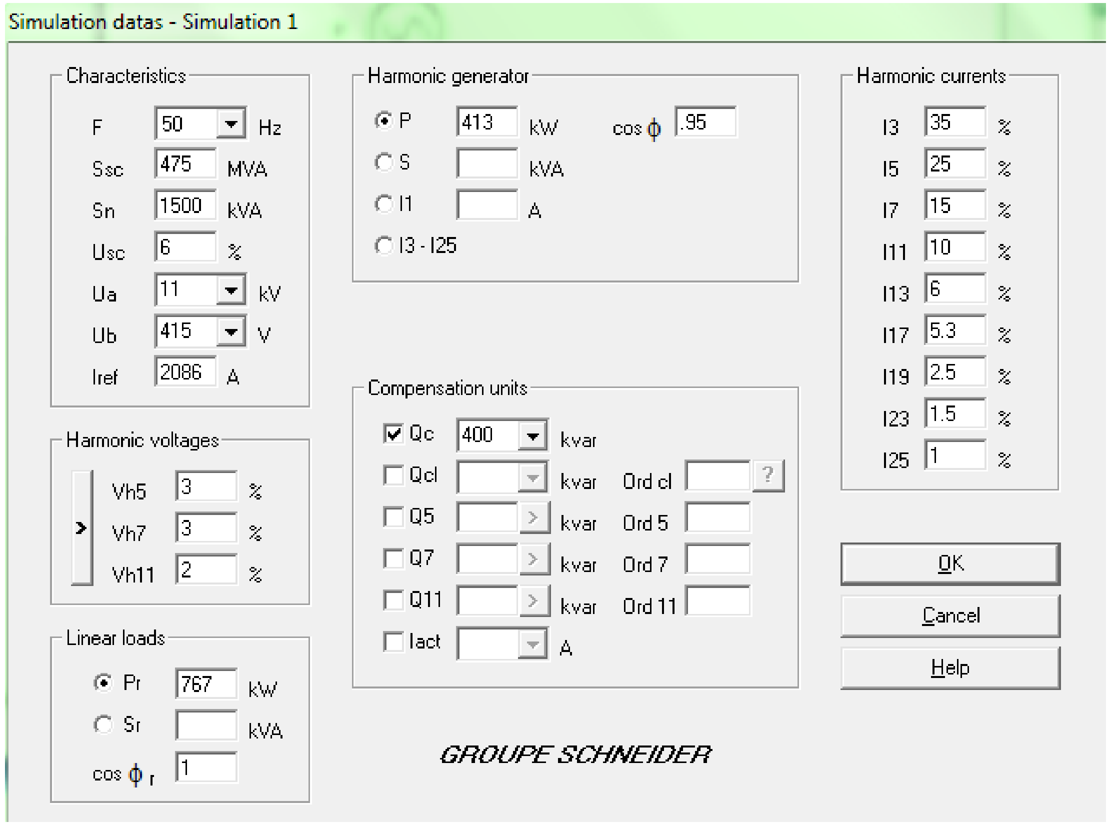
The detuning reactors are designed to protect the capacitors and prevent amplification of the harmonics present in the network.

tuning frequency (fr)	tuning order (n = fr/f)	relative impedance ($P = 1/n^2$)
135 Hz	2.7	13.7 %
190 Hz	3.8	6.92 %
215 Hz	4.3	5.4 %

Tuning frequency must be chosen according to the harmonic frequencies present on the installation (tuning frequency must always be lower than the harmonic spectrum)

Incorrect selection of tuning order can result in amplification of system harmonics.

Why detuned reactor ?

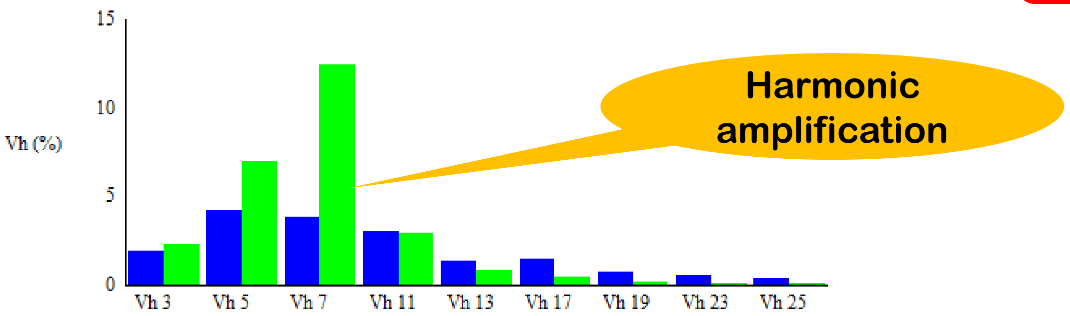


Considered system condition for simulation

Results of Harmonic Spectrum after compensation

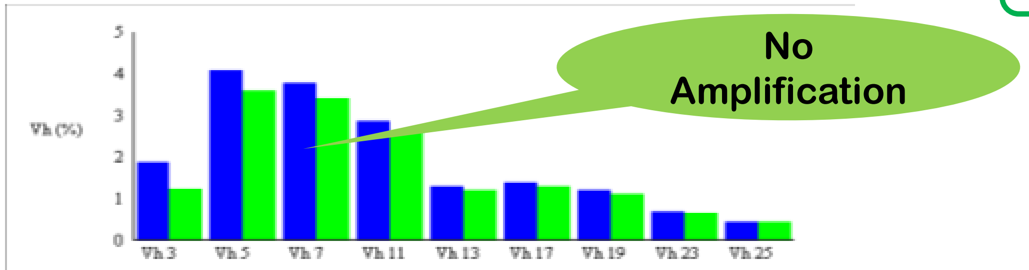
1. Using Capacitors without Detuned reactors

Order	3	5	7	11	13	17	19	23	25	THD(%)	Delta
LV wo comp.	1.9	4.13	3.82	2.95	1.29	1.41	0.72	0.48	0.34	6.97	
LV w comp.	2.23	6.87	12.35	2.86	0.74	0.42	0.16	0.07	0.04	14.62	2.09

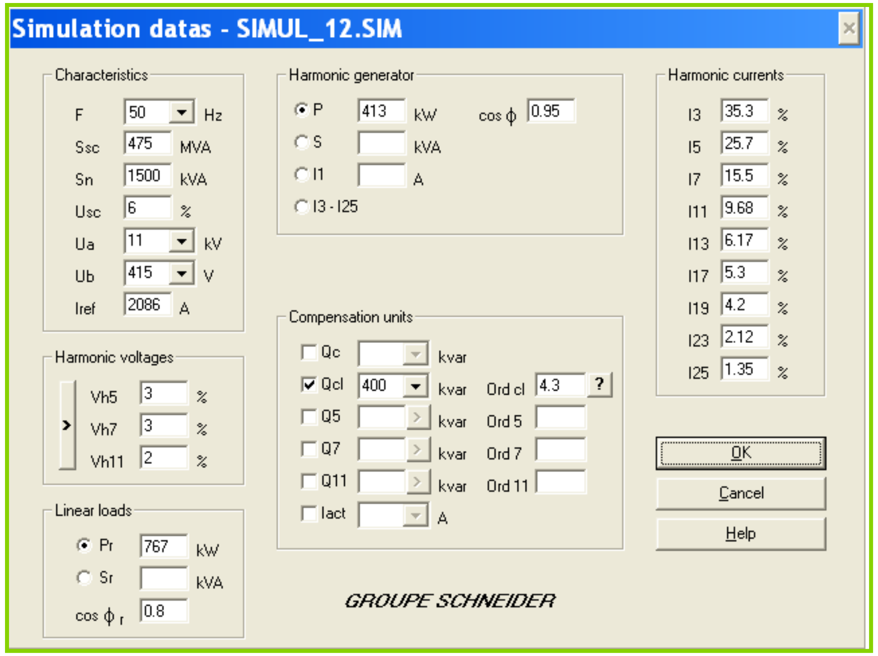


2. Using Capacitors with 14% Detuned reactors

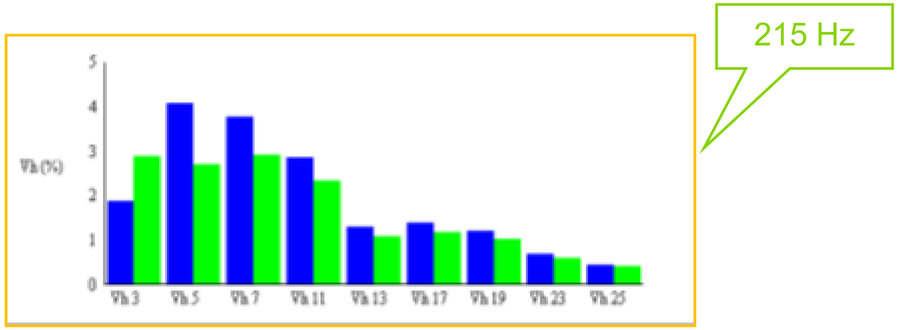
Order	3	5	7	11	13	17	19	23	25	THD(%)	Delta
LV wo comp.	1.9	4.13	3.82	2.95	1.29	1.41	0.72	0.48	0.34	6.97	
LV w comp.	1.22	3.61	3.42	2.69	1.18	1.3	0.67	0.45	0.32	6.11	0.87

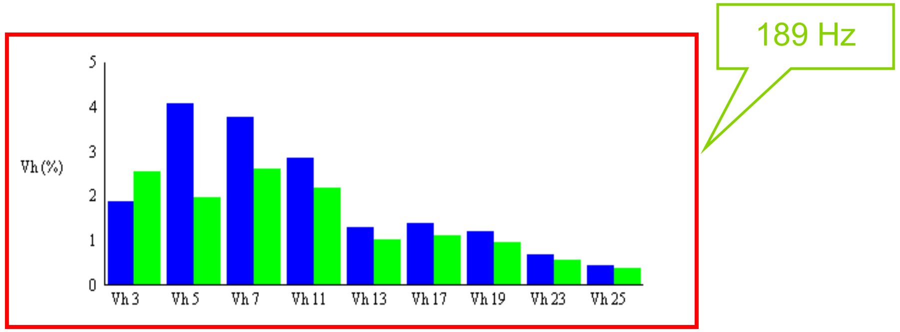


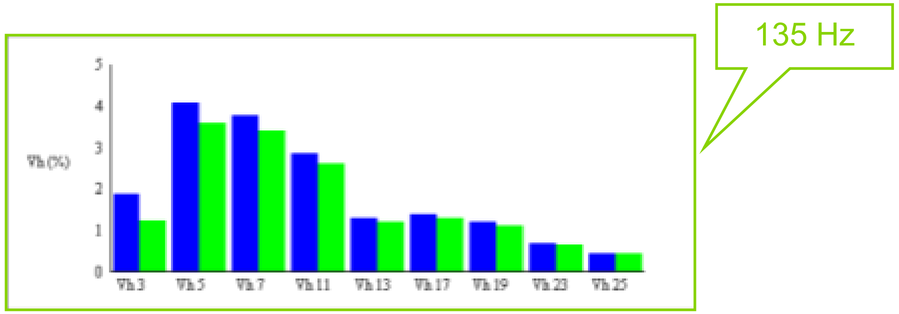
Selection of detuning reactors where 3rd harmonic current is predominant



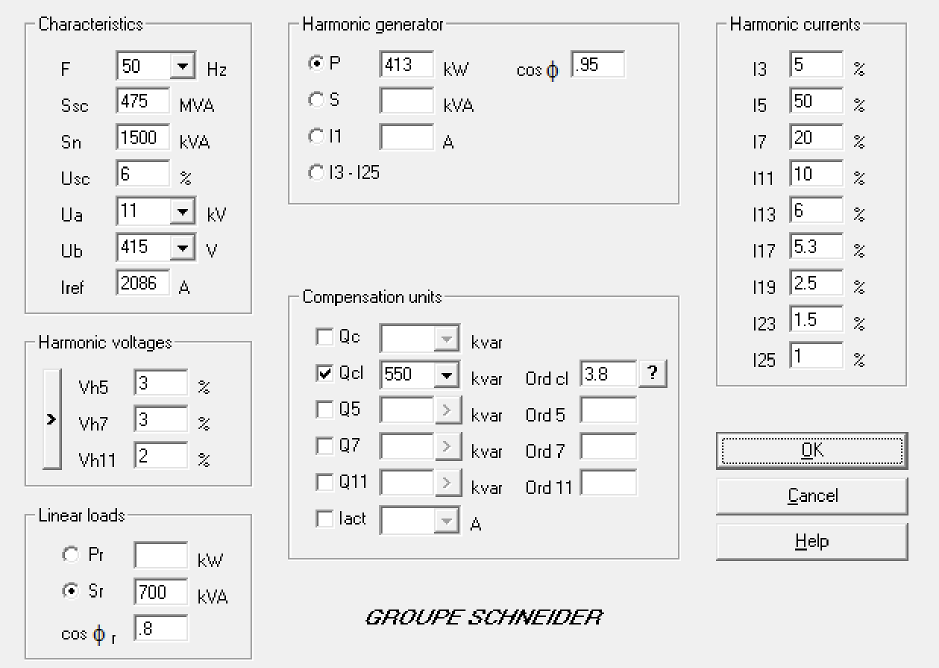
Tuning Frequency	3rd Harmonic component before	3rd Harmonic component after	THD V before	TDH V after
215Hz (5.7%)	1.87	2.55	6.95	5.08
190Hz (7%)	1.87	2.89	6.95	5.81
135Hz (14%)	1.87	1.22	6.95	6.12

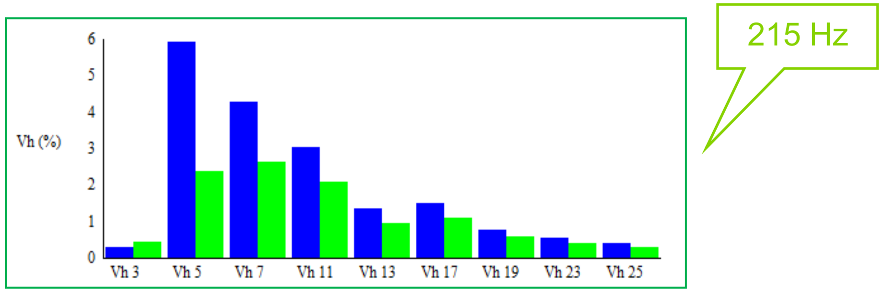


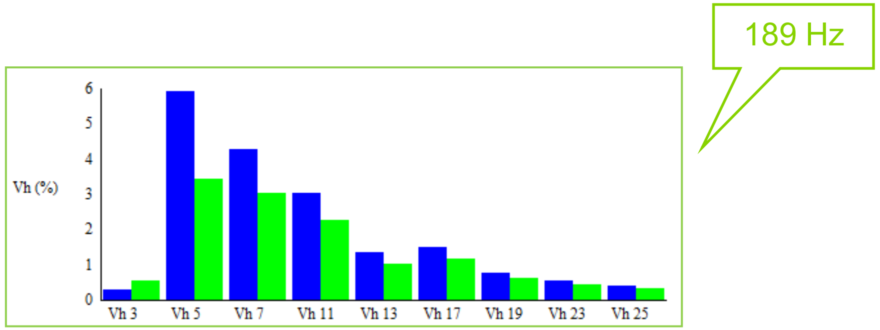


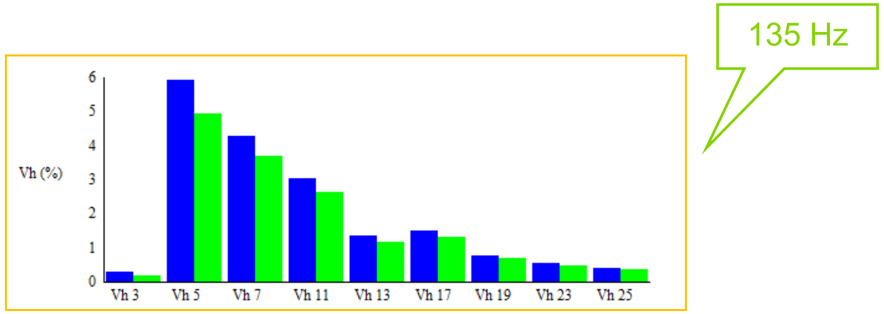


Selection of detuning reactors where 5th harmonic current is predominant









Tuning Frequency	5^{th} Harmonic component before	5^{th} Harmonic component after	THD V before	TDH V after
215Hz (5.7%)	5.9	2.35	8.18	4.43
190Hz (7%)	5.9	3.44	8.18	5.4
135Hz (14%)	5.9	4.92	8.18	6.97

Designed Harmonic levels for different tuning orders

The following table gives the typical percentage of harmonic currents considered for the different tuning orders.

(%)	Harmonic currents			
Tuning order / Relative Impedance	i_3	i_5	i_7	i_{11}
2.7 / 14%	5	15	5	2
3.8 / 7%	3	40	12	5
4.2 / 5.7%	2	63	17	5

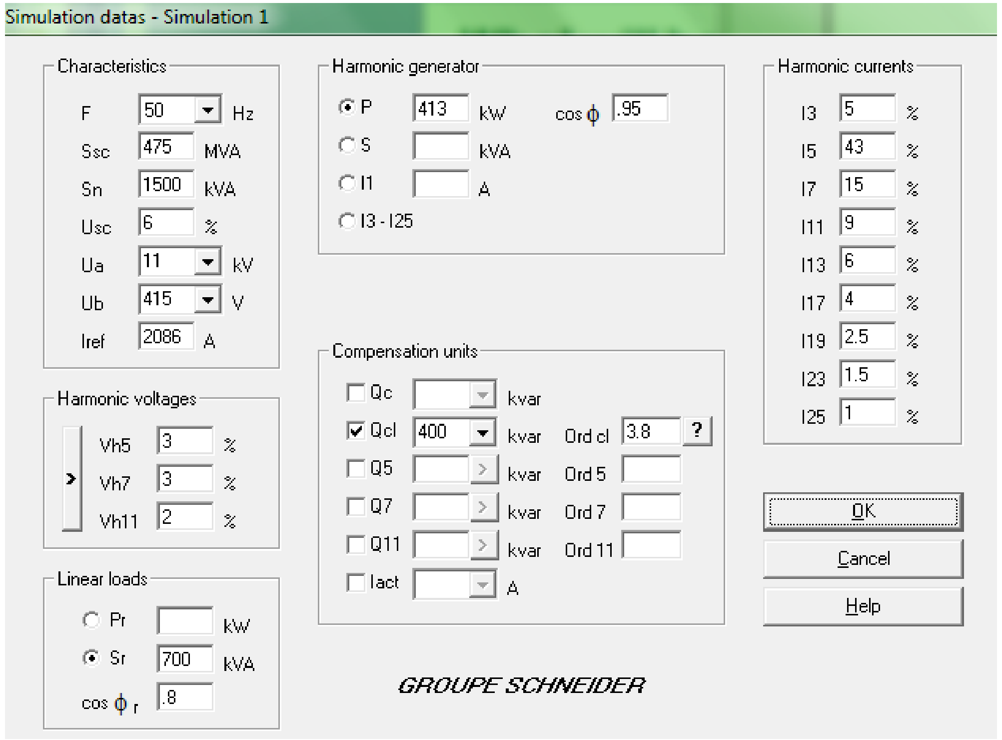
In order to operate safely in real conditions, a detuned reactor must be designed to accept a **maximum permanent current** (I_{MP}) taking account of harmonic currents and voltage fluctuations

Tuning order	I_{MP} (times I_s)
2.7 / 14%	1.12
3.8 / 7%	1.2
4.2 / 5.7%	1.3

What will happen if a wrong capacitor is selected with D.R

Scenario 1

With proper capacitor selection



System:

Linear Loads : 700KVA , Cos Phi=0.8

Non Linear Loads : 413 KW, Cos Phi =0.95

Harmonic Currents : 5th Harmonic Predominant

Suggested PF Correction solution: 400kvar with 7%(3.8) D.R

Steps : 25, 25, 50, 100,100,100

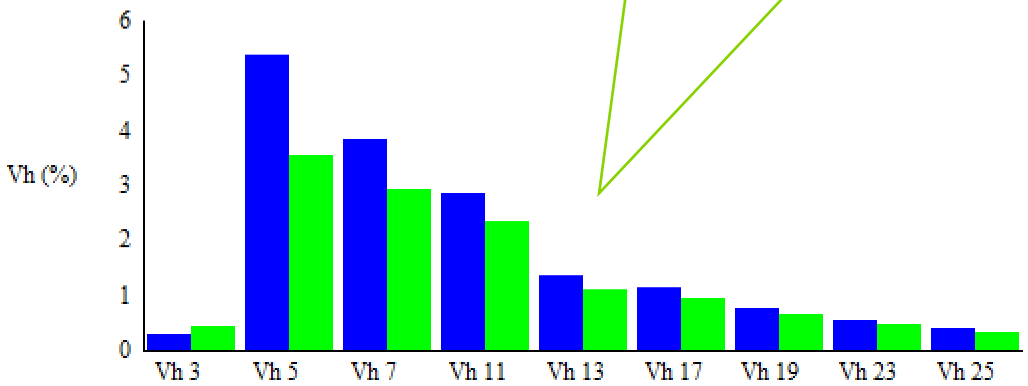
Capacitors to be uses : 34kvar, 480V , for 25 kvar step X 16 units

Delivered Kvar at 400V by Cap + DR = 400kvar

Desired tuning frequency =190 Hz

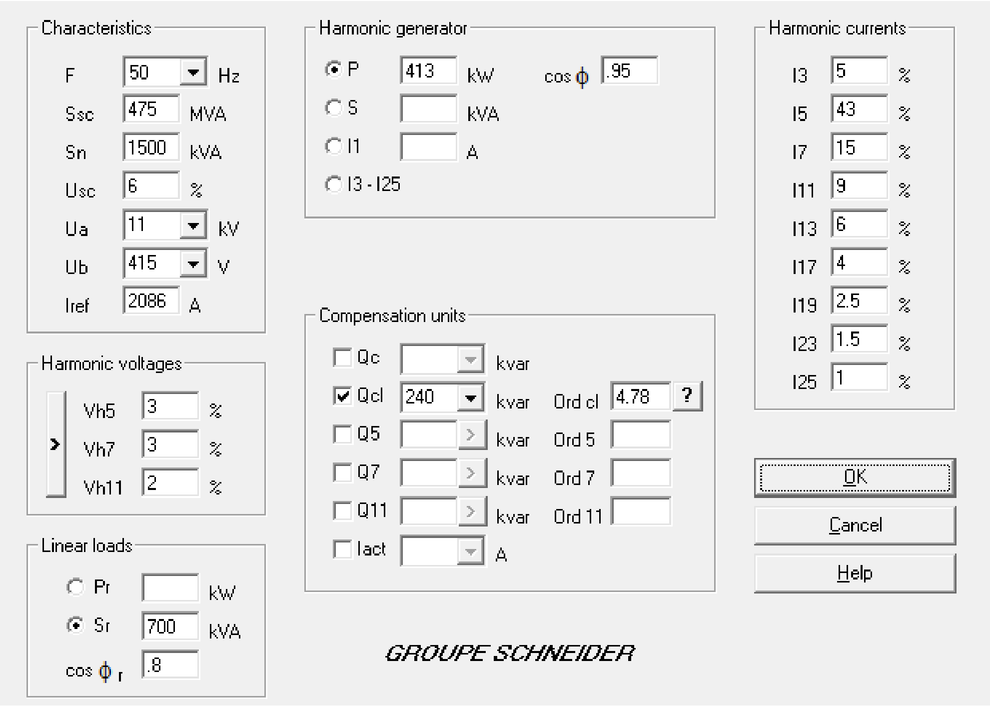
Actual Tuning frequency = 190Hz

Tuning Frequency	Delivered Kvar at 400V	5th Harmonic component before	5th Harmonic component after	THD V before	TDH V after	Capacitor+ D.R Current
400kvar, 7%	400kvar	5.37	3.53	7.45	5.41	1.12



What will happen if a wrong capacitor is selected with D.R

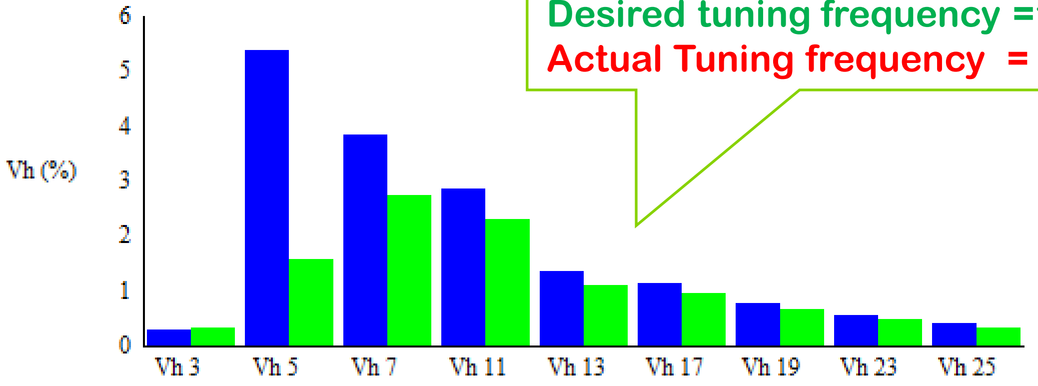
With a wrong capacitor selection



System:
Linear Loads : 700KVA , Cos Phi=0.8
Non Linear Loads : 413 KW, Cos Phi =0.95
Harmonic Currents : 5th Harmonic Predominant

Suggested PF Correction solution: 400kvar with 7% D.R
Steps : 25, 25, 50, 100,100,100
Capacitors Selected : 25kvar, 480V , for 25 kvar step X 16 units
Delivered Kvar at 400V by Cap + DR = 240 kvar

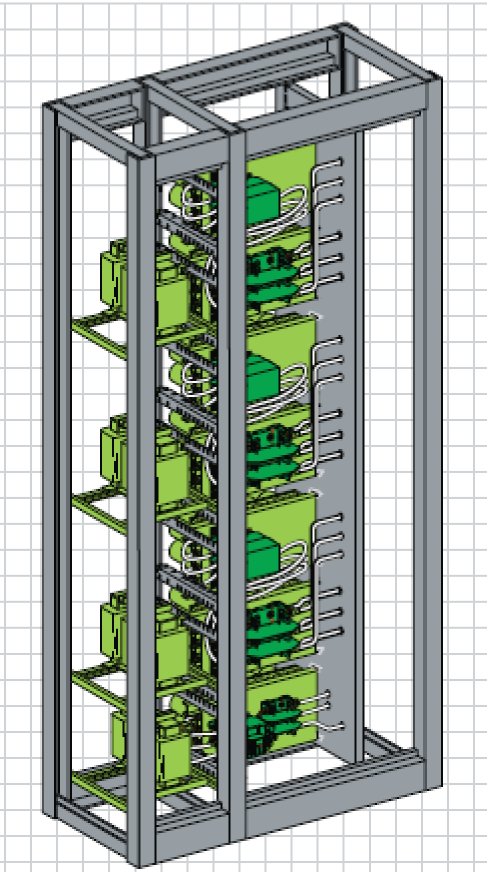
Tuning Frequency	Delivered Kvar at 400V	5th Harmonic component before	5th Harmonic component after	THD V before	TDH V after	Capacitor+ D.R Current
400kvar, 7%	240kvar	5.37	1.56	7.45	4.24	1.35



Desired tuning frequency =190 Hz
Actual Tuning frequency = 239Hz

Detuned reactor act almost like a tuned reactor for 5th harmonic and draw 30% current leading to failure

Where to install detuned reactor ?

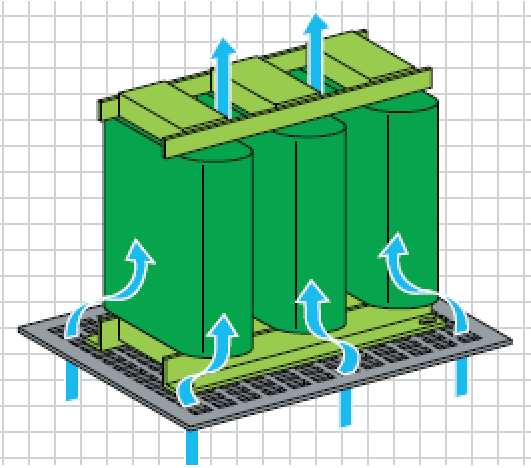


Temperature rise stresses

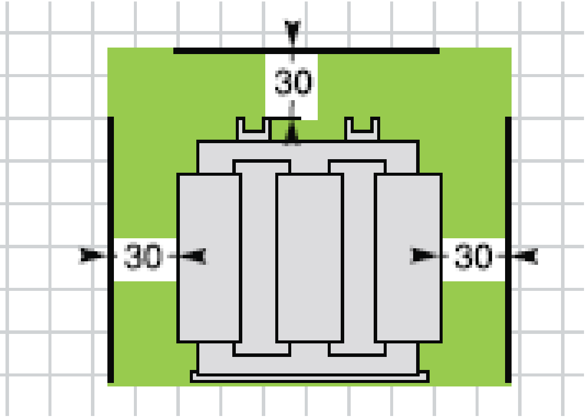
The preferred architecture of a PFC switch board with detuned reactors is with a separate column, specifically reserved for the reactors. (See picture)

Detuned reactors require forced ventilation.

***Note**: under no circumstances may the detuned reactors be fitted beneath the capacitors.*



Ventilation needed for detuned reactors



Spacing of detuned reactors in a panel

VarPlus Can + Detuned Reactor + Contactor + MCCB

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Network 400 V, 50 Hz Capacitor Voltage 480 V 5.7 % / 7 % Detuned Reactor						
Effective Power (kvar)	Q_N at 480 V	Capacitor Ref.	5.7% fr = 210Hz	7% fr = 190Hz	Switching: Contactor Ref.	Protection: Compact NSX (Icu=50kA) Ref.
			D R Ref.	D R Ref.		
6.5	8.8	BLRCH088A106B48 × 1	LVR05065A40T x 1	LVR07065A40T x 1	LC1D12 × 1	LV429847 × 1
12.5	17	BLRCH170A204B48 × 1	LVR05125A40T x 1	LVR07125A40T x 1	LC1D18× 1	LV429846 × 1
25	33.9	BLRCH339A407B48 × 1	LVR05250A40T x 1	LVR07250A40T x 1	LC1D32 × 1	LV429843 × 1
50	67.9	BLRCH339A407B48 × 2	LVR05500A40T x 1	LVR07500A40T x 1	LC1D80 × 1	LV429840 × 1
100	136	BLRCH339A407B48 × 4	LVR05X00A40T x 1	LVR07X00A40T x 1	LC1D150 × 1	LV431831 × 1

Network 400 V, 50 Hz Capacitor Voltage 480 V 14 % Detuned Reactor					
Effective Power (kvar)	Q_N at 480 V	Capacitor Ref.	14% fr = 135Hz	Switching: Contactor Ref.	Protection: Compact NSX (Icu=50kA) Ref.
			D R Ref.		
6.5	8.8	BLRCH088A106B48 × 1	LVR14065A40T x 1	LC1D12 × 1	LV429847 × 1
12.5	15.5	BLRCH155A186B48 × 1	LVR14125A40T x 1	LC1D18× 1	LV429846 × 1
25	31.5	BLRCH315A378B48 × 1	LVR14250A40T x 1	LC1D32 × 1	LV429844 × 1
50	63	BLRCH315A378B48 × 2	LVR14500A40T x 1	LC1D80 × 1	LV429841 × 1
100	126	BLRCH315A378B48 × 4	LVR14X00A40T x 1	LC1D150 × 1	LV430840× 1

EasyCan + Detuned Reactor + Contactor + MCCB

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Network 400 V, 50 Hz Capacitor Voltage 480 V 5.7 % / 7 % Detuned Reactor						
Effective Power (kvar)	Q_N at 480 V	Capacitor Ref.	5.7% fr = 210Hz D R Ref.	7% fr = 190Hz D R Ref.	Switching: Contactor Ref.	Protection: Easypact CVS (Icu=36kA)Ref.
6.5	8.8	BLRCS088A106B48 × 1	LVR05065A40T x 1	LVR07065A40T x 1	LC1D12 × 1	LV510330 × 1
12.5	17	BLRCS170A204B48 × 1	LVR05125A40T x 1	LVR07125A40T x 1	LC1D18× 1	LV510331 × 1
25	33.9	BLRCS339A407B48 × 1	LVR05250A40T x 1	LVR07250A40T x 1	LC1D32 × 1	LV510334 × 1
50	67.9	BLRCS339A407B48 × 2	LVR05500A40T x 1	LVR07500A40T x 1	LC1D80 × 1	LV510337 × 1
100	136	BLRCS339A407B48 × 4	LVR05X00A40T x 1	LVR07X00A40T x 1	LC1D150 × 1	LV516332 × 1

Network 400 V, 50 Hz Capacitor Voltage 480 V 14 % Detuned Reactor					
Effective Power (kvar)	Q_N at 480 V	Capacitor Ref.	14% fr = 135Hz D R Ref.	Switching: Contactor Ref.	Protection: Easypact CVS (Icu=36kA)Ref.
6.5	8.8	BLRCS088A106B48 × 1	LVR14065A40T x 1	LC1D12 × 1	LV510330 × 1
12.5	15.5	BLRCS155A186B48 × 1	LVR14125A40T x 1	LC1D18× 1	LV510331 × 1
25	31.5	BLRCS315A378B48 × 1	LVR14250A40T x 1	LC1D32 × 1	LV510334 × 1
50	63	BLRCS315A378B48 × 2	LVR14500A40T x 1	LC1D80 × 1	LV510336 × 1
100	126	BLRCS315A378B48 × 4	LVR14X00A40T x 1	LC1D150 × 1	LV516333 × 1

+

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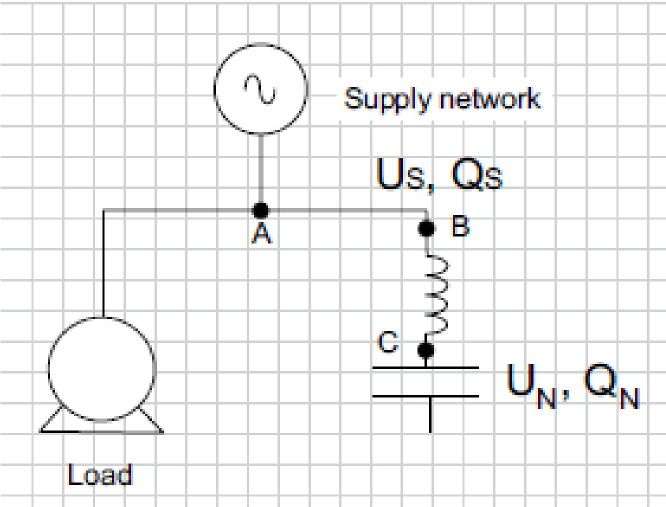
Without Detuned Reactors

** : Power contactor - To be used with series inductor or any current limiting devices

Network 400V, 50Hz			
Capacitor Power	Capacitor Ref.	Switching: Contactor Reference	Protection: Easypact CVS (Icu=36kA) reference
6.5	BLRCS063A075B40 x 1	LCIDFK•• x 1	LV510330 x 1
10	BLRCS104A125B40 x 1	LCIDFK•• x 1	LV510331 x 1
12.5	BLRCS125A150B40 x 1	LCIDFK•• x 1	LV510332 x 1
20	BLRCS200A240B40 x 1	LCIDLK•• x 1	LV510334 x 1
25	BLRCS250A300B40 x 1	LCIDMK•• x 1	LV510335 x 1
50	BLRCS250A300B40 x 2	LCIDWK•• x 1	LV516332 x 1
100	BLRCS250A300B40 x 4	LC1D150 x 1**	LV525333 x 1

Capacitor selection with detuned reactor



Why do we select capacitor with higher rated voltage than network voltage ?

Detuned Reactor (Inductor) will induce voltage and the voltage seen by capacitor will increase

$U_c = U_s - [\, U_s * Z_L / (Z_L + Z_C) \,]$ ---- (1)

$P = |Z_L| \;/\; |Z_c|$

$Z_L = -P\,Z_c$ - See the derivation here →

$$Z_c = \frac{1}{jC\omega} \qquad Z_L = jL\omega$$

The relative impedance is noted P:

$$P = \frac{|Z_L|}{|Z_C|}$$ ratio of the reactor impedance to the capacitor impedance

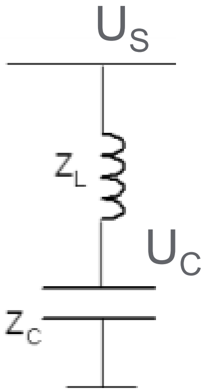
Then: $$P = \frac{|Z_L|}{|Z_C|} = \frac{L.\omega}{\frac{1}{C.\omega}} = LC.\omega^2$$

And: $$Z_L = jL\omega = j\left(\frac{P}{C\omega}\right) = P.j^2.\frac{1}{jC\omega}$$

$$\boxed{Z_L = -P.Z_C}$$

Apply this in the formula (1)

$U_c = U_s/(1-P)$



Example :

In a 440V network by using a 7% detuned reactor the voltage induced in the capacitor is = 440/(1-7%) = 440/.93 = 473V

Hence we will select capacitor above 473V.

Capacitor selection with detuned reactor

Capacitor rating selection .

Qc = Power delivered from capacitor at Supply voltage (Us) = **Qs X (1-P)**

Q_N = Rated power of capacitor at capacitor rated voltage **(U_N) = Qc X (U_N / U_S)^2**

Example :

Case: We need a compensation of 25kvar in a 440V network by using a capacitor and 5.7% detuned reactor .

Qc = Qs X (1-P)
= 25 X (1-5.7%)
= 25 X .947 = 23.68 kvar @ Us

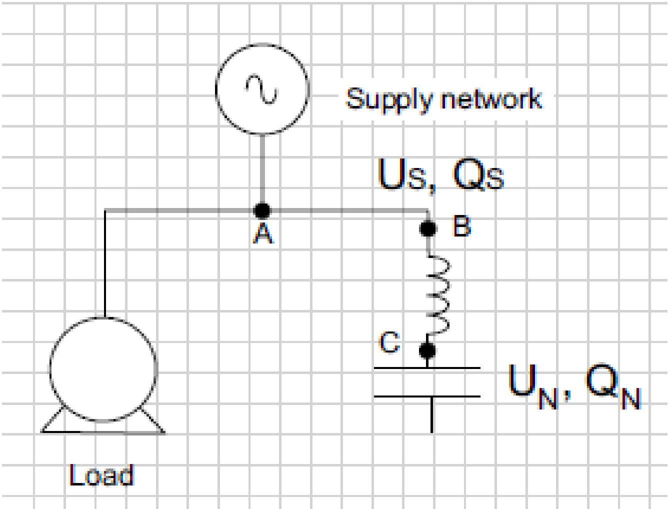
Uc = Us/(1-P)
= 440 / (1-5.7%)
= 440 / .947 = 464.62V

U_N > 465V and we can select 480V ; Hence U_N = 480V

Q_N = Rated power of capacitor at capacitor rated voltage **(U_N) = Qc X (U_N / U_S) ^{2}**

Q_N = 23.68 X (480/440) ^{2} = 28.1 kvar

Hence you can select **MEHVCHDY281A48** ; VarPlus Can HDY, 28.1kvar @ 480V 50Hz



Refer to the picture above and consider the following:
U_s: system voltage (V),
Q_S: requested reactive power (kvar)
U_N: capacitor rated voltage (V)
Q_N: capacitor rated power (kvar)

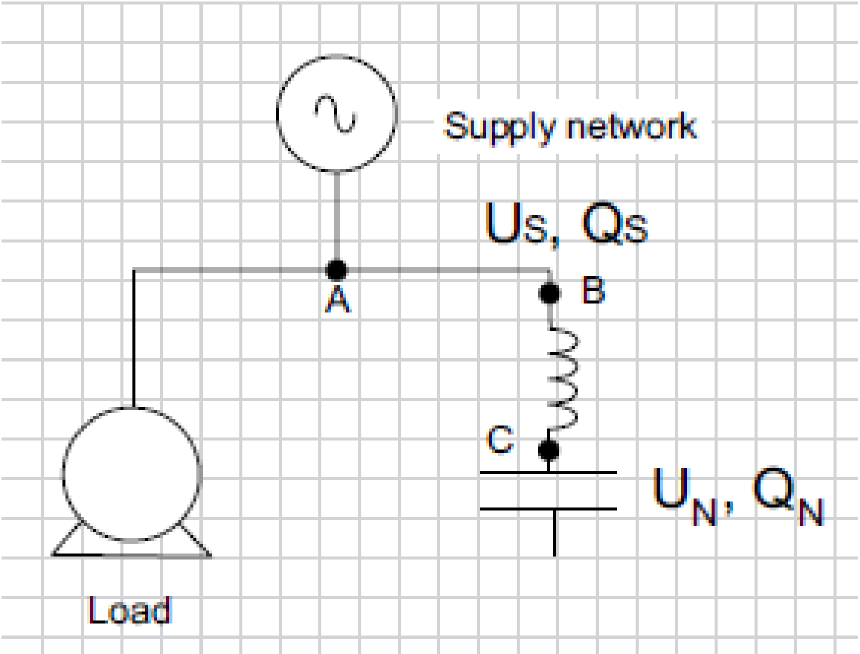
Capacitor selection with detuned reactor

Summary

U_N (Minimum) Should be next available voltage rating above $\frac{U_S}{(1-P)}$

$$Q_N = Q_S \times \left(\frac{U_N}{U_S} \right)^2 \times (1-P)$$

Select the capacitor of Q_N power at U_N Rated Voltage



Refer to the picture above and consider the following:

U_s: system voltage (V),
Q_S: requested reactive power (kvar)
U_N: capacitor rated voltage (V)
Q_N: capacitor rated power (kvar)

Basics of Design and Installation rules

Blokset Certificate
PFC Panel

asefa

Certificat de conformité / *Certificate of conformity*
N° 029-13BT

délivré à / *issued to* : SCHNEIDER ELECTRIC INDUSTRIES SAS
35 rue Joseph Monier
92500 RUEIL MALMAISON
FRANCE

Pour le produit / *For the product* : Ensemble d'appareillage à basse tension / *Low-voltage switchgear and controlgear assembly*

Référence(s) / *Reference(s)* : Blokset 132 DC with VarplusCan

Marque commerciale / *Trademark* : Schneider Electric

Fabricant / *Manufacturer* : SCHNEIDER ELECTRIC SA

Informations complémentaires / *Additional information* :

Tension assignée d'emploi / *Rated operational voltage*, (Ue)	Up to 690 V (circuit principal / *main circuit*)
Fréquence assignée / Rated frequency	50 Hz / 60 Hz
Puissance assignée / *Rated power*	Up to 600 KVAR – 400V
Tension assignée d'isolement / *Rated insulation voltage*, (Ui)	Up to 1000 V (circuit principal / *main circuit*)
Tension assignée de tenue aux chocs / *Rated impulse voltage*, (Uimp)	12 kV (circuit principal / *main circuit*)
Degré de protection / *Degree of protection*	Up to IP54
Disposition des séparations intérieures / *Form of internal separations*	Maxi 4a

Document(s) de référence / *Reference document(s)* :
CEI/IEC 61439-1(ed. 2.0, 2011-08), CEI/IEC 61439-2 (ed. 2.0, 2011-08), §10.10 et/and CEI/IEC 61921 (ed. 1.0, 2003-04), § 7.2.1 : Vérification de l'échauffement / *Verification of temperature rise*

Caractéristiques certifiées / *Certified characteristics* :
Puissance assignée / *Rated power* : jusqu'à/up to 600 kVAR – 400V

Document(s) pris en compte (s) / *Relevant document(s)* :
Rapport (s) d'essai / *Test report (s)* : N° 201300247_001 du / *dated* 2013-02-11,
(émis par L2E (F01) laboratoire homologué ASEFA / *issued by L2E (F01) as ASEFA approved laboratory*)

Ce certificat ne s'applique qu'à l'échantillon soumis à l'essai de type / *This certificate applies only to the sample submitted to the type test.*

Fontenay-aux-Roses,
Le / *On* : 20/03/2013

Le Président de l'ASEFA / *The Chairman of ASEFA*,

Michel BRENON

Clause 5.0: Guide for design, installation, operation and safety

NORME INTERNATIONALE
INTERNATIONAL STANDARD

CEI
IEC
831-1

Deuxième édition
Second edition
1996-11

5.1 General

Unlike most electrical apparatus, shunt capacitors, whenever energized, operate continuously at full load, or at loads that deviate from this value only as a result of voltage and frequency variations.

Overstressing and overheating shorten the life of a capacitor, and therefore the operating conditions (that is temperature, voltage and current) should be strictly controlled.

It should be noted that the introduction of a capacitance in a system might produce unsatisfactory operating conditions (for example amplification of harmonics, self-excitation of machines, overvoltage due to switching, unsatisfactory working of audio-frequency remote-control apparatus, etc.).

Clause 5.3.2: Free standing power factor correction system

The equipment is free standing and usually installed adjacent or close to the main switchboard or relevant sub-board. It generally has a main bus bar arrangement of the required fault level to match the adjacent main switchboard or sub-board or the required fault current of that section of the installation.

This bus bar section is bus barred or cabled back to the main supply of the installation.

Feeding off this bus bar section is a group of fuses, circuit-breakers or fused switch which are wired to a switching device and then to the capacitor banks.

Selection of Breakers and Contactors

Schneider Electric highly recommends individual **MCCB** step protection in PFC Panels to protect the steps from over current as well as short circuit

Schneider Electric recommends our specially designed **capacitor duty contactor** for usage in installation where **capacitors are used alone** to prevent inrush current

Schneider Electric recommends normal **power contactor** for usage in installation where **capacitors are used with detuned reactors** as detuned reactors act as a inrush current limiter too

Breaker / Contactor Sizing

NORME INTERNATIONALE
INTERNATIONAL STANDARD

CEI
IEC
831-1

Deuxième édition
Second edition
1996-11

34 Switching and protective devices and connections

The switching and protective devices and the connections shall be designed to carry continuously a current of 1,3 times the current that would be obtained with a sinusoidal voltage of an r.m.s. value equal to the rated voltage at the rated frequency. As the capacitor may have a capacitance equal to 1,15 times the value corresponding to its rated output (see 7.2), this current may have a maximum value of 1,3 × 1,15 times the rated current.

$$In = \frac{Qn}{\sqrt{3} \times Un}$$

Qn: Nominal power of the equipment (var).
Un: Nominal voltage of the equipment (V)

In: Fundamental current of the capacitor bank

Breakers and contactors should be sized for 1.43~1.5 times the rated fundamental current of capacitor bank/step

Over load relay setting in MCCB

1. When used with Capacitors alone

Over load relay setting = 1.3 X In

2. When used with Detuned reactors

Over load relay setting = Maximum permissible (permanent) current of the detuned reactor

Tuning order	I_{MP} (times I_s)
2.7 / 14%	1.12
3.8 / 7%	1.2
4.2 / 5.7%	1.3

Over load relay setting in MCCB

Example

Example 1:
150kvar/400v – 50Hz Capacitor

Us = 400V; Qs = 150kvar

Un = 400V; Qn = 150kvar

In = 150000/400√3 = 216A

Circuit Breaker Rating = 216 x 1.5 = 324A
Select a 400A Circuit Breaker.

Circuit Breaker thermal setting = 216 x 1.5 = 324

Conclusion:- Select a Circuit Breaker of 400A with

Thermal Setting at 324A and

Magnetic Setting (Short Circuit) at 3240A

Example 2:

20kvar/400v – 50Hz Harmonic Range with 7% Detuned Reactor

Us = 400V; Qs = 20kvar

Un = 440V; Qn = 22.51kvar
Refer: Selection of capacitor with detuned reactor

In = 22510/440√3 = 29.9A

Circuit Breaker Rating = 29.9*1.5 = 45A

Circuit Breaker thermal setting = 29.9 x 1.19 = 35.6A

Conclusion:- Select a Circuit Breaker of 45A (or next available appropriate range) with

Thermal Setting at 35.6A and

Magnetic Setting (Short Circuit) at 356A

PFC design considerations

The failure of capacitor banks can be due to non compliance with any of the following design considerations.

- > Discharge Time (Clause 22, IEC 60831 – 75V in 3 Minutes)
- > Temperature (Clause 4.1, IEC 60831 – Class D, 55 deg ambient)
- > Temperature De-rating
- > Ventilation requirement
- > Overvoltage Condition (Clause 5.3.5 IEC 61921)
- > Resonance Condition
- > Over Load (Clause 5.3.7 IEC 61921 – Continuous current – 1.3 times)
- > IP (Clause 5.3.8 IEC 61921 – IP 20 for Indoor Application)
- > Physical location of components and Accessibility (Clause 5.3.9 IEC 61921)
- > Protection & Alarms (Clause 5.5.3 / 5.5.4, IEC 61921 – Fire Hazard)

Discharge Time

NORME INTERNATIONALE
INTERNATIONAL STANDARD

CEI IEC 60831-1

Edition 2.1
2002-11

22 Discharge device

Each capacitor unit and/or bank shall be provided with a means for discharging each unit in 3 min to 75 V or less, from an initial peak voltage of $\sqrt{2}$ times rated voltage U_N.

Parameter	*Settings*	*Comment*
Delay	50 s minimum mandatory value	⚠ Time delay < 50 s can lead to transient over current and over voltage that can cause damage on capacitors and contactors and in the worst case, it can lead to fire.

Before touching any live parts, allow at least 5 min for the bank to self-discharge and then short-circuit each capacitor terminal together and ground.

Temperature Category

NORME INTERNATIONALE
INTERNATIONAL STANDARD

CEI
IEC
60831-1
Edition 2.1
2002-11

4 Service conditions

Capacitors are classified in temperature categories, each category being specified by a number followed by a letter. The number represents the lowest ambient air temperature at which the capacitor may operate.

For indoor use, a lower limit of –5 °C is normally applicable.

Table 1 – Letter symbols for upper limit of temperature range

Symbol	Ambient temperature °C		
	Maximum	Highest mean over any period of 24 h	Highest mean over any period of 1 year
A	40	30	20
B	45	35	25
C	50	40	30
D	55	45	35

Ventilation System

The ventilation rules discussed here are valid under normal operating conditions. They ensure that the temperatures within the cubicles do not exceed the maximum temperatures to which the components can be subjected. The rules provide for an average **delta T of 10 to 15 °C** between the outside and inside of the cubicle.

Normal operating conditions according to IEC61439-1

- Maximum temperature in the electrical room: ≤ 40˚C
- Average temperature over 24hrs in the electrical room: ≤ 35˚C
- Average annual temperature in the electrical room: ≤ 25˚C
- Minimum temperature: ≥ 5˚C
- Maximum altitude: ≤ 2000m

Ventilation System design

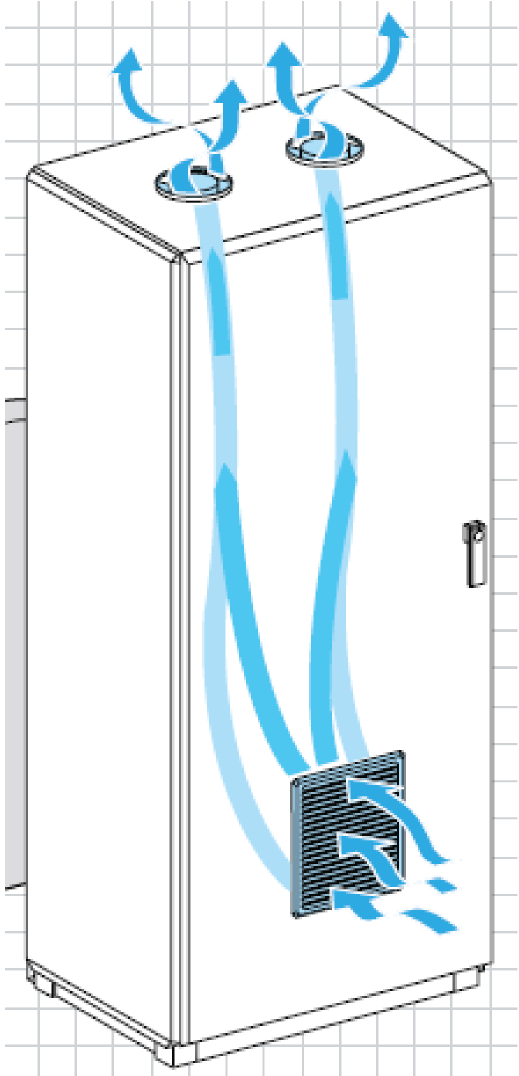
Selection of Fan

It is better to use a fan with thermal switches. In this case the positioning of the fans should be taken care so as to not place the fan's thermal switch close to heat dissipating devices so as to avoid any malfunctioning of thermal switch.

The selection of fans shall be based on several parameters:

- Total watt loss including all components in the panel,
- IP level of the panel.
- Total volume of the enclosure,
- Outside ambient temperature,
- Desired internal ambient temperature.

The cubic meter per hour capacity of the fan and the ambient temperature at which the fan can continuously operate are also to be taken into account for deciding the number of fans.



Ventilation System design

How many fans need to be used for a given capacitor panel ?

Maximum throughput of fans required for a capacitor panel
= 0.3 X Total power dissipated by the panel

Example 1:

200kvar panel with out detuned reactors

Total Power dissipated by panel = 200 X 2.5w/kvar = 500W / Panel

Maximum through put of Fan required = 0.3 X 500 = 150 M^3/h

User can use one fan of 165 M^3/h for this panel.

Example 1:

200kvar panel with detuned reactors

Total Power dissipated by panel = 200 X 9.0w/kvar = 1800W / Panel

Maximum through put of Fan required = 0.3 X 1800 = 540 M^3/h

User can use two fans , of 300 M^3/h

Air Inlet

Up to a power of 100 kvar panel need to have air inlet of 100CM^2.

From 100-200kvar panel need to have air inlet of 200CM^2.

Above 200kvar panel need to have multiple air inlet of 200CM^2.

Minimum number of fans required in the panel

without detuned reactors

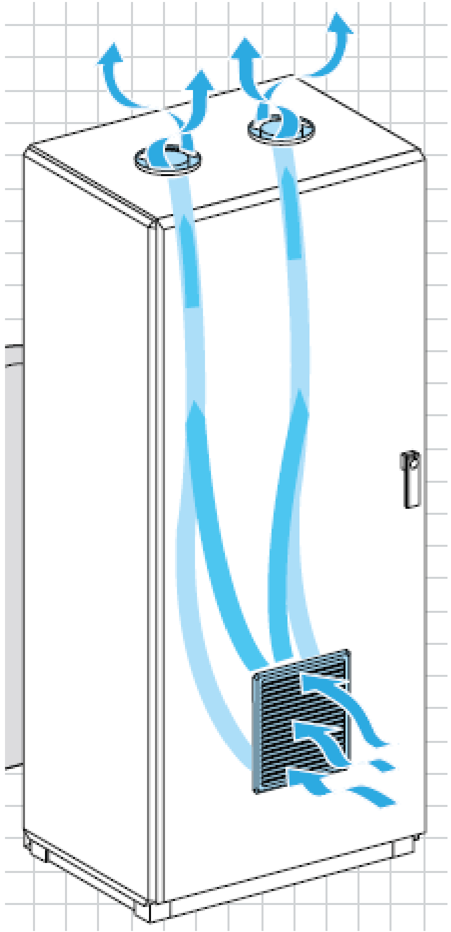
Kvar Rating	Watt loss	Fan through put required	Number of fans*	Through put per fan
100	250	75	1	85 M³/h
200	500	150	1	165 M³/h
300	750	225	2	165 M³/h
400	1000	300	2	165 M³/h
500	1250	375	3	165 M³/h
600	1500	450	3	165 M³/h

with detuned reactors

Kvar Rating	Watt loss	Fan through put required	Number of fans*	Through put per fan
100	900	270	2	165 M³/h
200	1800	540	2	300 M³/h
300	2700	810	3	300 M³/h
400	3600	1080	4	300 M³/h
500	4500	1350	2	560 M³/h
600	5400	1620	2	560 M³/h

Ventilation system with out detuned reactors

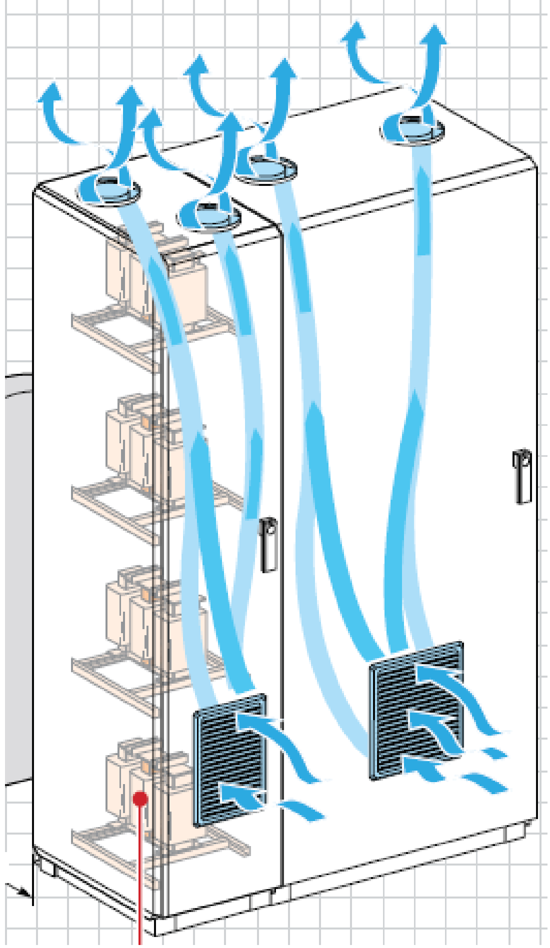
Losses in Capacitor Banks without reactors : Capacitors, contactors, breakers / fuses and electrical connections dissipate 2.5 W/ kvar. With out detuned reactors.



- The air within the cubicle must flow upwards.
- It is recommended that extractor fans be fitted on top of the cubicle.
- The bottom air inlet must be as low as possible for better ventilation
- The cross-section of the top air outlet must be more than the cross-section of the bottom air inlet
- The openings must be compatible with the safety rating (IP)
- There should be at least 100 mm between the fan and the modules or components
- The air inlet at the bottom air intake grille must not be obstructed or restricted by a component or module
- Always let a gap of minimum 600 mm between the back of the panel and the wall for a front open panel and a minimum gap of 1000 mm for the rear opened panel. It allows to have a good ventilation

Ventilation system with detuned reactors

Losses in Capacitor Banks with reactors : Capacitors, contactors, breakers / fuses and electrical connections dissipate 9 W/ kvar. With detuned reactors.



This equipment must always **include a forced ventilation system.**

- The DRs must be installed: in a separate enclosure or in the same enclosure as the capacitors, but in a separate compartment, or possibly above the capacitors.
- The part of the enclosure containing the capacitors must be ventilated according to the standard capacitor bank rules.
- The part of the enclosure containing the DRs must be ventilated according to the dissipated power.

The ventilation rules in the previous page are applicable here also.Ventilation fans are required with respect to Watt losses.

Power losses in detuned reactors

Network voltage 400 V, 50 Hz											
50 Hz Relative Impedance (%)	kvar	Inductance (mH)	I_{MP} (A)	Max losses at I_{MP}(W)	W (mm)	W1 (mm)	D (mm)	D1 (mm)	H (mm)	Weight (kg)	Reference Number
5.70% (4.2)	6.5	4.727	12	100	240	200	160	125	220	9	LVR05065A40T
	12.5	2.445	24	150	240	200	160	125	220	13	LVR05125A40T
	25	1.227	47	200	240	200	160	125	220	18	LVR05250A40T
	50	0.614	95	320	260	200	200	125	270	24	LVR05500A40T
	100	0.307	190	480	350	200	220	125	350	46	LVR05X00A40T
7% (3.8)	6.5	5.775	11	100	240	200	160	125	220	8	LVR07065A40T
	12.5	2.987	22	150	240	200	160	125	220	10	LVR07125A40T
	25	1.499	43	200	240	200	160	125	220	15	LVR07250A40T
	50	0.750	86	320	260	200	200	125	270	22	LVR07500A40T
	100	0.375	172	480	350	200	220	125	350	37	LVR07X00A40T
14% (2.7)	6.5	11.439	10	100	240	200	160	125	220	10	LVR14065A40T
	12.5	6.489	20	150	240	200	160	125	220	15	LVR14125A40T
	25	3.195	40	200	240	200	160	125	220	22	LVR14250A40T
	50	1.598	80	400	260	200	200	125	270	33	LVR14500A40T
	100	0.799	160	600	350	200	220	125	350	55	LVR14X00A40T

- The losses from reactors of 7%(3.8) in a 450KVAR capacitor bank with stage rating of 2 x 25 + 8 x 50 KVAR would be :2X200+8X320 = 2960 Watts
- The losses from reactors 7%(3.8) in a 450KVAR capacitor bank with stage rating of 1 x 50 + 4 x 100 KVAR would be :1X320+4X480=2240 Watts

25% less losses

Step optimization in APFC panel.

Reducing the mechanical steps to all electrical steps.

Consider an APFC System of 250 kvar

Solution 1: Electrical control 10 x 25 kvar

25 + 25 + 25 + 25 + 25 + 25 + 25 + 25 + 25 + 25 ;
sequence : 1.1.1.1.1.1
10 physical steps
10 contactors – Refer Contactor Selection
12-step controller – (Varlogic – NR12) Refer PFC relays- Varlogic Selection
Capacitors- VarPlusCan – 10 x 25kvar

Conclusion

High Labor, high cost: non-optimised solution.
Possible Power levels (kvar) : 25,50,75,100,125,150,175, 200, 225, 250

Possible power levels (kvar)	Physical Steps			
	25	50	75	100
25	•			
50		•		
75			•	
100				•
125	•			•
150		•		•
175			•	•
200	•		•	•
225		•	•	•
250	•	•	•	•

Step optimization in APFC panel.

Reducing the mechanical steps to all electrical steps.

2/2

Solution 2: Electrical control 10 x 25 kvar

25 + 50 + 75 +100 = 10 x 25 kvar electrical;
sequence: 1.2.3.4:4
4 physical steps allowing for 10 different power levels
4 contactors (refer contactor selection)
6-step controller (Varlogic NR6 - refer PFC relays- Varlogic selection)
Capacitors - VarPlusCan - 2 x 25kvar + 2 x 50kvar + 1 x 100kvar

Conclusion

Optimised Solution.
Optimisation of compensation cubicle - Possible power levels (kvar)

Possible power levels (kvar)	Physical Steps			
	25	50	75	100
25	•			
50		•		
75			•	
100				•
125	•			•
150		•		•
175			•	•
200	•		•	•
225		•	•	•
250	•	•	•	•

Solution 2 will be much efficient , cost effective and compact

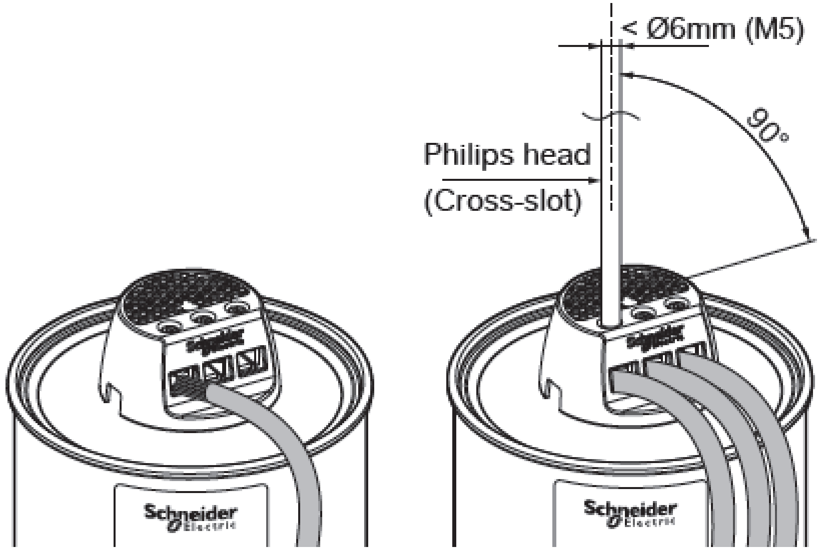
User Tip:

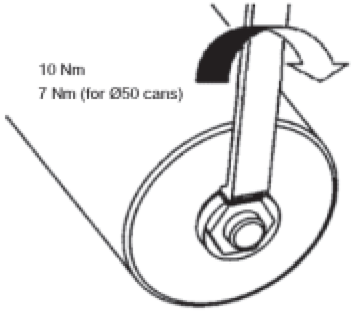
Optimising the step sizes in the APFC panel can reduce watt loss in the panel and you can save energy.

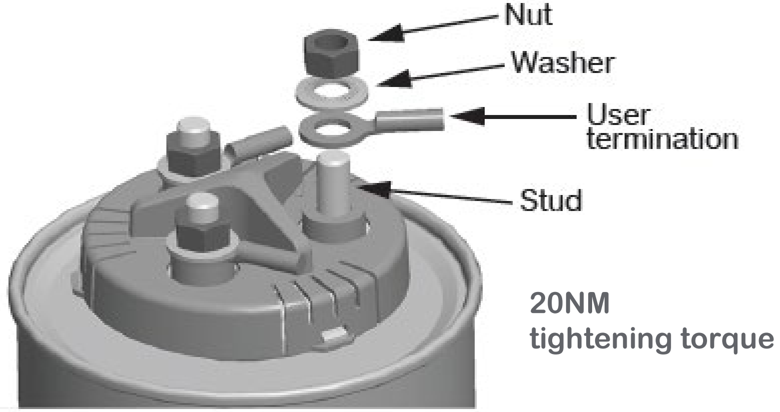
Capacitors installation rules

Installation and mounting

- Indoor installation on firm support in a correctly ventilated local or envelope.
- Ambient temperature around capacitors must not exceed 35°C over one year, 45°C over 24hours and 55°C max (according to IEC 60831 for -25/D temperature category) (Except for Energy range (55°C over 24 hours and 70° Max).
- Maintain a gap of min. 30mm between capacitor units and min. 30mm between capacitors and panel enclosure for better air circulation
- Electrical clearance between phases shall be 30mm.
- For 3ph capacitors keep min. 30mm gap above the top of the capacitor
- Use capacitor duty contactor or inductor coil in series with two phases in order to limit the inrush current when capacitors are switched in parallel with other energized capacitor units.
- Please ensure that there is no force by any means on the Pressure Sensitive Disconnector (PSD) in such a way to affect the operation of PSD when it is required to operate.



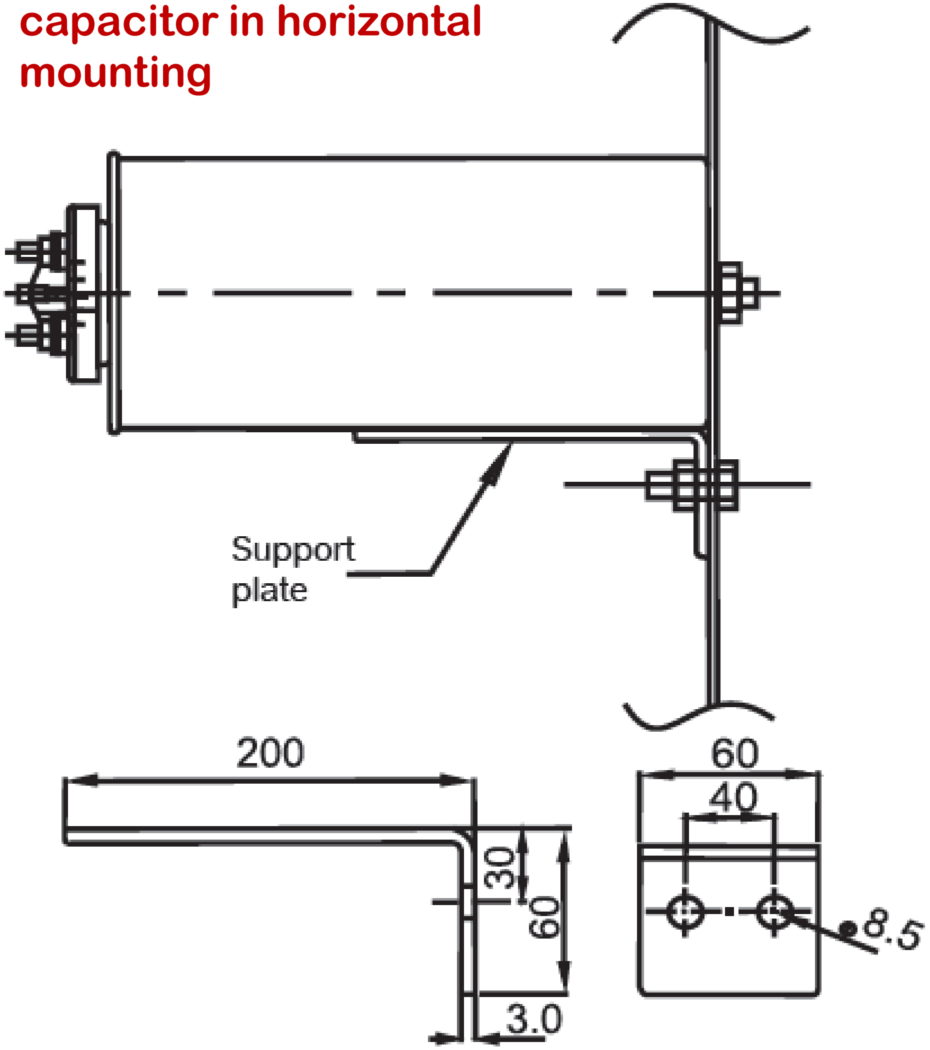




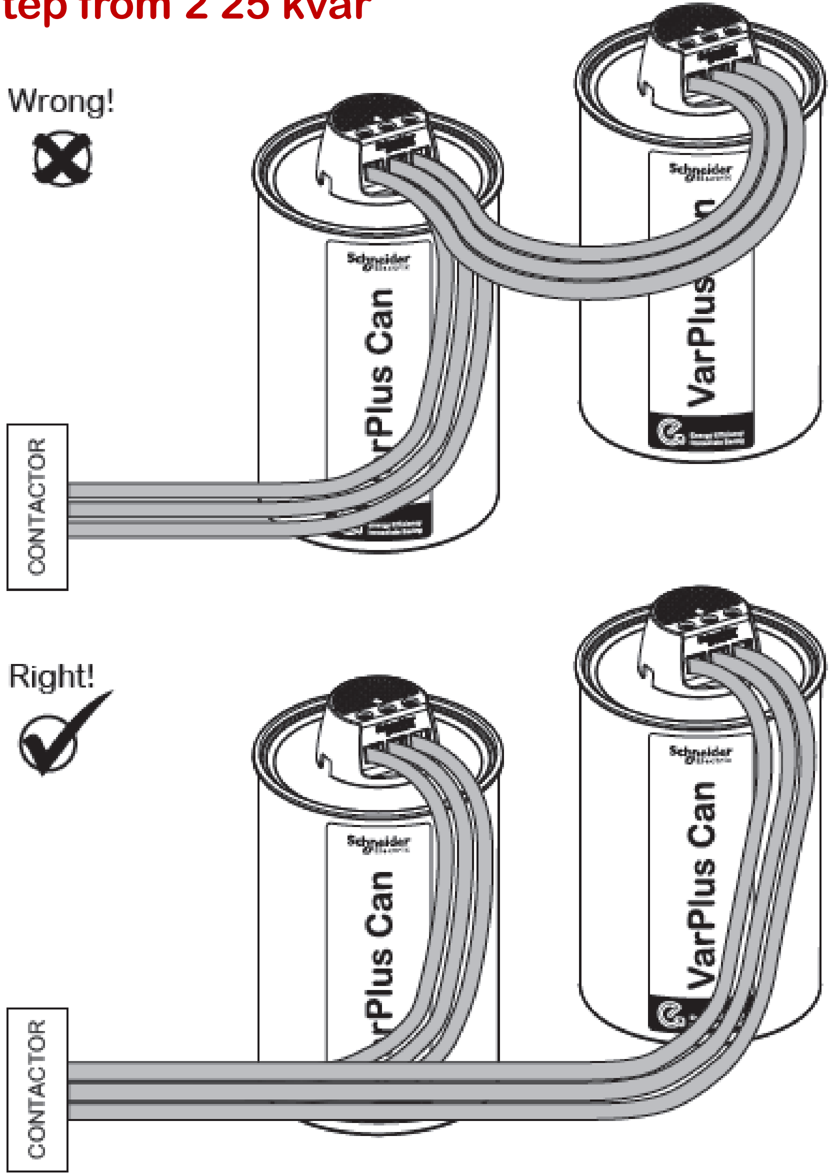
Capacitors installation rules

Installation and mounting

Installation of stud type capacitor in horizontal mounting



How to parallel capacitors (Eg: to make 50 kvar step from 2 25 kvar capacitor)



Capacitors installation rules

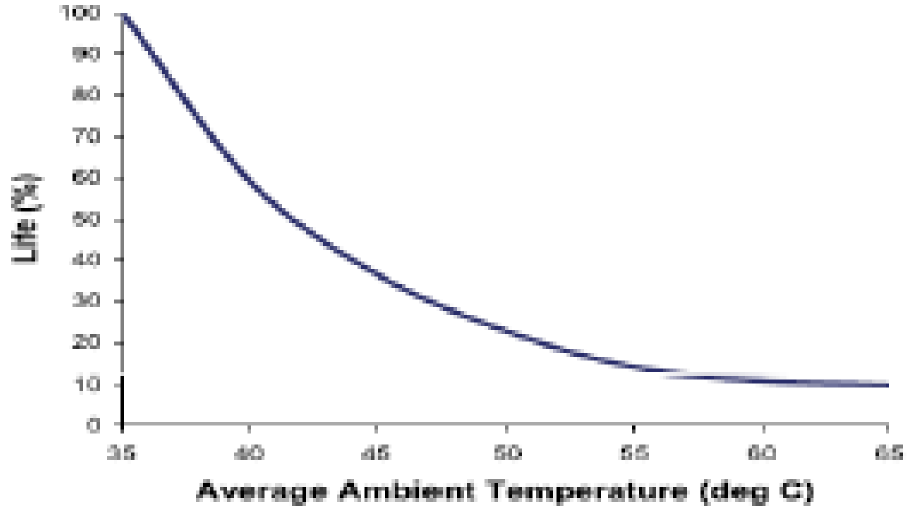
Cable selection

kvar	Cable Size in mm^2					
	230V/240V		400 to 480V		>600V	
	Al	Cu	Al	Cu	Al	Cu
5	6	6	6	6	6	6
7.5	10	6	6	6	6	6
10	16	10	6	6	6	6
12.5			10	6	6	6
15			10	6	6	6
20			16	10	10	6
25			25	16	16	10
30			-	25	16	10
40			-	35	25	16
50			-	35	35	25

Derating for an ambient temperature 50 °C

Compensation installation can be provided for the following operating conditions:

- maximum temperature in the electrical room: 50 °C
- average temperature over 24 hours in the electrical room: 45 °C
- average annual temperature in the electrical room: 35 °C
- minimum temperature: -5 °C



Change in capacitor life with respect to average ambient temperature (at constant voltage)

The following precautions must be taken:

• Ventilation must be forced, irrespective of the power, and the ventilation rate increased by 25 %
• For capacitor banks with Reactors : Air Flow = (m3/h) = 0.3 x Ps x 1.25
• The capacitor unit voltage must be higher than that normally required (minimum 1(% higher than that specified by the normal rating, Typically 550V and above)
• The contactors must be derated, the operating current must be increased by 10 % with respect to the maximum constant current of the step.

Example: 50 kvar 415 V step, rated current = 69.5 A: Imax = 1.5 x 69.5 = 104.3 A. At a maximum ambient temperature of 50 °C, the contactor must be able to accept a current of 104.3 x 1.1 = 114.7 A

• The cables must be appropriate for a current of at least 1.5 times the rated current of the capacitor at a minimum temperature of 60 °C.

Overvoltage Condition

CEI
IEC
61921

Première édition
First edition
2003-04

D.3 Voltage rise

$$\Delta U/U \approx Q/S$$

where

ΔU is the voltage rise in volts (V);

U is the voltage before connection of the capacitor (V);

S is the short-circuit power (MVA) where the capacitor is to be installed;

Q is expressed in megavars (Mvar).

The voltage on the capacitor terminals may be particularly high at times of light load conditions (see Annex D); in such cases, some or all of the capacitors should be switched out of circuit in order to prevent overstressing of the capacitors and undue voltage increase in the network.

If the voltage rise at times of light load is increased by capacitors, the saturation of transformer cores may be considerable. In this case, harmonics of abnormal magnitude are produced, one of which may be amplified by resonance between the transformer and capacitor. This is a further reason for recommending the disconnection of capacitor banks at times of light load.

Over Load Condition

Use MCCB not fuses

CEI
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61921

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First edition
2003-04

5.3.7 Switching and overload protection

It is recommended that capacitors be protected against overcurrent by means of suitable overcurrent relays, which are adjustable to operate the switching devices when the current exceeds the permissible limit specified in IEC 60831-1 and IEC 60931-1. Fuses do not

Fuses do not generally provide suitable overcurrent protection.

Harmonic distortion

D.2 Resonance frequency

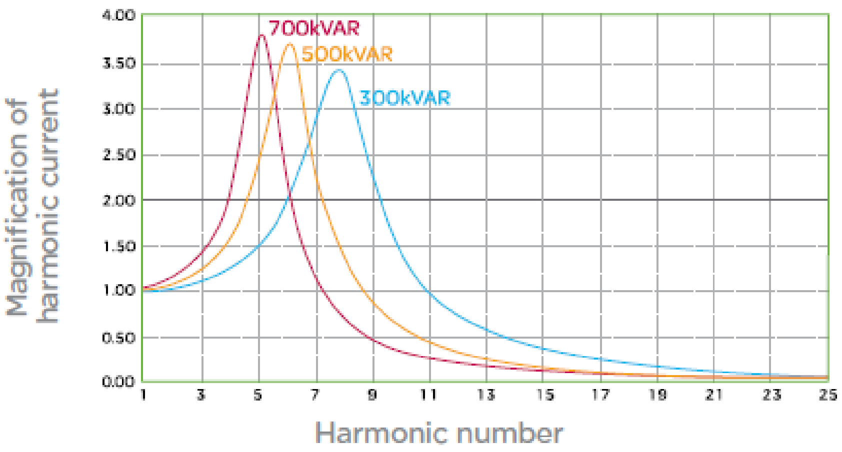
$$hr = \sqrt{\frac{kVAsc}{kVARc}}$$

where…

h_r = resonant frequency as a multiple of the fundamental frequency

kVA_{SC} = short circuit current at the point of study

$kVAR_C$ = capacitor rating at the system voltage



5.4.2.1 Harmonic distortion

PFC equipment when connected onto a system where harmonics are being generated will generally increase the amplitude of the harmonics, unless a well suited detuning reactor is placed in series with each capacitor step.

The capacitive reactance decreases with frequency, the capacitors, therefore, acts as a sink for higher harmonic currents. This increases the heating and dielectric stresses in capacitors. The result of increased heating and voltage stress due to harmonics results in a shortened capacitor life.

LV Capacitor bank-Installation

Installation guidelines for APFC panel

- Shift the panel to the location where it is required to be installed.
  a. Position the panel on the foundation and lock the panel base frame with the foundation bolts for free standing panels, by using spirit level and plumber block for achieving horizontal and vertical leveling.
  b. Position the panel on the wall or structure and fix with wall mounting brackets provided along with the panel. Leveling should be done here also as explained above.
- Connect the earth conductor to the panel terminal provided on either side of the panel.
- Use the key provided to open the door of the panel and make sure that electrical connection of all equipments are intact. This is particularly important since vibration in transportation sometimes may have resulted in loose connections.
- The cable rated for current capacity equivalent to main incomer of panel should be used. Use suitable size lugs for connecting the power cables.
- Connect the cable to the terminals provided for the power supply. Make sure that the correct phase identification is maintained while connecting the incoming terminals to the panel with respect to phases of supply line, as any mistake will lead to the malfunctioning of relay.
- Connect the APFC relay as mentioned in the checklists.
- Check the preset values of the CT secondary current of the relay. It should match with the CT used.

For VarplusCan

There are no restrictions in number of VarplusCan capacitors to be put on parallel; the following points have to be taken care before deciding the maximum kvar per step

a) Contactor rating.
b) VA burden of the relay.
c) Ventilation
d) Minimum clearances

a) Contactor Rating

Capacitor duty contactors are normally rated up to 60kvar. Whenever higher rated steps exist such as 75kvar, 100kvar or 120kvar, the contactors are connected in such a way to be operateed by a single contact of the relay.

However for rating 120kvar and above AC3 duty contactors can be used along with the suitable inductor coils in series with capacitors in two phases for suppressing the inrush current. *(refer to selection of capacitor switching and protection devices - Contactors)*

b) VA burden of the relay

The maximum kvar per step also depends on the VA burden of each output contact of the power factor relay. The coil rating of all the contactors in the step should not exceed the VA burden of the relay contact.

c) Ventilation

The maximum ambient temperature on the capacitors is +55°C. The capacitors have to be placed in the rack in such a way that temperature should not exceed this limit. So, proper ventilation is very much required.

d) Minimum clearances

For better air circulation, a minimum clearence of 30mm between capacitor units and panel enclosure need to be kept. Also maintain a 30mm gap above the top of the capacitor. These are the points to be considered while deciding the number of capacitors in a rack.

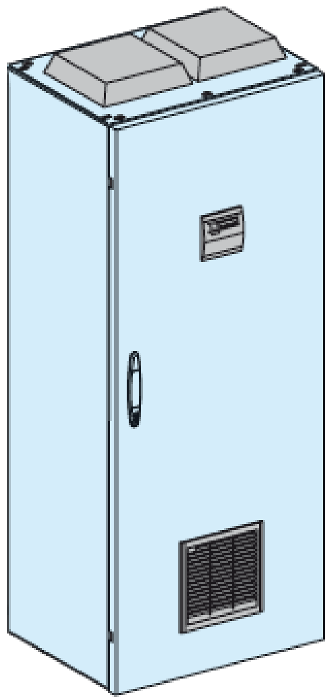
For more detail on Installation rules ,please Refer 2012 LV PFC PB Guide

Standard Examples

Installation

Mounting plates are equipped with the power factor correction modules, made up of a contactor, the corresponding protection fuses and a set of busbars.

- They are installed in a 650 mm + 150 mm wide cubicle that is either 400 or 600 mm deep depending on the depth of the switchboard to which it will be added.
- Each cubicle can be equipped with up to 5 VarplusCan power factor correction Modules (100 kvar) or up to 4 VarplusCan with self power factor correction Modules (50 kvar), positioned one above the other.
- The cubicle has a ventilated roof that can be equipped with one or two fans.
- The door has cut-outs, one for the Varlogic power factor controller and another in the bottom for a filter.



Standard cubicle supplied via the bottom..

Cubicle with a 300 mm wide compartment for incoming cables via the top.

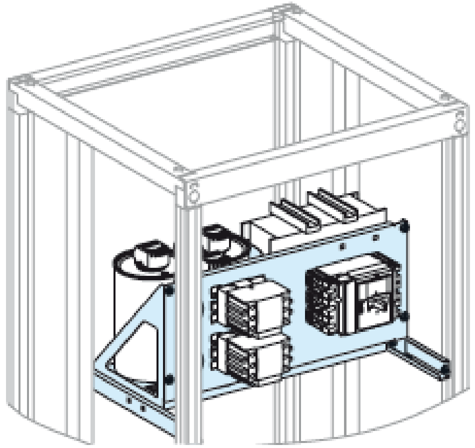
Device installation

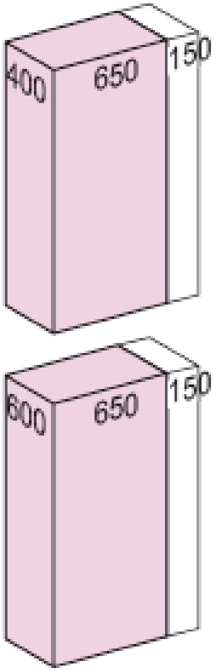
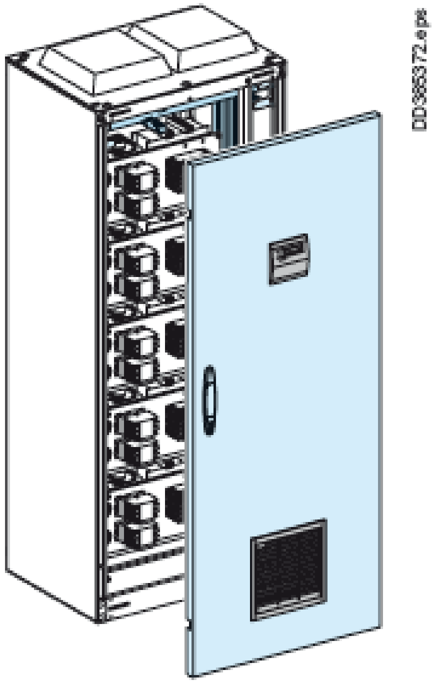
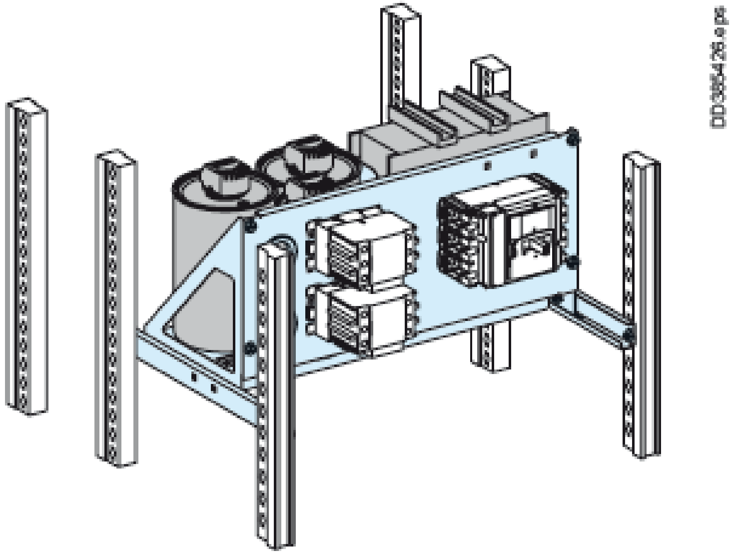
VarplusCan with self :

- No. of power factor correction modules per cubicle: 4
- Power range (kvar): 200
- Catalogue number: **03979**.

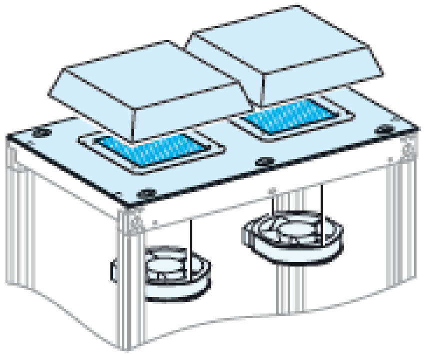
VarplusCan without self :

- No. of power factor correction modules per cubicle: 5
- Power range (kver): 500
- Catalogue number: **03979**.



Mounting	Door with cut-outs	Mounting plate
		
Catalogue number	03970	03979
Characteristics	Standard cover panels are used. However, a special door is used (hinges on left only) that has cut-outs, one for the Varlogic power factor controller and another in the bottom for a filter.	The mounting plates are designed for installation of capacitors, contactors and devices protecting against internal faults. The power factor correction modules are installed horizontally in the cubicle. Gasket gland plate NSYTPV is necessary for mounting plate wiring.

Note: *for further details, see page B-63.*

Mounting	Ventilation accessories						
							
Cover panels	Roof with cut-out		Fan + top hood	Top hood without fan	Outlet grill	Fan with filter	Spare filter
	D = 400 mm	D = 600 mm					
Catalogue number	**08478**	**08678**	**NSYCVF575M230MF**	**NSYCAC228RMF**	**NSYCAG291LPF**	**NSYCVF850M230PF**	**NSYCAF228R**
Characteristics	A roof with a cut-out ensures natural ventilation of the equipment. It can also be equipped with two fans.		**Fan characteristics** ■ Power: 85 W ■ Input voltage: 230 V ■ Throughput via outlet grill : □ with 1 outlet grill: 350 m³/hr □ Free with filter: 575 m³/hr ■ Noise level: 64 dB. **Top hood characteristics** ■ Material: steel ■ Finishing parts: painted with epoxy-polyester resin, textured RAL 7035 grey ■ IP54 ■ Fixing to the top by means of caged nuts and special screws	■ Material: steel ■ Finishing parts: painted with epoxy-polyester resin, textured RAL 7035 grey ■ IP54 ■ Fixing to the top by means of caged nuts and special screws	■ Material: Injected thermoplastic (ASA PC). self-extinguishing according to UL 94 V-0 ■ RAL 7035 grey ■ IP54	■ Power: 150/195 W ■ Input voltage: 207 V... 244 V (230 V) ■ Throughput via outlet grill: □ with 1 outlet grill: (m³/h): 718 (50 Hz) 568 (60 Hz) ■ Free with filter: 838 (50 Hz) 803 (60 Hz) ■ Noise level: 76/75 dB	For outlet grill or filter IP54, cut-out 228 x 228 mm

VarPlus Can + Detuned Reactor + Contactor + MCCB

+

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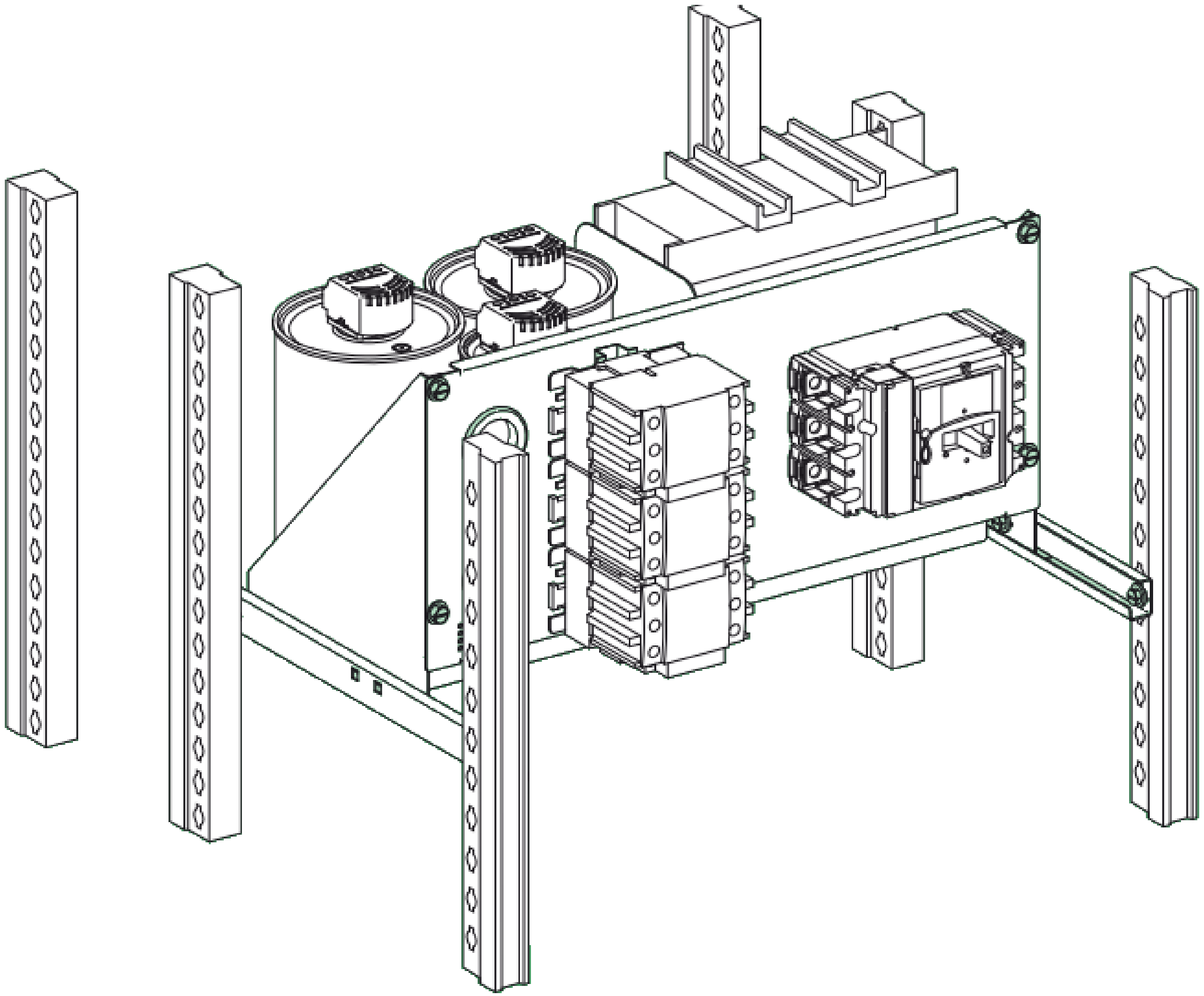

VarPlus Can + Detuned Reactor + Contactor + MCCB

Annexe au Certificat de conformité / *Annex to the Certificate of conformity*
n° 014-14BT

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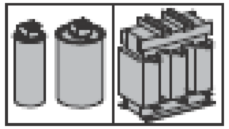
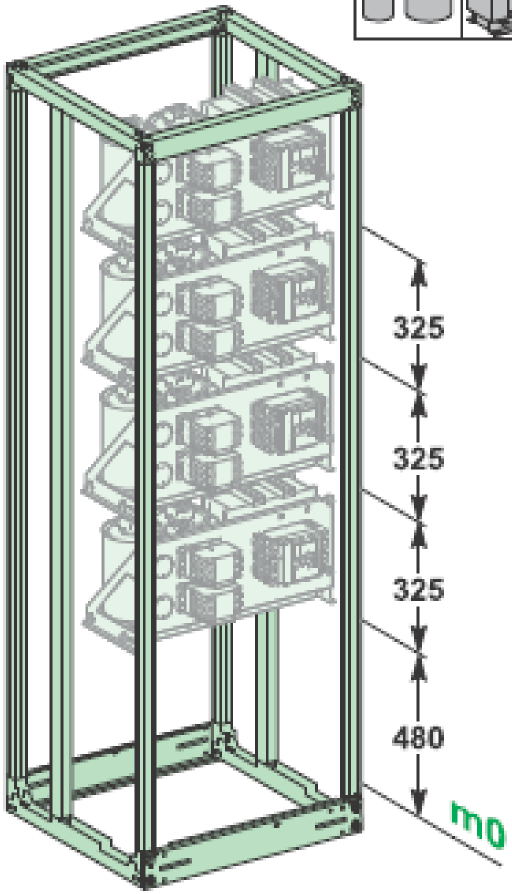
Caractéristiques techniques / *Technical characteristics*

Tension assignée d'emploi *Rated operational voltage* (Ue)	Circuit principal / *Main circuit*	jusqu'à / *up to* 690 V a.c.
Fréquence assignée / *Rated frequency*		50/60 Hz
Courant assigné / *Rated current* (In)	A la temperature ambiante moyenne de 35 °C *At average ambient temperature of 35 °C*	jusqu'à / *up to* 4000 A (En fonction des condensateurs installés / *Depending on the capacitors installed*)
Puissance réactive assignée / *Rated reactive power*	jusqu'à / *up to* 500 kvar (jusqu'à / *up* 200 kvar avec inductance non accordée / *with detuned reactor*)	

Maximum of 200KVAR with de-tuning reactors !!!





4 units maximum (with DRs)

Presentation

Prisma Plus cubicles can be used for installation of the new "VarplusCan" power factor correction modules designed to improve power system quality and reduce consumption of reactive energy.

These modules are made up of capacitors, contactors and special protection against internal faults.

The power factor correction modules are installed horizontally in a cubicle.

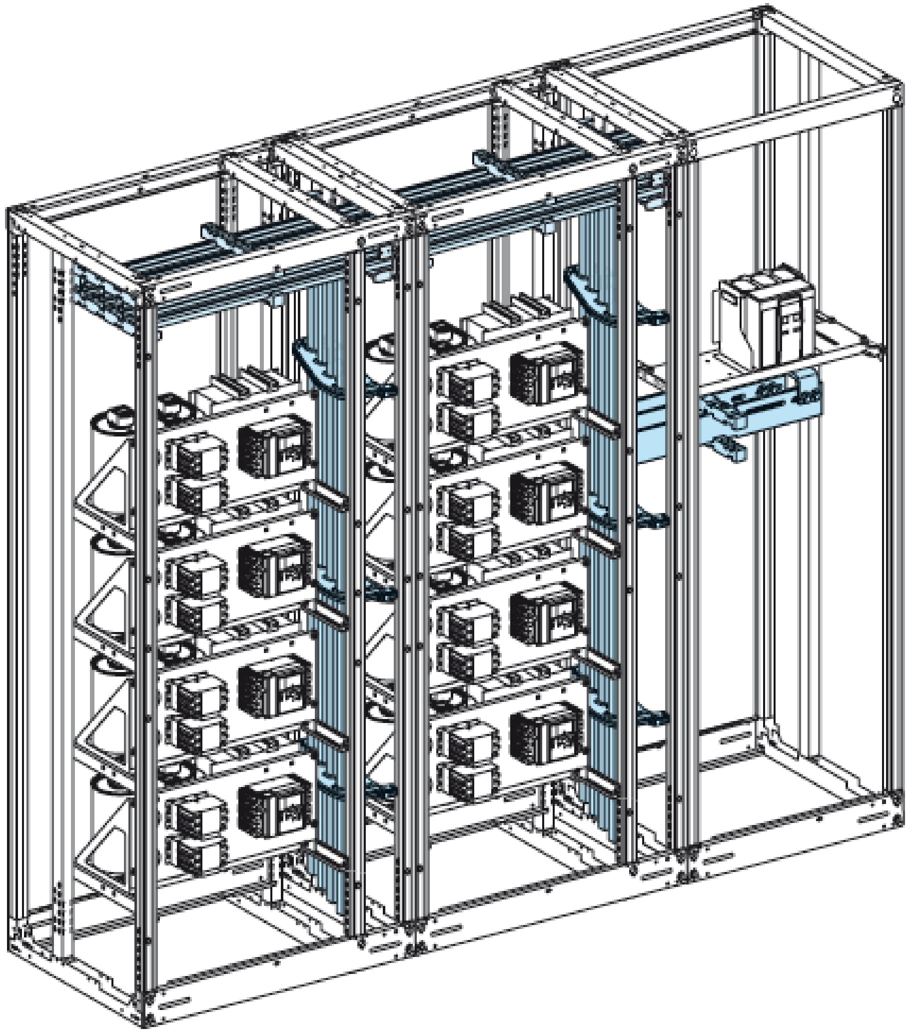
It is necessary to select each devices to create the power factor correction module according to the "Panelbuilder guide of Power Factor correction" number PFCED111008EN.

The busbars are supplied by a protection device installed in an adjacent cubicle.

Special Prisma P cubicles are used for power factor correction, given the temperature rise inside the cubicles.

They comply with and are tested according to standard CEI 61439-1 et 2.

DD385374.EPS



Pre Commissioning, Commissioning & Periodic Maintenance

Pre-Commissioning

Check list – 1 – for Capacitors

The following points should be verified before charging capacitor banks installed in APFC panel.

- Capacitor voltage rating is equal to or more than the maximum voltage recorded in the installation
- Capacitor is mounted and installed as per mounting and installation guidelines in this document
- The plant has the facility to trip the capacitor under over voltage conditions.(10%)
- Ensure each capacitor bank is provided with suitable protection devices.
- Suitable inrush current device is connected in series with contactor to limit the inrush current or capacitor duty contactor is connected.
- Capacitor is installed in the area free from entry of dust, chemical fumes and rain water. PF Controller provided in the panel should be set for 60 seconds On-delay. (Not applicable for capacitors used with the fast switching devices - Static Switched)
- The capacitor with detuned reactor banks are provided with MCCB for protection apart from above points. Use the switchgear selection guidelines for selection of breaker.

Pre-Commissioning

Check list – 2 – for APFC Panel

Following points are required to be verified before charging APFC panel.

✓All the electrical connection is checked for loose termination in the panel.
✓The CT is located before the cable connection of APFC panel towards source / main breaker of installation. Ensure the CTs are
✓connected to the PF Controller.
✓It is suggested to mount measurement C.T of the APFC Relay on the Highest current carrying phase (Eg: R) and the Voltage input for the relay is taken from other two phases (Eg: YB) . This is not applicable for a three phase sensing APFC relays.
✓Neutral cable is connected to the panel.
✓Current carrying capacity of cable in the APFC panel is rated equal to incomer switch current rating.
✓Capacitor terminals are checked for any loose connection.
✓Earthing bus is connected to the panel.
✓All the control fuses are intact.
✓If MCBs are used for step protection make sure they are switched on.
✓Emergency push button is released.
✓Panel are installed in the area free from entry of dust, chemical fumes and rain water.

Pre-Commissioning

Check list – 3 – for Capacitors with Detuned reactor

Verify the following points in the installation before commissioning capacitor with detuned reactor banks.

- ✓ Capacitor banks without reactor should not be permitted on the secondary side of transformer circuit which is having capacitor + Detuned reactor banks connected. In this case please remove capacitors without reactors from the same network.
- ✓ Capacitors used with reactors are always of higher voltage than network voltage. Please do not use normal capacitor rated for network voltage.
- ✓ Earthling should be done at capacitors and reactors separately.
- ✓ Make sure all the cable and termination guidelines are followed.
- ✓ Forced cross ventilation should be provided in the installation area. If the filter banks are installed inside the panel the fans need to be provided.
- ✓ Detuned reactors are provided with thermal protection, the Normally Closed (NC) dry contact must be used to disconnect the step in the event of overheating.

Commissioning

Following points are required to be verified before commissioning APFC panel.

✓Connect the 3-phase incoming cable to the Incoming terminal of the Incomer Switch / Circuit breaker of the APFC panel.
✓If the APFC controller / relay are programmable type, program the various settings as per instructions given in the respective instruction manual.
✓Ensure that the CT shorting links are removed after the CT secondary connections are made properly.
✓Keep the Auto /off / Manual selector switch in the Auto position.
✓Ensure that the power supply to the Incomer switch is 'ON' from the glowing of the indicating lamps 'R', 'Y', and 'B'. Cross check the system voltage.
✓Switch "ON" the Incomer SFU / MCCB / ACB of the APFC Panel.
✓The APFC relay will be energized and displays the present power factor, when R-Phase load CT connections and phase sequence of voltage (Y & B) are correct.

Note: Before interchanging the C.T. secondary wires, ensure that the terminals of the C.T. are shorted by a small wire, which should be removed after the inter change.

Periodic Maintenance

The following periodic checks are recommended to be conducted

> Visual check of components and current carrying parts,especially bus bar.

> Check tightness of all electrical connections.

> Check current drawn by the individual capacitor steps.

> Check the operation of contactors manually by switching of theAPFC equipment

> Visually check for rust and corrosions in bolts, nuts and other accessories

> Visually check for the sparks and burn outs in the panels.

Others

Site Tests – Inspection & Operations

Inspection operations			Comments Q.I
1- dielectric test	☐ test 2500 V - 50 Hz - 1 second minimum ☐ insulation measurement at 500 V CC		
2a- conformity			
Capacitor (kvar)	☐ conform	☐ not conform	
Fuse (A)	☐ conform	☐ not conform	
Contactor (type)	☐ conform	☐ not conform	
DR (mH)	☐ conform	☐ not conform	
DR (A)	☐ conform	☐ not conform	
Cable cross-section	☐ conform	☐ not conform	
Busbar cross-section	☐ conform	☐ not conform	
Connection pads	☐ conform	☐ not conform	
Earth circuit	☐ conform	☐ not conform	
Component identification	☐ conform	☐ not conform	
Conductor identification	☐ conform	☐ not conform	
Rating plate	☐ conform	☐ not conform	
Documentation	☐ conform	☐ not conform	
Frame continuity	☐ conform	☐ not conform	
Degree of protection	☐ conform	☐ not conform	
Locking	☐ conform	☐ not conform	
Presentation, appearance	☐ conform	☐ not conform	

Site Tests – Inspection & Operations

Inspection operations	Steps no.												Comments Q.I
	1	2	3	4	5	6	7	8	9	10	11	12	
2b- operation													
Contactor	□ OK	□ OK	□ OK	□ OK	□ OK	□ OK	□ OK	□ OK	□ OK	□ OK	□ OK	□ OK	
Controller	□ conform						□ not conform						
Indication	□ OK	□ OK	□ OK	□ OK	□ OK	□ OK	□ OK	□ OK	□ OK	□ OK	□ OK	□ OK	
2c- capacitance measurement C between Ø (mF)													
Capacitor no. reading	no.: no.: no.:	no.: no.: no.:	no.: no.: no.:	no.: no.: no.:	no.: no.: no.:	no.: no.: no.:	no.: no.: no.:	no.: no.: no.:	no.: no.: no.:	no.: no.: no.:	no.: no.: no.:	no.: no.: no.:	

Observations:..

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Failure Analysis - Background

> Failure of capacitors - major concern – with Utilities and Consultants.

> In majority of the cases, the failures are due to **non compliance with the design guidelines** of the original equipment manufacturer.

> **Assembled capacitor bank are of non type tested design.**

> Lack of knowledge of **IEC 61921**: Power Capacitors – Low voltage power factor correction banks.

> Components from various manufacturers are **MIXED** which dilutes the design / performance responsibility.

> **De tuning reactors** for de tuning are often referred to as **harmonic filters.**

> Limited space is often sighted as the reason for proposing super compact designs.

Failure Analysis : Case-1

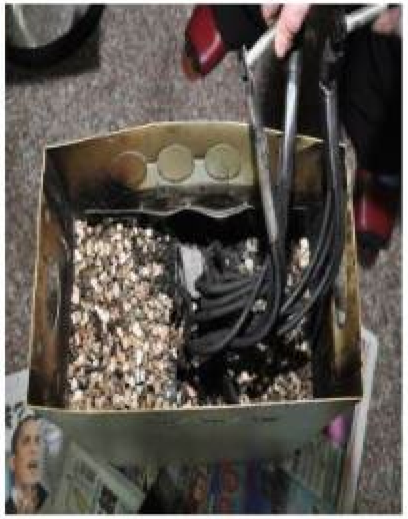



- > Ventilation inadequate
- > Lack of clearance between the reactors.
- > No over temperature & over load protection.
- > Non Type tested design.

Failure Analysis : Case-2

> Ventilation inadequate
> Lack of clearance between the reactors.
> No over temperature & over load protection.
> Component Mix.


EPCOS
PhaseCap
EPCOS
PhaseCap



For detailed information

> Reactive Energy Management – Low Voltage Components – Catalog 2014
PFCED310003EN_2014(print).pdf

> Guide for the Design and Production of LV Power Factor Correction Cubicles
2012 01 LV PFC PB Guide (print).pdf

Relevant Standards

> IEC 60831 - Shunt power capacitors of the self healing for a.c. systems up to 1000V
> IEC 61642 - Application of filters and shunt capacitors for industrial a.c. networks affected by harmonics
> IEC 61921 - Power capacitors-low voltage power factor correction capacitor banks

Relevant websites

> http://www.schneider-electric.com
> https://www.solution-toolbox.schneider-electric.com/segment-solutions
> http://engineering.electrical-equipment.org/
> http://www.electrical-installation.org

Relevant documents published by Schneider Electric

> Electrical Installation Guide.
> Expert Guide n°4: "Harmonic detection & filtering".
> Expert Guide n°6: "Power Factor Correction and Harmonic Filtering Guide"
> Technical Guide 152: "Harmonic disturbances in networks, and their treatment".
> White paper: controlling the impact of Power Factor and Harmonics on Energy Efficiency.