Varplus^2 capacitors installation guide

2006

a brand of Schneider Electric

Merlin Gerin

Contents

Power definition

Network characteristics

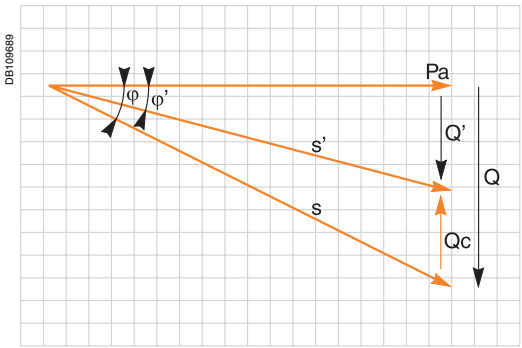
Network voltage and frequency are the basic factors that determine the size of an LV compensation cubicle. The reactive power Q varies according to the squared voltage and the frequency.

$Q = U^2 \times C \times \omega$

where:
Q = reactive power
U = network voltage
C = capacitance
$\omega = 2\pi f$
f = network frequency

Calculation of the reactive power to be installed

It is calculated:
- either from the electricity bills, to avoid paying for the reactive energy
- or from tan φ and a target tan φ'.



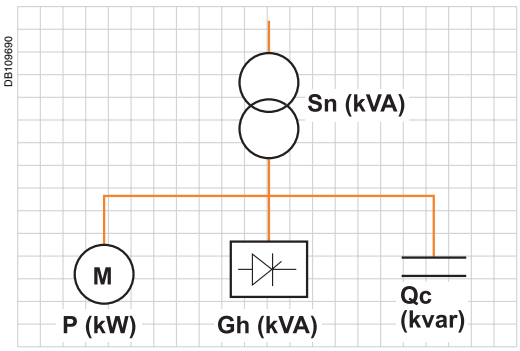
Compensation schematic diagram:
Qc = Pa (tg φ - tg φ').

kvar installation calculation table

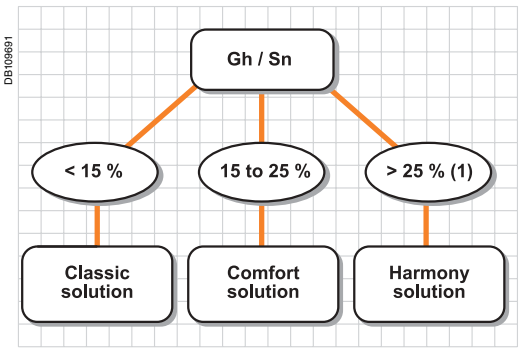
Before compensation		Capacitor power in kvar to be installed per kW of load to increase the power factor (cos φ) or tan φ to a given value													
		tg φ	**0.75**	**0.59**	**0.48**	**0.46**	**0.43**	**0.40**	**0.36**	**0.33**	**0.29**	**0.25**	**0.20**	**0.14**	**0.08**
tg φ	**cos φ**	**cos φ**	**0.80**	**0.86**	**0.90**	**0.91**	**0.92**	**0.93**	**0.94**	**0.95**	**0.96**	**0.97**	**0.98**	**0.99**	**1**
1.33	0.60		0.584	0.733	0.849	0.878	0.905	0.939	0.971	1.005	1.043	1.083	1.131	1.192	1.334
1.30	0.61		0.549	0.699	0.815	0.843	0.870	0.904	0.936	0.970	1.008	1.048	1.096	1.157	1.299
1.27	0.62		0.515	0.665	0.781	0.809	0.836	0.870	0.902	0.936	0.974	1.014	1.062	1.123	1.265
1.23	0.63		0.483	0.633	0.749	0.777	0.804	0.838	0.870	0.904	0.942	0.982	1.030	1.091	1.233
1.20	0.64		0.450	0.601	0.716	0.744	0.771	0.805	0.837	0.871	0.909	0.949	0.997	1.058	1.200
1.17	0.65		0.419	0.569	0.685	0.713	0.740	0.774	0.806	0.840	0.878	0.918	0.966	1.007	1.169
1.14	0.66		0.388	0.538	0.654	0.682	0.709	0.743	0.775	0.809	0.847	0.887	0.935	0.996	1.138
1.11	0.67		0.358	0.508	0.624	0.652	0.679	0.713	0.745	0.779	0.817	0.857	0.905	0.966	1.108
1.08	0.68		0.329	0.478	0.595	0.623	0.650	0.684	0.716	0.750	0.788	0.828	0.876	0.937	1.079
1.05	0.69		0.299	0.449	0.565	0.593	0.620	0.654	0.686	0.720	0.758	0.798	0.840	0.907	1.049
1.02	0.70		0.270	0.420	0.536	0.564	0.591	0.625	0.657	0.691	0.729	0.769	0.811	0.878	1.020
0.99	0.71		0.242	0.392	0.508	0.536	0.563	0.597	0.629	0.663	0.701	0.741	0.783	0.850	0.992
0.96	0.72		0.213	0.364	0.479	0.507	0.534	0.568	0.600	0.634	0.672	0.712	0.754	0.821	0.963
0.94	0.73		0.186	0.336	0.452	0.480	0.507	0.541	0.573	0.607	0.645	0.685	0.727	0.794	0.936
0.91	0.74		0.159	0.309	0.425	0.453	0.480	0.514	0.546	0.580	0.618	0.658	0.700	0.767	0.909
0.88	0.75		0.132	0.282	0.398	0.426	0.453	0.487	0.519	0.553	0.591	0.631	0.673	0.740	0.882
0.86	0.76		0.105	0.255	0.371	0.399	0.426	0.460	0.492	0.526	0.564	0.604	0.652	0.713	0.855
0.83	0.77		0.079	0.229	0.345	0.373	0.400	0.434	0.466	0.500	0.538	0.578	0.620	0.687	0.829
0.80	0.78		0.053	0.202	0.319	0.347	0.374	0.408	0.440	0.474	0.512	0.552	0.594	0.661	0.803
0.78	0.79		0.026	0.176	0.292	0.320	0.347	0.381	0.413	0.447	0.485	0.525	0.567	0.634	0.776
0.75	0.80			0.150	0.266	0.294	0.321	0.355	0.387	0.421	0.459	0.499	0.541	0.608	0.750
0.72	0.81			0.124	0.240	0.268	0.295	0.329	0.361	0.395	0.433	0.473	0.515	0.582	0.724
0.70	0.82			0.098	0.214	0.242	0.269	0.303	0.335	0.369	0.407	0.447	0.489	0.556	0.698
0.67	0.83			0.072	0.188	0.216	0.243	0.277	0.309	0.343	0.381	0.421	0.463	0.530	0.672
0.65	0.84			0.046	0.162	0.190	0.217	0.251	0.283	0.317	0.355	0.395	0.437	0.504	0.645
0.62	0.85			0.020	0.136	0.164	0.191	0.225	0.257	0.291	0.329	0.369	0.417	0.478	0.620
0.59	0.86				0.109	0.140	0.167	0.198	0.230	0.264	0.301	0.343	0.390	0.450	0.593
0.57	0.87				0.083	0.114	0.141	0.172	0.204	0.238	0.275	0.317	0.364	0.424	0.567
0.54	0.88				0.054	0.085	0.112	0.143	0.175	0.209	0.246	0.288	0.335	0.395	0.538
0.51	0.89				0.028	0.059	0.086	0.117	0.149	0.183	0.230	0.262	0.309	0.369	0.512
0.48	0.90					0.031	0.058	0.089	0.121	0.155	0.192	0.234	0.281	0.341	0.484

Choice of compensation type

Devices using power electronics (variable speed drives, rectifiers, UPS, arc furnaces, fluorescent lamps, etc.) circulate harmonic currents in electrical networks. Such harmonics can interfere with the operation of many devices. Capacitors are highly sensitive to harmonics. A high level of harmonic pollution causes capacitors to overheat and age prematurely (breakdown).
Different types of compensation must be chosen according to the power of the harmonic generators.



***Sn**: apparent power of the transformer.*
***Gh**: apparent power of harmonics-generating receivers (variable speed motors, static converters, power electronics, etc.).*
***Qc**: power of the compensation equipment.*
***U**: network voltage.*



(1) Beyond 50 %, a harmonic filtering study is required.

Compensation solution can be of three types (classic, comfort, harmony), depending on the level of network harmonic pollution.
It can be selected as follows:

■ according to the Gh/Sn ratio

Example 1
U = 400 V P = 450 kW
Sn = 800 kVA Gh = 50 kVA
$\frac{Gh}{Sn} = 6{,}2\ \%$ → **Classic range**

Example 2
U = 400 V P = 300 kW
Sn = 800 kVA Gh = 150 kVA
$\frac{Gh}{Sn} = 18{,}75\ \%$ → **Comfort range**

Example 3
U = 400 V P = 100 kW
Sn = 800 kVA Gh = 400 kVA
$\frac{Gh}{Sn} = 50\ \%$ → **Harmony range**

■ according to the percentage of total harmonic current distortion THD(I) measured.

$THD(I) \times \frac{S}{Sn} < 5\ \%$ → **Classic range**

$5\ \% < THD(I) \times \frac{S}{Sn} < 10\ \%$ → **Comfort range**

$10\ \% < THD(I) \times \frac{S}{Sn} < 20\ \%$ → **Harmony range**

Sn = apparent power of the transformer.
S = load in kVA at the transformer secondary at the time of measurement.

***Note:** harmonics must be measured at the transformer secondary, at maximum load and without capacitors.*
The apparent power at the time of measurement must be taken into account.

Choice of compensation type

Customer needs

Below table describes typical solutions used in several types of activities.

Very frenquently

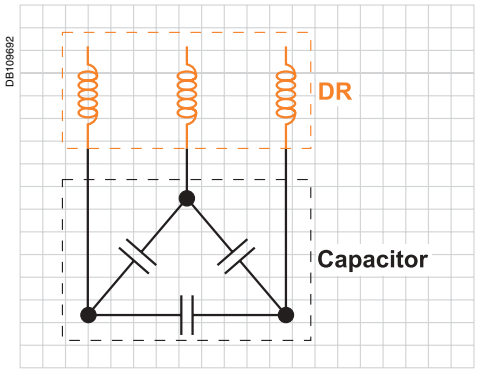
Usually

Occasionally

In any case, it is recommended to make measurements at site in order to validate the final solution.

	Classic	Comfort	Harmony
Pollution rate	**Gh/Sn ⩽ 5 %**	**15 % < Gh/Sn ⩽ 25 %**	**25 % < Gh/Sn ⩽ 50 %**
Industry			
Food and beverage			
Textile			
Wood			
Paper			
Printing			
Chemical - pharmac			
Plastic			
Glass - Ceramic			
Steel making			
Metallurgy			
Automotive			
Cement			
Mines			
Reffinery			
Micro-electronic			
Tertiary			
Banks - insurances			
Supermarkets			
Hospitals			
Stadium			
Amusement parks			
Hotels - Offices			
Energy & Infrastructures			
Sub-station			
Water distribution			
Internet farm			
Wind mills			
Railways			
Airports			
Subway			
Harbours			
Tunnels			

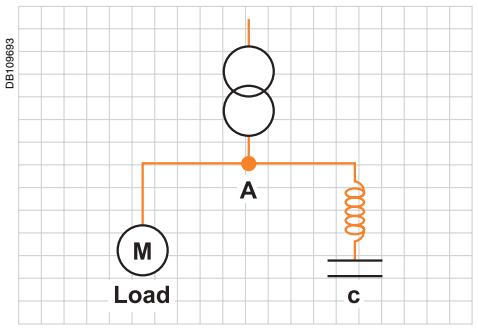
Choice of detuned reactor tuning frequency

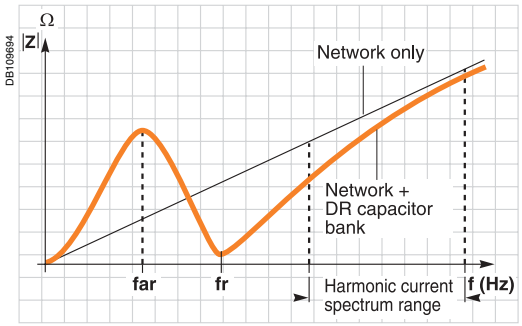


General

The detuned reactors (DR) are designed to avoid any amplification of the harmonics present on the network and to protect the capacitors (it corresponds to our Harmony range).

The detuned reactors generate an overvoltage at the capacitor terminals. Capacitors of at least 480 V must be used for a 400 V network.





Curve: impedance module at point A

Technical data

Choice of tuning

The tuning frequency **fr** corresponds to the resonance frequency of the L-C assembly.

$$fr = \frac{1}{2\pi\sqrt{LC}}$$

We also speak of tuning order **n**.
For a 50 Hz network:

$$n = \frac{fr}{50\ Hz}$$

- the tuning frequency chosen must ensure that the harmonic current spectrum range is outside the resonance frequency
- it is essential to ensure that no remote control frequencies are disturbed.

The most common tuning orders are 3.8 or 4.3 (2.7 is used for 3rd order harmonics).

DR, 400 V, 50 Hz tuning frequency selection table

Harmonic generators (Gh)	Remote control frequency (Ft)			
	Without	165 < Ft ⩽ 250 Hz	250 < Ft ⩽ 350 Hz	Ft > 350 Hz
Three-phase	**Tuning frequency**			
Variable speed drives, rectifiers, UPS, starters	135 Hz	135 Hz (1)	190 Hz	215 Hz
	190 Hz	-	-	-
	215 Hz	-	-	-
Single-phase (Gh > 10 % Sn)	**Tuning frequency**			
Discharge lamps, electronic ballast lamps, fluorescent lamps, UPS, variable speed drives, welding machines	135 Hz	135 Hz	135 Hz	135 Hz

Single-phase Gh: power of single-phase harmonic generators in kVA.
***(1)** A tuning frequency of 215 Hz can be used in France with a remote control frequency of 175 Hz.*

Concordance between tuning frequency, tuning order and relative impedance (50 Hz network)

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

Physical and electrical control

The Varlogic power factor controllers continually measure the reactive power of the system and switch the capacitor steps ON and OFF to obtain the required power factor. Their ten step combinations enable them to control capacitors of different powers.

Step combinations

1.1.1.1.1.1 1.2.3.3.3.3
1.1.2.2.2.2 1.2.3.4.4.4
1.1.2.3.3.3 1.2.3.6.6.6
1.1.2.4.4.4 1.2.4.4.4.4
1.2.2.2.2.2 1.2.4.8.8.8

These combinations ensure accurate control, by reducing:
- the number of power factor correction modules
- labour.

Optimising the control in this way generates considerable financial benefits.

Explanations

Q1 = Power of the first step
Q2 = Power of the second step
Q3 = Power of the third step
Q4 = Power of the fourth step
etc.
Qn = Power of the n^{th} step (maximum 12)

Examples

1.1.1.1.1.1 : Q2 = Q1, Q3 = Q1, …, Qn = Q1
1.1.2.2.2.2 : Q2 = Q1, Q3 = 2Q1, Q4 = 2Q1, …, Qn = 2Q1
1.2.3.4.4.4 : Q2 =2Q1, Q3 = 3Q1, Q4= 4Q1, …, Qn = 4Q1
1.2.4.8.8.8 : Q2 = 2Q1, Q3 = 4Q1, Q4= 8 Q1, …, Qn = 8 Q1

Calculating the number of electrical steps

The number of electrical steps (e.g. 13)
Depends on:
- the number of controller outputs used (e.g. 7)
- the chosen combination, according to the power of the various steps (e.g. 1.2.2.2).

Number of electrical steps

Combinations	Number of controller outputs used											
	1	2	3	4	5	6	7	8	9	10	11	12
1.1.1.1.1.1…	1	2	3	4	5	6	7	8	9	10	11	12
1.1.2.2.2.2…	1	2	4	6	8	10	12	14	16	18	20	22
1.2.2.2.2.2…	1	3	5	7	9	11	13	15	17	19	21	23
1.1.2.3.3.3…	1	2	4	7	10	13	16	19	22	25	28	31
1.2.3.3.3.3…	1	3	6	9	12	15	18	21	24	27	30	33
1.1.2.4.4.4…	1	2	4	8	12	16	20	24	28	32	36	40
1.2.3.4.4.4…	1	3	6	10	14	18	22	26	30	34	38	42
1.2.4.4.4.4…	1	3	7	11	15	19	23	27	31	35	39	43
1.2.3.6.6.6…	1	3	6	12	18	24	30	36	42	48	54	60
1.2.4.8.8.8…	1	3	7	15	23	31	39	47	55	63	71	79

Physical and electrical control

Example
150 kvar 400 V 50 Hz

Solution 1: physical control 10 x 15 kvar
15 + 15 + 15 + 15 + 15 + 15 + 15 + 15 + 15 + 15 ; sequence : 1.1.1.1.1.1
■ 10 physical steps
■ 10 contactors
■ 12-step controller.
Labour, high cost: non-optimised solution.

Solution 2: electrical control 10 x 15 kvar
15 + 30 + 45 + 60 = 10 x 15 kvar electrical; sequence: 1.2.3.4
■ 4 physical steps allowing for 10 different powers
■ 4 contactors
■ 6-step controller.
Optimisation of the compensation cubicle.

Possible powers (kvar)	Physical steps			
	15	30	45	60
15	■	-	-	-
30	-	■	-	-
45	■	■	(□)	-
60	■	-	■	(□)
75	(□)	■	■	(□)
90	■	■ (□)	■	(□)
105	■	■	(□)	■ (□)
135	-	■	■	■
150	■	■	■	■

(□) Other possible combinations.

Other solutions
10 x 15 kvar electrical
Sequence: 1.1.2.2.2 : 15 + 15 + 30 + 30 + 30 + 30 kvar.
Sequence: 1.1.2.3.3 : 15 + 15 + 30 + 45 + 45 kvar.

Safety delay

The Varplus capacitors have an internal discharge resistor that reduces the voltage to 50 V in 1 minute after disconnection from the network.
It is essential that the discharge time be observed to prevent the capacitors and contactors from ageing prematurely.

Automatic capacitor bank
The safety delay of the Varlogic controller must be set to **a minimum of 60 seconds**.
When the supply to the contactors is separate or different from the supply to the controller, the control circuit must be wired to ensure that the discharge time (60 s) of the capacitor is observed (for example the contactors and the controller must be disconnected at the same time).

Fixed capacitor bank
In the case of manually controlled capacitors, there must be a system to ensure that no capacitor can be connected more than once in less than **1 minute**.

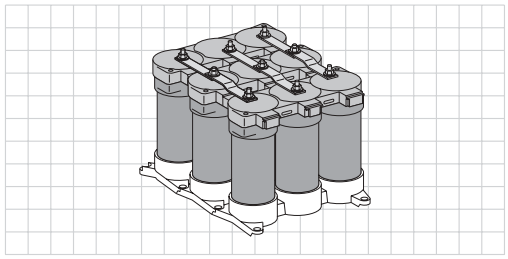
Varplus² capacitors

Varplus² modular capacitors allow by their different assembly combination to cover many power ratings (kvar) depending on the voltage (V), frequency (Hz) and harmonic pollution level of the network.

PB100058

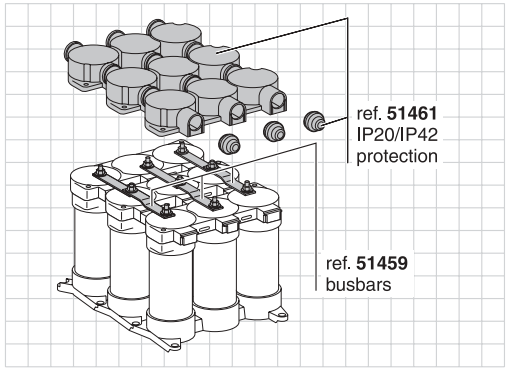
Varplus² IP00.

DB109695



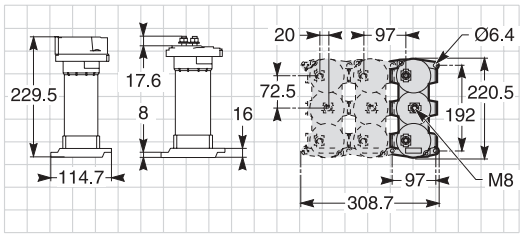
Example of Varplus² IP00 assembly.

DB109696



Varplus² accessories.

DB109697



Weight of Varplus² 2.1 kg.

Classic range (Gh/Sn ⩽ 15 %)

Varplus²			
400 V (kvar)	**415 V (kvar)**		**Reference**
5	5.5		**51311**
6.25	6.5		**51313**
7.5	7.75		**51315**
10	10.75		**51317**
12.5	13.5		**51319**
15	15.5		**51321**
20	21.5		**51323**
Assembly advised			
25	27	2 x	**51319**
30	31	2 x	**51321**
40	43	2 x	**51323**
50	53.5	2 x	**51321 + 51323**
55	58.5	2 x	**51323 + 51321**
60	64.5	3 x	**51323**
65		3 x	**51323 + 51311**

Maximum mechanical assembly: 4 capacitors and 65 kvar.
Assembly > 65 kvar: see conditions to respect in Varplus² user manual.

Technical data

- ■ capacitor rated voltage: 415 V, 3-phase 50 Hz
- ■ HQ protection system built into each single phase element
- □ high current fault protection by HRC cartridge fuse
- □ low current fault protection by combination of single phase internal overpressure device with the HRC fuse
- ■ capacitance value tolerance: -5, +10 %
- ■ insulation level:
- □ withstand 50 Hz 1 minute: 4 kV
- □ impulse wave withstand 1.2/50 µs: 15 kV
- ■ voltage test: 2.15 Un (rated voltage) for 10 s
- ■ maximum permissible overloads at service voltage network as per IEC 60831 1/2:
- □ current: 30 % permanently
- □ voltage: 10 % (8 hours over 24 hours)
- ■ with internaly fitted discharge resistors: residual voltage less than 50 V in 1 minute
- ■ total losses: less than 0.5 Watt/kvar (discharge resistors included)
- ■ temperature class D (+55 °C):
- □ maximum: 55 °C
- □ average over 24 hours: 45 °C
- □ average over 1 year: 35 °C
- □ maximum: -25 °C
- ■ colour:
- □ elements RAL 9005
- □ base and cover RAL 7030
- ■ standards: IEC 60831 1/2, CSA 22-2 N°190, UL 810
- ■ execution: indoor
- ■ protection:
- □ IP00 without cover (option)
- □ IP20 or IP42 see accessories
- ■ no earth connection is needed
- ■ terminals: 3 M8 rods allowing 360° cable connection (without cover).

Accessories for Varplus²	Reference
1 set of 3-phase copper bars for connection and assembly of 2 and 3 capacitors	**51459**
1 set of protective cover (IP20) and cable glands (IP42) for 1, 2 and 3 capacitors	**51461**

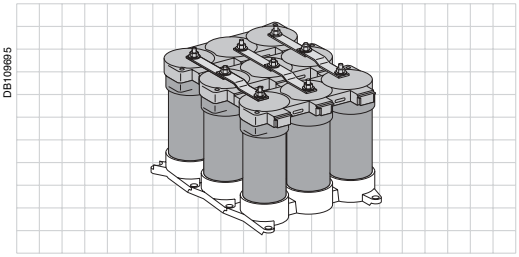
Installation

All positions are convenient except vertical one with connecting terminals upside down. Fixing holes for M6 screws.
A kit to replace Varplus by Varplus² is available (ref. **51298**).

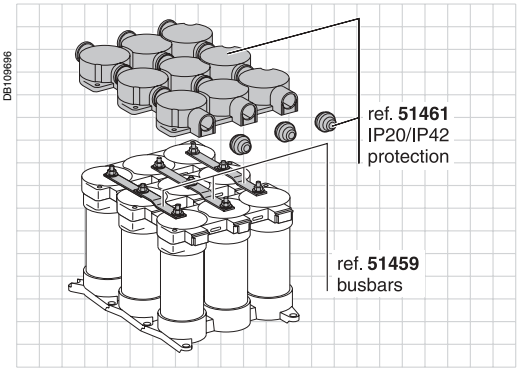
Varplus² capacitors

Varplus² modular capacitors allow by their different assembly combination to cover many power ratings (kvar) depending on the voltage (V), frequency (Hz) and harmonic pollution level of the network.

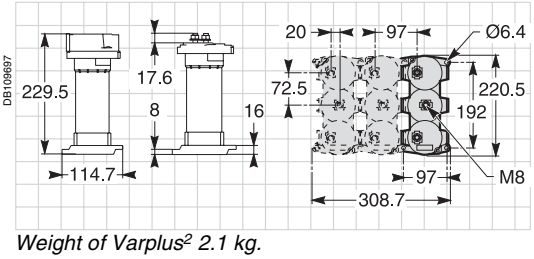
Varplus² IP00.



Example of Varplus² IP00 assembly.



Varplus² accessories.



Weight of Varplus² 2.1 kg.

Comfort range (15 % < Gh/Sn ⩽ 25 %)

Capacitors rated 480 V are necessary.

Varplus²				
Usefull powers		**Rated values**		
400 V (kvar)	**415 V (kvar)**	**440 V (kvar)**	**480 V (kvar)**	**Reference**
5	5.5	6.1	7.2	**51325**
6.25	6.5	7.6	9	**51327**
7.5	8	8.8	10.4	**51329**
10	11	13	15.5	**51331**
12.5	13.5	14.3	17	**51333**
15	16.5	19.1	22.7	**51335**
Assembly advised				
20	23		2 x	**51331**
25	25		2 x	**51333**
30	34		2 x	**51335**
45	51		3 x	**51335**
60	68		4 x	**51335**

Maximum mechanical assembly: 4 capacitors and 62/68 kvar 400/415 V.
Assembly > 62 kvar: see conditions to respect in Varplus² user manual.

Technical data

■ capacitor rated voltage: 480 V, 3-phase 50 Hz
■ HQ protection system built into each single phase element
□ high current fault protection by HRC cartridge fuse
□ low current fault protection by combination of single phase internal overpressure device with the HRC fuse
■ capacitance value tolerance: -5, +10 %
■ insulation level:
□ withstand 50 Hz 1 minute: 4 kV
□ impulse wave withstand 1.2/50 µs: 15 kV
■ voltage test: 2.15 Un (rated voltage) for 10 s
■ maximum permissible overloads at service voltage network as per IEC 60831 1/2:
□ current: 30 % permanently
□ voltage: 10 % (8 hours over 24 hours)
■ with internaly fitted discharge resistors: residual voltage less than 50 V in 1 minute
■ total losses: less than 0.5 Watt/kvar (discharge resistors included)
■ temperature class D (+55 °C):
□ maximum: 55 °C
□ average over 24 hours: 45 °C
□ average over 1 year: 35 °C
□ minimum: -25 °C
■ colour:
□ elements RAL 9005
□ base and cover RAL 7030
■ standards: IEC 60831 1/2, CSA 22-2 No190, UL 810
■ execution: indoor
■ protection:
□ IP00 without cover
□ IP20 or IP42 see accessories
■ no earth connection is needed
■ terminals: 3 M8 rods allowing 360° cable connection (without cover).

Accessories for Varplus²	Reference
1 set of 3-phase copper bars for connection and assembly of 2 and 3 capacitors	**51459**
1 set of protective cover (IP20) and cable glands (IP42) for 1, 2 and 3 capacitors	**51461**

Installation

All positions are convenient except vertical one with connecting terminals upside down. Fixing holes for M6 screws.
A kit to replace Varplus by Varplus² is available (ref. **51298**).

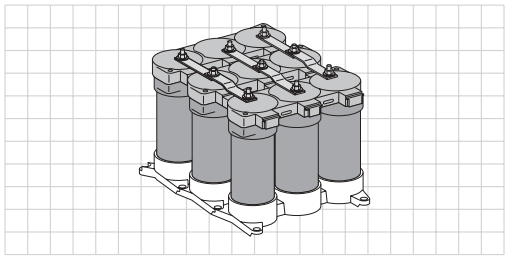
Varplus² capacitors

Varplus² modular capacitors allow by their different assembly combination to cover many power ratings (kvar) depending on the voltage (V), frequency (Hz) and harmonic pollution level of the network.

PB100058

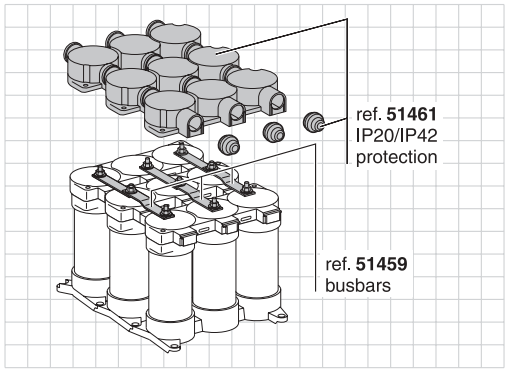
Varplus² IP00.

DB109695



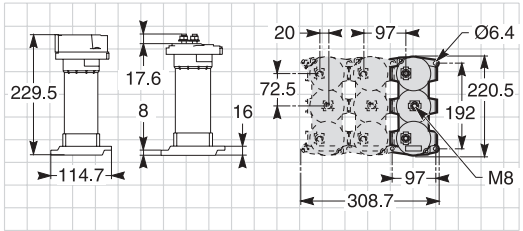
Example of Varplus² IP00 assembly.

DB109696



Varplus² accessories.

DB109697



Weight of Varplus² 2.1 kg.

Comfort range (25 % < Gh/Sn ⩽ 50 %)

Capacitors rated 480 V will be used with detuned reactor.

Varplus²					
Usefull powers tuning order	**400 V (kvar)**	**415 V (kvar)**	**Rated values 440 V (kvar)**	**480 V (kvar)**	**Ref**
2.7	6.5	7	6.7	8	**51337**
(135 Hz - 13.7 %)	12.5	13.5	13	15.5	**51331**
Assembly advised					
	25	27			2 x **51331**
	50	54			2 x **51335 + 51333**

Maximum mechanical assembly: 4 capacitors and 50/54 kvar 400/415 V.
Assembly > 50 kvar: see conditions to respect in Varplus² user manual.

Usefull powers tuning order	**400 V (kvar)**	**415 V (kvar)**	**Rated values 440 V (kvar)**	**480 V (kvar)**	**Ref**
3.8 (190 Hz - 6.92 %)	6.5	7	7.6	9	**51327**
or	7.75	8.25	8.8	10.4	**51329**
4.3 (215 Hz - 5.4 %)	10	11	11.8	14	**51345**
	12.5	13.5	14.3	17	**51333**
	16.5	17.75	19.1	22.7	**51335**
Assembly advised					
	25	27			2 x **51333**
	30	31.25			**51333 + 51335**
	50	53.25			3 x **51335**

Maximum mechanical assembly: 4 capacitors and 65 kvar 400/415 V.
Assembly > 65 kvar: see conditions to respect in Varplus² user manual.

Technical data

- ■ capacitor rated voltage: 480 V, 3-phase 50 Hz
- ■ HQ protection system built into each single phase element
- □ high current fault protection by HRC cartridge fuse
- □ low current fault protection by combination of single phase internal overpressure device with the HRC fuse
- ■ capacitance value tolerance: -5, +10 %
- ■ insulation level:
- □ withstand 50 Hz 1 minute: 4 kV
- □ impulse wave withstand 1.2/50 µs: 15 kV
- ■ voltage test: 2.15 Un (rated voltage) for 10 s
- ■ maximum permissible overloads at service voltage network as per IEC 60831 1/2:
- □ current: 30 % permanently
- □ voltage: 10 % (8 hours over 24 hours)
- ■ with internaly fitted discharge resistors: residual voltage less than 50 V in 1 mn
- ■ total losses: less than 0.5 Watt/kvar (discharge resistors included)
- ■ temperature class D (+55 °C):
- □ maximum: 55 °C
- □ average over 24 hours: 45 °C
- □ average over 1 year: 35 °C
- □ minimum: -25 °C
- ■ colour:
- □ elements RAL 9005
- □ base and cover RAL 7030
- ■ standards: IEC 60831 1/2, CSA 22-2 No190, UL 810
- ■ execution: indoor
- ■ protection:
- □ IP00 without cover
- □ IP20 or IP42 see accessories
- ■ no earth connection is needed
- ■ terminals: 3 M8 rods allowing 360° cable connection (without cover).

Accessories for Varplus²	**Ref.**
1 set of 3-phase copper bars for connection and assembly of 2 and 3 capacitors	**51459**
1 set of protective cover (IP20) and cable glands (IP42) for 1, 2 and 3 capacitors	**51461**

Installation

All positions are convenient except vertical one with connecting terminals upside down. Fixing holes for M6 screws. A kit to replace Varplus by Varplus² is available (ref. **51298**).

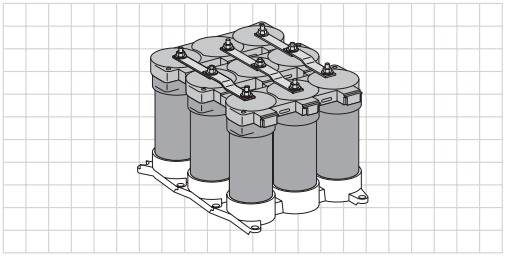
Varplus² capacitors

525 / 550 V - 50 Hz range for DR application, 400 / 415 V network.
Maximum ambient temperature: 50 °C
Maximum altitude: 1000 m
25% < Gh/Sn ⩽ 50% (see chapter 6 p 25)

PB100058

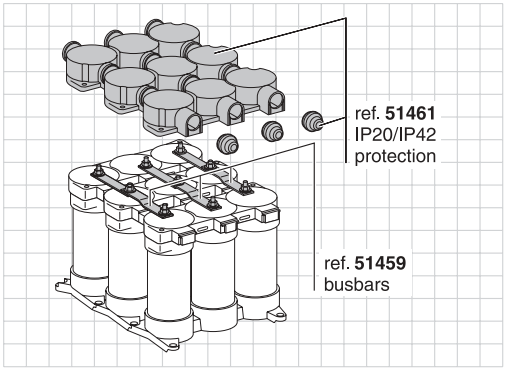
Varplus² IP00.

DB109695



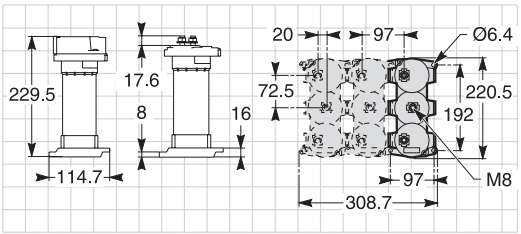
Example of Varplus² IP00 assembly.

DB109696



Varplus² accessories.

DB109697



Weight of Varplus² 2.1 kg.

Classic range (Gh/Sn ⩽ 15 %)

Varplus²		
Usefull powers 480 V (kvar)	**Rated values 525 V (kvar)**	**Reference**
12.5	15	**51383**
Usefull powers 525 V (kvar)	**Rated values 550 V (kvar)**	**Reference**
10.5	11.5	**51351**
12.3	13.5	**51353**
16.4	18	**51357**
Assembly advised		
21	23	2 x **51351**
24.6	27	2 x **51353**
32.8	36	2 x **51357**
49.2	54	3 x **51357**
59.7		3 x **51357 + 51351**
	59	2 x **51351 + 51357**
65.6	72	4 x **51357**

Maximum mechanical assembly: 4 capacitors and 66/72 kvar 525/550 V.
Assembly > 66 kvar: see conditions to respect in Varplus² user manual.

Polluted and highly polluted network (15 % < Gh/Sn ⩽ 50 %)

Capacitors rated 690 V will be used with detuned reactor 190/215 Hz, 135 Hz turning order on request.

Technical data

- ■ capacitor rated voltage: 550 V, 3-phase 50 Hz for slightly polluted network
- ■ HQ protection system built into each single phase element
- □ high current fault protection by HRC cartridge fuse
- □ low current fault protection by combination of single phase internal overpressure device with the HRC fuse
- ■ capacitance value tolerance: -5, +10 %
- ■ insulation level:
- □ withstand 50 Hz 1 minute: 4 kV
- □ impulse wave withstand 1.2/50 µs: 15 kV
- ■ voltage test: 2.15 Un (rated voltage) for 10 s
- ■ maximum permissible overloads at service voltage network as per IEC 60831 1/2:
- □ current: 30 % permanently
- □ en tension : 10 % (8 h sur 24 h)
- □ voltage: 10 % (8 hours over 24 hours)
- ■ with internaly fitted discharge resistors: residual voltage less than 50 V in 1 minute
- ■ total losses: less than 0.5 Watt/kvar (discharge resistors included)
- ■ temperature class D (+55 °C):
- □ maximum: 55 °C
- □ average over 24 hours: 45 °C
- □ average over 1 year: 35 °C
- □ minimum: -25 °C
- ■ colour:
- □ elements RAL 9005
- □ base and cover RAL 7030
- ■ standards: IEC 60831 1/2, CSA 22-2 N°190, UL 810
- ■ execution: indoor
- ■ protection:
- □ IP00 without cover
- □ IP20 or IP42 see accessories
- ■ no earth connection is needed
- ■ terminals: 3 M8 rods allowing 360° cable connection (without cover).

Accessories for Varplus²	Ref.
1 set of 3-phase copper bars for connection and assembly of 2 and 3 capacitors	**51459**
1 set of protective cover (IP20) and cable glands (IP42) for 1, 2 and 3 capacitors	**51461**

Installation

All positions are convenient except vertical one with connecting terminals upside down. Fixing holes for M6 screws. A kit to replace Varplus by Varplus² is available (ref. **51298**).

Detuned reactors

Characteristics

The detuned reactors (DR) are designed to protect the capacitors and prevent amplification of the harmonics present on the network.

PB100069

Detuned reactor.

Power restored by the assembly reactor-capacitor	L (mH)	I_1 (A)	Power losses (W)	Ref.
Detuned reactor for 400 V - 50 Hz network Tuning order: 4.3 (215 Hz)				
6.25 kvar/400 V - 50 Hz	4.71	9	100	**51573**
12.5 kvar/400 V - 50 Hz	2.37	17.9	150	**52404**
25 kvar/400 V - 50 Hz	1.18	35.8	200	**52405**
50 kvar/400 V - 50 Hz	0.592	71.7	320	**52406**
100 kvar/400 V - 50 Hz	0.296	143.3	480	**52407**
Tuning order: 3.8 (190 Hz)				
6.25 kvar/400 V - 50 Hz	6.03	9.1	100	**51568**
12.5 kvar/400 V - 50 Hz	3	18.2	150	**52352**
25 kvar/400 V - 50 Hz	1.5	36.4	200	**52353**
50 kvar/400 V - 50 Hz	0.75	72.8	300	**52354**
100 kvar/400 V - 50 Hz	0.37	145.5	450	**51569**
Tuning order: 2.7 (135 Hz)				
6.25 kvar/400 V - 50 Hz	12.56	9.3	100	**51563**
12.5 kvar/400 V - 50 Hz	6.63	17.6	150	**51564**
25 kvar/400 V - 50 Hz	3.14	37.2	200	**51565**
50 kvar/400 V - 50 Hz	1.57	74.5	400	**51566**
100 kvar/400 V - 50 Hz	0.78	149	600	**51567**

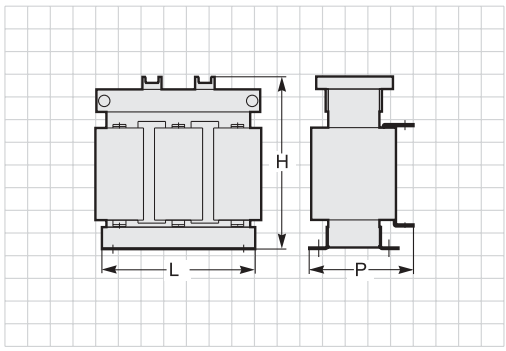
Characteristics

- three-phase, dry, magnetic circuit, impregnated
- cooling: natural
- degree of protection: IP00
- insulation class: H
- standards: IEC 60289, EN 60289
- rated voltage: 400/415 V three-phase 50 Hz
- tuning order (relative impedance): 4.3 (5.4 %); 3.8 (6.9 %); 2.7 (13.7 %)
- inductance tolerance per phase: - 5, +5 %
- maximum constant current: Imp = $\sqrt{[(1,1 \cdot I_1)^2 + I_3^2 + I_5^2 + I_7^2 + I_{11}^2]}$
  - Imp = 1.31 . I1 for 4.3 tuning
  - Imp = 1.19 . I1 for 3.8 tuning
  - Imp = 1.12 . I1 for 2.7 tuning
- harmonic current spectrum

As a % of the current of the fundamental (I_1)	Tuning order 4.3	Tuning order 3.8	Tuning order 2.7
Current I_3	2 %	3 %	6 %
Current I_5	69 %	44 %	17 %
Current I_7	19 %	13 %	6 %
Current I_{11}	6 %	5 %	2 %

- insulation level: 1.1 kV
- thermal withstand Isc: 25 x Ie, 2 x 0.5 second
- dynamic withstand: 2.2 Isc (peak value)
- dielectric test 50 Hz between windings and windings/earth: 3.3 kV, 1 min
- thermal protection restored on terminal block 250 V AC, 2 A.

Detuned reactors



Detuned reactor.

Operating conditions

- use: indoor
- storage temperature -40 °C, +60 °C
- relative humidity in operation: 20 to 80 %
- saline mist withstand: 250 hours
- operating temperature/altitude:

Altitude	Minimum	Maximum	Highest average over any period of:	
(m)	(°C)	(°C)	1 year	24 hours
1000	0	55	40	50
> 1000, ⩽ 2000	0	50	35	45

Installation

- forced ventilation required (see chapter 6 page 24)
- vertical detuned reactor winding for better heat dissipation
- electrical connection:
  - to a screw terminal block for 6.25 and 12.5 kvar detuned reactors
  - to a drilled pad for 25, 50 and 100 kvar detuned reactors
- 470 V capacitors must be used with the detuned reactors in the case of a 400/415 V, 50 Hz network
- as the detuned reactor is fitted with thermal protection, it is recommended that the normally closed dry contact be used to disconnect the step in the event of overheating.

Dimensions

Tuning order: 4.3 (215 Hz)					
Power restored by the detuned reactor/ capacitor assembly	Fixing centre distance (mm)	Maximum dimensions (mm) H	W	D	Weight (kg)
6.25 kvar/400 V - 50 Hz	110 x 87	230	200	140	8.6
12.5 kvar/400 V - 50 Hz	205 x 110	230	245	140	12
25 kvar/400 V - 50 Hz	205 x 110	230	240	140	18.5
50 kvar/400 V - 50 Hz	(1)	270	260	160	25
100 kvar/400 V - 50 Hz	205 x 120	330	380	220	42
Tuning order: 3.8 (190 Hz)					
Power restored by the detuned reactor/ capacitor assembly	Fixing centre distance (mm)	Maximum dimensions (mm) H	W	D	Weight (kg)
6.25 kvar/400 V - 50 Hz	110 x 87	230	200	140	8.5
12.5 kvar/400 V - 50 Hz	205 x 110	230	245	140	10
25 kvar/400 V - 50 Hz	205 x 110	230	240	140	18
50 kvar/400 V - 50 Hz	(1)	270	260	160	27
100 kvar/400 V - 50 Hz	205 x 120	330	380	220	42
Tuning order: 2.7 (135 Hz)					
Power restored by the detuned reactor/ capacitor assembly	Fixing centre distance (mm)	Maximum dimensions (mm) H	W	D	Weight (kg)
6.25 kvar/400 V - 50 Hz	110 x 87	230	200	140	9
12.5 kvar/400 V - 50 Hz	205 x 110	230	245	145	13
25 kvar/400 V - 50 Hz	205 x 110	230	240	140	22
50 kvar/400 V - 50 Hz	(1)	270	260	160	32
100 kvar/400 V - 50 Hz	205 x 120	330	380	220	57

(1) *205 x 120 or 205 x 130 mm.*

Detuned reactors

Detuned reactor / capacitor / contactor combination tables

Maximum temperature 40 °C and maximum altitude 2000 m

480 V capacitors			fr = 135 Hz		
Qc 400 V	**Qc 480 V**	**Capacitor ref.**	**DR ref.**	**Specific contactors**	**Standard contactors**
6.25 kvar	8 kvar	**51337** x 1	**51563** x 1	LC1-DFK11M7 x 1	LC1D12 x 1
12.5 kvar	15,5 kvar	**51331** x 1	**51564** x 1	LC1-DFK11M7 x 1	LC1D25 x 1
25 kvar	31 kvar	**51331** x 2	**51565** x 1	LC1-DMK11M7 x 1	LC1D38 x 1
50 kvar	62 kvar	**51335** x 2 + **51333**	**51566** x 1	LC1-DWK12M7 x 1	LC1D95 x 1
100 kvar	124 kvar	**51335** x 4 + **51333** x 2	**51567** x 1	-	LC1D115 x 1

480 V capacitors			fr = 215 Hz	fr = 190 Hz		
Qc 400 V	**Qc 480 V**	**Capacitor ref.**	**DR ref.**	**DR ref.**	**Specific contactors**	**Standard contactors**
6.25 kvar	9 kvar	**51327** x 1	**51573** x 1	**51568** x 1	LC1-DFK11M7 x 1	LC1D12 x 1
12.5 kvar	17 kvar	**51333** x 1	**52404** x 1	**52352** x 1	LC1-DFK11M7 x 1	LC1D25 x 1
25 kvar	34 kvar	**51333** x 2	**52405** x 1	**52353** x 1	LC1-DMK11M7 x 1	LC1D38 x 1
50 kvar	68 kvar	**51335** x 3	**52406** x 1	**52354** x 1	LC1-DWK12M7 x 1	LC1D95 x 1
100 kvar	136 kvar	**51335** x 6	**52407** x 1	**51569** x 1	-	LC1D115 x 1

4

Maximum temperature 50 °C and maximum altitude 1000 m (see chapter 6 page 25)

550 V capacitors			fr = 135 Hz		
Qc 400 V	**Qc 550 V**	**Capacitor ref.**	**DR ref.**	**Specific contactors**	**Standard contactors**
6.25 kvar	10,5 kvar	**51363** x 1	**51563** x 1	LC1-DFK11M7 x 1	LC1D12 x 1
12.5 kvar	21 kvar	**51363** x 2	**51564** x 1	LC1-DGK11M7 x 1	LC1D25 x 1
25 kvar	40,5 kvar	**51353** x 3	**51565** x 1	LC1-DPK11M7 x 1	LC1D40 x 1
50 kvar	81 kvar	3 x **51357** + 2 x **51353**	**51566** x 1	LC1-DWK12M7 x 1	LC1D95 x 1
100 kvar	162 kvar	9 x **51357**	**51567** x 1		LC1F185 x 1

550 V capacitors			fr = 215 Hz	fr = 190 Hz		
Qc 400 V	**Qc 550V**	**Capacitor ref.**	**DR ref.**	**DR ref.**	**Specific contactors**	**Standard contactors**
6.25 kvar	11,5 kvar	**51351** x 1	**51573** x 1	**51568** x 1	LC1-DFK11M7 x 1	LC1D12 x 1
12.5 kvar	23 kvar	**51351** x 2	**52404** x 1	**52352** x 1	LC1-DGK11M7 x 1	LC1D25 x 1
25 kvar	46 kvar	1 x **51357** + 2 x **51353**	**52405** x 1	**52353** x 1	LC1-DPK11M7 x 1	LC1D40 x 1
50 kvar	90 kvar	5 x **51357**	**52406** x 1	**52354** x 1	LC1-DWK12M7 x 1	LC1D95 x 1
100 kvar	180 kvar	10 x **51357**	**52407** x 1	**51569** x 1		LC1F185 x 1

Note: *LC1D contactors not incorporating a preinstalled resistor can be used with detuned reactors.*
The inductance of the detuned reactor limits the energising current to a value that can be accepted by the contactor.

Varlogic power factor controllers

The Varlogic N controllers permanently measure the reactive power of the installation and control connection and disconnection of capacitor steps in order to obtain the required power factor.

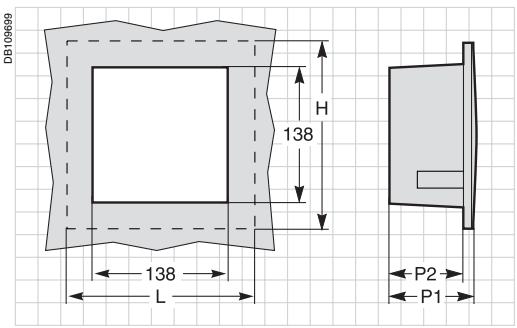
PB100056

Varlogic NR6/NR12

PB100057

Varlogic NRC12

DB109699



Varlogic NR6, NR12, NRC12

Technical data

■ **general data**

□ Modbus communication option NRC12
□ operating temperature: 0…60 °C
□ storage temperature: -20° C…60 °C
□ colour: RAL 7016
□ standard:
- EMC: IEC 61326
- electrical: IEC/EN 61010-1.

□ panel mounting
□ mounting on 35 mm DIN rail (EN 50022)
□ protection class in panel mounting:
- front face: IP41
- rear face: IP20.

- display:
- NR6, NR12 type: backlighted screen 65 x 21 mm
- NRC12 type: backlighted graphic screen 55 x 28 mm.
- languages: English, French, German, Portuguese, Spanish

□ alarm contact
□ temperature internal probe
□ separate contact to control fan inside the power factor correction bank
□ access to the history of alarm.

■ **inputs**

□ phase to phase or phase to neutral connection
□ insensitive to CT polarity
□ insensitive to phase rotation polarity
□ current input:
- NR6, NR12 type: CT… X/5 A
- NRC12 type: CT… X/5 A et X/1 A.

■ **outputs**

□ potential free output contacts:
- AC : 1 A/400 V, 2 A/250 V, 5 A/120 V
- DC : 0,3 A/110 V, 0,6 A/60 V, 2 A/24 V.

■ **settings and parameters**

□ target cos φ setting: 0,85 ind…0,9 cap
□ possibility of a dual cos φ target (type NRC12)
□ manual or automatic parameter setting of the power factor controller
□ choice of different stepping programs:
- linear
- normal
- circular
- optimal.

□ main step sequences:

1.1.1.1.1.1	1.2.3.3.3.3
1.2.2.2.2.2	1.2.4.4.4.4
1.2.3.4.4.4	1.1.2.3.3.3
1.1.2.2.2.2	1.2.4.8.8.8

□ personalized sequences for NRC12 type
□ delay between 2 successive switch on of a same step:
- NR6, NR12 type: 10 … 600 s
- NRC12 type: 10 … 900 s

□ step configuration programming (fixed/auto/disconnected) (NRC12 type)
□ 4 quadrant operation for generator application (NRC12 type)
manuel control for operating test.

Dimensions

Varlogic N	Dimensions (mm) H	L	D1	D2	Weight (kg)
Varlogic NR6/NR12	150	150	70	60	1
Varlogic NRC12	150	150	80	70	1

Varlogic power factor controllers

Type	Number of step output contacts	Supply voltage (V) network 50-60 Hz	Measuring voltage (V)	ref.
NR6	6	110-220/240-380/415	110-220/240-380/415	**52448**
NR12	12	110-220/240-380/415	110-220/240-380/415	**52449**
NRC12	12	110-220/240-380/415	110-220/240-380/415-690	**52450**

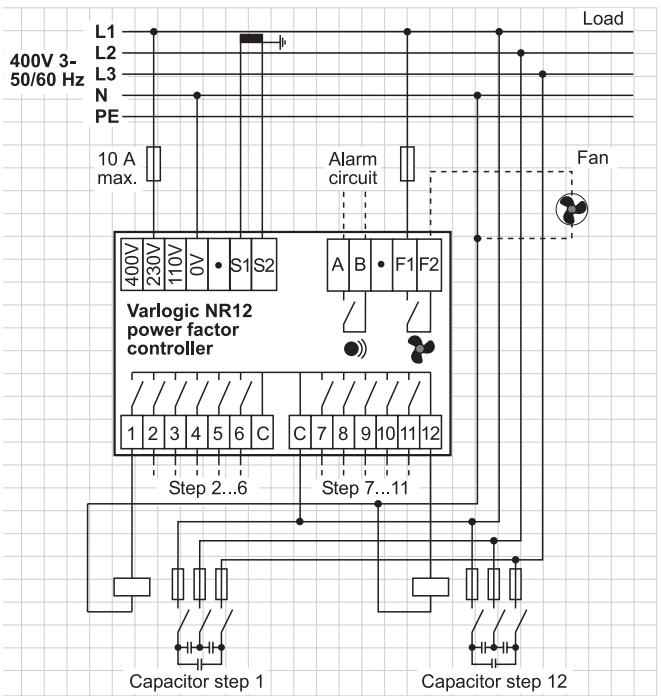
Varlogic N accessories	**ref.**
Communication RS485 Modbus set for NRC12	**52451**
Temperature external probe for NRC12 type. In addition to internal proble, allows measurement at the hotest point inside the capacitor bank. Better tuning of alarm and/or disconnection level.	**52452**

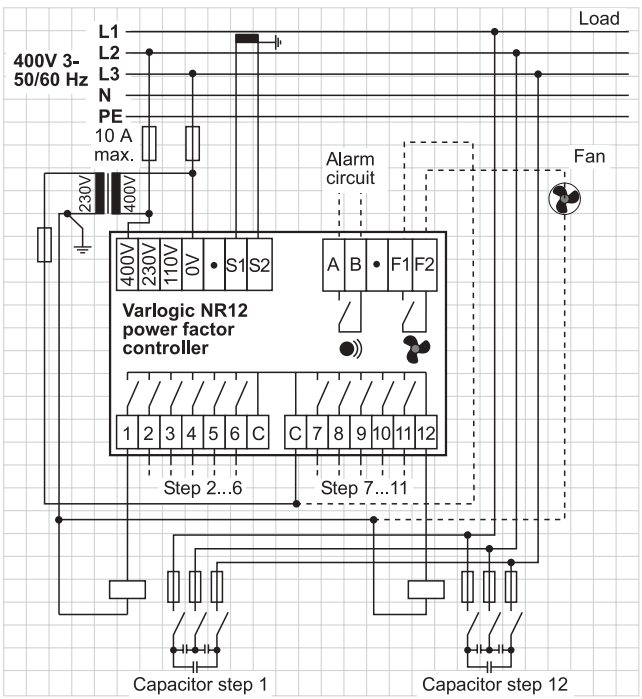
Information supplied	**NR6/NR12**	**NRC12**
Cos φ	■	■
Connected steps	■	■
Switching cycles and connected time counter	■	■
Step configuration (fixed step, auto, disconnected)		■
Step output status (capacitance loss monitoring)		■
Network technical data: load and reactive currents, voltage, powers (S, P, Q)	■	■
Ambient temperature inside the cubicle	■	■
Total voltage harmonic distortion THD (U)	■	■
Total current harmonic distortion THD (I)		■
Capacitor current overload Irms/I_1		■
Voltage and current harmonic spectrum (orders 3, 5, 7, 11, 13)		■
History of alarms	■	■

Alarms	**Threshold**	**Action**		**NR6/NR12**	**NRC12**
Low power factor		message and alarm contact		■	■
Hunting (unstable regulation)		message and alarm contact	disconnection **(2)**	■	■
Abnormal cos φ	< 0.5 ind or 0.8 cap	message and alarm contact		■	■
Overcompensation		message and alarm contact		■	■
Overcurrent	> 115 % I_1	message and alarm contact		■	■
Voltage low	< 80 % Uo within 1 s	message and alarm contact	disconnection **(2)**	■	■
Overvoltage	> 110 % Uo	message and alarm contact	disconnection **(2)**	■	■
Overtemperature	θ ≥ θo (θo = 50 °C max)**(1)**	message and alarm contact	disconnection **(2)**	■	■
	θ ≥ θo - 15 °C	fan switch	disconnection **(2)**	■	■
Total harmonic distortion	> 7 % **(1)**	message and alarm contact	disconnection **(2)**	■	■
Capacitor current overload (Irms/I_1)	> 1.5 **(1)**	message and alarm contact	disconnection **(2)**		■
Capacitor capacitance loss	- 25 %	message and alarm contact	disconnection **(2)**		■
Low current	< 2,5 %	message		■	■
High current	> 115 %	message		■	■
Under voltage	5 % Uo	message			■

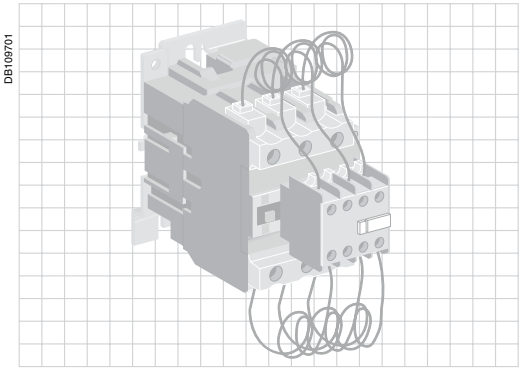
***Uo**: input voltage (measurement)*
***(1)**: alarm threshold values can be modified according to the installation*
***(2)**: capacitor steps are automatically reconnected after fault clearance and a safety delay*

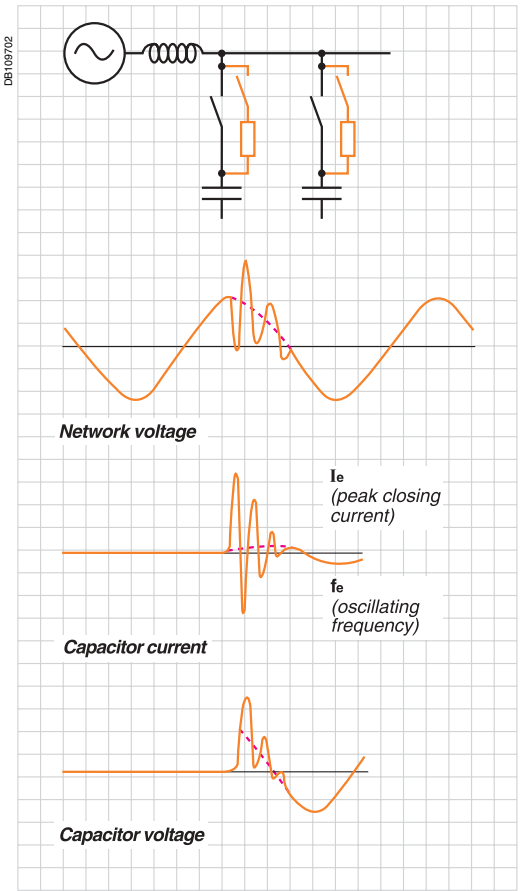
DB109700





Contactors





General

Capacitor control is accompanied by transient operating conditions resulting from the capacitor load which, amongst other things, generates a very high overcurrent equivalent to a short-circuit of short duration.
The use of standard contactors may compromise the safety of persons and installations.

Telemecanique contactors for capacitor control

The LC1-D•K contactors are specially designed for capacitor control.
They are fitted with a contact block allowing the current to pass on closing and with damping resistors limiting the current on energisation.
This technology, which is unique, has been patented.

Personal safety

The contactors cannot be operated manually.
The contactors are fitted with covers for protection against direct contact.

Safety of installations

The damping resistors are disconnected after the capacitor current energising peak. A faulty contactor pole therefore does not allow the permanent current to flow through the resistor and prevents it from burning.

Simplicity and durability

LC1-D•K contactors are a ready-to-use solution that does not require the installation of shock coils.
Their durability is far greater than that of conventional solutions (300,000 operating cycles at 400 V).

Note: *if specific contactors cannot be used to control the capacitors, then energising current limiting reactors must be used. Please consult the contactor manufacturer.*

Note: *LC1D contactors not incorporating a preinstalled resistor can be used with detuned reactors.*
The inductance of the detuned reactor limits the energising current to a value that can be accepted by the contactor.

Contactors

References and maximum power ratings (1)

Power ratings temp. ⩽ 55 °C 220 V 240 V kvar	400 V 440 V kvar	660 V 690 V kvar	Instantaneous auxiliary contacts "F"	"O"	Tightening torque on end-piece Nm	Basic reference no. to which the control voltage reference no. should be added (2)	Weight kg
6.5	12.5	18	1	1	1.2	LC1-DFK11••	0.43
				2	1.2	LC1-DFK02••	0.43
6.5	15	24	1	1	1.7	LC1-DGK11••	0.45
				2	1.7	LC1-DGK02••	0.45
10	20	30	1	1	1.9	LC1-DLK11••	0.6
				2	1.9	LC1-DLK02••	0.6
15	25	36	1	1	2.5	LC1-DMK11••	0.63
				2	2.5	LC1-DMK02••	0.63
20	30	48	1	2	5	LC1-DPK12••	1.3
25	40	58	1	2	5	LC1-DTK12••	1.3
40	60	92	1	2	9	LC1-DWK12••	1.65

(1) *The power values in the above table are valid for the following conditions:*

Prospective peak energising current	LC1-D•K		200 In
Maximum rate	LC1-DKF/DKG/DLK/DMK/DPK		240 operating cycles/hour
	LC1-DTK/DWK		100 operating cycles/hour
Electrical durability at nominal load	LC1-DKF/DKG/DLK/DMK/DPK	400 V	300000 operating cycles
	LC1-DTK/DWK	690 V	300000 operating cycles

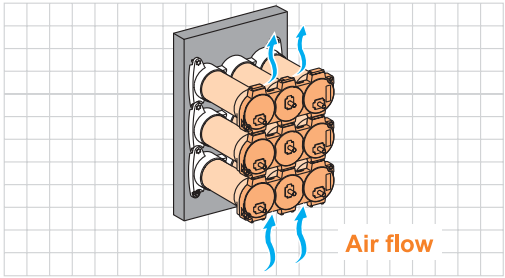
(2) *Control circuit voltage (••) :*

Tension (V)	110	220	230	240	380	400	415
50/60 Hz	F7	M7	P7	U7	Q7	V7	N7

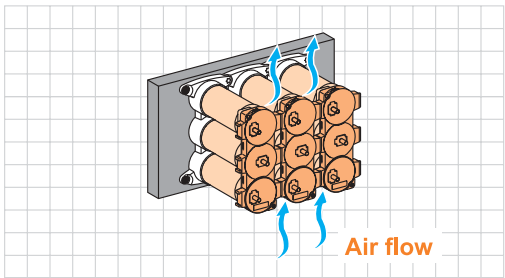
Other voltages: contact us.

4

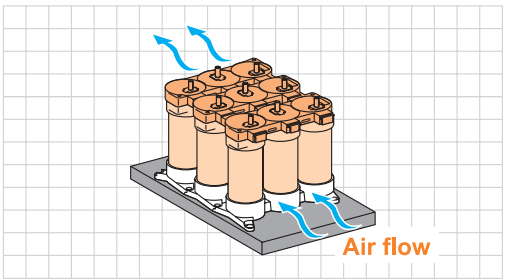
Varplus² capacitors



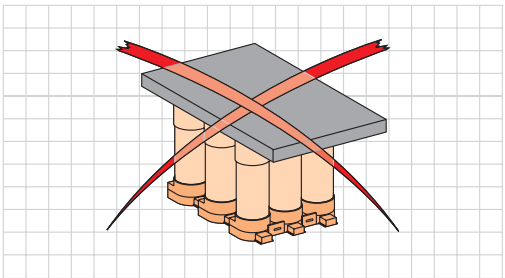
Right.



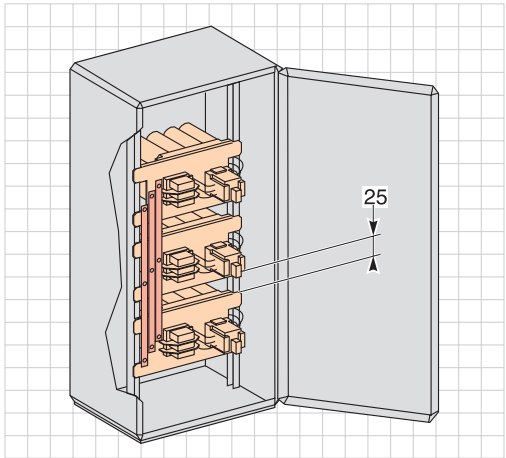
Right.



Right.



Wrong.

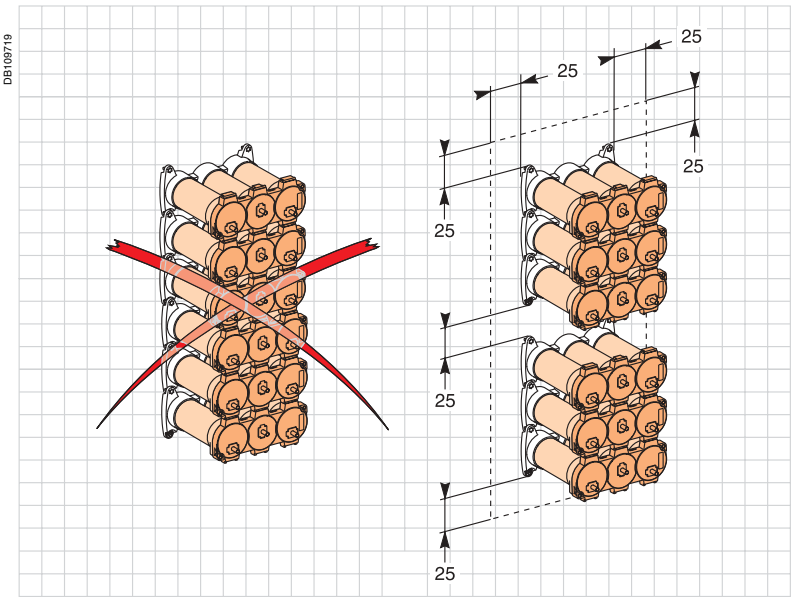


Fixing and installation

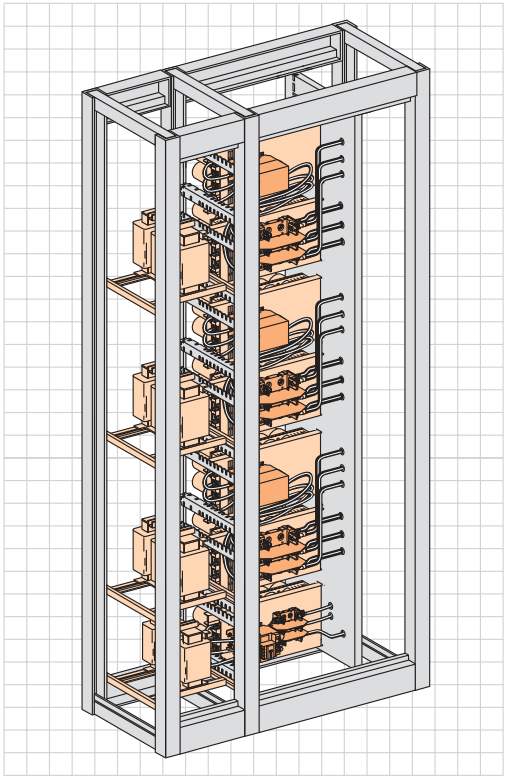
■ the capacitors must be installed in well ventilated rooms or enclosures to ensure that they do not exceed the temperature category limits (see chapter 4, page 10 and chapter 6)
■ whatever the installation conditions, the capacitors can be installed in any position but upside down, like you can see on the drawings.
■ capacitors mounted one above the other inside an enclosure should be at least 25 mm apart
■ for a lightning withstand of 25 kV, there should be at least 15 mm between the rear panel and any metal part.

Assembly until 130 kvar

There are 3 conditions to respect:
■ adapted bus bar section is expected to connect the capacitor assemblies shown below
■ minimum space of 25 mm is expected between 2 groups of capacitors (see following figure)
■ according to "Ventilation" chapter, specific precautions must be taken in order to not exceed temperature category of -25 °C/D inside the cubicle.



Detuned reactors



Example of capacitor banks with detuned reactors (DRs).

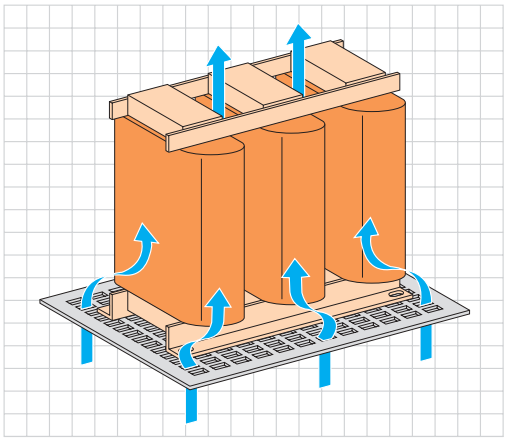
Temperature rise stresses

The detuned reactors should be mounted in the upper part of the cubicle to avoid overheating the installed switchgear.

In the case of a correction switchboard with detuned reactors, a separate column should be specifically reserved for the reactors.

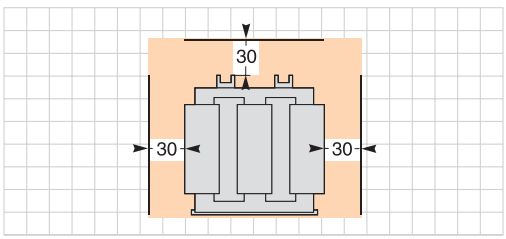
Detuned reactors require forced ventilation (see page 24).

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



Location of the detuned reactors

To ensure proper ventilation, the DR windings must be vertical.



Installation distance

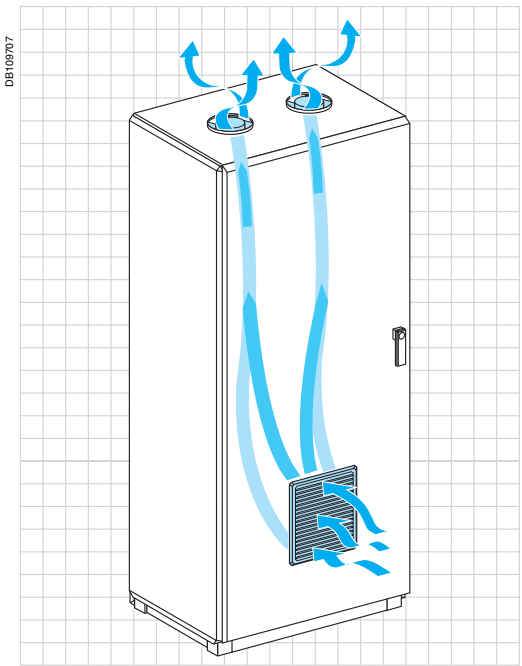
The minimum distances illustrated opposite must be observed for insulation purposes and to prevent overheating.

The ventilation rules given in this manual 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 to IEC 60439-1

- maximum temperature in the electrical room: 40 °C
- average temperature over 24 hours in the electrical room: 35 °C
- average annual temperature in the electrical room: 25 °C
- minimum temperature: -5 °C
- maximum altitude: 2000 m.

The following rules apply to Varplus² capacitors for classic and comfort solutions.



Ventilation rules

Capacitors, contactors, fuses and electrical connections dissipate heat: 2.5 W/kvar.
The following ventilation rules must therefore be complied with:
- the air within the cubicle must flow upwards.

It is recommended that extractor fans be fitted on top of the cubicle.
- the cross-section of the top air outlet must be at least 1.1 times the cross-section of the bottom air outlet
- 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.

Applications

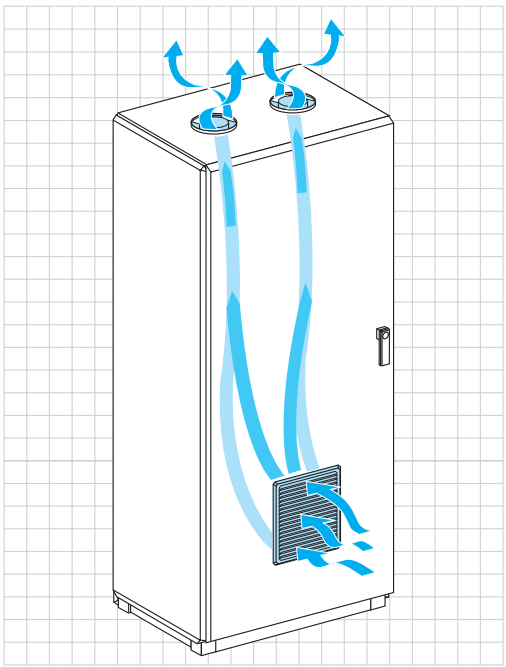
The ventilation rules apply to cubicles with the following dimensions:
- height H = 2000 mm
- width W = 600 mm minimum
- depth D = 400 mm minimum
- and power less than or equal to 405 kvar 400 V - 50 Hz per column.

Reactive power (kvar at 400 V - 50 Hz)	Type of ventilation	Air inlet	Min. air flow (m^3/hour)
Cubicle safety rating (IP) ⩽ 3X			
Power ⩽ 100 kvar	Natural	200 cm^2	-
Power 100 to 200 kvar	Natural	400 cm^2	-
Power > 200 kvar	Forced	-	⩾ 0.75 times the power in kvar
Cubicle safety rating (IP) > 3X			
All power values	Forced	-	⩾ 0.75 times the power in kvar

Design using Varplus² capacitors and detuned reactors (DR)

The ventilation rules given in this manual 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.

DB109707



Normal operating conditions to IEC 60439-1

- maximum temperature in the electrical room: 40 °C
- average temperature over 24 hours in the electrical room: 35 °C
- average annual temperature in the electrical room: 25 °C
- minimum temperature: -5 °C
- maximum altitude: 2000 m.

The following rules apply to Varplus² capacitors associated with detuned reactors (Harmony range).

Ventilation for capacitor banks 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, see page 23.
The part of the enclosure containing the DRs must be ventilated according to the dissipated power.
The minimum air flow must be: F = 0.3 x Ps
(Ps = power dissipated by the DRs).

Example
250 kvar 400 V DR capacitor bank, tuning 190 Hz,
in 1 x 50 kvar + 2 x 100 kvar:
- DR compartment: forced ventilation

Ps = 300 + 2 x 450 = 1200 W
F = 0.3 x Ps = 0.3 x 1200 = 400 m^3/h
- capacitor compartment: forced ventilation

(cubicle: 600 x 400 x 2000)
fan rate: 0.75 x 250 = 187.5 m^3/h.

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
- maximum altitude: 1000 m.

The following precautions must be taken:
- ventilation must be forced, irrespective of the power, and the ventilation rate increased by 25 % (see the rules on pages 23 and 24):
  - classic and comfort installation consisting of modules or capacitors: rate (m^3/h) = 0.75 x Q (kvar) x 1.25, whatever the power of Q
  - harmony installation consisting of components (capacitors + DR):
    - capacitor compartment rate: see rule point 1
    - DR compartment rate: (m^3/h): 0.3 x Ps x 1.25
- the capacitor voltage must be higher than that normally required (minimum 10 % higher than that specified by the normal dimensioning rules)
- the DR temperature sensor must be connected so that the step can be disconnected if the temperature is too high
- the contactors must be derated, the operating current must be increased by 10 % with respect to the maximum constant current of the step.

Example: 30 kvar 400 V step, classic range, rated current = 43.3 A:
Imp = 1.36 x 43.3 = 58.9 A.
At a maximum ambient temperature of 50 °C, the contactor must be able to accept a current of 58.9 x 1.1 = 65 A

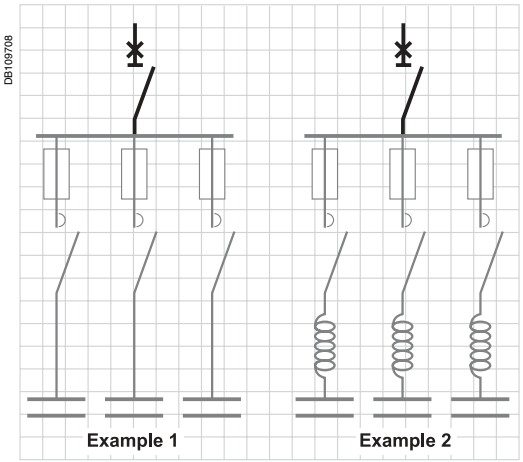
- the cables must be appropriate for a current of at least 1.5 times the rated current of the capacitor at a minimum temperature of 60 °C.

Summary

400/415 V 50 Hz network

Gh/Sn ⩽ at 15 %	15 % < Gh/Sn ⩽ 25 %	25 % < Gh/Sn ⩽ 50 %
Comfort capacitors (480 V)	550 V capacitors	550 V capacitors + DR from the catalogue

Capacitor bank protection by means of a circuit breaker



Their rating must be chosen to allow the thermal protection to be set to:
- 1.36 In for classic range
- 1.5 In for comfort range
- 1.12 In for harmony range: 2.7 tuning
- 1.19 In for harmony range: 3.8 tuning
- 1.31 In for harmony range: 4.3 tuning

The short-circuit (magnetic) protection setting thresholds must allow the energising transients to pass through:
10 x In for classic, comfort and harmony ranges.
In= Qc/ (1.732 x Un)

Example 1
150 kvar / 400 V - 50 Hz - classic range

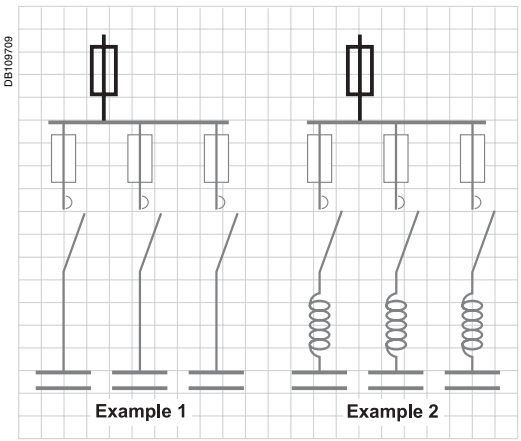
$$In = \frac{150000}{400\sqrt{3}} = 216\ A$$

Thermal protection: 1.36 x 216 = 294 A
Magnetic protection > 10 In = 2160 A.

Example 2
150 kvar / 400 V - 50 Hz - harmony range (4.3 tuning)

In = 216 A
Thermal protection: 1.31 x 216 = 283 A
Magnetic protection > 10 In = 2160 A.

Capacitor bank protection by means of fuses



Type Gg HBC fuses must be used with the following ratings:
- classic range: 1.4 In
- comfort range: 1.6 In
- harmony range: 1.4 In.

Example 1
150 kvar / 400 V - 50 Hz – comfort range

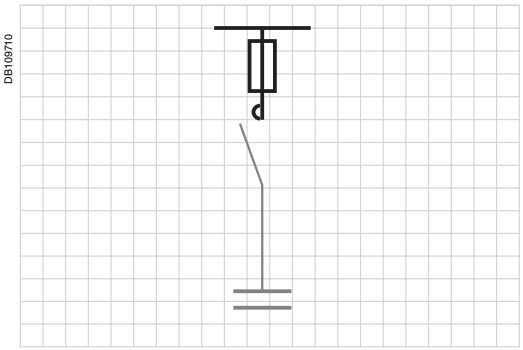
In = 216 A
Fuse rating ⩾ 1,6 x 216 ⩾ 346 A

Exemple 2
150 kvar / 400 V - 50 Hz - harmony range

In = 216 A
Fuse rating ⩾ 1,4 x 216 ⩾ 302 A

The fuse rating immediately above the calculated value must be used.

Step protection by means of fuses



Type Gg HBC fuses must be used with the following ratings:
- classic and comfort ranges: 1.6 In
- harmony range: 1.5 In.

Note: *when 2 steps are protected by the same set of fuses, the coefficients are:*
- *1.4 In for classic and harmony steps*
- *1.6 In for comfort steps.*

Protection of the transformer supplying the auxiliaries

Use of a transformer to supply the auxiliaries

The transformer must be sufficiently powerful to supply the contactor coils (drive and holding), the controllers and other energy-consuming devices (fans, lamps, etc.).

Table showing the choice of protective devices at the transformer primary for transformers with an inrush current of 25 In (primary voltage 400 V)

Power VA	Primary In A	aM fuse A	Circuit breaker Curve B
63	0.16	1	1
100	0.25	1	1
160	0.4	1	1
250	0.62	2	2
400	1	4	2
630	1.57	4	3
800	2	4	4
1000	2.5	6	6

Table showing the choice of protective devices at the transformer secondary (secondary voltage 230 V single-phase)

Power VA	Secondary In A	gG fuse A	Circuit breaker Curve C
63	0.27	0.5 (1)	0.5 (1)
100	0.43	0.5	0.5
160	0.70	1	0.75
250	1.09	1	1
400	1.74	2	2
630	2.74	4	3
800	3.49	4	4
1000	4.35	4	4

(1) *No overload protection provided.*

Power and auxiliary circuits

Step power cables

Flexible, rigid or semi-rigid copper cables are generally used inside the switchboard.
A U 1000 V cable (insulation 1000 V) is recommended.
For a working voltage that is less than half the insulation voltage of the cable, i.e. < 500 V, these cables are considered to be class 2.
They can therefore be flanged directly onto metal supports without the use of an insulating material.
The cable cross-section must be compatible with:
- the current to be carried
- the ambient temperature around the conductors.

Dimensioning rules:
- the ambient temperature in the electrical room must not exceed 40 °C: the cables must be appropriate for a current of at least 1.5 times the capacitor current at a temperature of 50 °C
- the ambient temperature in the electrical room must not exceed 50 °C: the cables must be appropriate for at least 1.5 In at a temperature of 60 °C.

Auxiliary circuits

Unless otherwise stated in the specifications, the following cable cross-sections are recommended for the auxiliary wiring:
- 1.5 mm^2 for the auxiliary voltage circuits
- 2.5 mm^2 for the auxiliary current circuits.

Capacitor bank connection cables

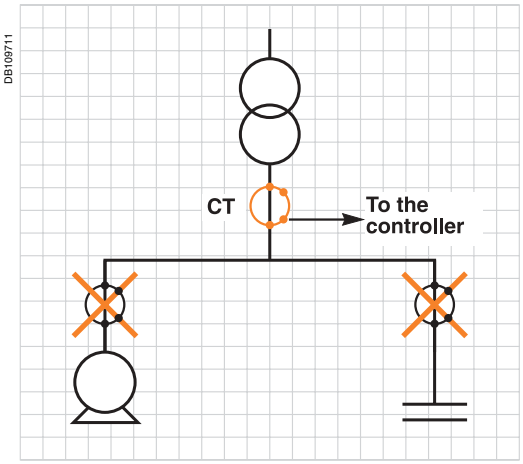
Dimensioning current
The cables must be appropriate for a current of at least 1.5 In.

Cross-section
It must be compatible with:
- the ambient temperature around the conductor
- the method of installation (trunking, duct, etc.).

See the cable manufacturer's recommendations.

Recommended cable cross-sections (U1000 R02V cables)
For capacitor connections at an ambient temperature of 35 °C.

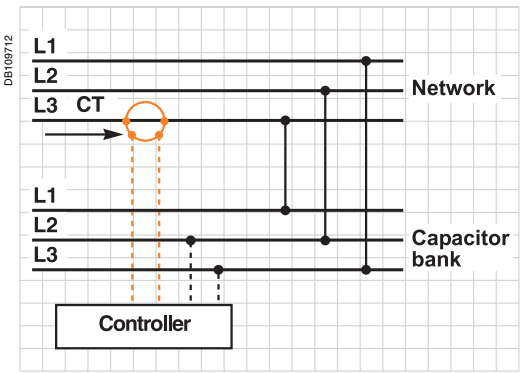
Power (kvar)		Cross-section (mm^2)	
230 V	400 V	Cu	Al
15	25	6	16
20	30	10	16
25	45	16	25
30	60	25	35
40	75	35	50
50	90	50	70
60	110	70	95
80	135	95	2 x 50
90	150	120	2 x 70
100	180	2 x 50	2 x 70
120	200	2 x 70	2 x 95
135	240	2 x 70	2 x 150
165	275	2 x 95	2 x 150
180	300	2 x 120	2 x 185
200	360	2 x 150	2 x 240
240	400	2 x 185	2 x 300

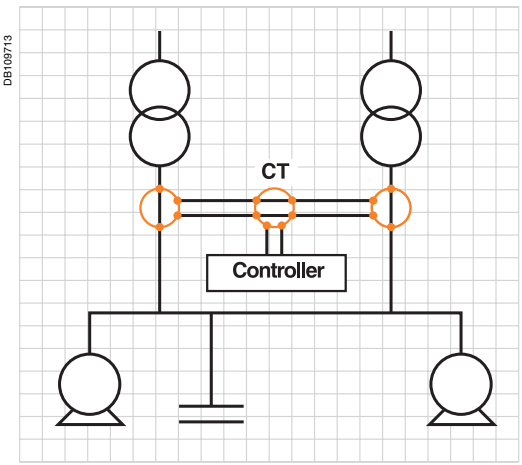


Installation recommendations

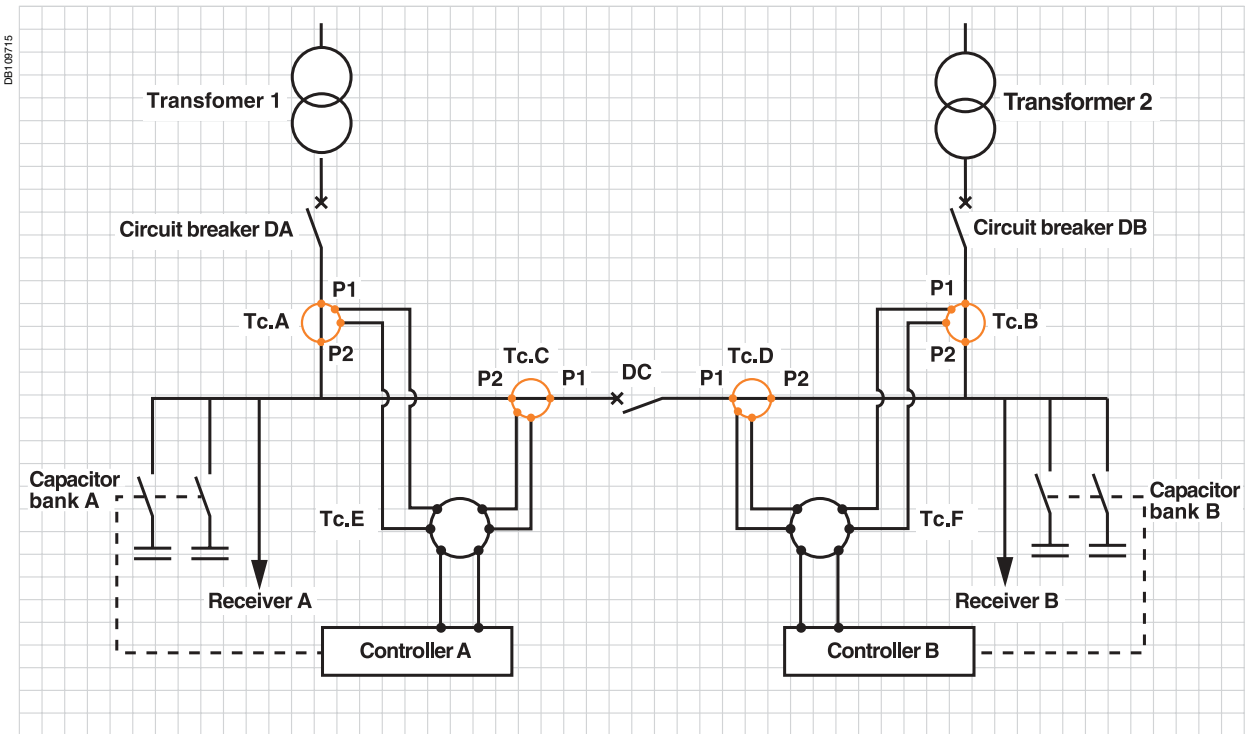
- the CT current transformer must be installed upstream of the installation to be compensated
- the controller voltage should be set between L2 and L3 and the CT to phase L1
- the capacitor bank wiring diagram should be designed to ensure that the time required to discharge the capacitors is observed (minimum 1 minute), for example in the event of a loss of contactor auxiliary voltage
- if the installation comprises two or more supply transformers, a summing CT that will take all the energy consumed by the installation into account must be provided. The ratio to be used to calculate the C/K is the sum of the ratios of the various measuring CTs
- if the installation includes a generator set, a contact will disconnect the capacitor bank in the event of generator set operation.
The best method is to use it to cut off the supply to the controller.

Measuring current on phase L3





Connecting two transformers in parallel



Current transformers and C/K

Calculation of the response current C/K for power factor controllers

All the Ct.A, Ct.B, Ct.C and Ct.D current transformers must have the same ratio (same primary and secondary 5 A).

C = current of the first capacitor bank step.
K = current transformer ratio.

Assumptions

- transformer 1 = transformer 2 = 1600 kVA
- network: 400 V 50 Hz
- capacitor bank A = 300 kvar 400 V, 5 x 60 kvar
- capacitor bank B = 250 kvar 400 V, 5 x 50 kvar

Calculation of the current transformer ratio

Transformer rated current: 160000/400/1.732 = 2310 A.
The transformer primary current must therefore be greater than 2310 A.
A transformer with a primary current of 2500 A should therefore be used.
The transformer secondary current must be 5 A.
We therefore obtain: Ct.A = Ct.B = Ct.C = Ct.D = 2500/5 A.

Choice of summing current transformers

Ct.E = Ct.F = (5 + 5)/5 A.

Calculation of C/K for capacitor bank A

Ca = first step current = 60000/400/1.732 = 86.6 A.
Ka = (Ct.A primary + Ct.C)/5 = 1000.
Ca/Ka= 86.6/1000 = 0.086.

Calculation of C/K for capacitor bank B

Cb = first step current = 50000/400/1.732 = 72 A.
Kb = (Ct.B primary + Ct.D primary)/5 = 1000.
Cb/Kb = 72/1000 = 0.072.

Varpact solution

PB100061

Varpact classic without bus bars

PB100062

Varpact classic with bus bars

PB100063

Varpact harmony without bus bars

PB100064

Varpact harmony with bus bars

Save time, Save money!

Schneider Electric can offer you a simple prewired solution : the Varpact power correction modules.
It allows you to do your cubicle installation much quicker and easier.

The Varpact modules form a prewired subassembly designed for fittings in power factor correction cubicles.
There are single modules (with one contactor) and double modules (with 2 contactors).

It covers all the need you can have, depending of the pollution rate on the network (see chapter 2 p 4):
- Varpact classic
- Varpact comfort
- Varpact harmony

As you can see on the pictures besides, all the modules can be assembled with or without busbars, depending of your choice.

Varpact modules benefits

Varpact means " simplicity ":
- complete range according to network pollution level
- easy installation in all cubicles type

Varpact means " peace of mind ":
- fully tested before dispatch
- includes protection against direct contacts

Notes

Schneider Electric Industries SAS
Rectiphase
399, rue de la Gare
74370 Pringy
France
Tél : +33 (0)4 50 66 95 00
Fax : +33 (0)4 50 27 24 19
http://www.schneider-electric.com
http://www.merlin-gerin.com

Printed on recycled paper.

Création, published by: Schneider Electric - Ameg
Photos : Schneider Electric
Printed by:

ART816860
CFIED206099EN

04-2006