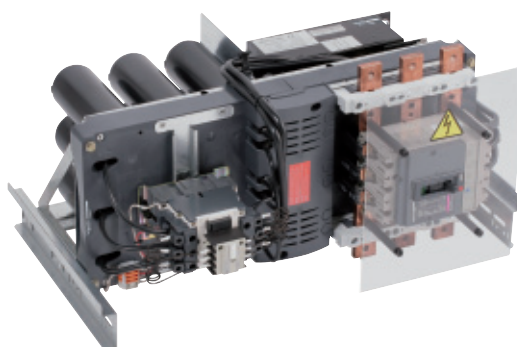


Guide for the design and production of LV compensation cubicles

400/415 V - 50 Hz network

Conception guide
2009



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Design of a LV compensation cubicle

In addition to the rules and standards concerning production of electrical switchboards the LV correction switchboards require the consideration of specific constraints.

1- The Varpact compensation modules (see pages 40 to 42)

The Varplus² capacitors (see pages 43 and 44)
Their positioning must ensure proper ventilation.
Their sizing must take into account ambient conditions (harmonics, temperature, etc...)

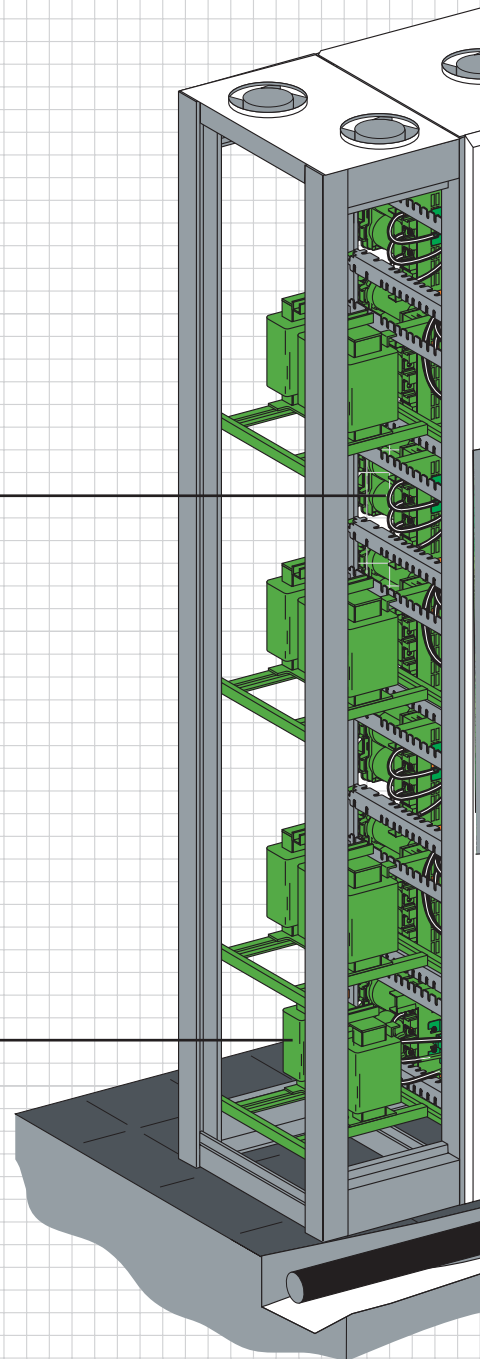
- mounted, pre-cabled and tested in the factory
- adaptation in all cubicle types
- perfect association of components

The contactors (see pages 38 and 39)
They must be suited to capacitor control.
Schneider Electric have designed and tested specific contactors (Telemecanique) for this application.
Their control voltage must be monitored in order to prevent rapid reclosing.

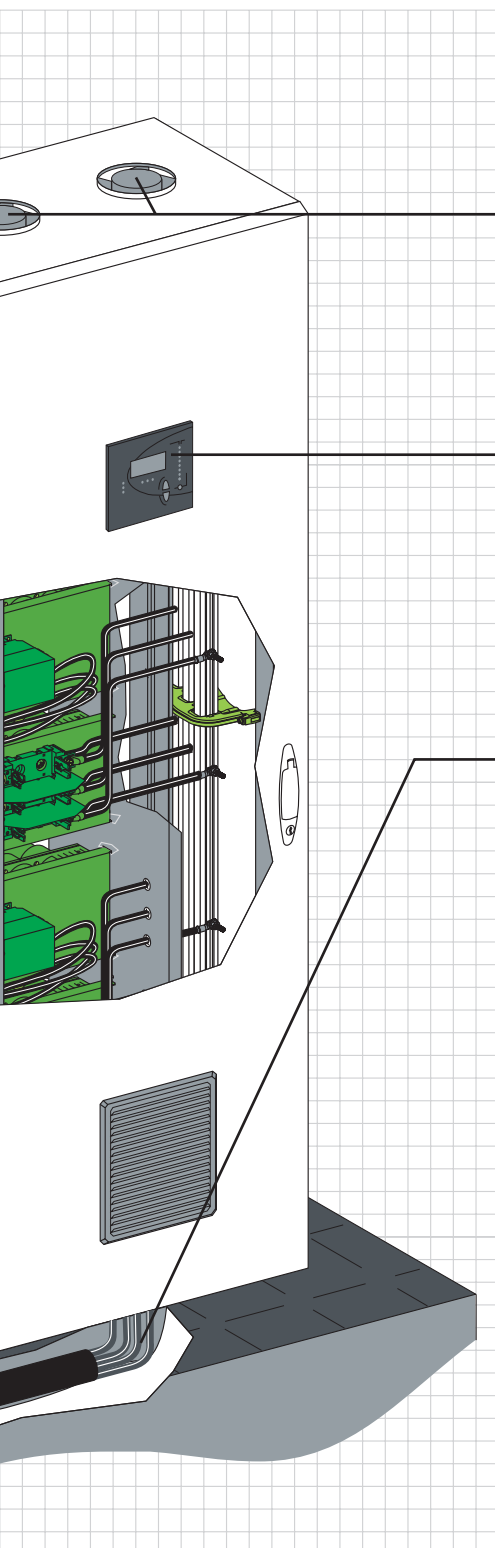
2- The detuned reactors (DR) (see pages 33 to 35 and 45)

They must be chosen according to harmonic stresses and installed in order to avoid, as far as possible, capacitor temperature rise.
The DR temperature sensor must be connected so that the step can be disconnected if the temperature is too high.

DB121406



To not respect one of these 7 rules can shorten the operating life of the capacitors (in a few months) as a result of an excessive temperature, harmonic stresses or an over voltage due to the wrong setting of the controller.
It can lead to the rupture of the capacitors, contactors, wirings or detuned reactors.
In the worst case, this can lead to fire.



3- Ventilation (see pages 46 to 49)

It must be efficient in order to keep operating temperature lower than maximum permissible temperature of components.

4- The power factor controller

(see pages 36 and 37)

Its functions must be adapted to the capacitor bank characteristics: number and power of steps, sequence, etc. The time delay must be adapted to capacitor discharge time.

Time delay must be set to a minimum of 50 seconds (see page 12).

5- Low voltage network (see pages 6 to 9)

Network characteristics, and in particular network harmonic pollution, must absolutely be taken into account when choosing capacitors and detuned reactors (if any).

6- Tests to be done after production of the bank (see p. 55 to 60)

At the end of the manufacturing process, a LV switchboard must undergo various routine inspections and tests in the factory, following an established programme.

The switchboard must comply with :

- the appropriate standards
- the design file (drawings, diagrams and specific requirements)
- manufacturer mounting instructions
- in-house instructions.

7- Maintenance must be done every year

One month after energising, check:

- contactor terminal tightening torques.

Each year check:

- general cleanliness of the equipment
- filters and ventilation system
- terminal tightening torques
- proper working order of switching and protective devices
- temperature in the premises:
 - 5 °C to +40 °C max
- capacitor capacitance, consult us if the capacitance value has changed by more than 10 %.

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

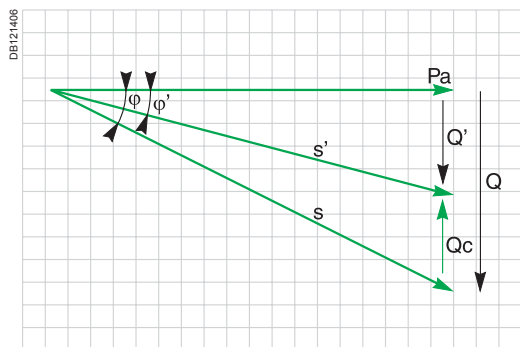
$\omega = 2 \pi f$

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 $\tan \varphi$ and a target $\tan \varphi'$.

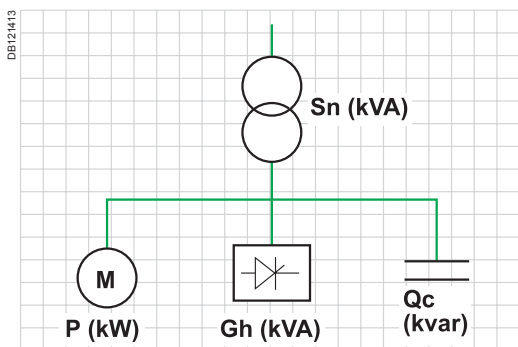


Compensation schematic diagram:

$$Q_c = P_a (\tan \varphi - \tan \varphi')$$

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	cos φ	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	
		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	

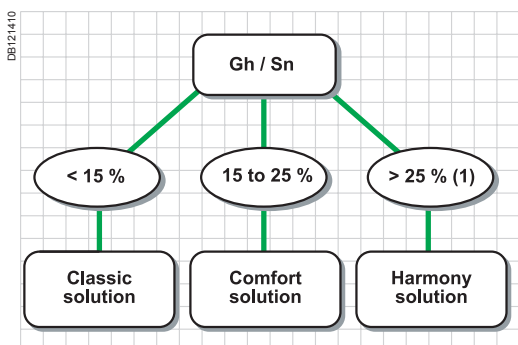


Sn: apparent power of the transformer.

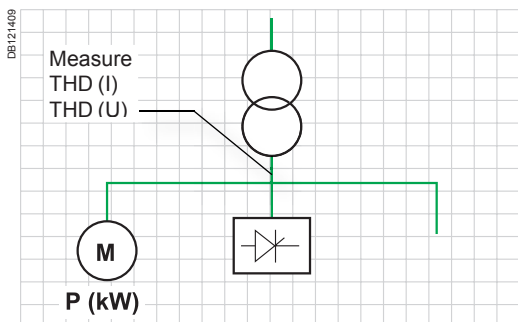
Gh: apparent power of harmonics-generating receivers (variable speed motors, static converters, power electronics, etc.).

Qc: power of the compensation equipment.

U: network voltage.



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



THD(I) or THD(U) measurement.

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.

Compensation equipment can be of three types (Classic, Comfort, Harmony), depending on the level of network harmonic pollution.

It can be selected as follows:

- with a theoretical way according to the Gh/Sn ratio if the data exist.



Becareful: the Gh/Sn ratio rule is right only if THD(I) of the sum of harmonics-generating receivers < 30 % and if background THD(U) < 2 %.

If these values are higher, you have to realise a harmonics study of the network, or to do measurements.

Example 1

U = 400 V; P = 300 kW; Sn = 800 kVA; Gh = 150 kVA

Gh: Sn = 18.75 % → Comfort equipment

Example 2

U = 400 V; P = 100 kW; Sn = 800 kVA; Gh = 300 kVA

Gh: Sn = 37.5 % → Harmony equipment

- with measurements: according to the percentage of total harmonic current distortion THD(I) measured at the transformer secondary, at **maximum load and without capacitors**:

THD (I)	Classic	Comfort	Harmony	Filters
≤ 5 %				
5% < ... ≤ 10%				
10% < ... ≤ 20%				
> 20 %				

- with measurements: according to the percentage of total harmonic voltage distortion THD(U) measured at the transformer secondary, at **maximum load and without capacitors**:

THD (U)	Classic	Comfort	Harmony	Filters
≤ 3 %				
3% < ... ≤ 4%				
4% < ... ≤ 7%				
> 7 %				

If you measure the both THD(I) and THD(U) and the results give two different type of power factor correction according to the above rules, you have to choose the most restricting solution.

Example, a measurement is giving the following results:

- THD(I) = 15 % → Harmony solution

- THD(U) = 3.5 % → Comfort solution.

You have to choose the Harmony solution.

Customer needs

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

	Very frequently
	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 ≤ 15 %	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			
Refinery			
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			

The following rules are only indicative.

In any case, if you have a doubt or if values are higher than the following limits, contact us.

All the components and applications you will find in this guide are right if you respect the following limits in order to avoid any overload of detuned reactors and capacitors.

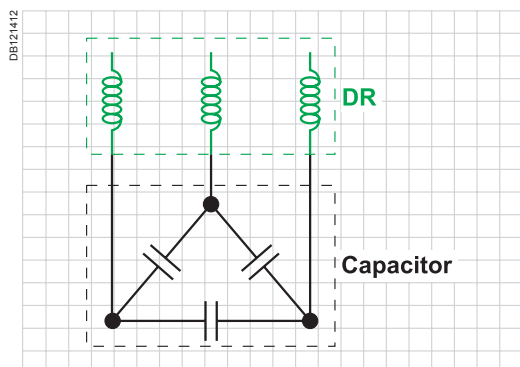
THD(U) have to be measured at the transformer secondary,
with the capacitors on.

Imp (maximum permissible current) have to be measured inside the capacitors :

Working limits	THD(U) max. %	Voltage measurement of the order					Imp/I1 max.
		U3	U5	U7	U11	U13	
Classic power factor correction	5 %	-	-	-	-	-	1.3
Comfort power factor correction	7 %	-	-	-	-	-	1.5
Harmony power factor correction (tuning order 2.7)	10 %	3 %	8 %	7 %	3.5 %	3 %	1.12
Harmony power factor correction (tuning order 3.8)	8 %	0.5 %	6 %	5 %	3.5 %	3 %	1.19
Harmony power factor correction (tuning order 4.3)	6 %	0.5 %	5 %	4 %	3.5 %	3 %	1.31

Imp = maximum permissible current.

Choice of detuned reactor tuning frequency

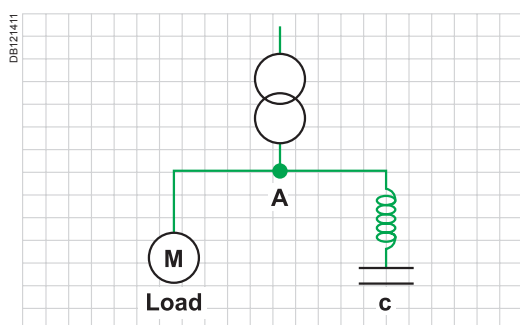


General

The detuned reactors (DR) are designed to protect the capacitors by preventing amplification of the harmonics present on the network. They must be connected in series with the capacitors.



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



Technical data

Choice of tuning

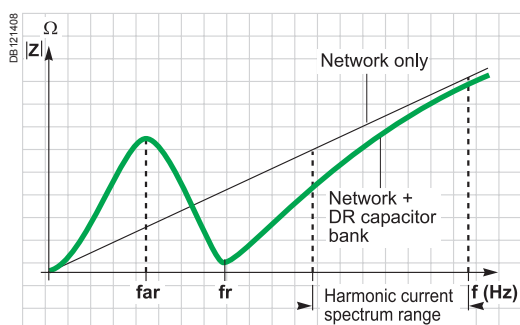
The tuning frequency f_r corresponds to the resonance frequency of the L-C assembly.

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

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

$$n = \frac{f_r}{50 \text{ Hz}}$$

- 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).



Curve: impedance module at point A

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	> 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 %

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	1.2.3.3.3.3
1.1.2.2.2.2.2	1.2.3.4.4.4
1.1.2.3.3.3.3	1.2.3.6.6.6
1.1.2.4.4.4.4	1.2.4.4.4.4
1.2.2.2.2.2.2	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 nth step (maximum 12)

Examples

1.1.1.1.1.1.1:	Q2 = Q1, Q3 = Q1, ..., Qn = Q1
1.1.2.2.2.2.2:	Q2 = Q1, Q3 = 2Q1, Q4 = 2Q1, ..., Qn = 2Q1
1.2.3.4.4.4.4:	Q2 = 2Q1, Q3 = 3Q1, Q4 = 4Q1, ..., Qn = 4Q1
1.2.4.8.8.8.8:	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

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.

The Varplus² 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 50 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**.

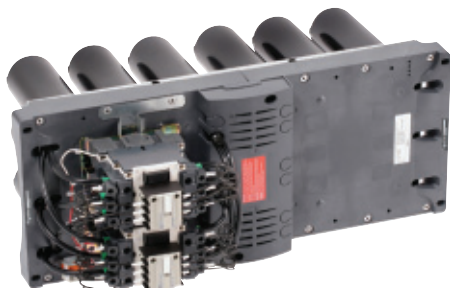
Power factor correction modules 50 Hz network

400/415 V network voltage

Varpact Classic power factor correction modules

Varpact power factor correction module form a prewired automatic compensation subassembly designed for fixing in stand-alone cubicles or inside Main Low Voltage Switchboard.

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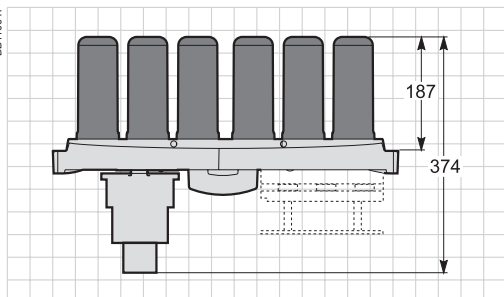
Varpact Classic «with cable connection».

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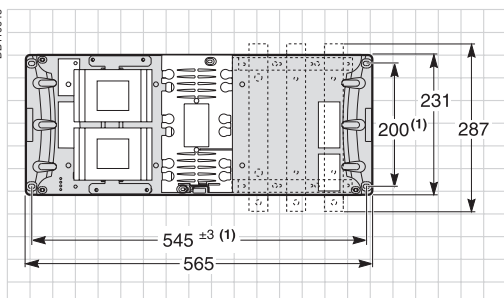
Varpact Classic B «with busbar connection».

DB110647



Varpact Classic and Classic B dimensions.

DB110648



(1) Fixing point.

Varpact Classic

For no polluted network (Gh/Sn ≤ 15 %)

Varpact «with cable connection»			
400 V (kvar)	Step	Reference	Weight (kg)
12.5	Single	51775	9
25	Single	51776	10
30	Single	51777	10
40	Single	51778	10
45	Single	51779	12
50	Single	51780	12
60	Single	51781	13
80	Single	51719	14
90	Single	51782	14.5
100	Single	51783	14.5
120	Single	51784	16
6.25 + 12.5	Double	51785	10.5
12.5 + 12.5	Double	51786	10.5
10 + 20	Double	51787	10.5
15 + 15	Double	51788	10.5
20 + 20	Double	51789	10.7
15 + 30	Double	51790	10.7
30 + 30	Double	51791	13.7
20 + 40	Double	51792	13.7
25 + 50	Double	51793	14.5
30 + 60	Double	51794	14.5
40 + 40	Double	51795	14.5
45 + 45	Double	51729	15.5
50 + 50	Double	51796	16
40 + 80	Double	51797	16
60 + 60	Double	51798	16

Varpact B «with busbar connection»			
400 V (kvar)	Step	Reference	Weight (kg)
12.5	Single	51950	12
25	Single	51951	13
30	Single	51952	13
40	Single	51953	13
45	Single	51954	15
50	Single	51977	15
60	Single	51978	16
80	Single	51967	17
90	Single	51979	17.5
100	Single	51980	17.5
120	Single	51981	19
6.25 + 12.5	Double	51982	13.5
12.5 + 12.5	Double	51983	13.5
10 + 20	Double	51984	13.5
15 + 15	Double	51985	13.5
20 + 20	Double	51986	13.7
15 + 30	Double	51987	13.7
30 + 30	Double	51988	16.7
20 + 40	Double	51989	16.7
25 + 50	Double	51990	17.5
30 + 60	Double	51991	17.5
40 + 40	Double	51992	17.5
45 + 45	Double	51970	18.5
50 + 50	Double	51993	19
40 + 80	Double	51994	19
60 + 60	Double	51995	19

Power factor correction modules 50 Hz network

400/415 V network voltage

Varpact Classic power factor correction modules

Technical data

- capacitor rated voltage: 415 V, three phase 50 Hz
- capacitance value tolerance: -5, +10 %
- insulation level:
 - 0.69 kV
 - withstand 50 Hz, 1 min: 3 kV
- maximum permissible overcurrent: 30 % max. (400 V)
- maximum permissible overvoltage: 10 % (8 hours over 24 hours as in IEC 60831)
- ambient temperature around the capacitor bank (electrical room):
 - maximum temperature: 40 °C
 - average temperature over 24 hours: 35 °C
 - average annual temperature: 25 °C
 - minimum temperature: -5 °C
- busbar withstand I_{sc}: 35 kA
- losses:
 - with cable connection: ≤ 1.9 W/kvar (maximum current)
 - with busbar connection: ≤ 2.3 W/kvar (maximum current)
- degree of protection: accidentals front face direct contact protection device
- colour: RAL 7016
- standards: IEC 60439-1, EN 60439-1, IEC 61921.

Accessories	Ref.
Connection module	
With fixing kit (600, 650, 700, 800 wide cubicle)	52800
Fastening crosspieces	
Set of 2 crosspieces	51670
Extension pieces	
For Prisma Plus cubicle W = 650 mm	51635
For universal cubicle W = 700 mm	51637
For universal cubicle W = 800 mm	51639
Circuit breaker protection	Maximum reactive power
Additionnal circuit breaker 60/63 A protection kit	Until 30 kvar
Additionnal circuit breaker 100 A protection kit	From 31 to 50 kvar
Additionnal circuit breaker 160 A protection kit	From 51 to 80 kvar
Additionnal circuit breaker 250 A protection kit	From 81 to 120 kvar
	51626
	51627
	51628
	51629

Installation

- horizontal fixing in functional and universal cubicles, 400 and 500 mm deep
- in cubicle W = 600 mm using fastening crosspieces
- in cubicle W = 650, 700 and 800 mm using fastening crosspieces and extension pieces
- vertical fastening every 300 mm (maximum 5 modules) directly to cubicle uprights using sliding crosspieces or to intermediate upright support
- control circuit power supply: 230 V, 50 Hz.

Power factor correction modules

50 Hz network

400/415 V network voltage

Varpact Comfort power factor correction modules

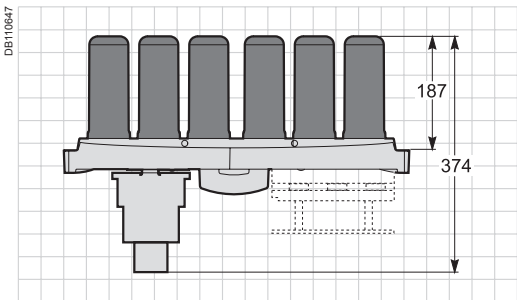
Varpact power factor correction module form a prewired automatic compensation subassembly designed for fixing in stand-alone cubicles or inside Main Low Voltage Switchboard.



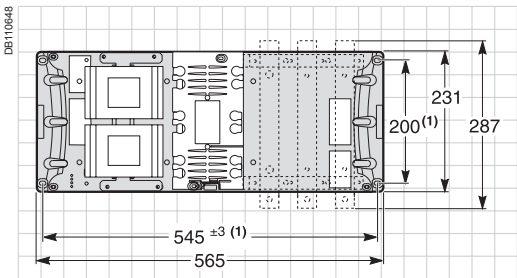
Varpact Comfort «with cable connection».



Varpact Comfort B «with busbar connection».



Varpact Comfort and Comfort B dimensions.



(1) Fixing point.

Varpact Comfort

For polluted network ($15 \% < G_h/S_n \leq 25 \%$)

Varpact «with cable connection»			
400 V (kvar)	Step	Reference	Weight (kg)
15	Single	51801	9
20	Single	51803	10
25	Single	51905	10
30	Single	51807	10
35	Single	51809	12
45	Single	81811	12
60	Single	51813	13
70	Single	51816	14.5
90	Single	51817	15
15 + 15	Double	51818	10
15 + 30	Double	51819	12.7
15 + 45	Double	51820	13.7
30 + 30	Double	51821	14.5
30 + 60	Double	51822	16.5
45 + 45	Double	51823	16.5

Varpact B «with busbar connection»			
400 V (kvar)	Step	Reference	Weight (kg)
15	Single	51740	12
20	Single	51741	13
25	Single	51742	13
30	Single	51743	13
35	Single	51744	15
45	Single	51745	15
60	Single	51746	16
70	Single	51747	17.5
90	Single	51748	18
15 + 15	Double	51749	13
15 + 30	Double	51750	15.7
15 + 45	Double	51751	16.7
30 + 30	Double	51752	17.5
30 + 60	Double	51753	19.5
45 + 45	Double	51754	19.5

Power factor correction modules 50 Hz network

400/415 V network voltage

Varpact Comfort power factor correction modules

Technical data

- capacitor rated voltage: 480 V, three-phase 50 Hz
- capacitance value tolerance: -5, +10 %
- insulation level:
 - 0.69 kV
 - withstand 50 Hz, 1 min: 3 kV
- maximum permissible overcurrent: 50 % max. (400 V)
- maximum permissible overvoltage: 10 % (8 hours over 24 hours as in IEC 60831)
- ambient temperature around the capacitor bank (electrical room):
 - maximum temperature: 40 °C
 - average temperature over 24 hours: 35 °C
 - average annual temperature: 25 °C
 - minimum temperature: -5 °C
- busbar withstand I_{sc}: 35 kA
- losses:
 - with cable connection: ≤ 2 W/kvar (maximum current)
 - with busbar connection: ≤ 2.4 W/kvar (maximum current)
- degree of protection: accidentals front face direct contact protection device
- colour: RAL 7016
- standards: IEC 60439-1, EN 60439-1, IEC 61921.

Accessories		Ref.
Connection module		
With fixing kit (600, 650, 700, 800 wide cubicle)		52800
Fastening crosspieces		
Set of 2 crosspieces		51670
Extension pieces		
For Prisma Plus cubicle W = 650 mm		51635
For universal cubicle W = 700 mm		51637
For universal cubicle W = 800 mm		51639
Circuit breaker protection	Maximum reactive power	
Additionnal circuit breaker 60/63 A protection kit	Until 30 kvar	51626
Additionnal circuit breaker 100 A protection kit	From 31 to 50 kvar	51627
Additionnal circuit breaker 160 A protection kit	From 51 to 80 kvar	51628
Additionnal circuit breaker 250 A protection kit	From 81 to 120 kvar	51629

Installation

- horizontal fixing in functional and universal cubicles, 400 and 500 mm deep
 - in cubicle W = 600 mm using fastening crosspieces
 - in cubicle W = 650, 700 and 800 mm using fastening crosspieces and extension pieces
- vertical fastening every 300 mm (maximum 5 modules) directly to cubicle uprights using sliding crosspieces or to intermediate upright support
- control circuit power supply: 230 V, 50 Hz.

Power factor correction modules

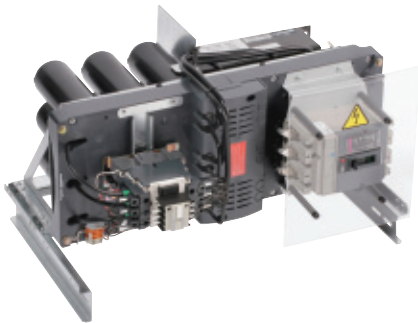
50 Hz network

400/415 V network voltage

Varpact Harmony power factor correction modules

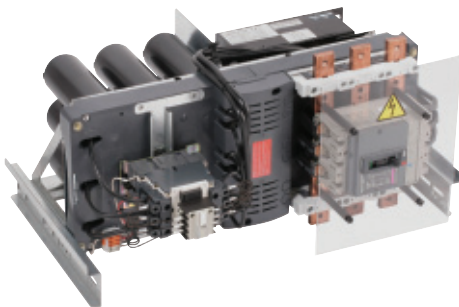
Varpact power factor correction module form a prewired automatic compensation subassembly designed for fixing in stand-alone cubicles or inside Main Low Voltage Switchboard.

PB101983_SE-45



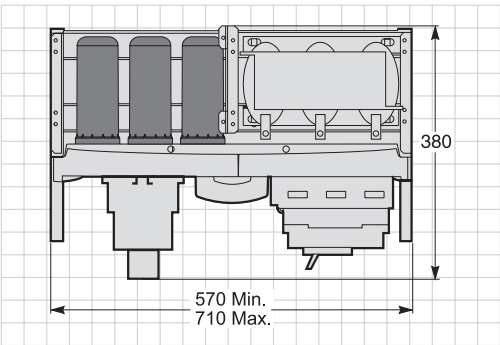
Varpact Harmony «with cable connection».

PB101982_SE-45

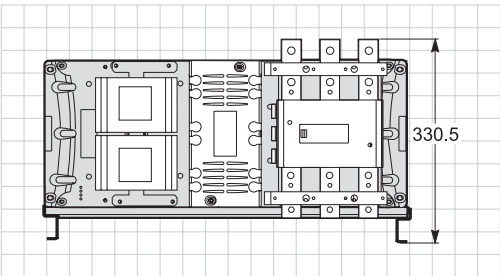


Varpact Harmony B «with busbar connection».

DB110645



DB110646



Varpact Harmony dimensions.

Varpact Harmony

For highly polluted network (25 % < Gh/Sn ≤ 50 %)

Varpact «with cable connection»				
Tuning order	400 V (kvar)	Step	Ref.	Weight (kg)
2.7 (135 Hz)	6.25 + 6.25	Double	51916	23
	6.25 + 12.5	Double	51917	31.5
	12.5 + 12.5	Double	51918	38.5
	12.5	Single	51919	23.5
	25	Single	51920	35.5
	50	Single	51921	46.5
3.8 (190 Hz)	6.25 + 6.25	Double	51925	21.5
	6.25 + 12.5	Double	51926	30
	12.5 + 12.5	Double	51927	37
	12.5	Single	51928	22
	25	Single	51929	34
	50	Single	51930	45
4.3 (215 Hz)	6.25 + 6.25	Double	51934	21.5
	6.25 + 12.5	Double	51935	30
	12.5 + 12.5	Double	51936	37
	12.5	Single	51937	22
	25	Single	51938	34
	50	Single	51939	45

Varpact B «with busbar connection»				
Tuning order	400 V (kvar)	Step	Ref.	Weight (kg)
2.7 (135 Hz)	6.25 + 6.25	Double	51757	26
	6.25 + 12.5	Double	51759	134.5
	12.5 + 12.5	Double	51761	41.5
	12.5	Single	51763	26.5
	25	Single	51765	38.5
	50	Single	51767	49.5
3.8 (190 Hz)	6.25 + 6.25	Double	51763	24.5
	6.25 + 12.5	Double	51764	33
	12.5 + 12.5	Double	51655	40
	12.5	Single	51656	25
	25	Single	51657	37
	50	Single	51658	48
4.3 (215 Hz)	6.25 + 6.25	Double	51501	24.5
	6.25 + 12.5	Double	51503	33
	12.5 + 12.5	Double	51505	40
	12.5	Single	51509	25
	25	Single	51511	37
	50	Single	51512	48

Power factor correction modules 50 Hz network

400/415 V network voltage

Varpact Harmony power factor correction modules

Technical data

- capacitor rated voltage: 480 V, three-phase 50 Hz
- tuning order: 2.7 (135 Hz) - 3.8 (190 Hz) - 4.3 (215 Hz)
- capacitance value tolerance: -5, +10 %
- insulation level:
 - 0.69 kV
 - withstand 50 Hz, 1 min: 3 kV
- maximum permissible overloads:

Tuning order	2.7 (135 Hz)	3.8 (190 Hz)	4.3 (215 Hz)
Overcurrent (max)	12 % under 400 V	19 % under 400 V	30 % under 400 V
Overvoltage	10 % (8 hours over 24 hours as in IEC 60831)		

- ambient temperature around the capacitor bank (electrical room):
 - maximum temperature: 40 °C
 - average temperature over 24 hours: 35 °C
 - average annual temperature: 25 °C
 - minimum temperature: -5 °C
- busbar withstand I_{sc}: 35 kA
- losses: ≤ 8 W/kvar
- degree of protection: accidentals front face direct contact protection device
- colour: RAL 7016
- standard: IEC 60439-1, EN 60439-1, IEC 61921.

Accessories	Ref.
Connection module	
With fixing kit (600, 650, 700, 800 wide cubicle)	52800

Installation

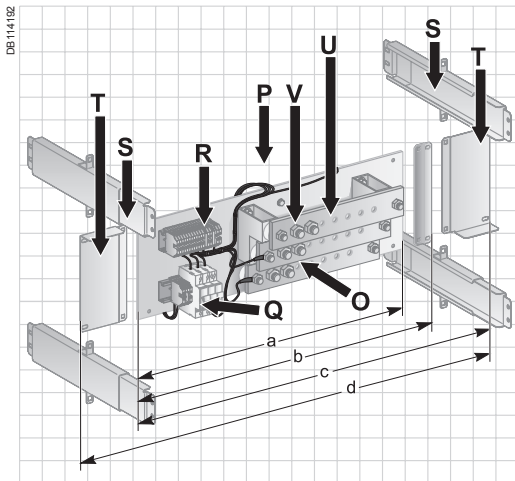
- horizontal fixing in functional and universal cubicles, 400 and 500 mm deep, fixing in cubicle W = 650, 700 and 800 mm using fastening crosspieces supplied
- vertical fixing every 300 mm (maximum 5 modules) directly to cubicle uprights using sliding crosspieces or to intermediate upright support
- control circuit power supply: 230 V, 50 Hz.

Power factor correction modules

50 Hz network

400/415 V network voltage

Accessories for Varpact power factor correction modules



Connection module

a : cubicle W = 600 without extension plate
 b : cubicle W = 650 with extension plate W650
 c : cubicle W = 700 with extension plate W700
 d : cubicle W = 800 two extension plates W700

Connection module

(Ref. 52800)

It is used to connect:

- the power and control cables for the power factor correction module contactors (maximum five power factor correction modules)

- the cubicle supply cables.

It is supplied with:

- 4 crosspieces

- 2 extension pieces

- 3 power connection bars (800 A max.), marked L1, L2, L3

- P Voltage transformer supplying the contactor coils 400/230 V, 250 VA

- Q Control circuit safety fuses

- R Contactor control distribution terminal block

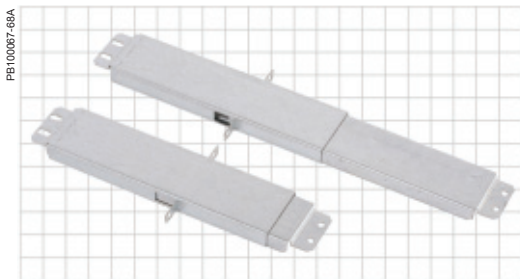
- S Sliding crosspieces for mounting in cubicles 400 and 500 mm deep

- T Extension pieces for mounting in cubicles 650, 700 or 800 mm wide

- U Power factor correction module connection: 5 holes Ø10 per phase

- V Customer's incoming cable connection: 2 x M12 bolts per phase.

To make it easier to connect the supply cables, we recommended that the connection module be installed at least 20 cm from the ground.



2 fastening crosspieces (ref. 51670)

Fastening crosspieces for Varpact Classic and Comfort

(Ref. 51670)

Specially designed horizontal crosspieces allow easy installation of the power factor correction modules in all types of functional and universal cubicles 400 ou 500 mm deep.

The crosspieces automatically ensure that the module is positioned correctly at the right depth and maintain a distance of 55 mm between the modules. The crosspieces are sold in pairs and must be ordered separately.

Extension pieces for cubicles W = 700 and W = 800 with Varpact Classic and Comfort

(Ref. 51637 et 51639)

They are used to extend the power factor correction modules for use in cubicles 700 and 800 mm wide.

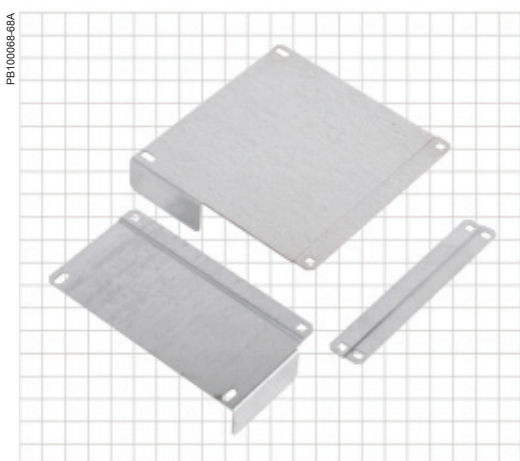
The extension pieces are supplied with the 4 screws required to attach them to the module.

Extension pieces for Prisma Plus cubicle W = 650 with Varpact Classic and Comfort

(Ref. 51635)

It allows the module to be attached directly to the Prisma Plus cubicle uprights.

The extension piece is supplied with the 4 screws required to attach it to the module.



Extension pieces for cubicles

W = 650 (ref. 51635)

W = 700 (ref. 51637)

W = 800 (ref. 51639)

Power factor correction modules 50 Hz network

400/415 V network voltage

Accessories for Varpact power factor correction module



Circuit breaker kit

Circuit breaker kit for Varpact Classic and Comfort

(Ref. 51626, 51627, 51628 et 51629)

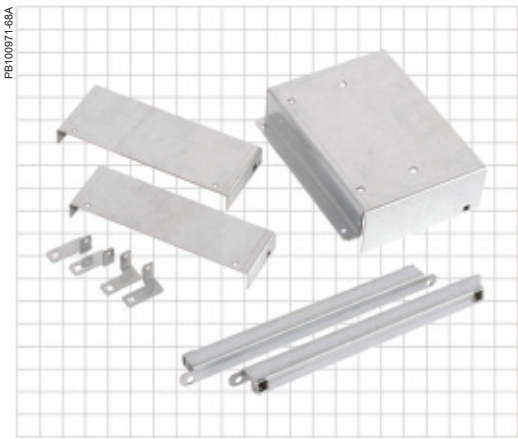
It allows to ensure individual and visible circuit breaking of each capacitor steps.

Retrofit kit

(Ref. 51617, 51619 et 51633)

Set of pieces using for installation and connection of Varpact in functionnal and universal existing cubicles. It is necessary to choose a Varpact module and to order separately associated retrofit kit.

Retrofit kit	Ref.
For P400 power factor correction module	51617
For P400 DR power factor correction module	51619
For Rectimat 2 capacitor bank in cubicle standard and H type	61633



Retrofit kit

Capacitors 50 Hz network

230 V network voltage

Varplus²

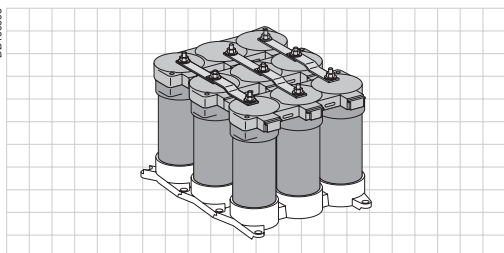
Varplus² modular capacitors allow by their different assembly combination to cover many power ratings (kvar) depending on the voltage (V), frequency (Hz) and harmonic pollution level of the network.

PB100036_SE-35



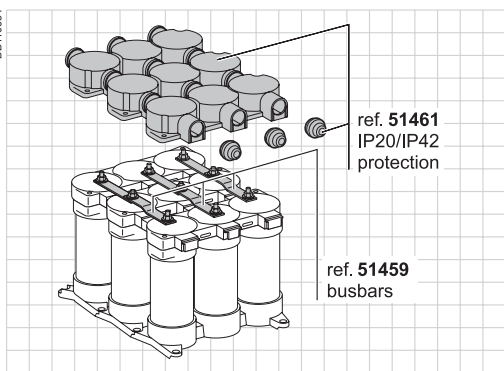
Varplus² IP00.

DB109695



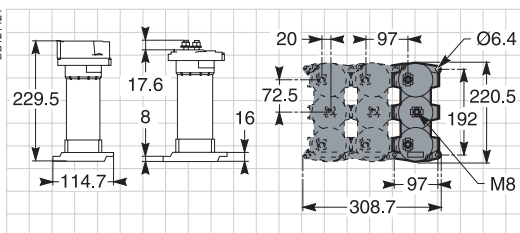
Example of Varplus² IP00 assembly.

DB110654



Varplus² accessories.

DB121424



Weight of Varplus² 2.1 kg.

Slightly polluted network ($Gh/Sn \leq 15\%$)

Varplus ²	
230 V (kvar)	Ref.
2.5	51301
5	51303
6.5	51305
7.5	51307
10	51309
Assembly advised	
15	2 x 51307
20	2 x 51309
30	3 x 51309
40	4 x 51309

Maximum mechanical assembly: 4 capacitors and 40 kvar.

Assembly > 40 kvar: see conditions to respect in Varplus² user manual

Polluted network ($15\% < Gh/Sn \leq 25\%$)

Same capacitors can be used.

Highly polluted network ($25\% < Gh/Sn \leq 50\%$)

Same capacitors can be used with detuned reactor.

Technical data

- 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 μ s: 15 kV
- voltage test: 2.15 U_n (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 internally 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 Varplus ²	
	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)

Capacitors 50 Hz network

400/415 V network voltage

Varplus² capacitors

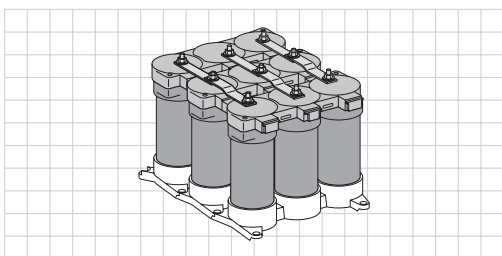
Varplus² modular capacitors allow by their different assembly combination to cover many power ratings (kvar) depending on the voltage (V), frequency (Hz) and harmonic pollution level of the network.

PB 100036_SE-35



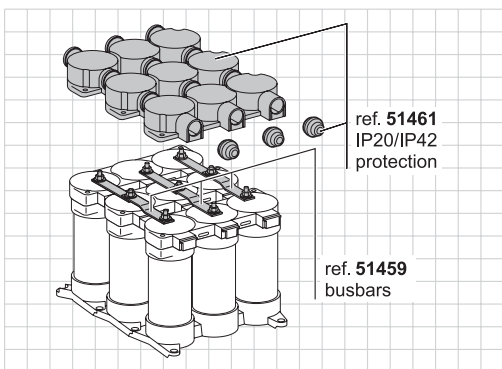
Varplus² IP00.

DB 109695



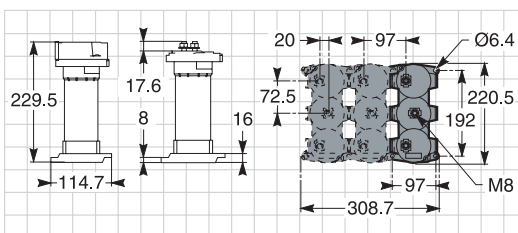
Example of Varplus² IP00 assembly.

DB 110654



Varplus² accessories.

DB 1121424



Weight of Varplus² 2.1 kg.

Slightly polluted network (Gh/Sn ≤ 15 %)

Varplus ²		
400 V (kvar)	415 V (kvar)	Ref.
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 internally 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 Varplus ²	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).

Capacitors 50 Hz network

400/415 V network voltage

Varplus² capacitors

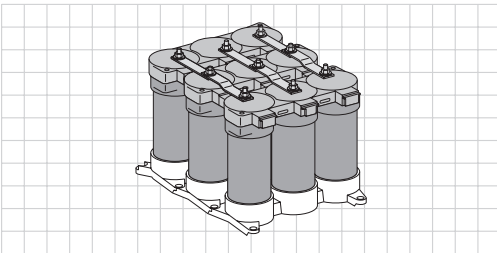
Varplus² modular capacitors allow by their different assembly combination to cover many power ratings (kvar) depending on the voltage (V), frequency (Hz) and harmonic pollution level of the network.

PB 100036_SE-35



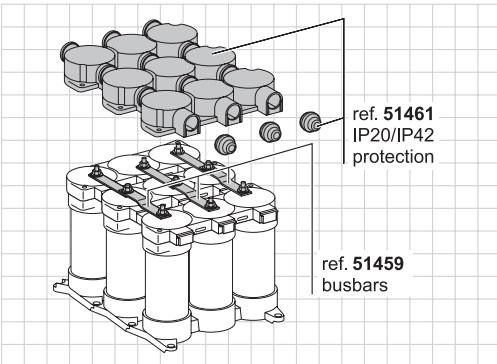
Varplus² IP00.

DB 109695



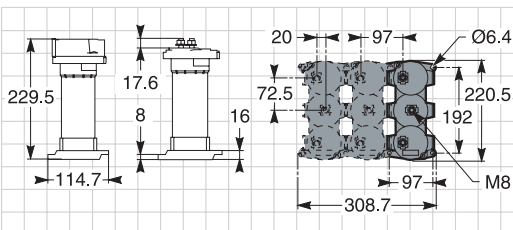
Example of Varplus² IP00 assembly.

DB 110654



Varplus² accessories.

DB 111424



Weight of Varplus² 2.1 kg.

Polluted network (15 % < Gh/Sn ≤ 25 %)

Capacitors rated 480 V are necessary.

Varplus ²				
Usefull powers		Rated values		
400 V (kvar)	415 V (kvar)	440 V (kvar)	480 V (kvar)	Ref.
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 internally 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 Varplus ²	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).

Capacitors 50 Hz network

400/415 V network voltage

Varplus² capacitors

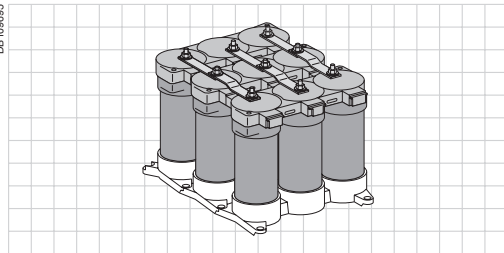
Varplus² modular capacitors allow by their different assembly combination to cover many power ratings (kvar) depending on the voltage (V), frequency (Hz) and harmonic pollution level of the network.

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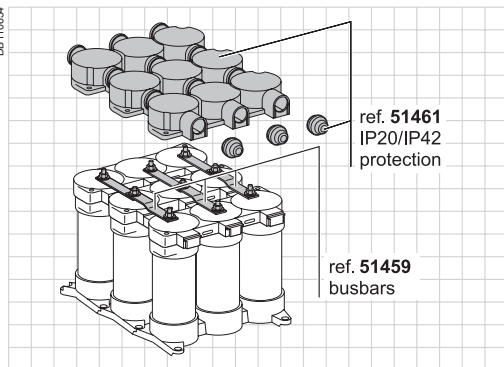
Varplus² IP00.

DB 109695



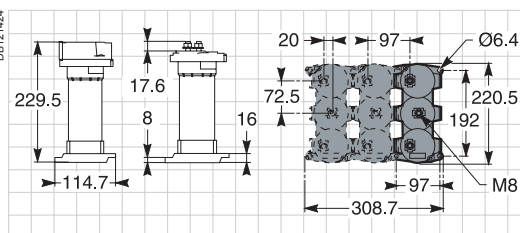
Example of Varplus² IP00 assembly.

DB 110654



Varplus² accessories.

DB 121424



Weight of Varplus² 2.1 kg.

Highly polluted network (25 % < Gh/Sn ≤ 50 %)

Capacitors rated 480 V will be used with detuned reactor.

Varplus ²				
Usefull powers Tuning order	400 V (kvar)	415 V (kvar)	Rated values 440 V (kvar)	480 V (kvar)
2.7 (135 Hz - 13.7 %)	6.5	7	6.7	8
	12.5	13.5	13	15.5
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)
3.8 (190 Hz - 6.92 %)	6.5	7	7.6	9
or	7.75	8.25	8.8	10.4
4.3 (215 Hz - 5.4 %)	10	11	11.8	14
	12.5	13.5	14.3	17
	16.5	17.75	19.1	22.7
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 internally 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 Varplus ²	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).

Capacitors 50 Hz network

525 V network voltage

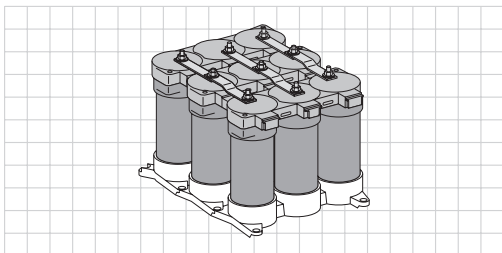
Varplus² capacitors

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.

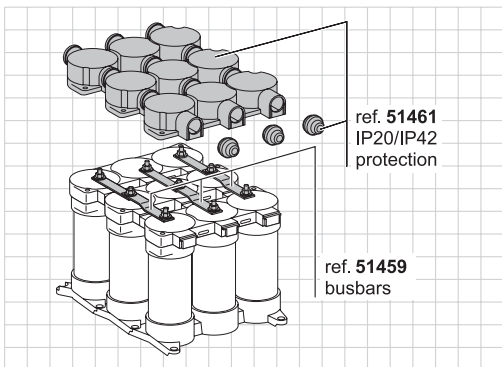
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Varplus² IP00.

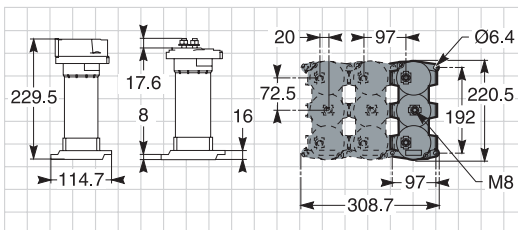
DB 109695

Example of Varplus² IP00 assembly.

DB 110654

Varplus² accessories.

DB 111424

Weight of Varplus² 2.1 kg.

Slightly polluted network ($Gh/Sn \leq 15\%$)

Varplus ²		
Usefull powers	Rated values	Ref.
480 V (kvar)	525 V (kvar)	
12.5	15	51311
Usefull powers	Rated values	
525 V (kvar)	550 V (kvar)	
10.5	11.5	51315
12.3	13.5	51317
16.4	18	51319
Assembly advised		
21	23	2 x 51351
26.4	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 ($15\% < Gh/Sn \leq 50\%$)

Capacitors rated 690 V will be used with detuned reactor 190/215 Hz, 135 Hz tuning 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 μ s: 15 kV
- voltage test: 2.15 U_n (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 internally 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 Varplus ²	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 screw.

A kit to replace Varplus by Varplus² is available (ref. 51298).

Capacitors 50 Hz network

690 V network voltage

Varplus² capacitors

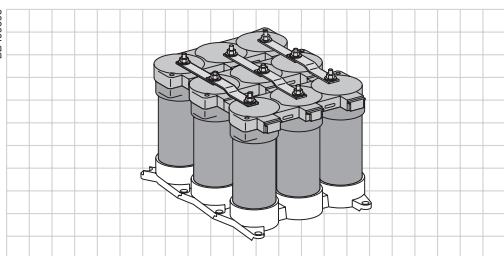
Varplus² modular capacitors allow by their different assembly combination to cover many power ratings (kvar) depending on the voltage (V), frequency (Hz) and harmonic pollution level of the network.

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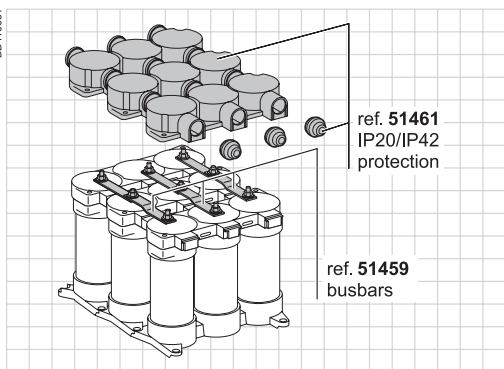
Varplus² IP00.

DB 109695



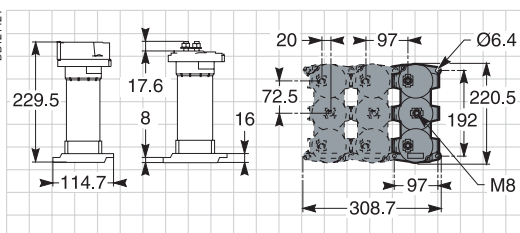
Example of Varplus² IP00 assembly.

DB 110654



Varplus² accessories.

DB 111424



Weight of Varplus² 2.1 kg.

Slightly polluted network ($Gh/Sn \leq 15\%$)

Varplus ²	
690 V (kvar)	Ref.
11	51359
14.6	51361
16.6	51363
Assembly advised	
22	2 x 51359
33.2	2 x 51363
43.8	3 x 51361
58.4	4 x 51361
60.8	3 x 51363 + 51359
66.4	4 x 51363

Maximum mechanical assembly: 4 capacitors and 67 kvar.

Assembly > 67 kvar: see conditions to respect in Varplus² user manual.

Polluted and highly polluted network ($15\% < Gh/Sn \leq 50\%$)

On request.

Technical data

- capacitor rated voltage: 690 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 μ s: 15 kV
- voltage test: 2.15 U_n (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 internally 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 Varplus ²	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).

Capacitors 60 Hz network

230/240 V network voltage

Varplus² capacitors

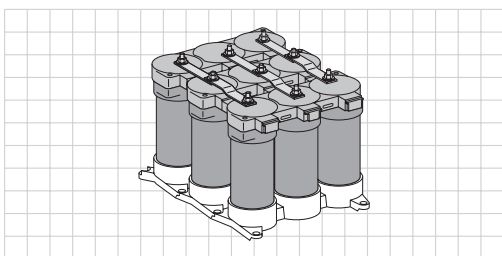
Varplus² modular capacitors allow by their different assembly combination to cover many power ratings (kvar) depending on the voltage (V), frequency (Hz) and harmonic pollution level of the network.

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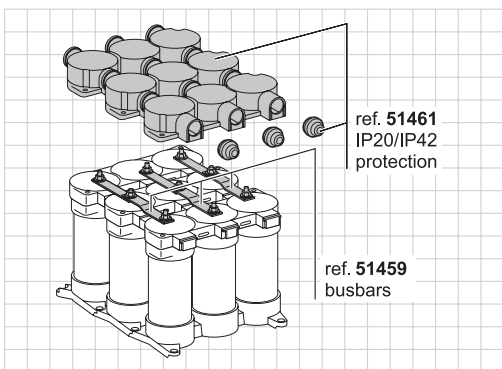
Varplus² IP00.

DB 109695



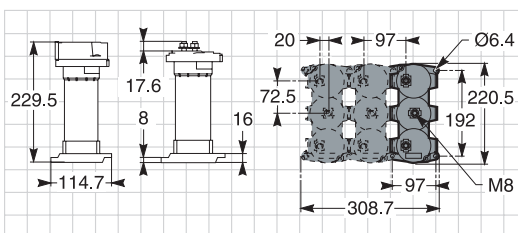
Example of Varplus² IP00 assembly.

DB 110654



Varplus² accessories.

DB 121424



Weight of Varplus² 2.1 kg.

Slightly polluted network ($Gh/Sn \leq 15\%$)

Varplus ²		
230 V (kvar)	240 V (kvar)	Ref.
3	3	51301
6	6.5	51303
8	8.5	51305
9	10	51307
12	13	51309
Assembly advised		
18	20	2 x 51307
24	26	2 x 51309
36	39	3 x 51309

Maximum mechanical assembly: 4 capacitors and 40 kvar.
Assembly > 40 kvar: see conditions to respect in Varplus² user manual.

Polluted network ($15\% < Gh/Sn \leq 25\%$)

Same capacitors can be used

Highly polluted network ($25\% < Gh/Sn \leq 50\%$)

Same capacitors can be used with detuned reactor.

Technical data

- 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 60 Hz 1 minute: 4 kV
 - impulse wave withstand 1.2/50 μ s: 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 internally 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 Varplus ²	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).

Capacitors 60 Hz network

400/415 V network voltage

Varplus² capacitors

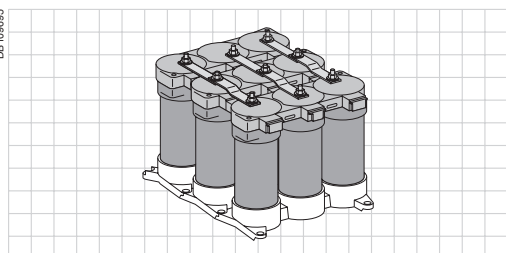
Varplus² modular capacitors allow by their different assembly combination to cover many power ratings (kvar) depending on the voltage (V), frequency (Hz) and harmonic pollution level of the network.

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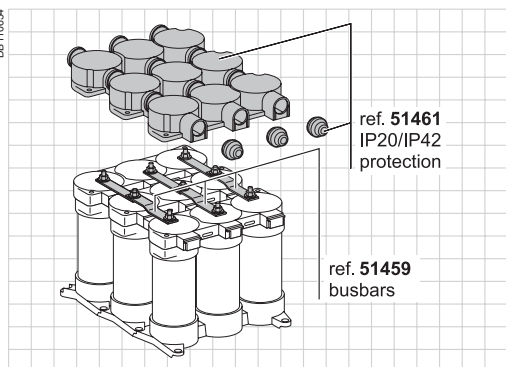
Varplus² IP00.

DB 109695



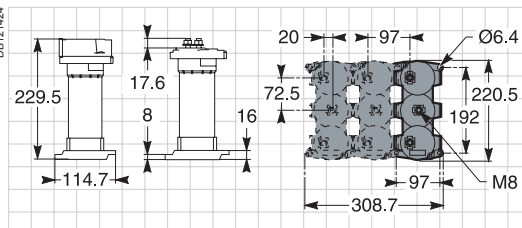
Example of Varplus² IP00 assembly.

DB 110654



Varplus² accessories.

DB 121424



Weight of Varplus² 2.1 kg.

Slightly polluted network ($Gh/Sn \leq 15\%$)

Varplus ²		
400 V (kvar)	415 V (kvar)	Ref.
6	6.25	51311
7.5	8	51313
9	9	51315
12	13	51317
15	16	51319
18	19	51321
Assembly advised		
24	26	2 x 51317
30	32	2 x 51319
36	38	2 x 51321
45	48	3 x 51319
54	57	3 x 51321
60	64	4 x 51319

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 60 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 60 Hz 1 minute: 4 kV
 - impulse wave withstand 1.2/50 μ s: 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 internally 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
 - IP20 or IP42 see accessories
- no earth connection is needed
- terminals: 3 M8 rods allowing 360° cable connection (without cover).

Accessories for Varplus ²	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).

Capacitors 60 Hz network

400/415 V network voltage

Varplus² capacitors

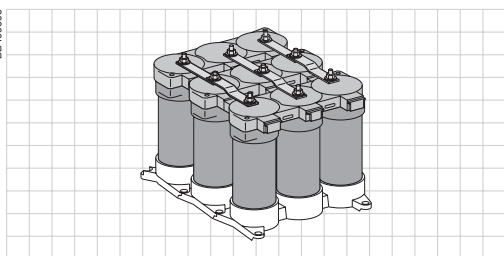
Varplus² modular capacitors allow by their different assembly combination to cover many power ratings (kvar) depending on the voltage (V), frequency (Hz) and harmonic pollution level of the network.

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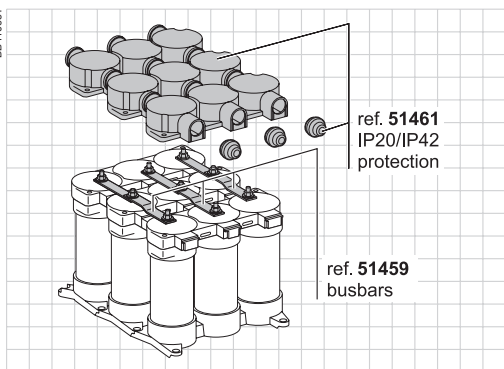
Varplus² IP00.

DB 109695



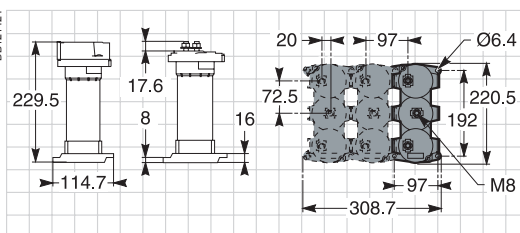
Example of Varplus² IP00 assembly.

DB 110654



Varplus² accessories.

DB 121424



Weight of Varplus² 2.1 kg.

Polluted network (15 % < Gh/Sn ≤ 25 %)

Capacitors rated 480 V are necessary.

Varplus ²				
Usefull powers		Rated values		Ref.
400 V (kvar)	415 V (kvar)	440 V (kvar)	480 V (kvar)	
6	6.25	7.3	8.6	51325
7.5	8	9.1	10.8	51327
9	9	10.5	12.5	51329
12.75	13.5	15.6	18.6	51331
14	15	17.1	20.4	51333
18.5		22.9		51335
Assembly advised				
25.5	27			2 x 51331
32.5				51333 + 51335
37				2 x 51335
42	45			3 x 51333
51				2 x 51335 + 51333
55				3 x 51335
61				3 x 51335 + 31325

Maximum mechanical assembly: 4 capacitors and 61/60 kvar 400/415 V.

Assembly > 60 kvar: see conditions to respect in Varplus² user manual.

Highly polluted network (25 % < Gh/Sn y 50 %) capacitors rated 550 V will be used with detuned reactor.

Technical data

- capacitor rated voltage: 480 V, 3-phase 60 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 60 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 internally 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 Varplus ²	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).

Capacitors 60 Hz network

440 V network voltage

Varplus² capacitors

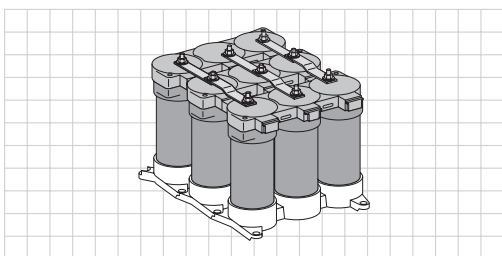
Varplus² modular capacitors allow by their different assembly combination to cover many power ratings (kvar) depending on the voltage (V), frequency (Hz) and harmonic pollution level of the network.

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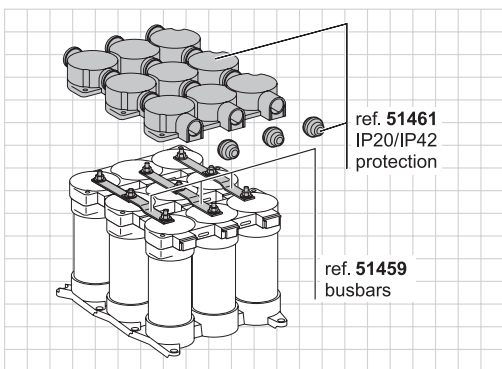
Varplus² IP00.

DB 109695



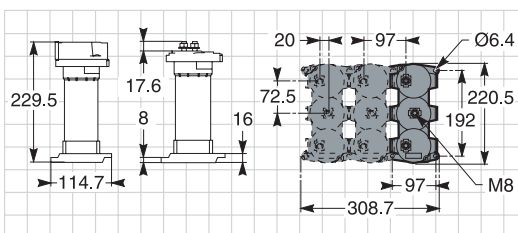
Example of Varplus² IP00 assembly.

DB 110654



Varplus² accessories.

DB 111424



Weight of Varplus² 2.1 kg.

Slightly polluted and polluted network ($Gh/Sn \leq 15\%$)

Varplus ²		
440 V (kvar)	480 V (kvar)	Ref.
7.3	8.6	51325
9.1	10.8	51327
10.9	13	51329
15.4	18.4	51331
16.9	20.2	51333
22.4		51335
Assembly advised		
30.8	36.8	2 x 51331
44.8		2 x 51335
50.7	60.6	3 x 51333
60.2		2 x 51335 + 51331
67.2		3 x 51335
76.3		3 x 51335 + 51327

Maximum mechanical assembly: 4 capacitors and 76 kvar 440/480 V.
Assembly > 76 kvar: see conditions to respect in Varplus² user manual.

Highly polluted network ($15\% < Gh/Sn \leq 50\%$)

Capacitors rated 550 V will be used with detuned reactor
(see page 480 V - 60 Hz).

Technical data

- capacitor rated voltage: 480 V, 3-phase 60 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 60 Hz 1 minute: 4 kV
 - impulse wave withstand 1.2/50 μ s: 15 kV
- voltage test: 2.15 U_n (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 internally 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
 - IP20 or IP42 see accessories
- no earth connection is needed
- terminals: 3 M8 rods allowing 360° cable connection (without cover).

Accessories for Varplus ²	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).

Capacitors 60 Hz network

480 V network voltage

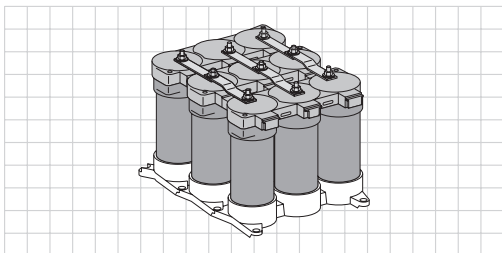
Varplus² capacitors

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.

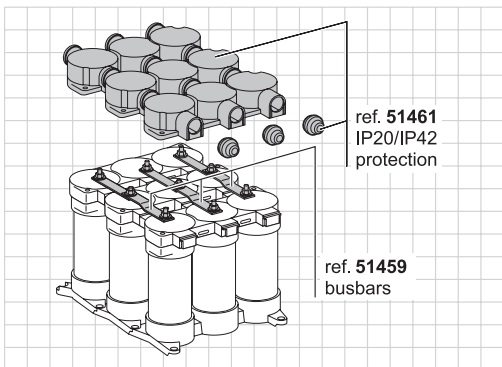
PB 100036_SE-35

Varplus² IP00.

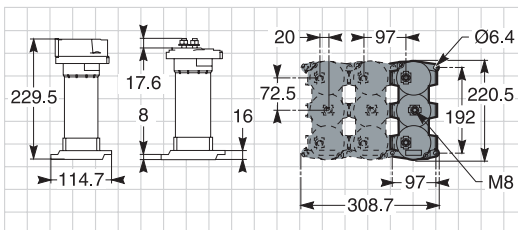
DB 109695

Example of Varplus² IP00 assembly.

DB 110654

Varplus² accessories.

DB 111424

Weight of Varplus² 2.1 kg.

Slightly polluted and polluted network ($Gh/Sn \leq 25\%$)

Varplus ²		
Usefull powers	Rated values	Ref.
480 V (kvar)	550 V (kvar)	
10.5	14	51351
12.5	16.5	51353
15	19.5	51383
16.5	21.5	51357
Assembly advised		
21	28	2 x 51351
25	33	2 x 51353
33	43	2 x 51357
43.5		2 x 51357 + 51351
49.5	64.5	3 x 51357
60		3 x 51357 + 51351
66	86	4 x 51357

Maximum mechanical assembly: 4 capacitors and 66/86 kvar 480/550 V.
Assembly > 66 kvar: see conditions to respect in Varplus² user manual.

Highly polluted network ($25\% < Gh/Sn \leq 50\%$)

- for the tuning orders 3.8 or 4.3 and THD(U) < 6 %, the capacitors above (rated at 550 V) have to be used with detuned reactors.
- for the tuning orders 2.7 and THD(U) > 6 %, capacitors rated at 690 V (see next page) have to be used with detuned reactors.

Technical data

- capacitor rated voltage: 550 V, 3-phase 60 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 60 Hz 1 minute: 4 kV
 - impulse wave withstand 1.2/50 μ s: 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 internally 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 Varplus ²	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).

Capacitors 60 Hz network

600 V network voltage

Varplus² capacitors

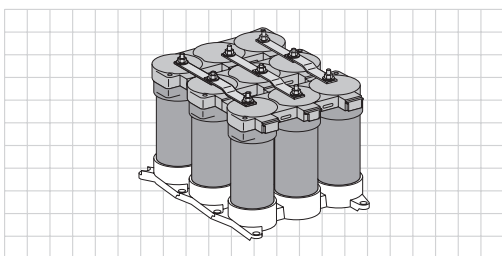
Varplus² modular capacitors allow by their different assembly combination to cover many power ratings (kvar) depending on the voltage (V), frequency (Hz) and harmonic pollution level of the network.

PB 100036_SE-35



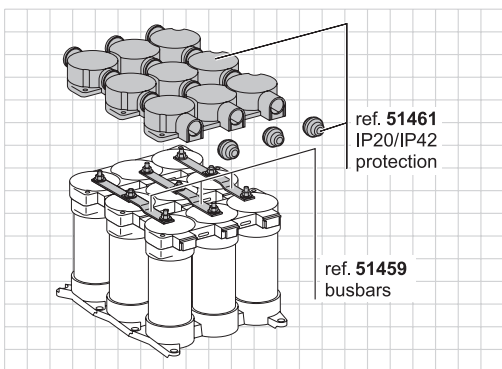
Varplus² IP00.

DB 109695



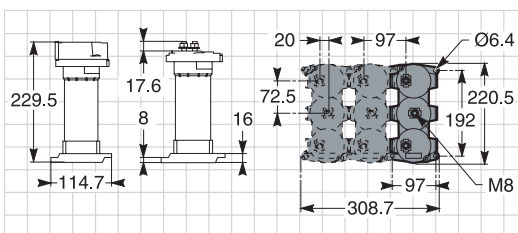
Example of Varplus² IP00 assembly.

DB 110654



Varplus² accessories.

DB 111424



Weight of Varplus² 2.1 kg.

Slightly polluted and polluted network ($Gh/Sn \leq 25\%$)

Varplus ²		
600 V (kvar)	690 V (kvar)	Ref.
10	13.3	51359
13.5	17.6	51361
15	20	51363
Assembly advised		
20	26.6	2 x 51359
30	40	2 x 51363
40.5	52.8	3 x 51361
54		4 x 51361
	60	3 x 51363
60	80	4 x 51363

Maximum mechanical assembly: 4 capacitors and 60/80 kvar 600/690 V.
Assembly > 60 kvar: see conditions to respect in Varplus2 user manual.

Highly polluted network ($25\% < Gh/Sn \leq 50\%$)

On request for association with detuned reactors

Technical data

- capacitor rated voltage: 690 V, 3-phase 60 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 60 Hz 1 minute: 4 kV
 - impulse wave withstand 1.2/50 μ s: 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 internally 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
 - IP20 or IP42 see accessories
- no earth connection is needed
- terminals: 3 M8 rods allowing 360° cable connection (without cover).

Accessories for Varplus ²	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).

Characteristics

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

PB100038_SE-35



Detuned reactor.

Detuned reactor for 400 V - 50 Hz network**Tuning order: 4.3 (215 Hz)**

Power restored by the assembly reactor- capacitor	Power losses		Ref.
	L (mH)	I ₁ (A)	
6.25 kvar/400 V - 50 Hz	4.71	9	51573
12.5 kvar/400 V - 50 Hz	2.37	17.9	52404
25 kvar/400 V - 50 Hz	1.18	35.8	52405
50 kvar/400 V - 50 Hz	0.592	71.7	52406
100 kvar/400 V - 50 Hz	0.296	143.3	52407

Tuning order: 3.8 (190 Hz)

Power restored by the assembly reactor- capacitor	Power losses		Ref.
	L (mH)	I ₁ (A)	
6.25 kvar/400 V - 50 Hz	6.03	9.1	51568
12.5 kvar/400 V - 50 Hz	3	18.2	53352
25 kvar/400 V - 50 Hz	1.5	36.4	53353
50 kvar/400 V - 50 Hz	0.75	72.8	52354
100 kvar/400 V - 50 Hz	0.37	145.5	51569

Tuning order: 2.7 (135 Hz)

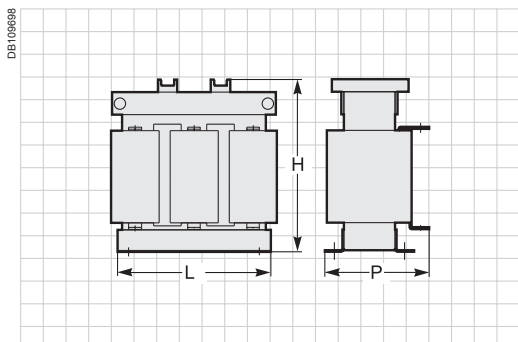
Power restored by the assembly reactor- capacitor	Power losses		Ref.
	L (mH)	I ₁ (A)	
6.25 kvar/400 V - 50 Hz	12.56	9.3	51563
12.5 kvar/400 V - 50 Hz	6.63	17.6	51564
25 kvar/400 V - 50 Hz	3.14	37.2	51565
50 kvar/400 V - 50 Hz	1.57	74.5	51566
100 kvar/400 V - 50 Hz	0.78	149	51567

Characteristics

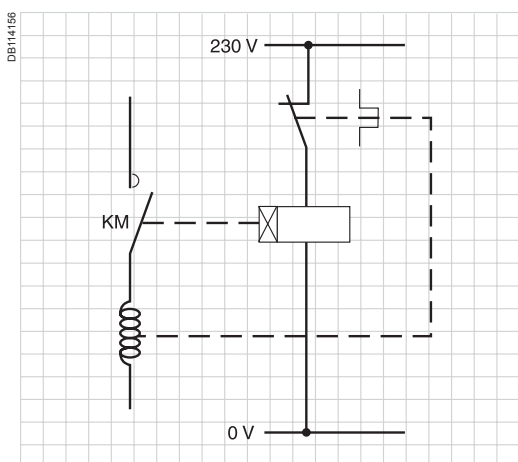
- three-phase, dry, magnetic circuit, impregnated
- cooling: natural
- degree of protection: IP00
- insulation class: H
- standards: IEC 60289, EN 60289
- rated voltage: 400/415 V three-phase 50 Hz
- tuning order (relative impedance): 4.3 (5.4 %); 3.8 (6.9 %); 2.7 (13.7 %)
- inductance tolerance per phase: - 5, +5 %
- maximum constant current: $I_{mp} = \sqrt{(1.1 \cdot I_1)^2 + I_3^2 + I_5^2 + I_7^2 + I_{11}^2}$
- $I_{mp} = 1.31 \cdot I_1$ for 4.3 tuning
- $I_{mp} = 1.19 \cdot I_1$ for 3.8 tuning
- $I_{mp} = 1.12 \cdot I_1$ 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 I_{sc}: 25 x I_e, 2 x 0.5 second
- dynamic withstand: 2.2 I_{sc} (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 reactor.



Normally closed dry contact.

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

Installation

- forced ventilation required (see chapter 6 page 48)
- 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
- 480 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 imperative that the normally closed dry contact be used to disconnect the step in the event of overheating (see drawing at left).

Dimensions

Tuning order: 4.3 (215 Hz)

Power restored by the detuned reactor/ capacitor assembly	Fixing centre distance (mm)	Maximum dimensions (mm)			Weight (kg)
		H	W	D	
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)			Weight (kg)
		H	W	D	
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)			Weight (kg)
		H	W	D	
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 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

Maximum temperature 50 °C and maximum altitude 1000 m
(see chapter 6 page 49)

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	51357 x 3 + 51353 x 2	51566 x 1	LC1-DWK12M7 x 1	LC1D95 x 1
100 kvar	162 kvar	51357 x 9	51567 x 1	-	LC1F185 x 1

550 V capacitors			fr = 215 Hz	fr = 190 Hz		
Qc 400 V	Qc 550 V	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	51357 x 1 + 51353 x 2	52405 x 1	52353 x 1	LC1-DPK11M7 x 1	LC1D40 x 1
50 kvar	90 kvar	51357 x 5	52406 x 1	53354 x 1	LC1-DWK12M7 x 1	LC1D95 x 1
100 kvar	180 kvar	51357 x 10	52407 x 1	53359 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 N power factor controller

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.

PB100031_SE-40



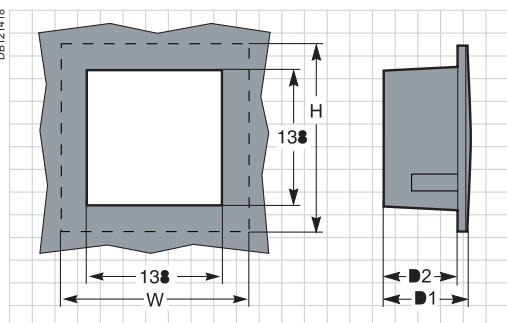
Varlogic NR6/NR12

PB100033_SE-50



Varlogic NRC12

DB121418



Varlogic NR6, NR12, NRC12

Technical data

■ general data

- 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: backlit screen 65 x 21 mm
 - NRC12 type: backlit 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
 - 1.2.2.2.2.2
 - 1.2.3.4.4.4
 - 1.1.2.2.2.2
 - 1.2.3.3.3.3
 - 1.2.4.4.4.4
 - 1.1.2.3.3.3
 - 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)				Weight (kg)
	H	L	P1	P2	
Varlogic NR6/NR12	150	150	70	60	1
Varlogic NRC12	150	150	80	70	1

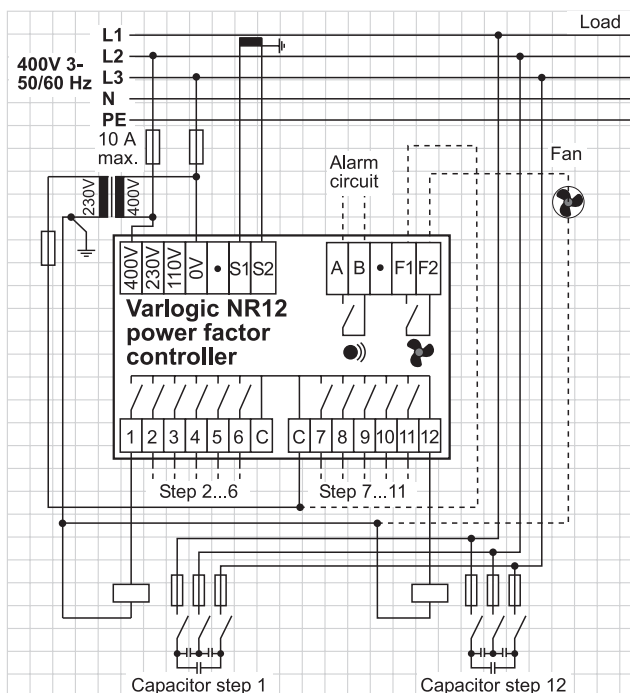
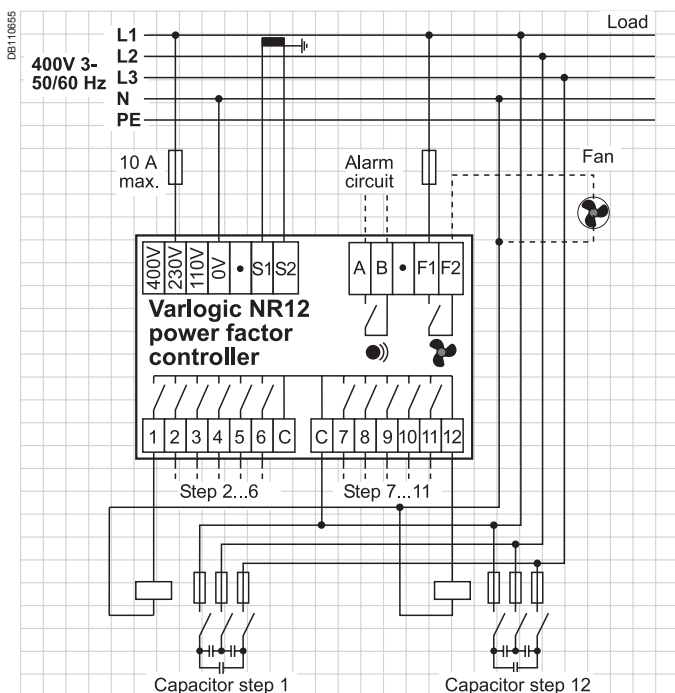
Varlogic N power factor controller

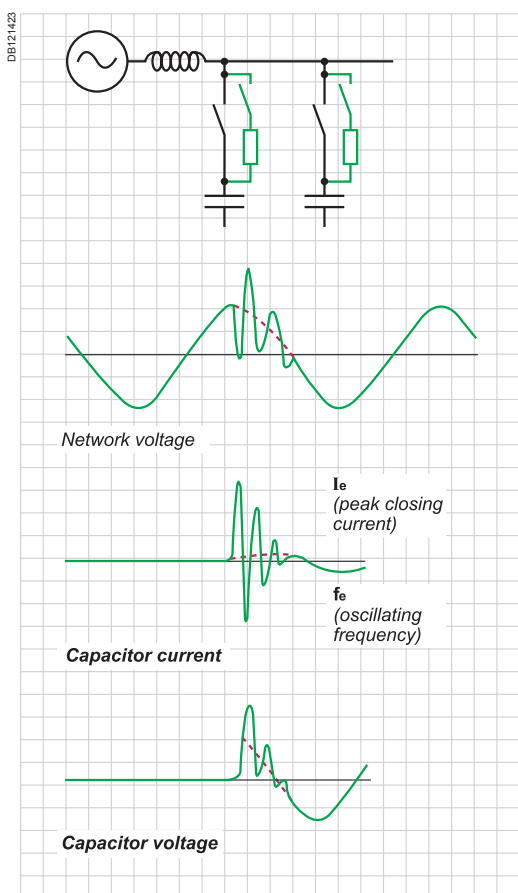
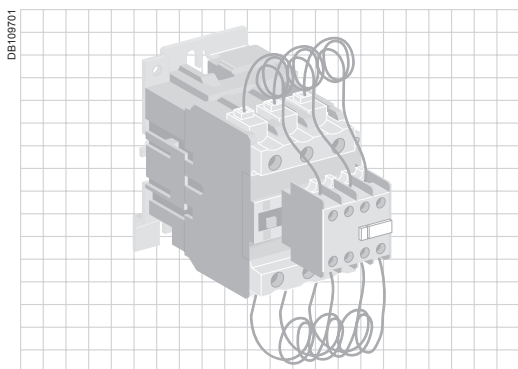
Type	Number of step output contacts	Supply voltage (V) network 50-60 Hz	Measuring voltage (V)	ref.
NR 6	6	110-220/240-380/415	110-220/240-380/415	52448
NR12	12	110-220/240-380/415	110-220/240-380/415	52449
NRC12	12	110-220/240-380/415	110-220/240-380/415-690	52450
Varlogic N accessories				ref.
Communication RS485 Modbus set for NRC12				52451
Temperature external probe for NRC12 type. In addition to internal probe, allows measurement at the hottest 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	■	■
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 % U ₀ within 1 s	message and alarm contact	■	■
Overvoltage	> 110 % U ₀	message and alarm contact	■	■
Overtemperature	$\theta \geq \theta_0$ ($\theta_0 = 50^\circ\text{C max}$)(1)	message and alarm contact	■	■
	$\theta \geq \theta_0 - 15^\circ\text{C}$	fan switch	■	■
Total harmonic distortion	> 7 % (1)	message and alarm contact	■	■
Capacitor current overload (Irms/I ₁)	> 1.5 (1)	message and alarm contact	■	■
Capacitor capacitance loss	- 25 %	message and alarm contact	■	■
Low current	< 2.5 %	message	■	■
High current	> 115 %	message	■	■
Under voltage	5 % U ₀	message		■

U₀: 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





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).



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.

References and maximum power ratings ⁽¹⁾							
Power ratings temp. ≤ 55 °C			Instantaneous auxiliary contacts		Tightening torque on end-piece	Basic reference no. to which the control voltage reference no. should be added ⁽²⁾	Weight
220 V 240 V kvar	400 V 440 V kvar	660 V 690 V kvar	 «F»	 «O»	Nm		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

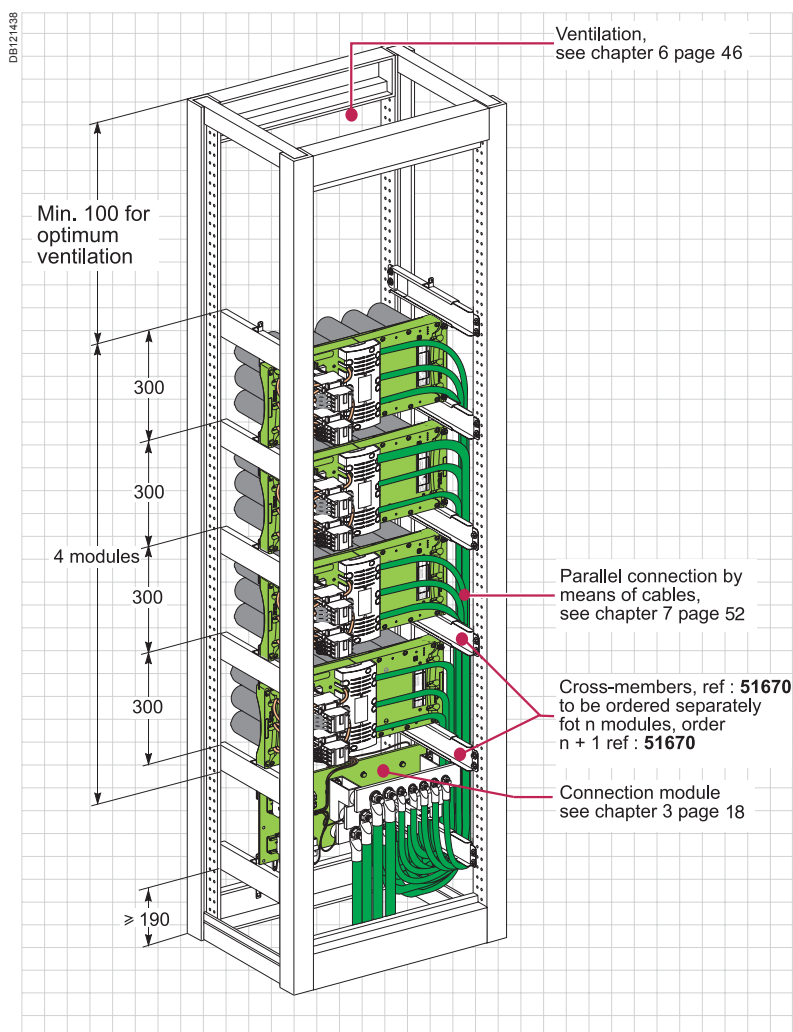
(2) Control circuit voltage (••):

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

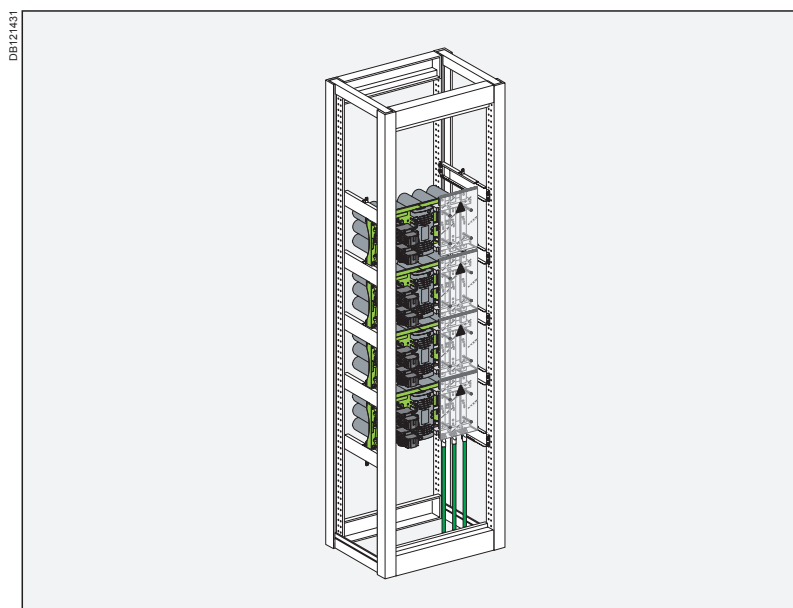
Other voltages: contact us.

Classic and Comfort Varpact

- 5 modules maximum per column with side connection or
- 4 modules maximum + one connection module per column
- maximum power per column:
 - Classic = 600 kvar (400 V, 50 Hz)
 - Comfort = 450 kvar (400 V, 50 Hz).

Installation in a 600 mm wide cubicle

Varpact without bus bars.

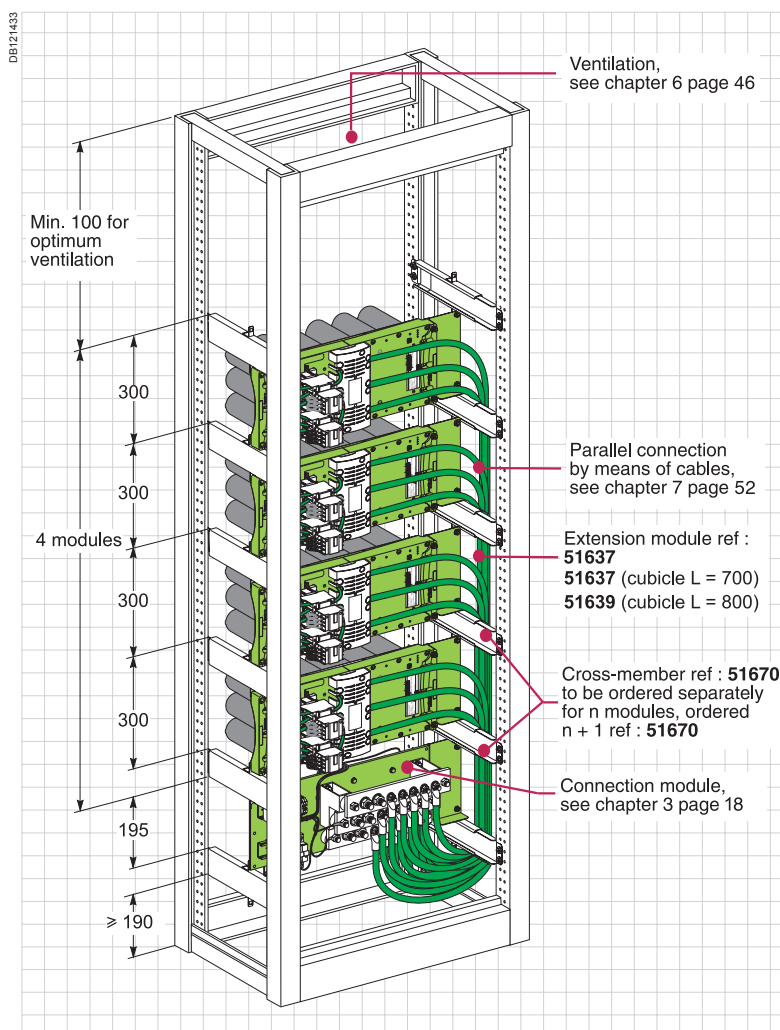
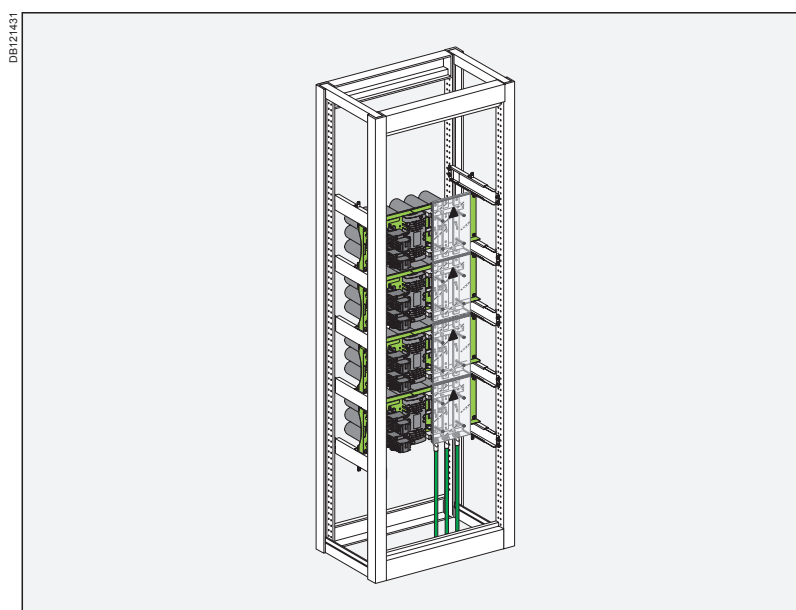


Varpact with bus bars.

Note: extension piece specific to Prisma Plus
W = 650 mm: ref. 51635.

Classic and Comfort Varpact

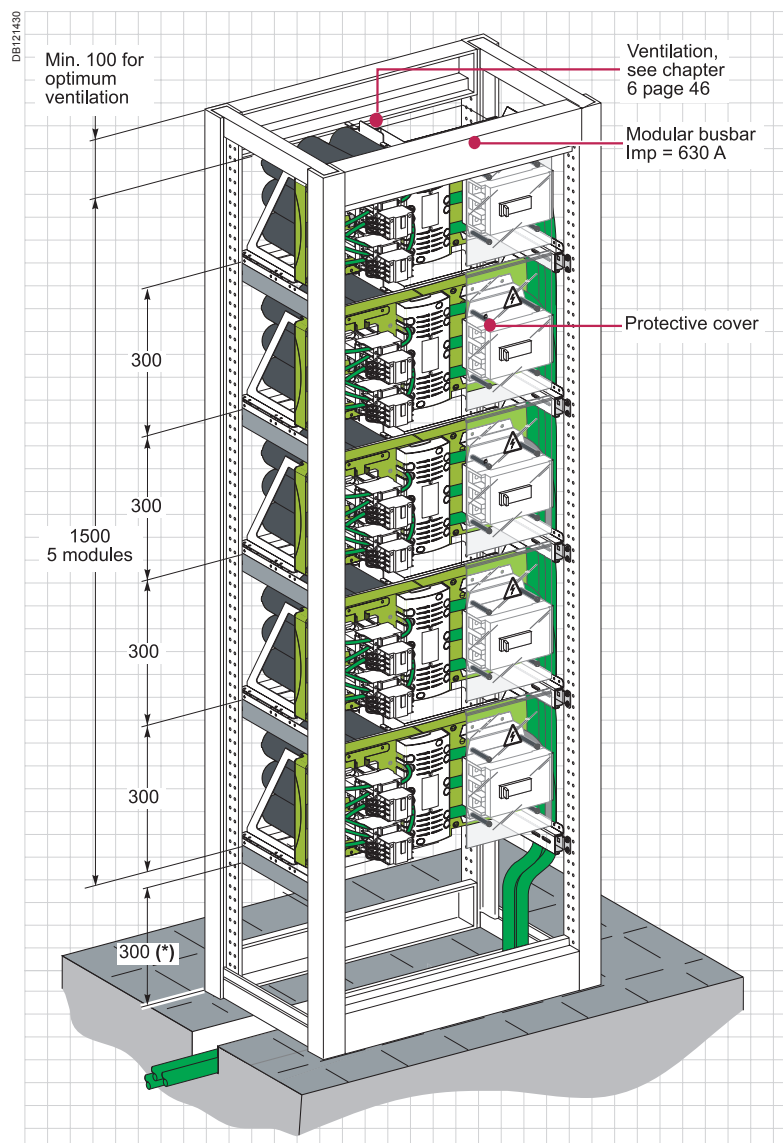
- 5 modules maximum per column with side connection or
- 4 modules maximum + one connection module per column
- maximum power per column:
 - Classic = 600 kvar (400 V, 50 Hz)
 - Comfort = 450 kvar (400 V, 50 Hz).

Installation in a 700 mm and 800 mm wide cubicle*Varpact without bus bars.**Varpact with bus bars.*

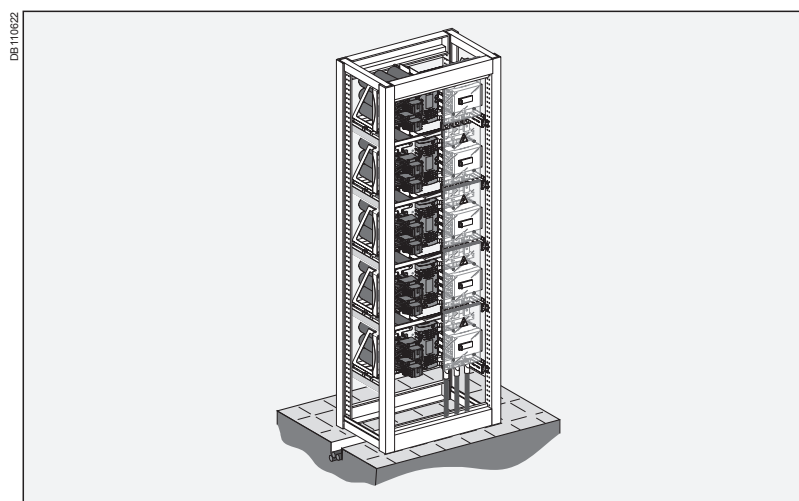
Note: extension piece specific to *Prisma Plus*
 W = 650 mm: ref. **51635**.

Varpact Harmony

For a 2000 mm high cubicle:
5 modules maximum and reactive power less than or
equal to 250 kvar, 400 V, 50 Hz

Installation in a cubicle 700 or 800 mm wide and 400 or 500 mm deep

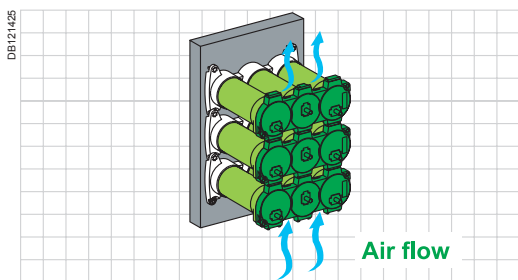
Varpact without bus bars.



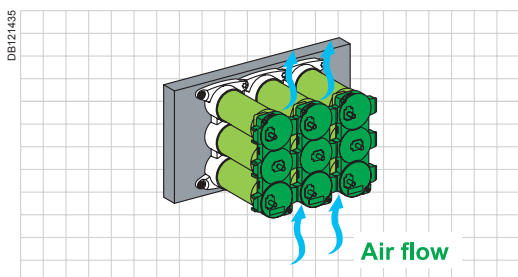
Varpact with bus bars.

Note: module compatible with Prisma Plus W = 650.

(*) Minimum distance recommended for easy connection by the customer.



Recommended installation.



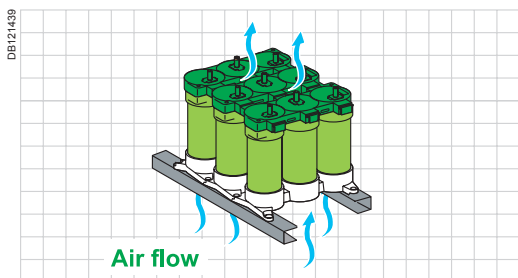
Recommended installation.

Fixing and installation

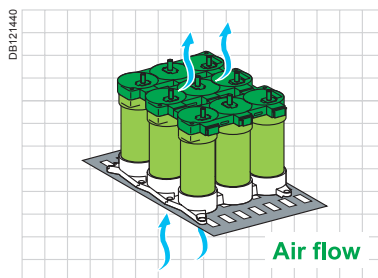
- the capacitors must be installed in well ventilated rooms or enclosures to ensure that they do not exceed the temperature category limits.
- whatever the installation conditions, the capacitors can be installed in any position but upside down, like you can see on the drawings.
- capacitors mounted 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.



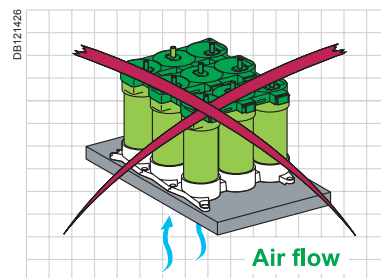
In vertical position, Varplus² capacitors must be installed on U metal section, or on a plate with large holes in order to have a good ventilation.



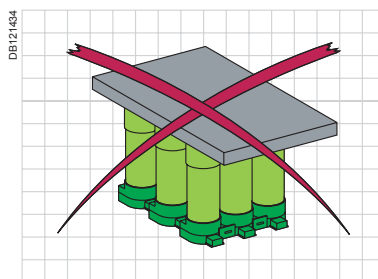
Recommended installation.



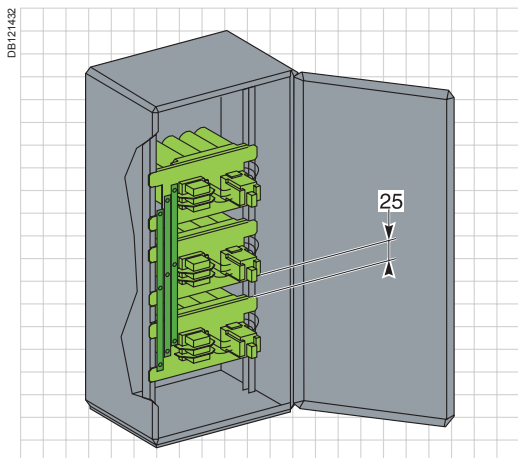
Acceptable



Wrong.

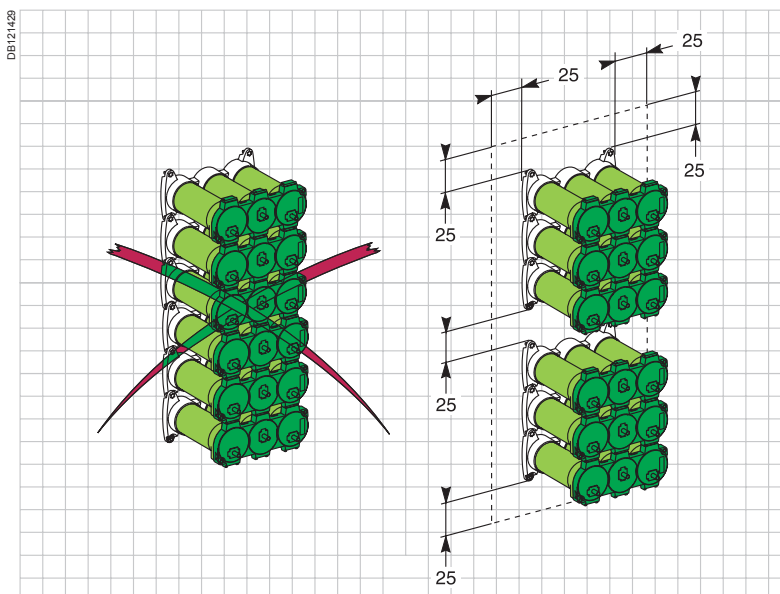


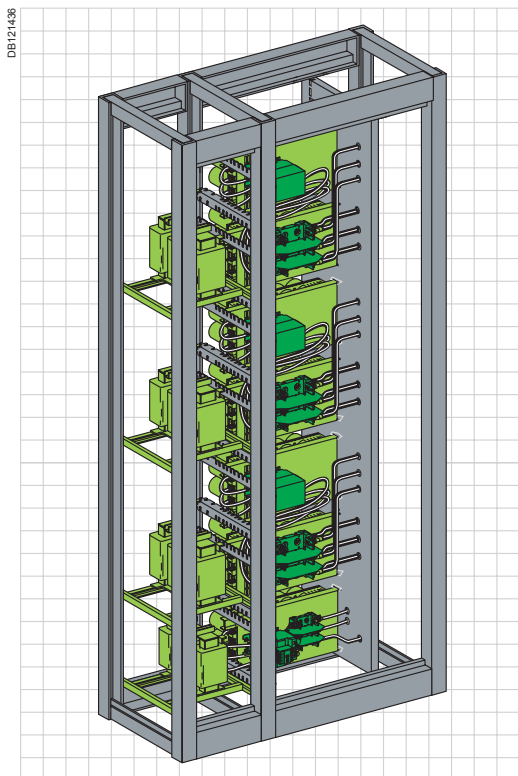
Wrong.

**Example: assembly of 120 kvar**

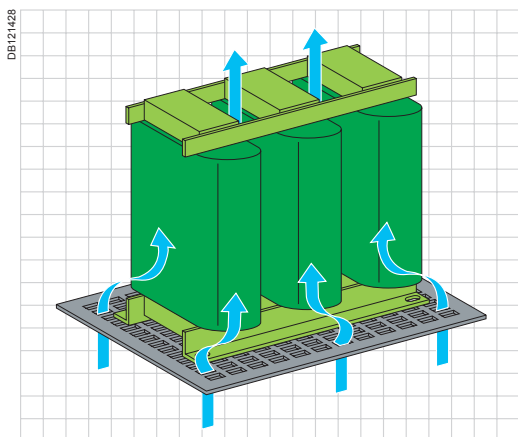
There are 3 conditions to respect:

- 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)
- the power and the maximum mechanical assembly (= 1 group of capacitors), are indicated in Varplus² catalogue (pages 20 to 32)
- according to «Ventilation» chapter (**see pages 45 to 47**), specific precautions must be taken in order to not exceed temperature category of -25 °C/D inside the cubicle.



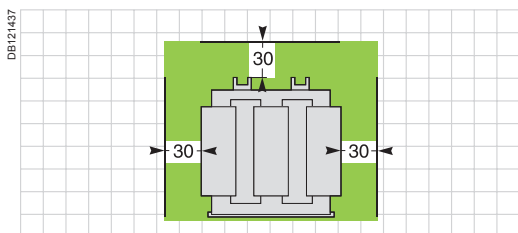
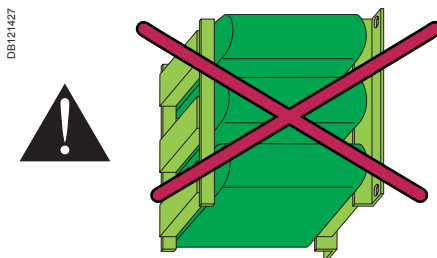


Example of capacitor banks with detuned reactors (DRs).



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.

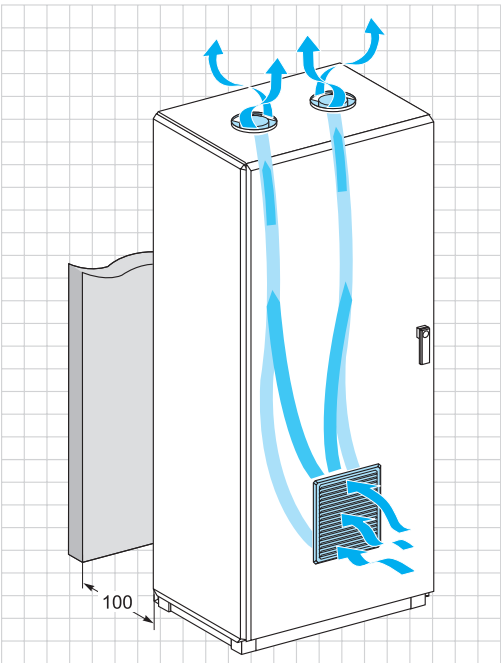
The rules provide for an average delta T of 10 to 15 °C between the outside and inside of the cubicle.

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
- other conditions, contact us.



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



Ventilation rules

Capacitors, contactors, fuses and electrical connections dissipate heat: 1.9 (Classic) to 2.4 W/kvar (Comfort).

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
- always let a gap of 100 mm between the back of the bank and the wall.

It allows to have a good ventilation

- take into account the pressure drops of the air entry and exit.

As an indication, the real airflow is 0.6 to 0.75 time the airflow announced by the fan manufacturer.

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:
 - Classic: 600 kvar 400 V - 50 Hz per column.
 - Comfort: 450 kvar 400 V - 50 Hz per column.

Reactive power (kvar at 400 V - 50 Hz)	Type of ventilation	Air inlet	Min. real air flow (m³/hour)
Cubicle safety rating (IP) ≤ 3X			
Power ≤ 100 kvar	Natural	200 cm²	-
Power 100 to 200 kvar	Natural	400 cm²	-
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 Varpact Harmony modules

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: $\leq 40\text{ }^{\circ}\text{C}$
- average temperature over 24 hours in the electrical room: $\leq 35\text{ }^{\circ}\text{C}$
- average annual temperature in the electrical room: $\leq 25\text{ }^{\circ}\text{C}$
- minimum temperature: $\geq -5\text{ }^{\circ}\text{C}$
- maximum altitude: $\leq 2000\text{ m}$
- other conditions, contact us.



The following rules apply to Varpact Harmony power factor correction modules.

Ventilation rules

Capacitors, detuned reactors, contactors, fuses and electrical connections dissipate heat: 8 W/kvar.

The following ventilation rules must therefore be complied with:

■ ventilation must be forced

- the **real** air flow (m^3/h - allow for incoming and outgoing air pressure drops) must be greater than or equal to 2.5 time the installed power (kvar).

Example: for an installed power of 200 kvar, the real air flow must be $500\text{ m}^3/\text{h}$

- the air within the cubicle must flow upwards.

It is recommended that extractor fans be fitted on top of the cubicle.

- 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 100 mm between the back of the bank and the wall.

It allows to have a good ventilation.

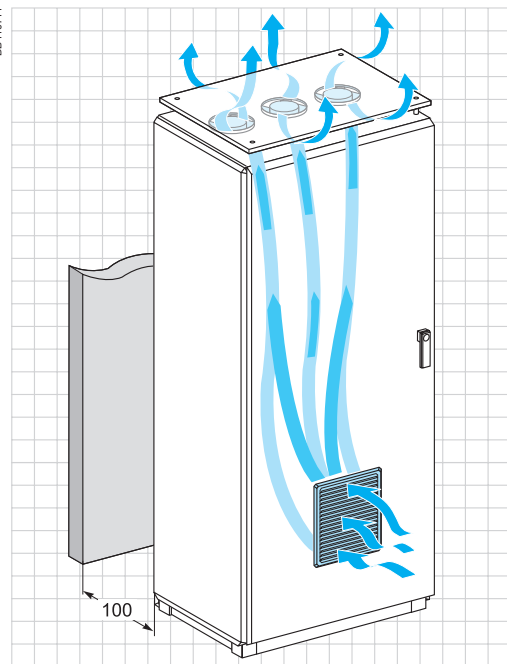
- take into account the pressure drops of the air entry and exit.

As an indication, the real airflow is 0.6 to 0.75 time the airflow announced by the fan manufacturer.

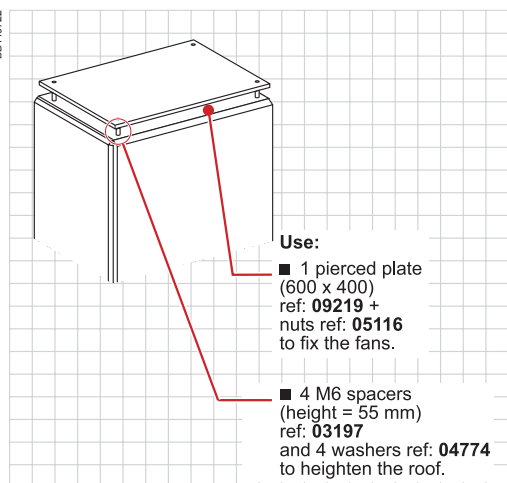
Applications

The ventilation rules apply to cubicles with the following dimensions:

- height $H = 2000\text{ mm}$
- width $W = 650\text{ mm}$ minimum
- depth $D = 400\text{ mm}$ or more and power less than or equal to $250\text{ kvar}/400\text{ V} - 50\text{ Hz}$ per column.



Example: heighten the roof of the bank



Note: Prisma Plus cubicles

Reactive power (kvar at 400V - 50 Hz)	Protection level of the bank	Recommended ventilation
Power $\leq 200\text{ kvar}$	$\text{IP} \leq 31$	Use the Prisma Plus ventilation kit (roof - depth 400: ref. 08476 and 2 fans $300\text{ m}^3/\text{h}$: ref. 08986). Let the upper place empty.
Power from 200 to 250 kvar	$\text{IP} \leq 21\text{D}$	3 fans $300\text{ m}^3/\text{h}$: ref. 08986 . Ex: heighten the roof of the bank like shown on the drawing. 1 air entry on the back side of the bank at the bottom: the upper air entry has to be filled up.

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.

Normal operating conditions to IEC 60439-1

- maximum temperature in the electrical room: $\leq 40\text{ °C}$
- average temperature over 24 hours in the electrical room: $\leq 35\text{ °C}$
- average annual temperature in the electrical room: $\leq 25\text{ °C}$
- minimum temperature: $\geq -5\text{ °C}$
- maximum altitude: $\leq 2000\text{ m}$.
- other conditions, contact us.



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 45.

The part of the enclosure containing the DRs must be ventilated according to the dissipated power.

The minimum air flow must be: $F = 0.3 \times P_s$

(P_s = power dissipated by the DRs), see page 33.

- the DR temperature sensor must be connected so that the step can be disconnected if the temperature is too high
- always let a gap of 100 mm between the back of the bank and the wall. It allows to have a good ventilation
- take into account the pressure drops of the air entry and exit.

As an indication, the real airflow is 0.6 to 0.75 time the airflow announced by the fan manufacturer.

Example

250 kvar 400 V DR capacitor bank, tuning 190 Hz, in 1 x 50 kvar + 2 x 100 kvar:

- DR compartment: forced ventilation

$P_s = 300 + 2 \times 450 = 1200\text{ W}$

$F = 0.3 \times P_s = 0.3 \times 1200 = 400\text{ m}^3/\text{h}$ (real airflow)

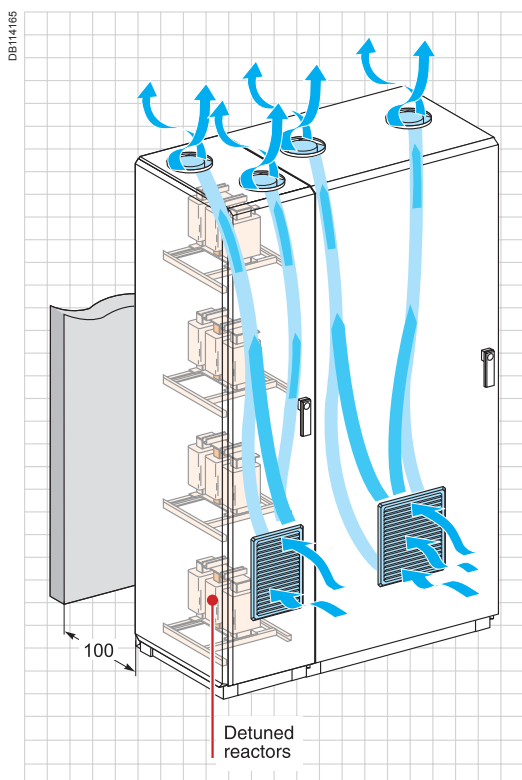
fan rate: $400 : 0.6 = 670\text{ m}^3/\text{h}$

- capacitor compartment: forced ventilation

(cubicle: $600 \times 400 \times 2000$)

real airflow: $0.75 \times 250 = 187.5\text{ m}^3/\text{h}$

fan rate: $187.5 : 0.6 = 312.5\text{ m}^3/\text{h}$.



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 46, 47 and 48):
 - classic or comfort equipment consisting of modules or capacitors:
rate (m³/h) = 0.75 x Q (kvar) x 1.25, whatever the power of Q
 - harmony equipment consisting of Varpact harmony modules:
rate (m³/h) = 2.5 x Q (kvar) x 1.25
 - harmony equipment consisting of components (capacitors + DR):
 - capacitor compartment rate: see rule point 1
 - DR compartment rate: (m³/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.

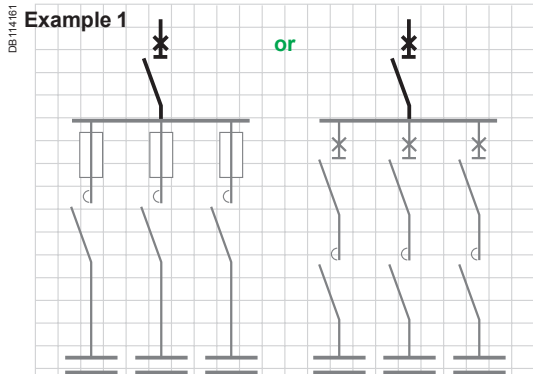
Summary

400/415 V 50 Hz network

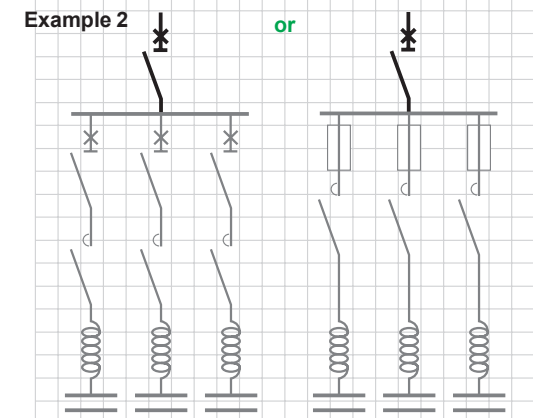
Gh/Sn ≤ at 15 %	15 % < Gh/Sn ≤ 25 %	25 % < Gh/Sn ≤ 50 %
Comfort capacitors (480 V)	550 V capacitors	550 V capacitors + DR from the catalogue
Modules: Varpact comfort	Modules: on request	Modules: on request

Capacitor bank protection by means of a circuit breaker

Example 1



Example 2



Their rating must be chosen to allow the thermal protection to be set to:

- 1.36 I_n for classic range
- 1.5 I_n for comfort range
- 1.12 I_n for harmony range: 2.7 tuning
- 1.19 I_n for harmony range: 3.8 tuning
- 1.31 I_n for harmony range: 4.3 tuning

The short-circuit (magnetic) protection setting thresholds must allow the energising transients to pass through:

10 x I_n for classic, comfort and harmony ranges.

$I_n = Q_c / (1.732 \times U_n)$

Example 1

150 kvar / 400 V - 50 Hz - classic range

$$I_n = \frac{150000}{4003\sqrt{3}} = 216 \text{ A}$$

Thermal protection: $1.36 \times 216 = 294 \text{ A}$

Magnetic protection $> 10 I_n = 2160 \text{ A}$.

Example 2

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

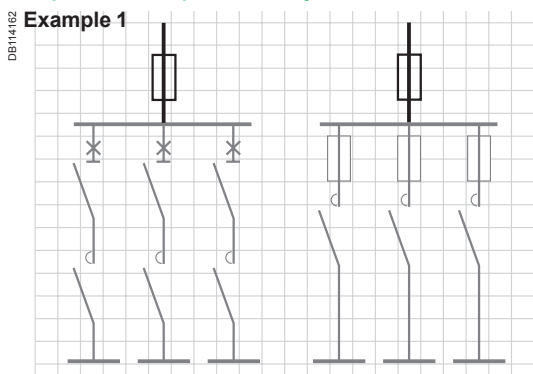
$I_n = 216 \text{ A}$

Thermal protection: $1.31 \times 216 = 283 \text{ A}$

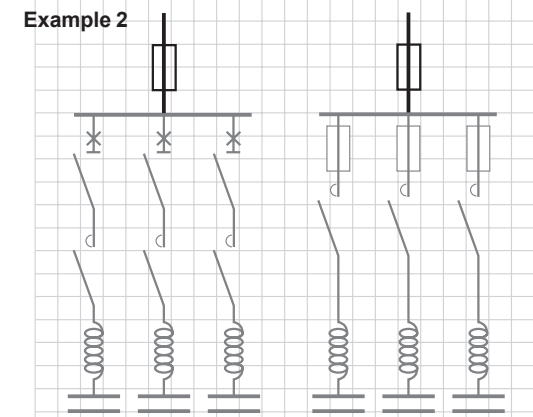
Magnetic protection $> 10 I_n = 2160 \text{ A}$.

Capacitor bank protection by means of fuses

Example 1



Example 2



Type Gg HBC fuses must be used with the following ratings:

- classic range: 1.4 I_n
- comfort range: 1.6 I_n
- harmony range: 1.4 I_n .

Example 1

150 kvar / 400 V - 50 Hz – comfort range

$I_n = 216 \text{ A}$

Fuse rating $\geq 1.6 \times 216 \geq 346 \text{ A}$

Example 2

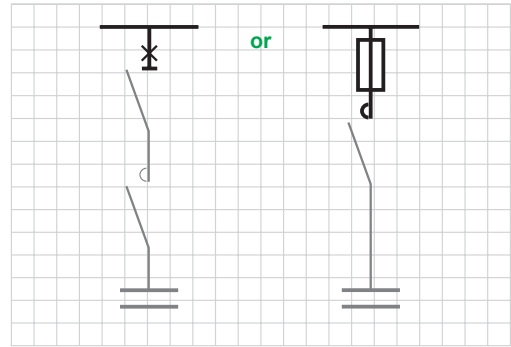
150 kvar / 400 V - 50 Hz - harmony range

$I_n = 216 \text{ A}$

Fuse rating $\geq 1.4 \times 216 \geq 302 \text{ A}$

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

Step protection by means of circuit breaker or fuses



Circuit breaker or fuses (type Gg HBC) 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 one circuit breaker or a 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.

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 mm² for the auxiliary voltage circuits
- 2.5 mm² 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:

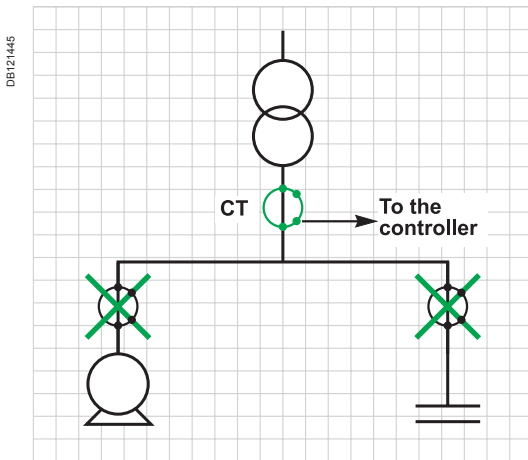
- the ambient temperature around the conductor
- the method of installation (trunking, duct, etc.).

See the cable manufacturer's recommendations.

Recommended cable cross-sections (U1000 R02V cables)

For capacitor connections at an ambient temperature of 35 °C.

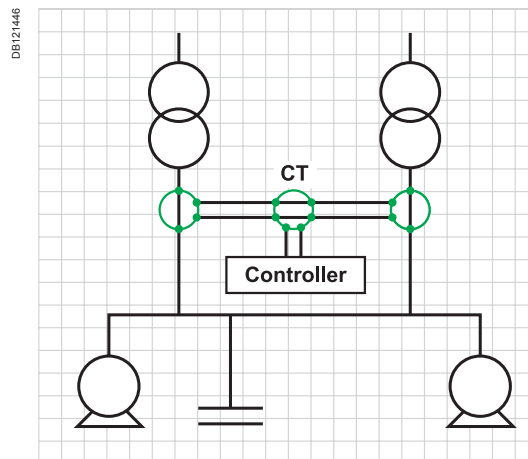
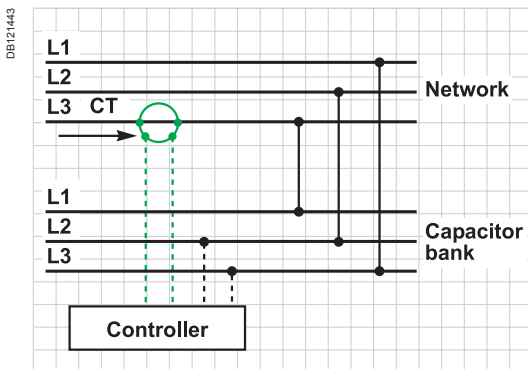
Power (kvar)		Cross-section (mm ²)	
230 V	400 V	Cu	Al
15	25	6	16
20	30	10	16
25	45	16	25
30	60	25	35
40	75	35	50
50	90	50	70
60	110	70	95
80	135	95	2 x 50
90	150	120	2 x 70
100	180	2 x 50	2 x 70
120	200	2 x 70	2 x 95
135	240	2 x 70	2 x 150
165	275	2 x 95	2 x 150
180	300	2 x 120	2 x 185
200	360	2 x 150	2 x 240
240	400	2 x 185	2 x 300
280	480	2 x 240	3 x 185
315	540	2 x 300	3 x 240
350	600	3 x 150	3 x 240



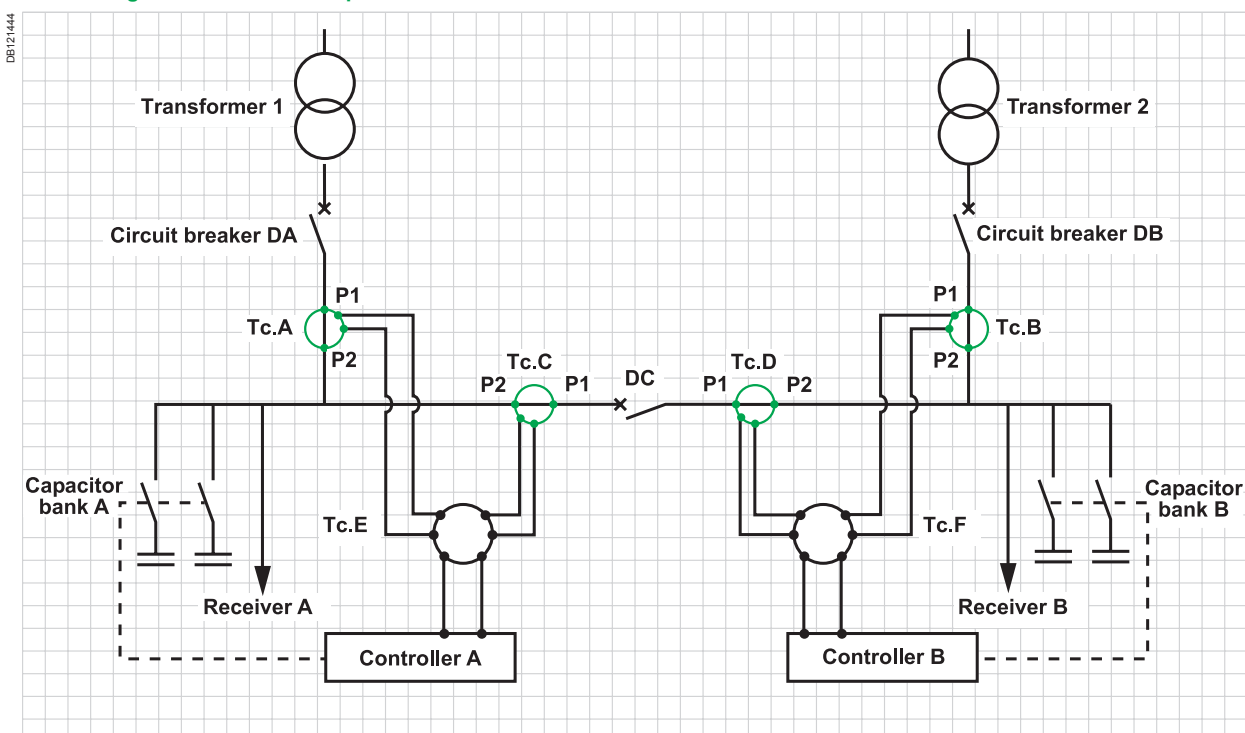
Installation recommendations

- 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



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 = $72/1000 = 0.072$.

Principe

Practical rules

At the end of the manufacturing process, a LV switchboard must undergo various routine inspections and tests in the factory, following an established programme.

The switchboard must comply with:

- the appropriate standards
- the design file (drawings, diagrams and specific requirements)
- manufacturer mounting instructions
- in-house instructions.

Test conditions

Tests must be carried out in a clearly defined area, in compliance with applicable legislation or regulations, by qualified personnel.

Inspection is carried out in a special area referred to as the test platform which is set aside for final testing. All inspectors must first attend a special training course and must be qualified for working in the proximity of live parts.

Inspection means



Megohmmeter.

The necessary parts should be suitable for the purpose, correctly calibrated and in good working order:

- dielectric test station
- megohmmeter
- multimeter
- capacitance meter
- torque wrench
- controller test bench...

The reference documents

Standards:

IEC 60439

IEC 60529

IEC 60831-1&2

IEC 61921

In addition to those items which are specific to the switchboard: drawings, diagrams and specific specifications, quality inspectors should refer to up-to-date documents, integrating revisions and updates:

- to technical files
- to in-house rules, etc.
- keeping track of changes in standards in order to have the most recent version at all times.

The main international standards are:

- IEC 60439-1, IEC 60529, IEC 60831-1&2 and IEC 61921.

Inspections and tests

Standards:
IEC 60439

Practical rules

Carry out all the compulsory inspections and tests and in particular the three routine tests specified by the IEC 60439-1 standards.
They complement any type tests which may have been carried out previously by the

Standard IEC 60439-1 defines 10 tests to be carried out on electrical switchboards:

- 7 type tests
- 3 routine tests.

The 7 type tests must be carried out in laboratories and test platforms on cubicles, using real working configurations: complete cubicles fitted with standard components and equipped with Varplus² capacitors.

The assembly instructions and the 3 routine tests (described below) provide the necessary proof that the switchboard is of the Type Tested Assembly (TTA) or Partially Tested Assembly (PTA) type, and in compliance with standards.

1st routine test

Inspection of the assembly, including inspection of wiring and, if necessary, an electrical operation test.

Conformity

- conformity of the finished switchboard to the drawings, part lists and diagrams:
 - number, type and rating of devices
 - conformity of cabling: auxiliary and power circuit connections
 - quality of cables: conductor cross-section, crimping and tightness
 - marking of conductors and devices.

Visual inspection

- check clearances and creepage distances at connections or part of busbars
 - check the degree of protection. Presence of protective elements, according to requirements (canopy, gasket, front plate, etc.).
- No enclosure infractions (cut-outs, holes, etc.) that might compromise the original degree of protection
- check the presence of a name plate or technical documentation showing the manufacturer's name, the project identity number and all the technical specifications relevant to the LV correction switchboard (kvar, voltage, frequency...).

Electrical operation

- inspect the cables and check the proper operation of the LV correction switchboard, preferably using a "controller test bench" (attached diagram).
 - capacitance measurement : check the capacitance of each step one measurement between two capacitor terminals is sufficient:
- $Q = 2 \times U_2 \times C \times w$ (C = capacitance, measured between two terminals).

2nd routine test Insulation testing



Dielectrometer.



Multimeter.

Practical rules

Dielectric test:

All devices must be connected, with the exception of those incapable of withstanding the test voltage (disconnect the controller). Tests must be done with all the contactors closed. For a switchboard with voltage rated up to 690 V, apply a test voltage of 2500 V - 50 Hz for 1 second minimum, between all the live parts and the interconnected frames of the assembly.

Note: due to capacitor presence, the test must be performed between the 3 short-circuited phases and the earth.

The tests are satisfactory if there is neither puncture nor flashover between the various parts being tested.

Alternative solution:

If the switchboard is not subjected to a dielectric test, an insulation measurement must be taken using an insulation tester, with a voltage of at least 500 V (DC). The minimum insulation resistance value must be higher than 1000 ohms/V.

3rd routine test Protective measures

Check for the presence of barriers to protect against direct and indirect contacts with live parts.

Visually check that:

- contact washers have been used on all assemblies
- earthing wires have been fitted to doors
- the PE conductor is present and must be connected.

Finishing

Clean the inside of the switchboard
Check presence of switchboard identification markers
Check external appearance: scratches, paintwork, etc.

Reports

Create a non quality input document used to quantify faults, evaluate their importance and assign them to relevant department that must take the necessary action to ensure conformity of the electrical switchboard.

Practical rules

Conformity of production:

- draw up a list of missing items
- draw up a list of equipment which will be dispatched separately from the switchboard.

Conformity of operation:

- issue a test report
 - this report notes any anomalies detected and the required corrective measures
 - establish with the customer, a check list of all the points to be checked (example enclosed)
 - issue a test report that remains in the panel-builder's possession but that can be supplied on request
 - this report certifies that all the tests have been carried out and avoids repeating all tests a second time once on site.
- Each panel-builder has his own test documents.

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

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Customer:	Customer order no:
Project no:	
List of equipment	
Workpost number:	Description:

Inspection performed

1- Conformity inspection

- Enclosures ☐
- Switchgear ☐
- Conductors ☐

2- Mechanical checks ☐

3- Electrical continuity of mechanical frames

Resistance value mΩ Visual ☐

Electrical ☐

4- Dielectric tests (2500 V - 50 Hz - 1 second minimum) ☐

5- Insulation resistance monitoring (500 V DC) ☐

Resistance value mΩ

6- Electrical operating tests ☐

Observations:

Conclusion:

☐ equipment accepted without reservations.

☐ equipment refused, to be presented for re-inspection.

☐ equipment accepted with reservations.

Customer inspection	Acceptance test organisation	Inspector	Q.I manager
Date:	Date:	Date:	
Signature:	Signature:	Signature:	

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As standards, specifications and design change from time to time, always ask for confirmation of the information given in this publication.



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