



REACTIVE ENERGY COMPENSATION  
AND POWER QUALITY MONITORING

# CATALOGUE

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# New products at a glance ...



Every day, in your professional life, installation after installation, you will have the power to contribute to energy saving while installing our solutions for reactive energy compensation. Hence you are able to help your customer to save energy and reduce their environmental impact.



(See p. 48-49)

## ALPTEC 2333

### Carry out a diagnosis of your electricity supply

> The Alptec 2333 is one of the first devices on the market to continuously analyse, characterise and record all the electrical values (powers, voltages, etc.) and anomalies encountered (harmonics, voltage dips, overvoltages, etc.). These recordings are characterised in accordance with current standards (EN 50160, IEC 61000-4-30, etc.). Analyses over long periods (7 days minimum) provide a true, meaningful picture of your electricity supply.

> Legrand offers to take over the measurement of your energy quality. You install the unit and we carry out remote measurement, performing the analysis and providing you with a measurement report.

> Please contact us on +33 4 50 64 05 13



(See p.36-42)

## ALPISTATIC

### Real-time reactive energy compensation

> The increased sophistication of industrial processes as a result of the arrival of large numbers of receivers that are sensitive to voltage variations (PLCs, industrial computing) or have ultra-fast cycles (robots, welding machines, variable speed drives, lifts) entails reactive energy compensation that is both “soft” and very fast, in order to adapt to this new generation of receivers.

> Alpistatic has **3 main advantages** in comparison with conventional systems:

- 1 / No transient currents** when capacitors are activated, which could cause voltage dips
- 2/ No transient overvoltages** when capacitors are deactivated due to difficulties extinguishing the electric arc on breaking
- 3/ Very short response time** of 40 milliseconds max.

#### ENERGY COMPENSATION PRINCIPLES & OTHER RANGES

General information See p. 4-19
Low voltage energy compensation See p. 20-49
Medium voltage energy compensation See p. 50-68

## LONG-TERM ENERGY SAVINGS

Legrand offers a comprehensive range of products and services that contribute to energy quality. By significantly reducing energy consumption, Legrand solutions have a positive environmental impact and are involved in energy efficiency.

### ▶ MORE POWER, LESS COST

Based around reactive energy compensation, the Legrand offer reduces the amount of reactive energy supplied by the source and improves the power factor of the installation.

Reactive energy compensation has the following advantages:

#### ▶ FOR ALL

- No billing of reactive energy
- Reduction of active energy losses in the cables, given the current carried in the installation (almost 3%)
- Improvement of the voltage level at the end of the line
- Increase in the active power available with the same installation

#### ▶ SUPPLIES FREE FROM INTERFERENCE

Legrand offers a complete range of capacitors with detuned reactors and harmonic filters. Harmonics can damage capacitors and generate resonance on the supply or cause equipment to malfunction. Whether in an industrial or commercial building, Legrand products increase the service life of the installation while improving its energy performance.

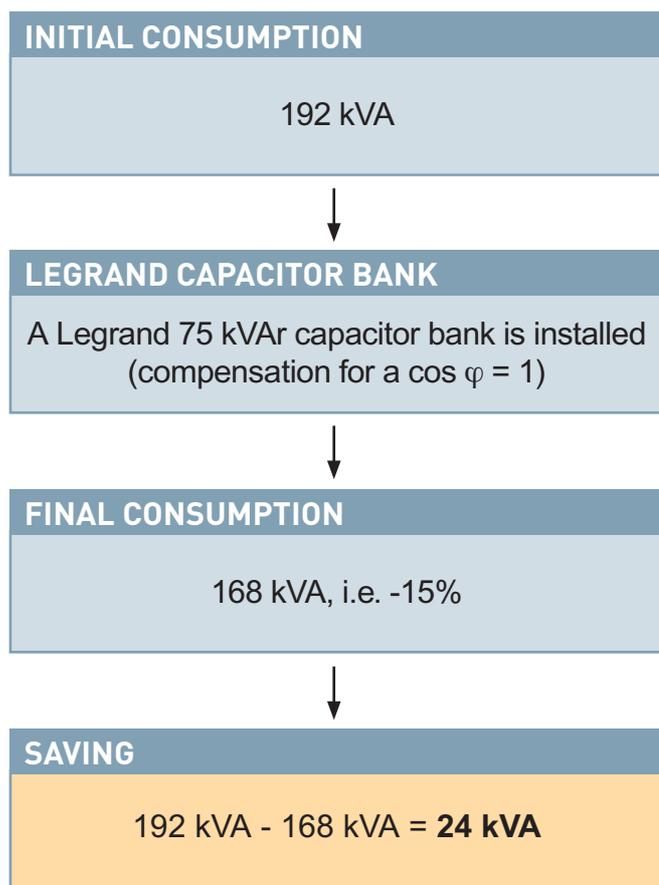
#### ▶ A SERVICE TAILORED TO YOUR REQUIREMENTS

Legrand has a team of experts available to carry out on-site measurement in order to determine the most suitable installation, diagnose the quality of the electricity supply, and perform monitoring and maintenance operations for you.

## LONG-TERM ENERGY SAVINGS (CONTINUED)

### > Calculation example

Installation of a 75 kVAr capacitor bank in a 1000 m<sup>2</sup> supermarket that wants to reduce its energy bills.



For a French billing system ("yellow" tariff) this represents a saving of 1128 €/year<sup>(1)</sup>.

This saving also represents a reduction in pollution of 1.6 T CO<sub>2</sub> equivalent/year.

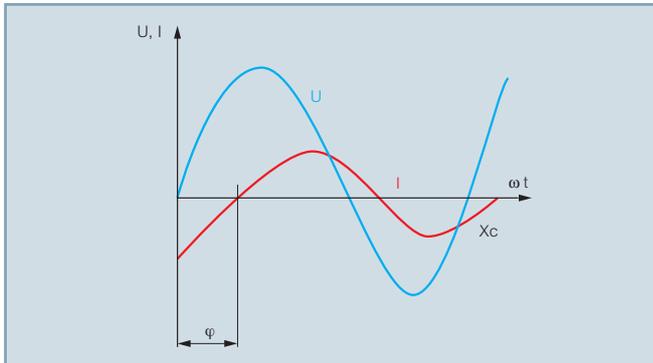
<sup>(1)</sup> Prices and data not contractual. Calculated according to Environmental Impact and Management Explorer (EIME) software, Électricité de France model.

# Power factor

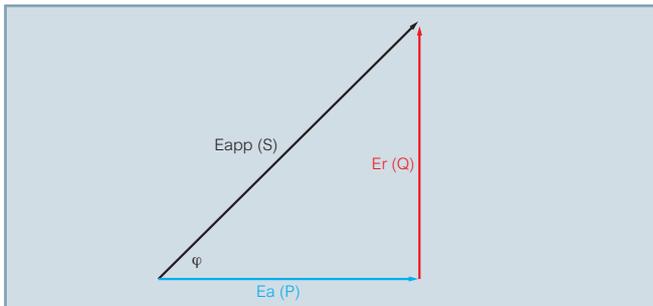
## PHASE SHIFT - ENERGIES - POWERS

### > Definition

An AC electrical installation comprising receivers such as transformers, motors, welding machines, power electronics, etc., and in particular any receivers for which the current is out of phase with the voltage, consumes a total energy which is called the apparent energy ( $E_{app}$ ).



This energy, which is generally expressed in kilovolt-ampere-hours (kVAh), corresponds to the apparent power  $S$  (kVA) and can be broken down as follows:



- Active energy ( $E_a$ ): expressed in kilowatt hours (kWh). This can be used, after being transformed by the receiver, in the form of work or heat. The active power  $P$  (kW) corresponds to this energy.
- Reactive energy ( $E_r$ ): expressed in kilovar hours (kVAh). This is used in particular in the windings of motors and transformers to create the magnetic field without which they would not be able to operate. The reactive power  $Q$  (kVAR) corresponds to this energy. Unlike active energy, reactive energy is said to be "unproductive" for the user.

### Energies

$$E_{app} = \vec{E}_a + \vec{E}_r$$

$$E_{app} = \sqrt{(E_a)^2 + (E_r)^2}$$

### Powers

$$\vec{S} = \vec{P} + \vec{Q}$$

$$S = \sqrt{(P)^2 + (Q)^2}$$

- Three-phase supply:

$$S = \sqrt{3} UI$$

$$P = \sqrt{3} UI \cos \varphi$$

$$Q = \sqrt{3} UI \sin \varphi$$

For a single phase supply the term  $\sqrt{3}$  disappears.

## POWER FACTOR

By definition, the power factor, or the  $\cos \varphi$ , of an electrical device is equal to the active power  $P$  (kW) over the apparent power  $S$  (kVA), and can vary from 0 to 1.

$$\cos \varphi = \frac{P \text{ (kW)}}{S \text{ (kVA)}}$$

It thus enables the reactive energy consumption level of devices to be easily identified.

- A power factor of 1 will result in no reactive energy consumption (resistance)
- A power factor of less than 1 will lead to reactive energy consumption which increases the closer it is to 0 (inductance)

In an electrical installation, the power factor could vary from one workshop to another depending on the equipment installed and the way it is used (off-load, full load operation, etc.).

Energy metering devices record active and reactive energy consumption. Electricity suppliers generally show the term  $\text{tg } \varphi$  on their bills.

### Calculation of the $\text{tg } \varphi$

$$\text{tg } \varphi = \frac{E_r \text{ (kVArh)}}{E_a \text{ (kWh)}}$$

The  $\text{tg } \varphi$  is the ratio between the reactive energy  $E_r$  (kVArh) and the active energy  $E_a$  (kWh) consumed during the same period.

Unlike the  $\cos \varphi$ , it is easy to see that the  $\text{tg } \varphi$  must be as small as possible in order to have the minimum reactive energy consumption.

$\cos \varphi$  and  $\text{tg } \varphi$  are linked by the following equation:

$$\cos \varphi = \frac{1}{\sqrt{1 + (\text{tg } \varphi)^2}}$$

But it is simpler to refer to a conversion table as on page 12.

# Power factor (continued)

## POWER FACTOR OF THE MAIN RECEIVERS

The following receivers consume the most reactive energy:

- Motors at low load
- Welding machines
- Arc and induction furnaces
- Power rectifiers

RECEIVER	COS $\varphi$	TG $\varphi$	
Ordinary asynchronous motors loaded at	0%	0.17	5.80
	25%	0.55	1.52
	50%	0.73	0.94
	75%	0.80	0.75
	100%	0.85	0.62
Incandescent lamps	approx. 1	approx. 0	
Fluorescent lamps	approx. 0.5	approx. 1.73	
Discharge lamps	0.4 to 0.6	approx. 2.29 to 1.33	
Resistance furnaces	approx. 1	approx. 0	
Compensated induction furnaces	approx. 0.85	approx. 0.62	
Dielectric heating furnaces	approx. 0.85	approx. 0.62	
Resistance welding machines	0.8 to 0.9	0.75 to 0.48	
Single phase static arc welding stations	approx. 0.5	approx. 1.73	
Arc welding transformers-rectifiers	0.7 to 0.9	1.02 to 0.48	
	0.7 to 0.8	1.02 to 0.75	
Arc furnaces	0.8	0.75	
Thyristor power rectifiers	0.4 to 0.8	2.25 to 0.75	

## ADVANTAGES OF A GOOD POWER FACTOR

A good power factor is:

- A high  $\cos \varphi$  (close to 1)
- Or a low  $\text{tg } \varphi$  (close to 0)

A good power factor makes it possible to optimise an electrical installation and provides the following advantages:

- No billing of reactive energy
- Reduction of the subscribed demand in kVA
- Limitation of active energy losses in the cables given the decrease in the current carried in the installation
- Improvement of the voltage level at the end of the line
- Additional power available at the power transformers if the compensation is performed at the secondary

## HOW TO IMPROVE THE POWER FACTOR

By installing capacitors or capacitor banks.

Improving the power factor of an electrical installation consists of giving it the means to "produce" a certain proportion of the reactive energy it consumes itself.

There are various different systems for producing reactive energy, including in particular asynchronous compensators and shunt capacitors (or serial capacitors for large transmission systems).

The capacitor is most frequently used, given:

- Its non-consumption of active energy
- Its purchase cost
- Its ease of use
- Its service life (approximately 10 years)
- Its low maintenance (static device)

### Equations

$$Q2 = Q1 - Qc$$

$$Qc = Q1 - Q2$$

$$Qc = P.tg \varphi 1 - P.tg \varphi 2$$

$$Qc = P(tg \varphi 1 - tg \varphi 2)$$

$\varphi 1$  phase shift without capacitor

$\varphi 2$  phase shift with capacitor

The capacitor is a receiver composed of two conductive parts (electrodes) separated by an insulator.

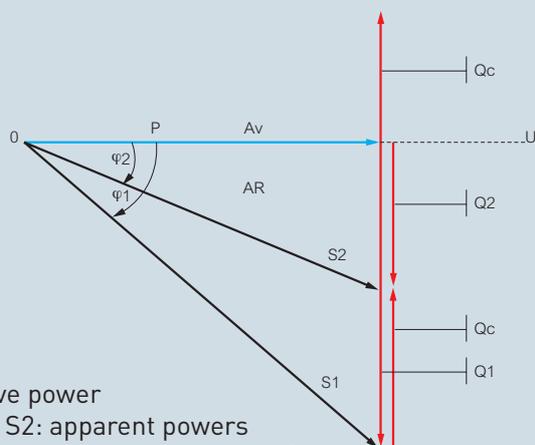
When this receiver is subjected to a sinusoidal voltage, the current and therefore its power (capacitive reactive) is leading the voltage by  $90^\circ$ .

Conversely, for all other receivers (motors, transformers, etc.) the current and therefore its power (reactive inductive) is lagging the voltage by  $90^\circ$ .

The vectorial composition of these currents or reactive powers (inductive and capacitive) gives a resulting current or power below the value which existed before the capacitors were installed.

In simple terms, it is said that inductive receivers (motors, transformers, etc.) consume reactive energy whereas capacitors (capacitive receivers) produce reactive energy.

### Power diagram



P: Active power

S1 and S2: apparent powers  
(before and after compensation)

Qc: capacitor reactive power

Q1: reactive power without capacitor

Q2: reactive power with capacitor

# How to calculate the power of capacitors

## BASED ON ELECTRICITY BILLS

### > Calculation

To calculate the capacitor banks to be installed, use the following method:

- Select the month in which the bill is highest (kVArh to be billed)
- Assess the number of hours the installation operates each month
- Calculate the capacitor power  $Q_c$  to be installed

$$Q_c = \frac{\text{kVArh to be billed (monthly)}}{\text{No. of hours' operation (monthly)}}$$

### > Example

For the subscriber:

- Highest reactive energy bill: December
- Number of kVArh to be billed: 70,000
- Monthly operating times:  
high-load + peak times = 350 hours

$$Q_c \text{ (bank to be installed)} = \frac{70,000}{350} = 200 \text{ kVAr}$$

## BASED ON MEASUREMENTS TAKEN ON THE HV/LV TRANSFORMER SECONDARY: PkW-cos $\varphi$

### > Example

An establishment supplied from an 800 KVA HV/LV subscriber station wanting to change the power factor of its installation to:

- Cos  $\varphi$  = 0.928 (tg  $\varphi$  = 0.4) at the primary
- I.e. Cos  $\varphi$  = 0.955 (tg  $\varphi$  = 0.31) at the secondary, with the following readings:
  - Voltage: 400 V 3-phase 50 HZ
  - PkW = 475
  - Cos (secondary) = 0.75 (i.e. tg  $\varphi$  = 0.88)

$$Q_c \text{ (bank to be installed) = } PkW \times (\text{tg } \varphi \text{ measured} - \text{tg } \varphi \text{ to be obtained})$$

$$Q_c = 475 \times (0.88 - 0.31) = 270 \text{ kVAr}$$

## CALCULATION FOR FUTURE INSTALLATIONS

In the context of future installations, compensation is frequently required right from the engineering stage. In this case, it is not possible to calculate the capacitor bank using conventional methods (electricity bill). For this type of installation, it is advisable to install at least a capacitor bank equal to approximately 25% of **the nominal power of the corresponding HV/LV transformer**.

### > Example

1000 kva transformer, Q capacitor = 250 kVAr

Note: This type of ratio corresponds to the following operating conditions:

- 1000 kVA transformer
- Actual transformer load = 75%
- Cos  $\varphi$  of the load = 0.80 }  $k = 0.421$
- Cos  $\varphi$  to be obtained = 0.95 } [see table on page 12]

$$Q_c = 1000 \times 75\% \times 0.80 \times 0.421 = 250 \text{ kVAr}$$

# How to calculate the power of capacitors (continued)

## CAPACITOR POWER CALCULATION TABLE

### > Conversion table

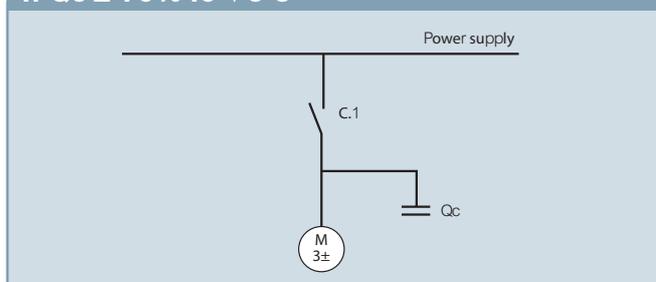
Based on the power of a receiver in kW, this table can be used to calculate the power of the capacitors to change from an initial power factor to a required power factor. It also gives the equivalence between  $\cos \varphi$  and  $\text{tg } \varphi$ .

Final power factor		Capacitor power in kVAr to be installed per kW of load to increase the power factor to:										
$\cos \varphi$		0.90	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	1
	$\text{tg } \varphi$	0.48	0.46	0.43	0.40	0.36	0.33	0.29	0.25	0.20	0.14	0.0
0.40	2.29	1.805	1.832	1.861	1.895	1.924	1.959	1.998	2.037	2.085	2.146	2.288
0.41	2.22	1.742	1.769	1.798	1.831	1.840	1.896	1.935	1.973	2.021	2.082	2.225
0.42	2.16	1.681	1.709	1.738	1.771	1.800	1.836	1.874	1.913	1.961	2.002	2.164
0.43	2.10	1.624	1.651	1.680	1.713	1.742	1.778	1.816	1.855	1.903	1.964	2.107
0.44	2.04	1.558	1.585	1.614	1.647	1.677	1.712	1.751	1.790	1.837	1.899	2.041
0.45	1.98	1.501	1.532	1.561	1.592	1.626	1.659	1.695	1.737	1.784	1.846	1.988
0.46	1.93	1.446	1.473	1.502	1.533	1.567	1.600	1.636	1.677	1.725	1.786	1.929
0.47	1.88	1.397	1.425	1.454	1.485	1.519	1.532	1.588	1.629	1.677	1.758	1.881
0.48	1.83	1.343	1.370	1.400	1.430	1.464	1.467	1.534	1.575	1.623	1.684	1.826
0.49	1.78	1.297	1.326	1.355	1.386	1.420	1.453	1.489	1.530	1.578	1.639	1.782
0.50	1.73	1.248	1.276	1.303	1.337	1.369	1.403	1.441	1.481	1.529	1.590	1.732
0.51	1.69	1.202	1.230	1.257	1.291	1.323	1.357	1.395	1.435	1.483	1.544	1.686
0.52	1.64	1.160	1.188	1.215	1.249	1.281	1.315	1.353	1.393	1.441	1.502	1.644
0.53	1.60	1.116	1.144	1.171	1.205	1.237	1.271	1.309	1.349	1.397	1.458	1.600
0.54	1.56	1.075	1.103	1.130	1.164	1.196	1.230	1.268	1.308	1.356	1.417	1.559
0.55	1.52	1.035	1.063	1.090	1.124	1.156	1.190	1.228	1.268	1.316	1.377	1.519
0.56	1.48	0.996	1.024	1.051	1.085	1.117	1.151	1.189	1.229	1.277	1.338	1.480
0.57	1.44	0.958	0.986	1.013	1.047	1.079	1.113	1.151	1.191	1.239	1.300	1.442
0.58	1.40	0.921	0.949	0.976	1.010	1.042	1.073	1.114	1.154	1.202	1.263	1.405
0.59	1.37	0.884	0.912	0.939	0.973	1.005	1.039	1.077	1.117	1.165	1.226	1.368
0.60	1.33	0.849	0.878	0.905	0.939	0.971	1.005	1.043	1.083	1.131	1.192	1.334
0.61	1.30	0.815	0.843	0.870	0.904	0.936	0.970	1.008	1.048	1.096	1.157	1.299
0.62	1.27	0.781	0.809	0.836	0.870	0.902	0.936	0.974	1.014	1.062	1.123	1.265
0.63	1.23	0.749	0.777	0.804	0.838	0.870	0.904	0.942	0.982	1.030	1.091	1.233
0.64	1.20	0.716	0.744	0.771	0.805	0.837	0.871	0.909	0.949	0.997	1.058	1.200
0.65	1.17	0.685	0.713	0.740	0.774	0.806	0.840	0.878	0.918	0.966	1.007	1.169
0.66	1.14	0.654	0.682	0.709	0.743	0.775	0.809	0.847	0.887	0.935	0.996	1.138
0.67	1.11	0.624	0.652	0.679	0.713	0.745	0.779	0.817	0.857	0.905	0.966	1.108
0.68	1.08	0.595	0.623	0.650	0.684	0.716	0.750	0.788	0.828	0.876	0.937	1.079
0.69	1.05	0.565	0.593	0.620	0.654	0.686	0.720	0.758	0.798	0.840	0.907	1.049
0.70	1.02	0.536	0.564	0.591	0.625	0.657	0.691	0.729	0.796	0.811	0.878	1.020
0.71	0.99	0.508	0.536	0.563	0.597	0.629	0.663	0.701	0.741	0.783	0.850	0.992
0.72	0.96	0.479	0.507	0.534	0.568	0.600	0.634	0.672	0.721	0.754	0.821	0.963
0.73	0.94	0.452	0.480	0.507	0.541	0.573	0.607	0.645	0.685	0.727	0.794	0.936
0.74	0.91	0.425	0.453	0.480	0.514	0.546	0.580	0.618	0.658	0.700	0.767	0.909
0.75	0.88	0.398	0.426	0.453	0.487	0.519	0.553	0.591	0.631	0.673	0.740	0.882
0.76	0.86	0.371	0.399	0.426	0.460	0.492	0.526	0.564	0.604	0.652	0.713	0.855
0.77	0.83	0.345	0.373	0.400	0.434	0.466	0.500	0.538	0.578	0.620	0.687	0.829
0.78	0.80	0.319	0.347	0.374	0.408	0.440	0.474	0.512	0.552	0.594	0.661	0.803
0.79	0.78	0.292	0.320	0.347	0.381	0.413	0.447	0.485	0.525	0.567	0.634	0.776
0.80	0.75	0.266	0.294	0.321	0.355	0.387	0.421	0.459	0.499	0.541	0.608	0.750
0.81	0.72	0.240	0.268	0.295	0.329	0.361	0.395	0.433	0.473	0.515	0.582	0.724
0.82	0.70	0.214	0.242	0.269	0.303	0.335	0.369	0.407	0.447	0.489	0.556	0.698
0.83	0.67	0.188	0.216	0.243	0.277	0.309	0.343	0.381	0.421	0.463	0.530	0.672
0.84	0.65	0.162	0.190	0.217	0.251	0.283	0.317	0.355	0.395	0.437	0.504	0.645
0.85	0.62	0.136	0.164	0.191	0.225	0.257	0.291	0.329	0.369	0.417	0.478	0.602
0.86	0.59	0.109	0.140	0.167	0.198	0.230	0.264	0.301	0.343	0.390	0.450	0.593
0.87	0.57	0.083	0.114	0.141	0.172	0.204	0.238	0.275	0.317	0.364	0.424	0.567
0.88	0.54	0.054	0.085	0.112	0.143	0.175	0.209	0.246	0.288	0.335	0.395	0.538
0.89	0.51	0.028	0.059	0.086	0.117	0.149	0.183	0.230	0.262	0.309	0.369	0.512
0.90	0.48		0.031	0.058	0.089	0.121	0.155	0.192	0.234	0.281	0.341	0.484

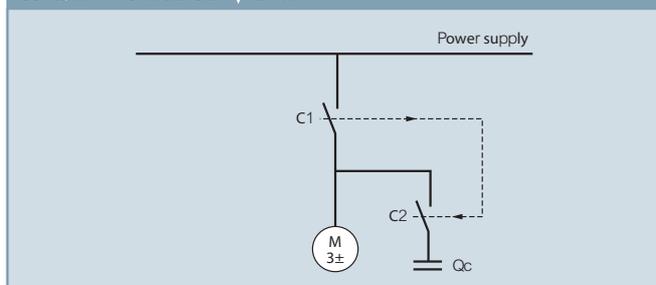
Example: 200 kW motor -  $\cos \varphi = 0.75$  - required  $\cos \varphi = 0.93$  -  $Q_c = 200 \times 0.487 = 98$  kVAr

## REACTIVE COMPENSATION OF ASYNCHRONOUS MOTORS (COMPENSATION AT MOTOR TERMINALS)

If  $Q_c \leq 90\% I_o \sqrt{3} U$



If  $Q_c > 90\% I_o \sqrt{3} U$



$I_o$ : motor off-load current  
 $U$ : supply voltage

The table below gives, for information purposes only, the maximum power of the capacitor that can be connected **directly to the terminals of an asynchronous motor with no risk of self-excitation**. It will be necessary to check in all cases that the maximum current of the capacitor does not exceed 90% of the magnetising current (off-load) of the motor.

Maximum power of the motor		Maximum speed rpm		
		3000	1500	1000
HP	kW	Max. power in kVAr		
11	8	2	2	3
15	11	3	4	5
20	15	4	5	6
25	18	5	7	7.5
30	22	6	8	9
40	30	7.5	10	11
50	37	9	11	12.5
60	45	11	13	14
100	75	17	22	25
150	110	24	29	33
180	132	31	36	38
218	160	35	41	44
274	200	43	47	53
340	250	52	57	63
380	280	57	63	70
482	355	67	76	86

If the capacitor power required to compensate the motor is greater than the values given in the above table or if, more generally:  $Q_c > 90\% I_o \sqrt{3} U$ , compensation at the motor terminals will however remain possible by inserting a contactor (C.2), controlled by an auxiliary contact of the motor contactor (C.1), in series with the capacitor.

# How to calculate the power of capacitors (continued)

## REACTIVE COMPENSATION OF TRANSFORMERS



When defining a reactive energy compensation installation, it is advisable to provide a fixed capacitor corresponding to the internal reactive consumption of the transformer at 75% load.

In order to operate correctly, a transformer requires internal reactive energy to magnetise its windings. The table opposite gives, for information purposes only, the value of the fixed capacitor bank to be installed according to the powers and loads of the transformer. These values may change, depending on the technology of the device. Each manufacturer can provide their own precise values.

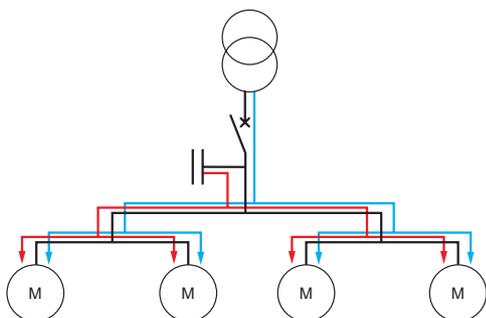
Nominal power of the transformer kVA	KVAr power to be provided for the internal consumption of the transformer		
	Operation		
	off-load	75% load	100% load
100	3	5	6
160	4	7.5	10
200	4	9	12
250	5	11	15
315	6	15	20
400	8	20	25
500	10	25	30
630	12	30	40
800	20	40	55
1000	25	50	70
1250	30	70	90
2000	50	100	150
2500	60	150	200
3150	90	200	250
4000	160	250	320
5000	200	300	425

# Installing capacitor banks

## INSTALLATION OPTIONS

In an LV electrical installation, capacitor banks can be installed at 3 different levels:

### > Global installation



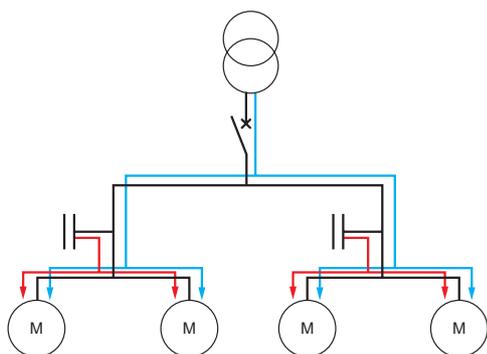
#### Advantages:

- No billing of reactive energy
- This is the most economical solution, as all the power is concentrated at one point and the expansion coefficient makes it possible to optimise the capacitor banks
- Makes less demands on the transformer

#### Note:

- The losses in the cables ( $RI^2$ ) are not reduced.

### > Sector installation



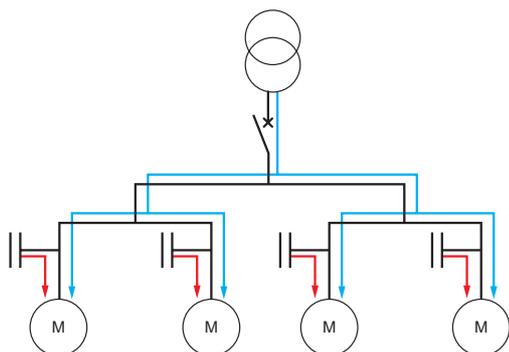
#### Advantages:

- No billing of reactive energy
- Makes less demands on the supply FEEDERS and reduces the heat losses in these FEEDERS ( $RI^2$ )
- Incorporates the expansion of each sector
- Makes less demands on the transformer
- Remains economical

#### Note:

- Solution generally used for very widespread factory supplies

### > Individual installation



#### Advantages:

- No billing of reactive energy
- From a technical point of view this is the ideal solution, as the reactive energy is produced at the point where it is consumed. Heat losses ( $RI^2$ ) are therefore reduced in all the lines.
- Makes less demands on the transformer.

#### Note:

- Most costly solution, given:
  - The high number of installations
  - The fact that the expansion coefficient is not incorporated

# Operation, protection and connection of capacitors

## PROTECTION AND CONNECTION OF CAPACITORS

### > Operating device

In the case of loads with ultra-fast cycles (welding machines, etc.), the conventional system for operating capacitors (electromechanical contactors) is no longer suitable. High-speed switching compensation systems using solid state contactors are necessary. LEGRAND offers this type of equipment.

The switching current of a capacitor depends on:

- The power of the capacitor
- The short-circuit power of the mains supply to which it is connected
- Whether or not any capacitor banks that have already been activated are present

Given these parameters, it is essential to use quick make and break operating devices (switch, contactor, etc.).

When selecting operating devices, the user must be made aware of the choice of equipment available (for operating capacitors).

Contactors are specially designed by contactor manufacturers for operating capacitors and in particular for assembling automatically controlled capacitor banks. These contactors have auxiliary poles combined in series with preload resistors that will limit the inrush current during activation.

### > Protection

In addition to the internal protection devices incorporated in the capacitor:

- Self-healing metallised film
  - Internal fuses
  - Overpressure disconnection devices
- it is essential to provide a protection device external to the capacitor.

This protection will be provided by:

- Either a circuit breaker:
  - Thermal relay, setting between 1.3 and 1.5  $I_n$
  - Magnetic relay, setting between 5 and 10  $I_n$
- Or GI type HRC fuses, rating 1.4 to 2  $I_n$

$I_n$  = capacitor nominal voltage

$$I_n = Qc / \sqrt{3}U$$

Example: 50 kVAr - 400 V three-phase

$$I_n = 50 / 1.732 \times 0.4 = 72 \text{ A}$$

### > Connection (sizing the cables)

Current standards for capacitors are defined so that capacitors can withstand a permanent overcurrent of 30%.

These standards also permit a maximum tolerance of 10% on the nominal capacitance.

Cables must therefore be sized at least for:

$$I_{\text{cable}} = 1.3 \times 1.1 (I_{\text{nominal capacitor}})$$

$$\text{i.e. } I_{\text{cable}} = 1.43 I_{\text{nominal}}$$

# Harmonics

## INTRODUCTION

In recent years, the modernisation of industrial processes and the sophistication of electrical machines and equipment have led to major developments in power electronics:

Semi-conductor-based systems (transistors, thyristors, etc.) designed for:

- Static power converters: AC/DC
- Rectifiers
- Inverters
- Frequency converters
- And many other multicycle or phase controlled devices.

These systems represent "non-linear" loads for electrical supplies. A "non-linear" load is a load for which the current consumption does not reflect the supply voltage (although the voltage of the source imposed on the load is sinusoidal, the current consumption is not sinusoidal).

Other "non-linear" loads are also present in electrical installations, in particular:

- Variable impedance loads, using electric arcs: arc furnaces, welding units, fluorescent tubes, discharge lamps, etc.
- Loads using strong magnetising currents: saturated transformers, inductors, etc.

The FOURIER decomposition (harmonic analysis) of the current consumption of a non-linear receiver shows:

- The fundamental, a sinusoidal term at the 50 Hz mains supply frequency
- The harmonics, sinusoidal terms whose frequencies are multiples of the fundamental frequency

According to the equation:

$$I_{\text{rms}} = \sqrt{I_1^2 + \sum_{h=2}^n I_h^2}$$

$\Sigma$  : Sum of all the harmonic currents from harmonic 2 (50 Hz x 2) to the last harmonic n (50 Hz x n)

These harmonic currents circulate in the source. The harmonic impedances of the source then give rise to harmonic voltages, according to the equation:

$$U_h = Z_h \times I_h$$

The harmonic currents give rise to most of the harmonic voltages causing the overall harmonic distortion of the supply voltage.

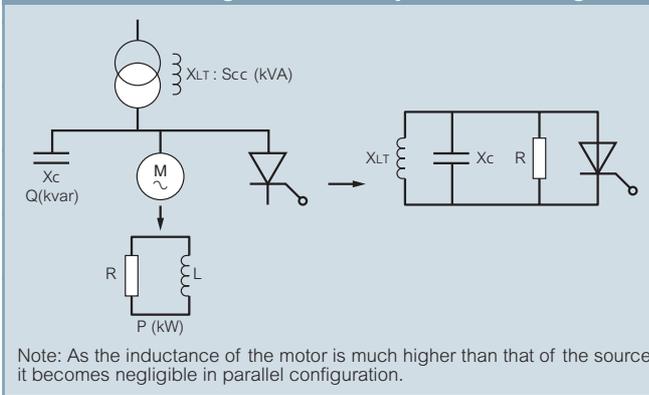
$$V_{\text{rms}} = \sqrt{U_1^2 + \sum_{h=2}^n U_h^2}$$

Note: The harmonic distortion of the voltage generated by construction defects in the windings of the alternators and transformers is generally negligible

# Harmonics (continued)

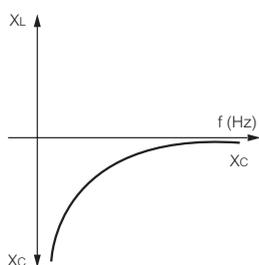
## EFFECT OF HARMONICS ON CAPACITORS

Schematic diagram      Equivalent diagram



- $S_{sc}$  (kVA): Source short-circuit power
- $Q$  (kVAr): Capacitor bank power
- $P$  (kW): Non-interfering load power

### > Reduction of the reactance of the capacitors



- The capacitor reactance  $X_c = \frac{1}{C \cdot \omega} = \frac{1}{C \cdot 2 \cdot \pi \cdot f}$  is inversely proportional to the frequency, its ability to cancel out harmonic currents decreases significantly when the frequency increases.



- The higher the source short-circuit power ( $S_{sc}$ ), the further the resonance frequency is from dangerous harmonic frequencies.
- The higher the power ( $P$ ) of the non-polluting loads, the lower the harmonic current amplification factor.

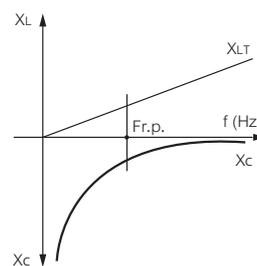
### > Main harmonic currents

The main harmonic currents present in electrical installations come from semi-conductor based systems. The theoretical rates of such systems are as follows:

- Harmonic 5 (250 Hz) - 15 - 20%  $I_1^*$
- Harmonic 7 (350 Hz) - 17 - 14%  $I_1^*$
- Harmonic 11 (550 Hz) - 111 - 9%  $I_1^*$
- Harmonic 13 (650 Hz) - 113 - 8%  $I_1^*$

(\*  $I_1$ : Semi-conductor system current at 50 Hz)

### > Parallel resonance or anti-resonance between capacitors and source



- The reactance of the source  $X_{LT}$  is proportional to the frequency
- The reactance of the capacitors  $X_c$  is inversely proportional to the frequency

At frequency  $f_{r.p.}$ , there is parallel resonance or anti-resonance (as the two reactances are equal but opposite) and amplification (F.A.) of the harmonic currents in the capacitors and in the source (transformers) where:

$$f_{r.p.} = F_{supply} \sqrt{\frac{S_{sc}}{Q}} \quad F.A. = \sqrt{\frac{S_{sc} \cdot Q}{P}}$$

## PROTECTING CAPACITORS USING DETUNED REACTORS

For supplies with a high level of harmonic pollution, installing a detuned reactor, tuned in series with the capacitor, is the only effective protection.

The detuned reactor performs a dual role:

- Increasing the impedance of the capacitor in relation to the harmonic currents
- Shifting the parallel resonance frequency (Fr.p) of the source and the capacitor to below the main frequencies of the harmonic currents that are causing interference

• Fr.p.: Detuned reactor/capacitor/MV/LV transformer parallel resonance frequency

• Fr.s.: Detuned reactor/capacitor serial resonance frequency

- The most commonly used F.r.s values are:

- 50 Hz fundamental: 215 Hz (n=4.3)  
190 Hz (n=3.8)  
135 Hz (n=2.7)

- 60 Hz fundamental: 258 Hz (n=4.3)  
228 Hz (n=3.8)  
162 Hz (n=2.7)

- For frequencies below Fr.s., the reactor/capacitor system behaves like a capacitance and compensates the reactive energy.
- For frequencies above Fr.s., the reactor/capacitor system behaves like an inductance which, in parallel with the inductance XLT, prevents any risk of parallel resonance at frequencies above Fr.s. and in particular at the main harmonic frequencies.

## HARMONIC FILTERS

For installations subject to a high level of harmonic pollution, the user may be faced with a dual requirement:

- To compensate for the reactive energy and protect the capacitors
- To reduce the harmonic distortion of the voltage to values that are acceptable and compatible with correct operation of most sensitive receivers (PLCs, industrial computers, capacitors, etc.)

For this, LEGRAND can offer "passive" harmonic filters. A "passive" harmonic filter is a combination of a capacitor and an inductance in series, for which each tuning frequency corresponds to the frequency of an unwanted harmonic voltage to be eliminated.

For this type of installation, LEGRAND offers the following services:

- Analysis of the mains supply on which the equipment is to be installed, with measurement of harmonic voltages and currents
- Computer simulation of the compatibility of the harmonic impedances of the supply and the various filters
- Calculation and definition of the various components of the filter
- Supply of capacitors, inductances, etc.
- Measurement of the efficiency of the system after installation on site

# Low voltage compensation



## MAIN ADVANTAGES OF THE LOW VOLTAGE RANGE

> **ALPIVAR<sup>2</sup> capacitors** are totally dry units that have been coated under vacuum, with triple electrical protection, for excellent resistance to overvoltages and partial discharges and a much longer service life than conventional units.

> **The universal mounting ranges of racks** are factory-wired and can be fitted in any type of cabinet to create automatic reactive energy compensation systems. Reactive power available up to 75 kVAR/step.

> **ALPIMATIC and ALPISTATIC automatic capacitor banks** are compact solutions, offering a fully modular design, for easy extension and maintenance and to meet all requirements: standard, H and SAH (standard class, reinforced and extra-reinforced class with detuned reactors). The power factor controller ensures easy commissioning. The AlpiSTATIC range of automatic capacitor banks also provides real-time compensation.

► **GENERAL INFORMATION**

(See p. 22-23)

**Systems and types of compensation**  
p. 22

**Protecting capacitors from harmonics**  
p. 23

► **ALPIVAR<sup>2</sup> CAPACITORS AND ALPIBLOC FIXED BANKS**

(See p. 24-29)



**Alipvar<sup>2</sup> capacitors**  
p. 24-27



**Alpibloc fixed capacitor banks**  
p. 28-29

► **AUTOMATIC RACKS AND CAPACITOR BANKS**

(See p. 30-42)



**Alpimatic automatic racks and capacitor banks**  
p. 30-35



**Alpistatic automatic racks and capacitor banks**  
p. 36-42

► **OTHER PRODUCTS AND SERVICES**

(See p. 43-49)



**Power factor controllers**  
p. 43

**Detuned reactors**  
p. 44-46

**Special products and services**  
p. 48

**Alptec network analysers**  
p. 49

**ENERGY COMPENSATION PRINCIPLES & OTHER RANGES**

**General information**  
See p. 4-19

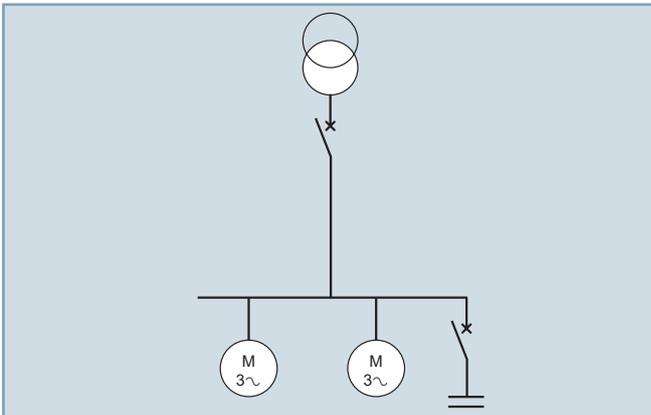
**Medium voltage energy compensation**  
See p. 50-68

# Compensation systems

## SYSTEMS AND TYPES OF COMPENSATION

When selecting a capacitor bank, there are two compensation systems.

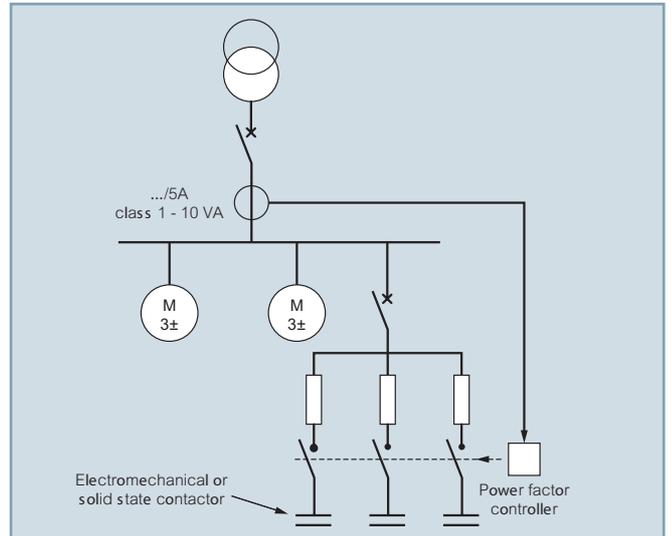
### > Fixed type capacitor banks



- The reactive power supplied by the capacitor bank is constant irrespective of any variations in the power factor and the load of the receivers, thus of the reactive energy consumption of the installation.
- These capacitor banks are switched on:
  - Either manually by a circuit breaker or switch
  - Or semi-automatically by a remote-controlled contactor
- This type of capacitor bank is generally used in the following situations:
  - Electrical installations with constant load operating 24 hours a day
  - Reactive compensation of transformers
  - Individual compensation of motors
  - Installation of a capacitor bank whose power is less than or equal to 15% of the power of the transformer

Capacitor bank  $Q_c \leq 15\% P_{kVA}$  transformer

### > Automatic type capacitor banks



- The reactive power supplied by the capacitor bank **can be adjusted** according to variations in the power factor and the load of the receivers, thus of the reactive energy consumption of the installation.
- These capacitor banks are made up of a combination of capacitor steps (step = capacitor + contactor) connected in parallel. Switching on and off of all or part of the capacitor bank is controlled by an integrated power factor controller.
- These capacitor banks are also used in the following situations:
  - Variable load electrical installations
  - Compensation of main LV distribution boards or major outgoing lines
  - Installation of a capacitor bank whose power is more than 15% greater than the power of the transformer

Capacitor bank  $Q_c > 15\% P_{kVA}$  transformer

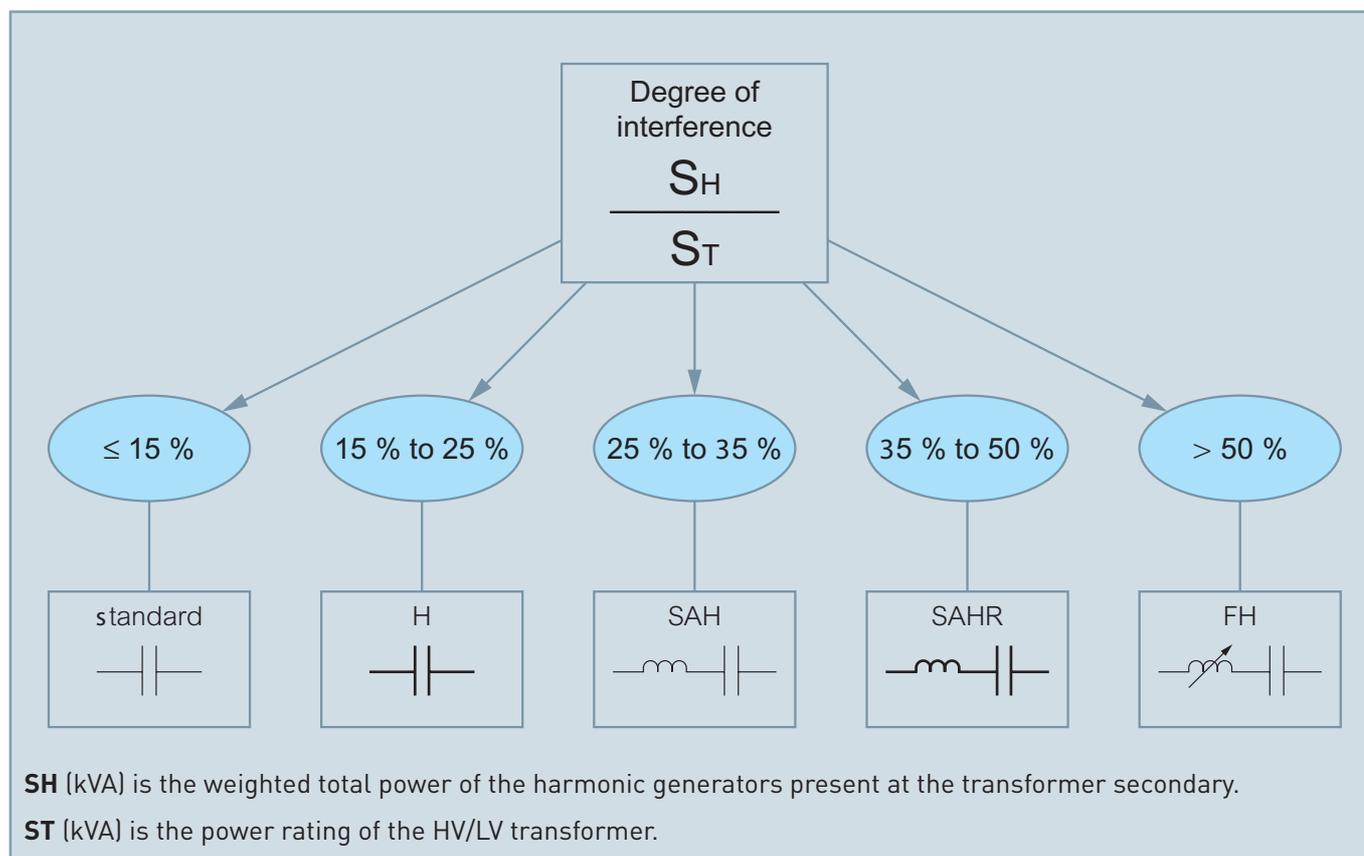
## PROTECTING CAPACITORS FROM HARMONICS

By design and in accordance with current standards, capacitors are capable of continuously withstanding an rms current equal to **1.3 times the nominal current** defined at the nominal voltage and frequency values.

This overcurrent coefficient has been determined to take account of the combined effects of the presence of harmonics and overvoltages (the capacitance variation parameter being negligible).

It can be seen that depending on the degree of harmonic pollution  $S_H$  (power of the harmonic generators), this coefficient is generally insufficient and that the parameter  $S_{sc}$  (short-circuit power), directly related to the power of the source  $S_T$ , is preponderant in the value of the parallel resonance frequency ( $F_{r.p}$ ).

By combining these two parameters,  $S_H$  and  $S_T$ , three types of mains supply can be defined, with a corresponding "type" of capacitor to be installed:



# ALPIVAR<sup>2</sup>® capacitors

## ALPIVAR<sup>2</sup>: VACUUM TECHNOLOGY CAPACITOR

### > Advantages of the range

**Alpivar<sup>2</sup>** patented capacitors are totally dry units with no impregnation, insulation liquid or gas.

They are designed by combining individual single phase windings, connected in a delta configuration, to produce a three-phase unit.

These windings are created using two polypropylene films with zinc coating on one side:

- The metal coating forms the electrode
- The polypropylene film forms the insulation

They are then **vacuum** coated with a self-extinguishing thermosetting polyurethane resin which forms the casing, providing mechanical and electrical protection.

This **vacuum** coating technique for the windings, which is unique to **LEGRAND**, gives **Alpivar<sup>2</sup>** capacitors excellent resistance over time and a much longer service life than conventional units.

**Vacuum** sealing ensures that there is no air or moisture near the windings. This design provides excellent resistance to overvoltages and partial discharges. This unit complies fully with environmental protection requirements (PCB-free).

### > Presentation

**Monobloc or modular**, the **Alpivar<sup>2</sup>** capacitor meets all user requirements.

The modular solution in particular, with its quick, easy assembly, can be used to create units with different power ratings, resulting in a significant reduction in storage costs for integrators and local distributors.

### > Installation

Its compact form makes it easy to install and significantly reduces the costs of cabinets and racks. The casing is particularly resistant to all solvents and atmospheric agents (rain, sun, salty air, etc.).

The **Alpivar<sup>2</sup>** capacitor is ideal for installations:

- In corrosive atmospheres
- Outdoor use (on request)

## ALPIVAR<sup>2</sup>: CONNECTION AND PROTECTION DEVICES

### > Connection

- The easy accessibility of the terminals on the top of the unit make the **Alpivar<sup>2</sup>** capacitor very easy to connect.
- The use of a system of "socket" terminals enables direct connection of the unit via cables and lugs.
- The **Alpivar<sup>2</sup>** double-insulated or class 2 capacitor does not need earthing.

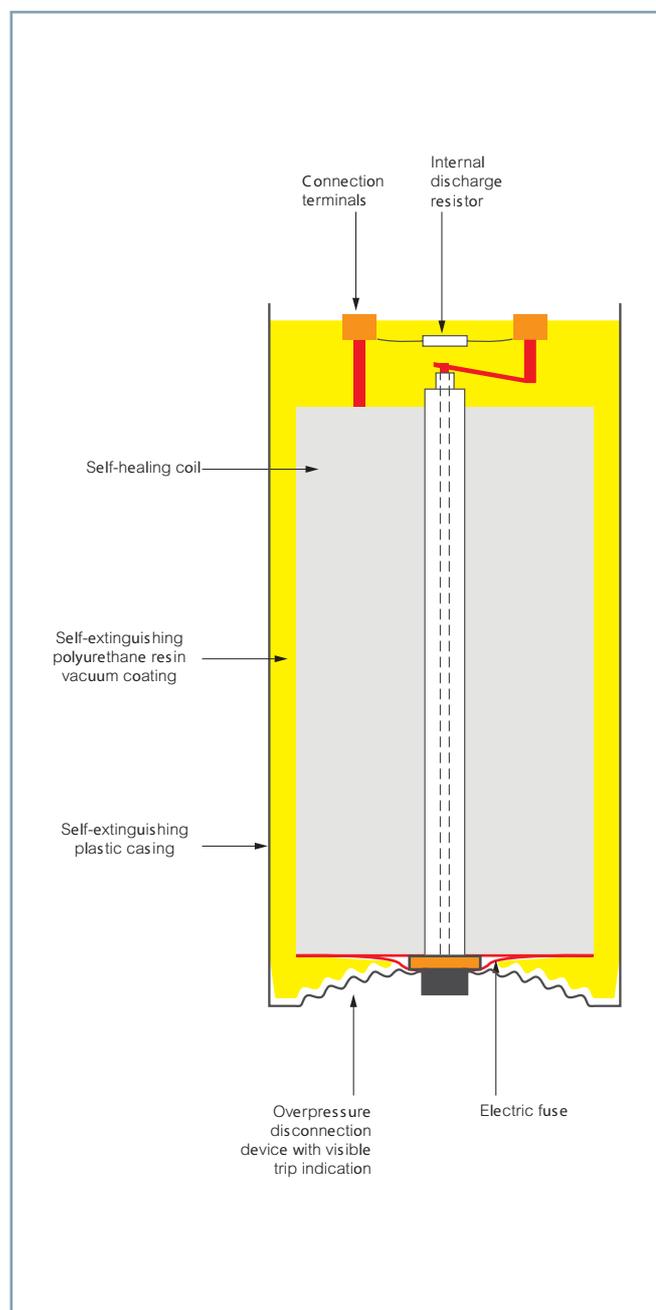
### > Electrical protection devices

- **Self-healing dielectric:** This self-healing property is connected with the characteristics of the metal deposit which forms the electrode and the nature of the insulating support (polypropylene film). This special manufacturing technique prevents breakdown of the capacitor due to electrical overvoltages. In fact overvoltages perforate the dielectric and cause discharges which vaporise the metal near the short circuit, thus instantaneously restoring the electrical insulation.

- **Internal fuses:** One per winding.

- **Pressure monitoring devices:** If an electrical fault cannot be overcome by the film self-healing or by means of the electric fuse, gas is emitted, causing a membrane to deform and disconnecting the faulty winding. The triggering of the pressure monitoring devices is visible from outside the capacitor. This feature makes it easy to carry out a quick check on the status of the unit.

**These three protection devices, together with the vacuum coating of the windings (technique patented by LEGRAND), result in a very high-tech unit.**



# Alpivar<sup>2</sup> capacitors

## 400 V network



V7540CB

**Technical characteristics (p. 27)**

Double or class II insulation. Totally dry  
Self-extinguishing polyurethane resin casing. Internal protection for each winding using:

- A self-healing metallised polypropylene film
- An electric fuse
- A disconnection device in case of overpressure

Colour: Casing RAL 7035  
Cover RAL 7001

Conforming to standards EN and IEC 60831-1 and 2

Pack	Cat.Nos	<b>Standard type three-phase 400 V - 50 Hz</b>
		<b>470 V max.</b>
		Harmonic pollution SH/ST ≤ 15%
		Nominal power (kVAr)
1	V2.540CB	2.5
1	V540CB	5
1	V7.540CB	7.5
1	V1040CB	10
1	V12.540CB	12.5
1	V1540CB	15
1	V2040CB	20
1	V2540CB	25
1	V3040CB	30
1	V3540CB	35
1	V4040CB	40
1	V5040CB	50
1	V6040CB	60
1	V7540CB	75
1	V9040CB	90
1	V10040CB	100
1	V12540CB	125

Pack	Cat.Nos	<b>H type three-phase 400 V - 50 Hz</b>
		<b>520 V max.</b>
		Harmonic pollution 15% < SH/ST ≤ 25%
		Can be associated with 7% detuned reactors
		Nominal power (kVAr)
1	VH2.540CB	2.5
1	VH540CB	5
1	VH7.540CB	7.5
1	VH1040CB	10
1	VH12.540CB	12.5
1	VH1540CB	15
1	VH2040CB	20
1	VH2540CB	25
1	VH3040CB	30
1	VH3540CB	35
1	VH4040CB	40
1	VH5040CB	50
1	VH6040CB	60
1	VH7540CB	75
1	VH8040CB	80
1	VH9040CB	90
1	VH10040CB	100
1	VH12540CB	125

Pack	Cat.Nos	<b>SAH type three-phase 400 V - 50 Hz</b>
		Capacitor combined with an detuned reactor
		Assembly fitted and wired in IP 31 - IK 05 cabinet
		Conforming to standards EN and IEC 60831-1 and 2
		<b>Standard class - Max. 470 V</b>
		Harmonic pollution 25% < SH/ST ≤ 35%
		Nominal power (kVAr)
1	VS5040.189	50
1	VS7540.189	75
1	VS10040.189	100
1	VS15040.189	150
1	VS20040.189	200
1	VS25040.189	250
1	VS30040.189	300
		<b>Reinforced class - Max. 520 V</b>
		Harmonic pollution 35% < SH/ST ≤ 50%
		Nominal power (kVAr)
1	VS.R4040.189	40
1	VS.R8040.189	80
1	VS.R12040.189	120
1	VS.R16040.189	160
1	VS.R20040.189	200
1	VS.R24040.189	240
1	VS.R28040.189	280
		<b>Extra-reinforced class - Max. 620 V</b>
		Harmonic pollution SH/ST > 50%
		Nominal power (kVAr)
1	VS.RS7240.189	72
1	VS.RS14440.189	144
1	VS.RS21640.189	216
1	VS.RS28840.189	288

# Alpivar<sup>2</sup> capacitors

## ■ Technical specifications

### Discharge resistors

Fitted inside (except by special request), these discharge the unit in accordance with current standards (discharge time, 3 minutes)

### Loss factor

Alpivar<sup>2</sup> capacitors have a loss factor of less than  $0.1 \times 10^{-3}$ . This value leads to a power consumption of less than 0.3 W per kVAR, including the discharge resistors.

### Capacitance

Tolerance on the capacitance value:  $\pm 5\%$   
Our manufacturing process, which avoids any inclusion of air in the coils, ensures excellent stability of the capacitance throughout the service life of the Alpivar<sup>2</sup> capacitor.

**Max. permissible voltage:** 1.18  $U_n$  rated

### Max. permissible current:

- Standard type: 1.3  $I_n$
- H type: 1.5  $I_n$

### Insulation class

- Withstand at 50 Hz for 1 min: 6 kV
- 1.2/50  $\mu$ s impulse withstand: 25 kV

### Standards

Alpivar<sup>2</sup> capacitors comply with:

- French standard: NF C 54 108 and 109
- European standard: EN 60831-1 and 2
- International standard: IEC 60831-1 and 2
- Canadian standard: CSA 22-2 No. 190
- End of life performance tests performed successfully in EDF and LCIE laboratories

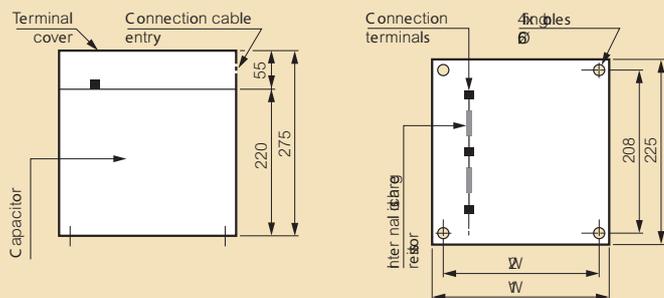
### Temperature class

Alpivar<sup>2</sup> capacitors are designed for a standard temperature class -25/+55°C

- Maximum temperature: 55°C
- Average over 24 hours: 45°C
- Annual average: 35°C
- Other temperature classes on request

## ■ Dimensions

### Standard type / H type - Three-phase



Standard type	H type	Dimensions (mm)			Weight (kg)
		W1	W2	H	
V2.540CB	VH2.540CB	90	70	275	3.5
V540CB	VH540CB	90	70	275	3.5
V7.540CB	VH7.540CB	90	70	275	3.5
V1040CB	VH1040CB	90	70	275	3.5
V12.540CB	VH12.540CB	90	70	275	3.5
V1540CB	VH1540CB	90	70	275	3.5
V2040CB	VH2040CB	90	70	275	3.5
V2540CB	VH2540CB	90	70	275	3.5
V3040CB	VH3040CB	180	156	275	7
V3540CB	VH3540CB	180	156	275	7
V4040CB	VH4040CB	180	156	275	7
V5040CB	VH5040CB	180	156	275	7
V6040CB	VH6040CB	270	244	275	10.5
V7540CB	VH7540CB	270	244	275	10.5
	VH8040CB	360	332	275	14
V9040CB	VH9040CB	360	332	275	14
V10040CB	VH10040CB	360	332	275	14
V12540CB	VH12540CB	450	419	275	17.5

## ■ Dimensions (continued)

### SAH type standard class - Three-phase

Cat.Nos	Dimensions (mm)			Weight (kg)
	Height	Width	Depth	
VS5040.189	1400	600	500	120
VS7540.189	1400	600	500	140
VS10040.189	1400	600	500	160
VS15040.189	1400	600	500	180
VS20040.189	1900	800	500	250
VS25040.189	1900	800	500	275
VS30040.189	1900	800	500	300

### SAH type reinforced class - Three-phase

Cat.Nos	Dimensions (mm)			Weight (kg)
	Height	Width	Depth	
VS.R4040.189	1400	600	500	120
VS.R8040.189	1400	600	500	150
VS.R12040.189	1400	600	500	180
VS.R16040.189	1900	800	500	220
VS.R20040.189	1900	800	500	260
VS.R24040.189	1900	800	500	280
VS.R28040.189	1900	800	500	300

### SAH type extra-reinforced class - Three-phase

Cat.Nos	Dimensions (mm)			Weight (kg)
	Height	Width	Depth	
VS.RS7240.189	2100	1000	600	180
VS.RS14440.189	2100	1000	600	250
VS.RS21640.189	2100	1000	600	320
VS.RS28840.189	2100	1000	600	380

# Alpibloc fixed capacitor banks

## 400 V network



B6040

Dimensions (p. 29)

Alpibloc is an Alpivar<sup>2</sup> capacitor with built-in circuit breaker  
 Assembly fitted and wired in an IP 31 - IK 05 box or cabinet  
 Equipment supplied ready for connection, for fixed compensation of low and medium power electrical devices  
 For certain applications (remote control, etc.) the circuit breaker can be replaced by a contactor and HRC fuses  
 Conforming to standards EN and IEC 60831-1 and 2

Pack	Cat.Nos	<b>Standard type three-phase 400 V - 50 Hz</b>	
		<b>470 V max.</b>	
		Harmonic pollution 15% ≤ SH/ST	
		Nominal power (kVAr)	Circuit breaker Isc (kA)
1	B1040	10	10
1	B1540	15	10
1	B2040	20	10
1	B2540	25	10
1	B3040	30	10
1	B4040	40	16
1	B5040	50	16
1	B6040	60	16
1	B7540	75	25
1	B9040	90	36
1	B10040	100	36
1	B12540	125	36
1	B15040	150	36
1	B17540	175	36

Pack	Cat.Nos	<b>H type three-phase 400 V - 50 Hz</b>	
		<b>520 V max.</b>	
		Harmonic pollution 15% < SH/ST ≤ 25%	
		Nominal power (kVAr)	Circuit breaker Isc (kA)
1	BH1040	10	10
1	BH1540	15	10
1	BH2040	20	10
1	BH2540	25	10
1	BH3040	30	10
1	BH4040	40	16
1	BH5040	50	16
1	BH6040	60	16
1	BH7540	75	25
1	BH9040	90	36
1	BH10040	100	36
1	BH12540	125	36
1	BH15040	150	36
1	BH17540	175	36

Pack	Cat.Nos	<b>SAH type three-phase 400 V - 50 Hz</b>	
		Alpivar <sup>2</sup> capacitor combined with an detuned reactor and a circuit breaker Assembly fitted and wired in IP 31 - IK 05 cabinet Conforming to standards EN and IEC 60831-1 and 2	
		<b>Standard class - Max. 470 V</b>	
		Harmonic pollution 25% < SH/ST ≤ 35%	
		Nominal power (kVAr)	Circuit breaker Isc (kA)
1	BS5040.189	50	16
1	BS7540.189	75	25
1	BS10040.189	100	36
1	BS15040.189	150	36
1	BS20040.189	200	36
1	BS25040.189	250	36
1	BS30040.189	300	36
		<b>Reinforced class - Max. 520 V</b>	
		Harmonic pollution 35% < SH/ST ≤ 50%	
		Nominal power (kVAr)	Circuit breaker Isc (kA)
1	BS.R4040.189	40	16
1	BS.R8040.189	80	25
1	BS.R12040.189	120	36
1	BS.R16040.189	160	36
1	BS.R20040.189	200	36
1	BS.R24040.189	240	36
1	BS.R28040.189	280	36
		<b>Extra-reinforced class - Max. 620 V</b>	
		Harmonic pollution SH/ST > 50%	
		Nominal power (kVAr)	Circuit breaker Isc (kA)
1	BS.RS7240.189	72	25
1	BS.RS14440.189	144	36
1	BS.RS21640.189	216	36
1	BS.RS28840.189	288	50

## Alpibloc fixed capacitor banks

### ■ Dimensions

#### Standard type - Three-phase

Cat.Nos	Dimensions (mm)			Weight (kg)
	Height	Width	Depth	
B1040	380	190	230	5
B1540	380	190	230	5
B2040	380	190	230	5
B2540	380	190	230	7.5
B3040	380	365	230	10
B4040	380	365	230	10
B5040	380	365	230	12.5
B6040	380	365	230	15
B7540	380	365	230	15
B9040	380	550	230	75
B10040	380	550	230	75
B12540	380	550	230	85
B15040	1000	350	500	100
B17540	1000	350	500	125

#### H type - Three-phase

Cat.Nos	Dimensions (mm)			Weight (kg)
	Height	Width	Depth	
BH1040	380	190	230	5
BH1540	380	190	230	5
BH2040	380	190	230	5
BH2540	380	190	230	7.5
BH3040	380	365	230	10
BH4040	380	365	230	10
BH5040	380	365	230	12.5
BH6040	380	365	230	15
BH7540	380	365	230	15
BH9040	1000	350	500	75
BH10040	1000	350	500	75
BH12540	1000	350	500	85
BH15040	1000	350	500	100
BH17540	1000	350	500	125

### ■ Dimensions (continued)

#### SAH type standard class - Three-phase

Cat.Nos	Dimensions (mm)			Weight (kg)
	Height	Width	Depth	
BS5040.189	1400	600	500	125
BS7540.189	1400	600	500	145
BS10040.189	1400	600	500	165
BS15040.189	1900	600	500	190
BS20040.189	1900	800	500	260
BS25040.189	1900	800	500	285
BS30040.189	1900	800	500	320

#### SAH type reinforced class - Three-phase

Cat.Nos	Dimensions (mm)			Weight (kg)
	Height	Width	Depth	
BS.R4040.189	1400	600	500	125
BS.R8040.189	1400	600	500	155
BS.R12040.189	1900	600	500	200
BS.R16040.189	1900	800	500	230
BS.R20040.189	1900	800	500	270
BS.R24040.189	1900	800	500	290
BS.R28040.189	2100	800	500	350

#### SAH type extra-reinforced class - Three-phase

Cat.Nos	Dimensions (mm)			Weight (kg)
	Height	Width	Depth	
BS.RS7240.189	2100	1000	600	185
BS.RS14440.189	2100	1000	600	255
BS.RS21640.189	2100	1000	600	325
BS.RS28840.189	2100	1000	600	385

# Alpimatic automatic capacitor banks

Alpimatic capacitor banks

## ↓ GENERAL CHARACTERISTICS

ALPIMATIC capacitor banks are automatic banks with switching via electromechanical contactors

These banks consist of racks:

- Standard and H types for M series
- SAH type for MS series

These are controlled by a power factor controller and integrated in a cabinet

- IP 31 - IK 05 box or cabinet
- Protection of live parts against direct contact: IP 2X
- Temperature class:
  - Operation -10/+45°C (average over 24 hours : 40°C)
  - Storage -30/+60°C
- Ventilation: natural or forced (SAH type)
- Colour: grey cabinet (RAL 7035), black base
- Standards: EN 60439-1  
IEC 60439-1 and 2



p. 33-35

## ↓ SPECIFIC CHARACTERISTICS

- Fully modular design for easy extension and maintenance
- Power factor controller with easy commissioning
- Extendable cabinet on request
- Cable entry via the bottom or the top (on request)

## ↓ OPTIONS

- Protective circuit breaker fitted - wired
- Fixed step
- Summing current transformer

## ↓ ELECTRICAL CHARACTERISTICS

- Insulation class: 0.66 kV (tested at 2.5 kV, 50 Hz for 1 minute)
- Built-in power supply for auxiliary circuits
- Integrated connector block for load shedding contact (generator set, specific electricity tariffs, etc.)
- Possible remote alarm feedback

## ↓ CONNECTION

- The following is required:
- Power cables in accordance with table on page 47
  - A current transformer to be positioned on phase L1 of the installation upstream all the receivers and the capacitor bank
    - Primary: according to the installation
    - Secondary: 5A
    - Power: 10 VA (recommended) - Class 1

Note: This transformer can be supplied separately on request

## Alpimatic racks

400 V network



P7540

Factory connected units for integration in universal cabinets for automatic compensation systems

Standard and H versions:

- 1 Alpivar<sup>2</sup> capacitor
- 1 contactor suitable for the capacitive currents
- 1 set of 3 HRC fuses
- 1 set of modular copper busbars with junction bars for connecting several racks
- 1 steel frame on which the components are assembled and wired

Pack	Cat.Nos	<b>Standard type three-phase 400 V - 50 Hz 470 V max.</b>
		Harmonic pollution SH/ST ≤ 15%
		Nominal power (kVAr)
1	P12.540	12.5
1	P12.512.540	12.5+12.5
1	P2540	25
1	P252540	25+25
1	P255040	25+50
1	P5040	50
1	P7540	75

		<b>H type three-phase 400 V - 50 Hz 520 V max.</b>
		Harmonic pollution 15% < SH/ST ≤ 25%
		Nominal power (kVAr)
1	PH12.540	12.5
1	PH12.512.540	12.5+12.5
1	PH2540	25
1	PH252540	25+25
1	PH255040	25+50
1	PH5040	50
1	PH7540	75

## Alpimatic racks

### ■ Technical specifications

#### Loss factor

Standard and H type Alpimatic racks have a loss factor of 2 W/kVAr, while that of SAH type racks is 6 W/kVAr

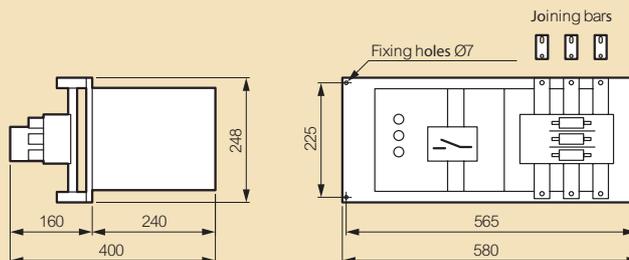
#### Standards

- International standard: IEC 60439-1
- European standard: EN 60439-2

#### Temperature class

- Operation: -10 to +45°C (average over 24 hours: 40°C)
- Storage: -30 to +60°C

### ■ Dimensions



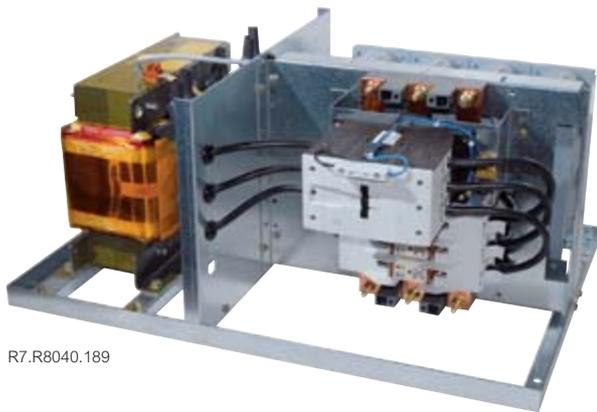
#### Standard type

	Weight (kg)
P12.540	6
P12.512.540	11
P2540	9
P252540	16
P255040	22
P5040	16
P7540	22

#### H type

	Weight (kg)
PH12.540	7
PH12.512.540	14
PH2540	10
PH252540	17
PH255040	23
PH5040	17
PH7540	23

## Alpimatic racks with detuned reactors 400 V network



R7.R8040.189

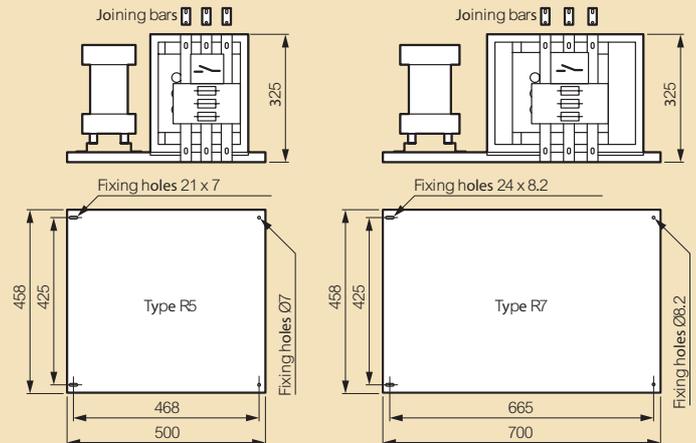
Factory connected units for integration in universal cabinets for automatic compensation systems  
SAH versions (detuned reactors):

- 1 Alpivar<sup>2</sup> capacitor
- 1 contactor suitable for the capacitive currents
- 1 detuned reactor with thermal protection
- 1 set of 3 HRC fuses
- 1 set of modular copper busbars with junction bars for connecting several racks
- 1 steel frame on which the components are assembled and wired

Pack	Cat.Nos	SAH type three-phase 400 V - 50 Hz
		<b>Standard class - Max. 470 V</b>
		Harmonic pollution 25% < SH/ST ≤ 35%
		Nominal power (kVAr)
1	R5.2540.189	25
1	R5.5040.189	50
1	R7.5040.189	50
1	R7.7540.189	75
		<b>Reinforced class - Max. 520 V</b>
		Harmonic pollution 35% < SH/ST ≤ 50%
		Nominal power (kVAr)
1	R5.R4040.189	40
1	R7.R4040.189	40
1	R7.R404040.189	40+40
1	R7.R8040.189	80
		<b>Extra-reinforced class - Max. 620 V</b>
		Harmonic pollution SH/ST > 50%
		Nominal power (kVAr)
1	R9.RS7240.189	72

## Alpimatic racks with detuned reactors

### ■ Dimensions

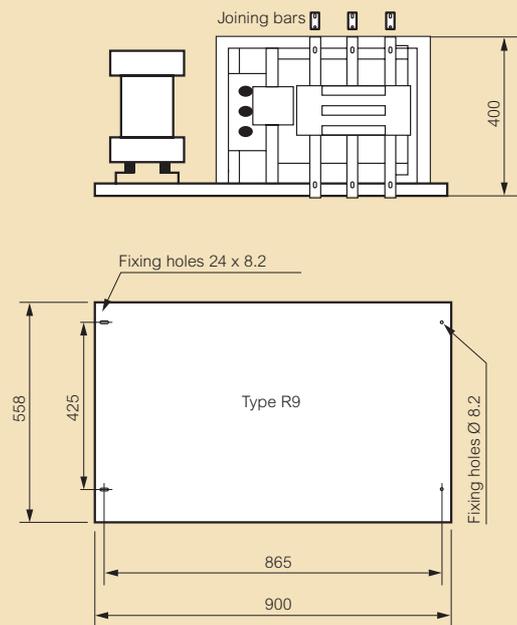


### Standard class

	Weight (kg)
R5.2540.189	45
R5.5040.189	50
R7.5040.189	55
R7.7540.189	60

### Reinforced class

	Weight (kg)
R5.R4040.189	50
R7.R4040.189	52
R7.R404040.189	65
R7.R8040.189	65



### Extra-reinforced class

	Weight (kg)
R9.RS7240.189	80

# Alpimatic automatic capacitor banks

400 V network



M6040



M20040

Dimensions (p. 35)

IP 31 - IK 05 cabinet

Fully modular design for easy extension and maintenance

Alpimatic is made up of one or several cabinets according to the capacitor bank model and the nominal current

The electromechanical contactors are controlled by the Alptec power controller with a simple commissioning procedure

Cable entry at the bottom (at the top on request)

Electrical parts protected against direct contact: IP 2 X (door open)

Grey cabinet (RAL 7035) with black base Conforming to standards IEC 60439-1 and 2 and EN 60439-1

Pack	Cat.Nos	<b>Standard type three-phase 400 V - 50 Hz 470 V max.</b>	
Harmonic pollution SH/ST ≤ 15%			
		Nominal power (kVAr)	Steps (kVAr)
1	M1040	10	2x5
1	M1540	15	5+10
1	M2040	20	2x10
1	M2540	25	10+15
1	M3040	30	3x10
1	M3540	35	5+10+20
1	M4040	40	2x10+20
1	M5040	50	10+15+25
1	M6040	60	3x20
1	M7540	75	3x25
1	M87.540	87.5	12.5+25+50
1	M10040	100	2x25+50
1	M12540	125	25+2x50
1	M15040	150	25+50+75
1	M17540	175	2x25+50+75
1	M20040	200	50+2x75
1	M22540	225	25+50+2x75
1	M25040	250	2x50+2x75
1	M27540	275	25+2x50+2x75
1	M30040	300	25+50+3x75
1	M35040	350	50+4x75
1	M40040	400	2x50+4x75
1	M45040	450	6x75
1	M50040	500	50+6x75
1	M55040	550	2x50+6x75
1	M60040	600	8x75
1	M67540	675	9x75
1	M75040	750	10x75
1	M82540	825	11x75
1	M90040	900	12x75

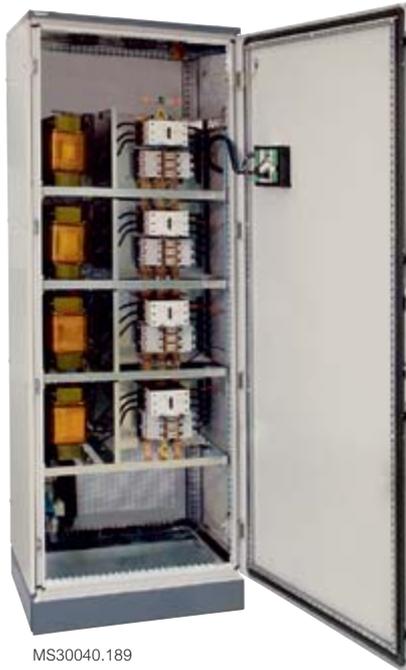
Pack	Cat.Nos	<b>H type three-phase 400 V - 50 Hz 520 V max.</b>	
Harmonic pollution 15% < SH/ST ≤ 25%			
		Nominal power (kVAr)	Steps (kVAr)
1	MH1040	10	2x5
1	MH1540	15	5+10
1	MH2040	20	2x10
1	MH2540	25	10+15
1	MH3040	30	3x10
1	MH3540	35	5+10+20
1	MH4040	40	2x10+20
1	MH5040	50	10+15+25
1	MH6040	60	3x20
1	MH7540	75	3x25
1	MH87.540	87.5	12.5+25+50
1	MH10040	100	2x25+50
1	MH12540	125	25+2x50
1	MH15040	150	25+50+75
1	MH17540	175	2x25+50+75
1	MH20040	200	50+2x75
1	MH22540	225	25+50+2x75
1	MH25040	250	2x50+2x75
1	MH27540	275	25+2x50+2x75
1	MH30040	300	25+50+3x75
1	MH35040	350	50+4x75
1	MH40040	400	2x50+4x75
1	MH45040	450	6x75
1	MH50040	500	50+6x75
1	MH55040	550	2x50+6x75
1	MH60040	600	8x75
1	MH67540	675	9x75
1	MH75040	750	10x75
1	MH82540	825	11x75
1	MH90040	900	12x75



**Other powers, voltages, frequencies  
on request, please consult us**

# Alpimatic automatic capacitor banks (continued)

400 V network



MS30040.189



MS.R40040.189

Pack	Cat.Nos	<b>SAH type three-phase 400 V - 50 Hz</b>	
		<b>Standard class - Max. 470 V</b>	
		Harmonic pollution 25% < SH/ST ≤ 35%	
		Nominal power (kVAr)	Steps (kVAr)
1	MS7540.189	75	25+50
1	MS10040.189	100	2x25+50
1	MS12540.189	125	25+2x50
1	MS15040.189	150	3x50
1	MS20040.189	200	50+2x75
1	MS22540.189	225	3x75
1	MS25040.189	250	2x50+2x75
1	MS27540.189	275	50+3x75
1	MS30040.189	300	4x75
1	MS35040.189	350	50+4x75
1	MS37540.189	375	5x75
1	MS45040.189	450	6x75
1	MS52540.189	525	7x75
1	MS60040.189	600	8x75
1	MS67540.189	675	9x75
1	MS75040.189	750	10x75
		<b>Reinforced class - Max. 520 V</b>	
		Harmonic pollution 35% < SH/ST ≤ 50%	
		Nominal power (kVAr)	Steps (kVAr)
1	MS.R12040.189	120	3x40
1	MS.R16040.189	160	2x40+80
1	MS.R20040.189	200	40+2x80
1	MS.R24040.189	240	2x40+2x80
1	MS.R28040.189	280	40+3x80
1	MS.R32040.189	320	4x80
1	MS.R36040.189	360	40+4x80
1	MS.R40040.189	400	5x80
1	MS.R44040.189	440	40+5x80
1	MS.R48040.189	480	6x80
1	MS.R52040.189	520	40+6x80
1	MS.R56040.189	560	7x80
1	MS.R60040.189	600	40+7x80
1	MS.R64040.189	640	8x80
1	MS.R72040.189	720	9x80
1	MS.R80040.189	800	10x80

Pack	Cat.Nos	<b>SAH type three-phase 400 V - 50 Hz (continued)</b>	
		<b>Extra-reinforced class - Max. 620 V</b>	
		Harmonic pollution SH/ST > 50%	
		Nominal power (kVAr)	Steps (kVAr)
1	MS.RS14440.189	144	2x72
1	MS.RS21640.189	216	3x72
1	MS.RS28840.189	288	4x72
1	MS.RS36040.189	360	5x72
1	MS.RS43240.189	432	6x72
1	MS.RS50440.189	504	7x72
1	MS.RS57640.189	576	8x72
1	MS.RS64840.189	648	9x72
1	MS.RS72040.189	720	10x72
1	MS.RS79240.189	792	11x72
1	MS.RS86440.189	864	12x72



Other powers, voltages, frequencies on request, please consult us

# Alpimatic automatic capacitor banks

## 400 V network

### ■ Dimensions

#### Standard type - Three-phase

Cat.Nos	Dimensions (mm)			Weight (kg)
	Height	Width	Depth	
M1040	650	260	320	40
M1540	650	260	320	40
M2040	650	260	320	40
M2540	650	260	320	40
M3040	650	260	320	45
M3540	650	260	320	45
M4040	650	260	320	45
M5040	650	260	320	45
M6040	770	260	320	50
M7540	770	260	320	75
M87.540	1000	350	500	80
M10040	1000	350	500	80
M12540	1000	350	500	90
M15040	1400	600	500	125
M17540	1400	600	500	140
M20040	1400	600	500	150
M22540	1400	600	500	160
M25040	1400	600	500	170
M27540	1400	600	500	190
M30040	1400	600	500	200
M35040	1900	600	500	260
M40040	1900	600	500	290
M45040	1900	600	500	300
M50040	1400	1200	500	370
M55040	1400	1200	500	400
M60040	1400	1200	500	430
M67540	1900	1200	500	490
M75040	1900	1200	500	500
M82540	1900	1200	500	540
M90040	1900	1200	500	560

#### H type - Three-phase

Cat.Nos	Dimensions (mm)			Weight (kg)
	Height	Width	Depth	
MH1040	650	260	320	40
MH1540	650	260	320	40
MH2040	650	260	320	40
MH2540	650	260	320	40
MH3040	650	260	320	45
MH3540	650	260	320	45
MH4040	650	260	320	45
MH5040	650	260	320	45
MH6040	770	260	320	50
MH7540	770	260	320	75
MH87.540	1000	350	500	80
MH10040	1000	350	500	80
MH12540	1000	350	500	90
MH15040	1400	600	500	125
MH17540	1400	600	500	140
MH20040	1400	600	500	150
MH22540	1400	600	500	160
MH25040	1400	600	500	170
MH27540	1400	600	500	190
MH30040	1400	600	500	200
MH35040	1900	600	500	260
MH40040	1900	600	500	290
MH45040	1900	600	500	300
MH50040	1400	1200	500	310
MH55040	1400	1200	500	370
MH60040	1400	1200	500	420
MH67540	1900	1200	500	450
MH75040	1900	1200	500	500
MH82540	1900	1200	500	550
MH 90040	1900	1200	500	600

### ■ Dimensions

#### SAH type standard class - Three-phase

Cat.Nos	Dimensions (mm)			Weight (kg)
	Height	Width	Depth	
MS7540.189	1400	600	500	180
MS10040.189	1400	600	500	230
MS12540.189	1400	600	500	250
MS15040.189	1400	600	500	300
MS20040.189	1900	800	500	340
MS22540.189	1900	800	500	360
MS25040.189	1900	800	500	380
MS27540.189	1900	800	500	400
MS30040.189	1900	800	500	420
MS35040.189	2100	800	500	460
MS37540.189	2100	800	500	470
MS45040.189	1900	1600	500	600
MS52540.189	1900	1600	500	630
MS60040.189	1900	1600	500	730
MS67540.189	2100	1600	500	800
MS75040.189	2100	1600	500	860

#### SAH type reinforced class - Three-phase

Cat.Nos	Dimensions (mm)			Weight (kg)
	Height	Width	Depth	
MS.R12040.189	1400	600	500	250
MS.R16040.189	1900	800	500	300
MS.R20040.189	1900	800	500	340
MS.R24040.189	1900	800	500	370
MS.R28040.189	1900	800	500	400
MS.R32040.189	1900	800	500	430
MS.R36040.189	2100	800	500	470
MS.R40040.189	2100	800	500	520
MS.R44040.189	1900	1600	500	600
MS.R48040.189	1900	1600	500	630
MS.R52040.189	1900	1600	500	670
MS.R56040.189	1900	1600	500	700
MS.R60040.189	1900	1600	500	750
MS.R64040.189	1900	1600	500	800
MS.R72040.189	2100	1600	500	860
MS.R80040.189	2100	1600	500	920

#### SAH type extra-reinforced class - Three-phase

Cat.Nos	Dimensions (mm)			Weight (kg)
	Height	Width	Depth	
MS.RS14440.189	2100	1000	600	300
MS.RS21640.189	2100	1000	600	380
MS.RS28840.189	2100	1000	600	460
MS.RS36040.189	2100	2000	600	600
MS.RS43240.189	2100	2000	600	680
MS.RS50440.189	2100	2000	600	760
MS.RS57640.189	2100	2000	600	820
MS.RS64840.189	2100	3000	600	950
MS.RS72040.189	2100	3000	600	1130
MS.RS79240.189	2100	3000	600	1200
MS.RS86440.189	2100	3000	600	1260

## Alpistatic automatic capacitor banks

### ↓ GENERAL CHARACTERISTICS

Alpistatic capacitor banks are automatic banks with switching via solid state contactors

They provide "soft, fast" reactive energy compensation suitable for receivers that are sensitive to voltage variations (PLCs, industrial computers) or that have ultra-fast cycles (robots, welding machines, speed drives)

These banks consist of:

- The capacitor part, subdivided into a number of steps depending on the power rating of the capacitor
- One three-pole solid state contactor per step (with switching off all three phases)
- Cooling of each solid state contactor by fan-cooled heat sink
- Standard and H type: 3 single phase damping reactors protecting the solid state contactor
- SAH type: 1 three-phase detuned reactor protecting the solid state contactor and providing protection against harmonics
- One set of 3 HRC fuses per step
- A system for controlling the solid state contactors, comprising:
  - \* A reactive energy controller for automatic control:
    - With automatic-manual operation
    - Front panel display showing the number of steps in operation and the  $\cos \varphi$  of the installation
    - Display of a number of other electrical parameters (harmonics, etc.)
  - \* One microprocessor instrumentation and control board per solid state contactor, used to:
    - Activate and deactivate the solid state contactors in 40 milliseconds max.
    - Prevent all transient voltage and current phenomena when activating and deactivating the steps
- IP 31 - IK 05 cabinet
- Protection of live parts against direct contact: IP 2X
- Temperature class:
  - Operation  $-10/+ 45^{\circ}\text{C}$  (average over 24 hours:  $40^{\circ}\text{C}$ )
  - Storage  $- 30/+ 60^{\circ}\text{C}$
- Ventilation: forced
- Cable entry via the bottom (or via the top on request)



### ↓ ELECTRICAL CHARACTERISTICS

- Insulation class: 0.66 kV (tested at 2.5 kV, 50 Hz for 1 minute)
- Built-in power supply for auxiliary circuits
- Connector block for built-in load-shedding contact

### ↓ OPTIONS

- Protective circuit breaker fitted - wired
- Fixed step
- Summing current transformer

## Alpistatic automatic capacitor banks (continued)

### ↓ CONNECTION

The following is required:

- Power cables in accordance with table on page 47
- A current transformer to be positioned on phase L3 of the installation upstream of all the receivers and the capacitor bank:
  - Primary: according to the installation
  - Secondary: 5 A
  - Power: 10 VA (recommended) – class 1

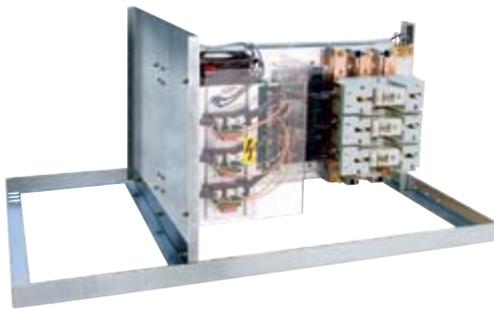
Note: This transformer can be supplied separately on request

### ↓ THE ADVANTAGES OF ALPISTATIC AUTOMATIC CAPACITOR BANKS COMPARED TO A CONVENTIONAL SYSTEM

Comparison criteria	Banks with electromechanical contactors	
	Alpistatic	Conventional system
Presence of electromechanical contactors	No	Yes
Wear of moving parts	No	Yes
Contact bounce phenomenon	No	Possible
Contact fatigue	None	High
Transient overcurrents on activation and deactivation of steps	No	Yes (may exceed 200 In)
Transient overvoltages	None	Yes (up to 100%)
Compatibility (PLCs, computer equipment, etc.)	Excellent	Average
Compatibility (welding machines, generator sets, etc.)	Excellent	Poor
Activation and deactivation response time	40 milliseconds max.	Approx. 30 seconds
Number of operations	Unlimited	Limited (electromechanical contactor)
Sound level during operation	None	Low (electromechanical contactor)
Reduction of FLICKER	Yes (for highly inductive loads)	No
Creation of harmonics	No	No

## Alpistatic racks

400 V network



RST7.5040

Factory connected units for integration in universal cabinets for automatic compensation systems

Comprise:

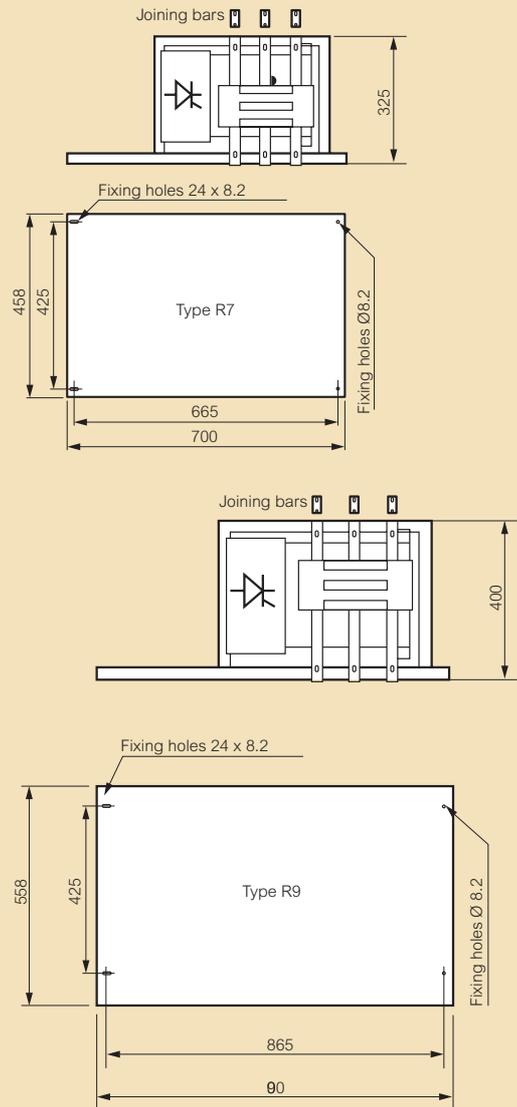
- 1 Alpivar<sup>2</sup> capacitor
- 1 solid state contactor
- 1 set of 3 HRC fuses
- 1 set of modular copper busbars with junction bars for connecting several racks
- 1 steel frame on which the components are assembled and wired

Pack	Cat.Nos	<b>Standard type three-phase 400 V - 50 Hz 470 V max.</b>
		Harmonic pollution SH/ST ≤ 15%
		Nominal power (kVAr)
1	RST7.2540	25
1	RST7.5040	50
1	RST7.7540	75
1	RST7.10040	100
1	RST9.12540	125

		<b>H type three-phase 400 V - 50 Hz 520 V max.</b>
		Harmonic pollution 15% < SH/ST ≤ 25%
		Nominal power (kVAr)
1	RST7.H2540	25
1	RST7.H5040	50
1	RST7.H7540	75
1	RST7.H10040	100
1	RST9.H12540	125

## Alpistatic racks

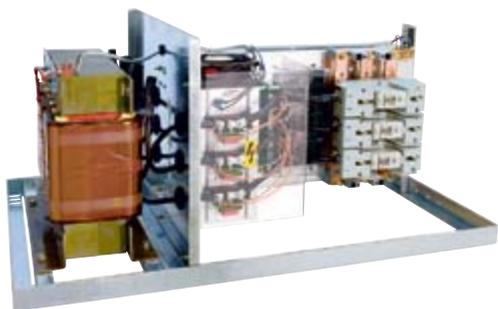
### ■ Dimensions



Standard type	Weight (kg)	H type	Weight (kg)
RST7.2540	45	RST7.H2540	50
RST7.5040	50	RST7.H5040	55
RST7.7540	55	RST7.H7540	60
RST7.10040	60	RST7.H10040	65
RST9.12540	65	RST9.H12540	70

## Alpistatic racks (continued)

400 V network



RST7.2540.189

Factory connected units for integration in universal cabinets for automatic compensation systems

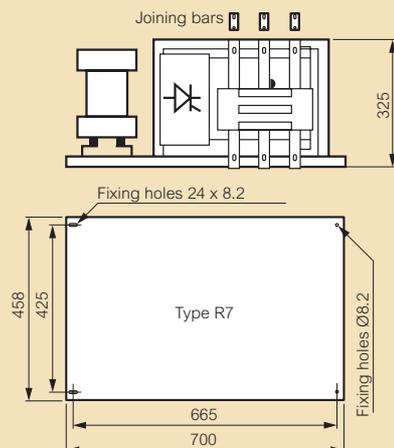
Comprise:

- 1 Alpivar<sup>2</sup> capacitor
- 1 solid state contactor
- 1 detuned reactor
- 1 set of 3 HRC fuses
- 1 set of modular copper busbars with junction bars for connecting several racks
- 1 steel frame on which the components are assembled and wired

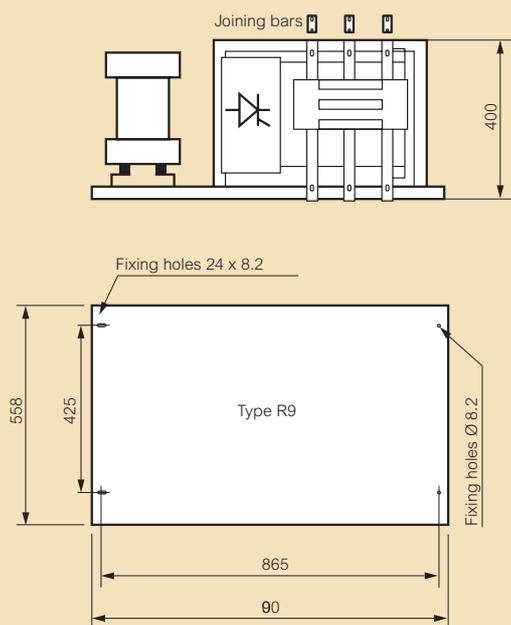
Pack	Cat.Nos	SAH type three-phase 400 V - 50 Hz
		<b>Standard class - Max. 470 V</b>
		Harmonic pollution $25\% < SH/ST \leq 35\%$
		Nominal power (kVAr)
1	RST7.2540.189	25
1	RST7.5040.189	50
1	RST7.7540.189	75
1	RST7.10040.189	100
1	RST9.12540.189	125
		<b>Reinforced class - Max. 520 V</b>
		Harmonic pollution $35\% < SH/ST \leq 50\%$
		Nominal power (kVAr)
1	RST7.R4040.189	40
1	RST7.R8040.189	80
1	RST9.R12040.189	120
		<b>Extra-reinforced class - Max. 620 V</b>
		Harmonic pollution $SH/ST > 50\%$
		Nominal power (kVAr)
1	RST9.RS7240.189	72

## Alpistatic racks

### ■ Dimensions



Standard class	Weight (kg)	Reinforced class	Weight (kg)
RST7.2540.189	50	RST7.4040.189	60
RST7.5040.189	60	RST7.8040.189	80
RST7.7540.189	70	RST7.12040.189	90
RST7.10040.189	80		
RST9.12540.189	90		



Extra-reinforced class	Weight (kg)
R9.RS7240.189	100

# Alpistatic automatic capacitor banks

400 V network



ST35040

Dimensions (p. 41)

IP 31 - IK 05 cabinet

Alpistatic is a real-time compensation system, with a response time  $\leq 40$  ms

It is specially designed for sites using fast changing loads, or for processes sensitive to harmonics and transient currents

All steps can be connected or disconnected at the same time, in order to exactly match to the reactive energy demand

Alpistatic is made up of one or several cabinets according to the capacitor bank model and the nominal current

Cable entry at the bottom (at the top on request)

Electrical parts protected against direct contact: IP 2 X (door open)

Grey cabinet (RAL 7035) with black base

Conforming to standards IEC 60439-1 and 2 and EN 60439-1

## Standard type three-phase 400 V - 50 Hz 470 V max.

Harmonic pollution SH/ST  $\leq 15\%$

Pack	Cat.Nos	Nominal power (kVAr)	Steps (kVAr)
1	ST10040	100	2x25+50
1	ST12540	125	25+2x50
1	ST15040	150	50+100
1	ST17540	175	2x50+75
1	ST20040	200	50+2x75
1	ST22540	225	25+50+2x75
1	ST25040	250	50+2x100
1	ST27540	275	50+3x75
1	ST30040	300	2x50+2x100
1	ST35040	350	50+3x100
1	ST40040	400	4x100
1	ST45040	450	75+3x125
1	ST50040	500	4x125
1	ST52540	525	2x75+3x125
1	ST57540	575	75+4x125
1	ST62540	625	5x125
1	ST70040	700	75+5x125
1	ST75040	750	6x125
1	ST82540	825	75+6x125
1	ST87540	875	7x125
1	ST95040	950	75+7x125
1	ST100040	1000	8x125
1	ST112540	1125	9x125
1	ST125040	1250	10x125
1	ST137540	1375	11x125
1	ST150040	1500	12x125

## H type three-phase 400 V - 50 Hz 520 V max.

Harmonic pollution 15% < SH/ST  $\leq 25\%$

Pack	Cat.Nos	Nominal power (kVAr)	Steps (kVAr)
1	STH10040	100	2x25+50
1	STH12540	125	25+2x50
1	STH15040	150	50+100
1	STH17540	175	2x50+75
1	STH20040	200	50+2x75
1	STH22540	225	25+50+2x75
1	STH25040	250	50+2x100
1	STH27540	275	50+3x75
1	STH30040	300	2x50+2x100
1	STH35040	350	50+3x100
1	STH40040	400	4x100
1	STH45040	450	75+3x125
1	STH50040	500	4x125
1	STH52540	525	2x75+3x125
1	STH57540	575	75+4x125
1	STH62540	625	5x125
1	STH70040	700	75+5x125
1	STH75040	750	6x125
1	STH82540	825	75+6x125
1	STH87540	875	7x125
1	STH95040	950	75+7x125
1	STH100040	1000	8x125
1	STH112540	1125	9x125
1	STH125040	1250	10x125
1	STH137540	1375	11x125
1	STH150040	1500	12x125



Other powers, voltages, frequencies  
on request, please consult us

# Alpistatic automatic capacitor banks (continued)

400 V network



STS50040.189

Pack	Cat.Nos	<b>SAH type three-phase 400 V - 50 Hz</b>	
		<b>Standard class - Max. 470 V</b>	
		Harmonic pollution 25% < SH/ST ≤ 35%	
		Nominal power (kVAr)	Steps (kVAr)
1	STS10040.189	100	2x25+50
1	STS12540.189	125	25+2x50
1	STS15040.189	150	50+100
1	STS17540.189	175	2x50+75
1	STS20040.189	200	50+2x75
1	STS22540.189	225	25+50+2x75
1	STS25040.189	250	50+2x100
1	STS27540.189	275	50+3x75
1	STS30040.189	300	2x50+2x100
1	STS35040.189	350	50+3x100
1	STS40040.189	400	4x100
1	STS45040.189	450	75+3x125
1	STS50040.189	500	4x125
1	STS52540.189	525	2x75+3x125
1	STS57540.189	575	75+4x125
1	STS62540.189	625	5x125
1	STS70040.189	700	75+5x125
1	STS75040.189	750	6x125
1	STS82540.189	825	75+6x125
1	STS87540.189	875	7x125
1	STS95040.189	950	75+7x125
1	STS100040.189	1000	8x125
1	STS112540.189	1125	9x125
1	STS125040.189	1250	10x125
1	STS137540.189	1375	11x125
1	STS150040.189	1500	12x125
		<b>Reinforced class - Max. 520 V</b>	
		Harmonic pollution 35% < SH/ST ≤ 50%	
		Nominal power (kVAr)	Steps (kVAr)
1	STS.R12040.189	120	40+80
1	STS.R16040.189	160	2x40+80
1	STS.R20040.189	200	40+2x80
1	STS.R24040.189	240	2x40+2x80
1	STS.R28040.189	280	40+3x80
1	STS.R32040.189	320	4x80
1	STS.R36040.189	360	40+4x80
1	STS.R40040.189	400	5x80

Pack	Cat.Nos	<b>SAH type three-phase 400 V - 50 Hz (continued)</b>	
		<b>Reinforced class - Max. 520 V</b>	
		Harmonic pollution 35% < SH/ST ≤ 50%	
		Nominal power (kVAr)	Steps (kVAr)
1	STS.R44040.189	440	80+3x120
1	STS.R48040.189	480	4x120
1	STS.R52040.189	520	2x80+3x120
1	STS.R56040.189	560	80+4x120
1	STS.R60040.189	600	5x120
1	STS.R68040.189	680	80+5x120
1	STS.R72040.189	720	6x120
1	STS.R80040.189	800	80+6x120
1	STS.R84040.189	840	7x120
1	STS.R92040.189	920	80+7x120
1	STS.R96040.189	960	8x120
1	STS.R108040.189	1080	9x120
1	STS.R120040.189	1200	10x120
1	STS.R132040.189	1320	11x120
1	STS.R144040.189	1440	12x120
		<b>Extra-reinforced class - Max. 620 V</b>	
		Harmonic pollution SH/ST > 50%	
		Nominal power (kVAr)	Steps (kVAr)
1	STS.RS.14440.189	144	2x72
1	STS.RS.21640.189	216	3x72
1	STS.RS.28840.189	288	4x72
1	STS.RS.36040.189	360	5x72
1	STS.RS.43240.189	432	6x72
1	STS.RS.50440.189	504	7x72
1	STS.RS.57640.189	576	8x72
1	STS.RS.68440.189	648	9x72
1	STS.RS.72040.189	720	10x72
1	STS.RS.79240.189	792	11x72
1	STS.RS.86440.189	864	12x72



Other powers, voltages, frequencies on request, please consult us

## ■ Dimensions

### Standard type - Three-phase

Cat.Nos	Dimensions (mm)			Weight (Kg)
	Height	Width	Depth	
ST10040	1900	800	500	170
ST12540	1900	800	500	200
ST15040	1900	800	500	210
ST17540	1900	800	500	220
ST20040	1900	800	500	250
ST22540	1900	800	500	260
ST25040	1900	800	500	280
ST27540	1900	800	500	300
ST30040	1900	800	500	320
ST35040	1900	800	500	350
ST40040	1900	800	500	375
ST45040	2100	1000	600	400
ST50040	2100	1000	600	425
ST52540	2100	2000	600	475
ST57540	2100	2000	600	525
ST62540	2100	2000	600	550
ST70040	2100	2000	600	575
ST75040	2100	2000	600	600
ST82540	2100	2000	600	625
ST87540	2100	2000	600	650
ST95040	2100	2000	600	700
ST100040	2100	2000	600	750
ST112540	2100	3000	600	800
ST125040	2100	3000	600	850
ST137540	2100	3000	600	1000
ST150040	2100	3000	600	1200

### H type - Three-phase

Cat.Nos	Dimensions (mm)			Weight (Kg)
	Height	Width	Depth	
STH10040	1900	800	500	170
STH12540	1900	800	500	200
STH15040	1900	800	500	210
STH17540	1900	800	500	220
STH20040	1900	800	500	250
STH22540	1900	800	500	260
STH25040	1900	800	500	280
STH27540	1900	800	500	300
STH30040	1900	800	500	320
STH35040	1900	800	500	350
STH40040	1900	800	500	375
STH45040	2100	1000	600	400
STH50040	2100	1000	600	425
STH52540	2100	2000	600	475
STH57540	2100	2000	600	525
STH62540	2100	2000	600	550
STH70040	2100	2000	600	575
STH75040	2100	2000	600	600
STH82540	2100	2000	600	625
STH87540	2100	2000	600	650
STH95040	2100	2000	600	700
STH100040	2100	2000	600	750
STH112540	2100	3000	600	800
STH125040	2100	3000	600	850
STH137540	2100	3000	600	1000
STH150040	2100	3000	600	1200

## ■ Dimensions (continued)

### SAH type standard class - Three-phase

Cat.Nos	Dimensions (mm)			Weight (Kg)
	Height	Width	Depth	
STS10040.189	1900	800	500	210
STS12540.189	1900	800	500	240
STS15040.189	1900	800	500	280
STS17540.189	1900	800	500	300
STS20040.189	1900	800	500	320
STS22540.189	1900	800	500	360
STS25040.189	1900	800	500	380
STS27540.189	1900	800	500	400
STS30040.189	1900	800	500	430
STS35040.189	1900	800	500	460
STS40040.189	1900	800	500	500
STS45040.189	2100	1000	600	530
STS50040.189	2100	1000	600	630
STS52540.189	2100	2000	600	660
STS57540.189	2100	2000	600	690
STS62540.189	2100	2000	600	720
STS70040.189	2100	2000	600	780
STS75040.189	2100	2000	600	810
STS82540.189	2100	2000	600	840
STS87540.189	2100	2000	600	870
STS95040.189	2100	2000	600	910
STS100040.189	2100	2000	600	930
STS112540.189	2100	3000	600	1000
STS125040.189	2100	3000	600	1100
STS137540.189	2100	3000	600	1200
STS150040.189	2100	3000	600	1300

### SAH type reinforced class - Three-phase

Cat.Nos	Dimensions (mm)			Weight (Kg)
	Height	Width	Depth	
STS.R12040.189	1900	800	500	250
STS.R16040.189	1900	800	500	280
STS.R20040.189	1900	800	500	320
STS.R24040.189	1900	800	500	360
STS.R28040.189	1900	800	500	400
STS.R32040.189	1900	800	500	430
STS.R36040.189	2100	800	500	460
STS.R40040.189	2100	800	500	500
STS.R44040.189	2100	1000	600	530
STS.R48040.189	2100	1000	600	630
STS.R52040.189	2100	2000	600	660
STS.R56040.189	2100	2000	600	690
STS.R60040.189	2100	2000	600	720
STS.R68040.189	2100	2000	600	780
STS.R72040.189	2100	2000	600	810
STS.R80040.189	2100	2000	600	850
STS.R84040.189	2100	2000	600	900
STS.R92040.189	2100	2000	600	930
STS.R96040.189	2100	2000	600	950
STS.R108040.189	2100	3000	600	1000
STS.R120040.189	2100	3000	600	1100
STS.R132040.189	2100	3000	600	1200
STS.R144040.189	2100	3000	600	1300

### SAH type extra-reinforced class - Three-phase

Cat.Nos	Dimensions (mm)			Weight (Kg)
	Height	Width	Depth	
STS.RS.14440.189	2100	1000	600	350
STS.RS.21640.189	2100	1000	600	430
STS.RS.28840.189	2100	1000	600	510
STS.RS.36040.189	2100	2000	600	650
STS.RS.43240.189	2100	2000	600	730
STS.RS.50440.189	2100	2000	600	810
STS.RS.57640.189	2100	2000	600	870
STS.RS.64840.189	2100	3000	600	1000
STS.RS.72040.189	2100	3000	600	1180
STS.RS.79240.189	2100	3000	600	1250
STS.RS.86440.189	2100	3000	600	1310

## Alptec power factor controllers



ALPTEC12.400



ALPTEC 12H

The Alptec power factor controller controls the connection and disconnection of the steps in order to maintain the target power factor. It operates digitally which ensures the accuracy and reliability of the measurements and values read, even on supplies subject to high levels of interference.

Conforming to standard IEC/EN 61010-1

Pack	Cat.Nos	Power factor controllers
		<b>Power supply 400 V - 50 Hz</b>
		Number of steps controlled
1	ALPTEC3.400	3
1	ALPTEC5.400	5
1	ALPTEC7.400	7
1	ALPTEC12.400	12
		<b>Power supply 230 V - 50 Hz</b>
		Number of steps controlled
1	ALPTEC3.230	3
1	ALPTEC5.230	5
1	ALPTEC7.230	7
1	ALPTEC12.230	12
1	ALPTEC 12H	12
1	ALPTEC 11ST	11

## Alptec power factor controllers

### ■ Technical specifications

#### For Alpmatic and Alpistic cabinets

- Digital power factor controller
- LED screen: 3 digits, 7 segments
- Membrane keypad
- RS 232 serial port for setting parameters and automatic testing via a PC
- Internal temperature sensor
- Advanced function for measuring capacitor overvoltages, average over a week
- 1 programmable relay for an alarm and/or controlling a fan

#### Versions

- 3, 5, 7 and 12 controlled steps

#### Temperature class

- Operation: - 10 to + 60°C
- Storage: - 20 to + 80°C

#### Current inputs

- Rated current: 5 A (1 A on request)
- Operating limit: 0.125 A to 6 A
- Input current: 0.65 W
- Not sensitive to the CT polarity
- Not sensitive to the phase rotation polarity

#### Frequency

- 50 Hz/60 Hz

#### Parameters

- Power factor: 0.8 inductive to 0.8 capacitive
- Same step reconnection time: 5 to 240 s
- Manual and automatic mode
- 4 quadrant operation (ALPTEC 12H) for operation on generator
- Internal temperature sensor
- Volt-free contact for remote alarm
- Alarm display (overvoltage, over/under compensation, overload, etc.)

### ■ Dimensions

Cat.Nos	Height x Width x Depth (mm)	Weight (kg)
ALPTEC3.400 ALPTEC3.230	96 x 96 x 65	0.42
ALPTEC5.400 ALPTEC5.230	96 x 96 x 65	0.44
ALPTEC7.400 ALPTEC7.230	96 x 96 x 65	0.46
ALPTEC12.400 ALPTEC12.230	144 x 144 x 65	0.77
ALPTEC12H	144 x 144 x 65	0.98
ALPTEC11ST	144 x 144 x 65	0.98

**↓ TECHNICAL DATA**

Rated line voltage: 400/415V

Rated frequency: 50Hz

Tolerance on inductance: 0/+6%

Dielectric test 50Hz3kV, 60s Protection class: IP 00

Cooling method: natural air (AN)

Ambient temperature: -5 to +40°C

Elevation above sea level: 1000m a.s.l.

Reference standard: IEC 60289 –EN 60289

Insulation class H

Insulation level 1.1kV

Blocking factor p% 7% - Tuning order 3.78

Thermal protection switch (250V, 2.5A) wired on terminal block

**↓ APPLICATION**

The detuned reactors are designed to protect the capacitors against harmonics and avoid parallel resonance and amplification of harmonics flowing on the network. The connection of these reactors in series with capacitors causes a shift of the resonance frequency of the circuit composed by feeding transformer-reactors- capacitors so that the resulting self-resonance frequency is well below the line harmonics

The blocking factor p% is expressed by the ratio between inductive reactance and capacitive reactance it corresponds to the increase of voltage applied to capacitors, with respect to line voltage, due to circulation of capacitive current in the reactor

**↓ CONSTRUCTION**

The windings of reactors are made by copper or aluminium wire (insulated by class H double-layer enamel or by double Nomex tape) The reactor is protected by a vacuum and pressure impregnation (VPI) by solventless polyester resin, followed by thermosetting in oven

The number and position of air gaps are selected in order to minimise losses in magnetic core and windings  
Limbs, yokes and air-gaps are blocked by adhesives and pressing elements designed to reduce acoustic noise  
The reactors are designed with natural air cooling

## detuned reactors - product range (suite)

### ↓ INSTALLATION

It will be responsibility of the installer to comply with the national and international installation standards

The reactors operate properly only under the specified conditions:

- Storage and transportation temperature : -25°C / +70 °C
- Selection of the right type according to harmonic pollution
- In operation an adequate air circulation has to be guaranteed
- Windings must be installed vertically for better heat dissipation
- The reactor must be protected against overloads and short-circuits by fuses and/or circuit breakers.
- Suitable protection against undesired contacts (IP00) must be provided by means of enclosures or boxes protecting the power system where the reactor is installed
- It is imperative to that the thermal N.C dry contact be connected in series with the contactor coil, in order to disconnect the step in case of overheating
- This range of detuned reactors can not be connected with standard capacitors. It must be connected with appropriate H type capacitors selected by our service (see selection table)

Available upon request :

- Ambient temperature higher than 40°C
- Other voltages (example 220V, 440V) lower than 1000V
- Other frequencies (example 60Hz)
- Other blocking factor p% : 5.67% ( tuning frequency 215Hz) - 13.7% ( tuning frequency 135Hz)

### ↓ TECHNICAL CHARACTERISTICS

#### DETUNED THREE-PHASE REACTORS 400V, 50 Hz

Tuning frequency 189Hz (p%=7 – n= 3.78)  
Standard Class designed for harmonic level 25% < SH/ST < 35%

Q (kVAr)	Capacitor part number	Ln (mH)	I <sub>RMS</sub> (A)	Part Number	Ptot (W)
12.5	VH12.540	2.85	21	SAH-2.85-21	100
25	VH2540	1.45	42	SAH-1.45-42	160
50	VH5040	0.72	83	SAH-0.72-83	230
75	VH7540	0.48	123	SAH-0.48-123	320

Tuning frequency 189Hz (p%=7 – n=3.78)  
Reinforced Class designed for harmonic level 35% < SH/ST < 50%

Q (kVAr)	Capacitor part number	Ln (mH)	I <sub>RMS</sub> (A)	Part Number	Ptot (W)
20	VH2040	1.78	38	SAH-1.78-38	200
40	VH4040	0.9	75	SAH-0.9-75	280
80	VH8040	0.45	150	SAH-0.45-150	380

Nota: If the ratio SH/ST is between the 2 values given in the table then you must select the most restricting alternative

p% : blocking factor, it is expressed by the percentage ratio between inductive reactance and capacitive reactance ( $p = X_L / X_C \times 100$ )

It is related to the resonance frequency (fris) of the system by the formula: 
$$fris = 50 \times \sqrt{\frac{100}{p\%}}$$

Q : compensation reactive power (KVAR)

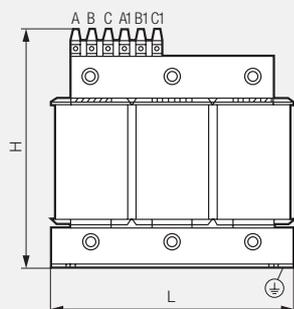
Ln : rated inductance, expressed in mH.

I<sub>RMS</sub> : current, expressed in A. It is given by the formula: 
$$I_{RMS} = \sqrt{1.075 \times I_1^2 + I_5^2 + I_7^2 + \dots}$$

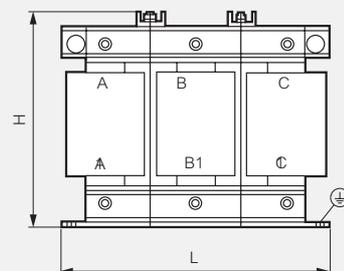
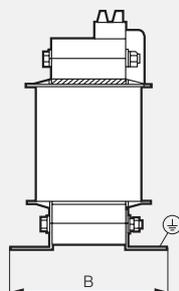
where I<sub>5</sub> is the rms value of the 5<sup>th</sup> harmonic current, I<sub>7</sub> of the 7<sup>th</sup> harmonic...

Ptot : total losses, including additional losses due to harmonics, expressed in W and referred to 75°C

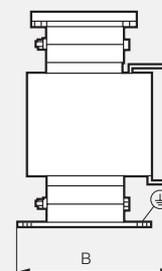
## ↓ TECHNICAL CHARACTERISTICS (CONTINUED)



T. Block



Aluminium bars



### DETUNED THREE-PHASE REACTORS 400V, 50 Hz

Tuning frequency 189Hz ( $p\%=7 - n=3.78$ )  
Standard Class designed for harmonic level  $25\% < SH/ST < 35\%$

Part Number	Dimensions (mm)			Weight (Kg)
	L	B	H	
SAH-2.85-21	160	130	170	7
SAH-1.45-42	240	160	220	13
SAH-0.72-83	240	160	240	20
SAH-0.48-123	240	160	240	26

Tuning frequency 189Hz ( $p\%=7 - n=3.78$ )  
Reinforced Class designed for harmonic level  $35\% < SH/ST < 50\%$

Part Number	Dimensions (mm)			Weight (Kg)
	L	B	H	
SAH-1.78-38	240	160	240	16
SAH-0.9-75	240	200	240	25
SAH-0.45-150	240	220	240	33

## protective circuit breakers and connection cables for capacitors

### circuit breaker selection chart

THREE-PHASE 400 V CAPACITOR nominal power (kVAr)	3P circuit breaker rating/thermal setting (A)	CABLES min. cross-section/phase	
		Cu (mm <sup>2</sup> )	Al (mm <sup>2</sup> )
10	20/20	6	10
20	40/40	10	16
30	63/60	16	25
40	80/80	25	35
50	100/100	35	50
60	125/125	35	50
70	160/140	35	50
80	160/160	50	70
90	200/180	50	70
100	200/200	70	95
125	250/250	70	95
150	400/300	95	120
175	400/350	120	185
200	400/400	150	240
225	630/450	150	240
250	630/500	185	2 x 120
275	630/550	185	2 x 120
300	630/600	2 x 95	2 x 150
325	630/630	2 x 95	2 x 150
350	800/700	2 x 120	2 x 185
375	800/750	2 x 120	2 x 185
400	800/800	2 x 150	2 x 240
450	1000/900	2 x 150	2 x 240
500	1000/1000	2 x 185	4 x 150
550	1250/1100	2 x 185	4 x 150
600	1250/1200	4 x 120	4 x 185
650	1250/1250	4 x 120	4 x 185
700	1600/1400	4 x 150	4 x 240
750	1600/1500	4 x 150	4 x 240
800	1600/1600	4 x 150	4 x 240
850	2000/1700	4 x 150	4 x 240
900	2000/1800	4 x 150	4 x 240
950	2000/1900	4 x 185	4 x 300
1000	2000/2000	4 x 185	4 x 300

Note: The cable cross-sections given in this table are minimum recommended cross-sections. They do not take additional correction factors into account (method of installation, temperature, long lengths, etc.). The calculations are for single pole cables fitted at an ambient temperature of 30°C



↓ **SPECIAL PRODUCTS**

The ALPIVAR<sup>2</sup>, ALPIBLOC, ALPIMATIC and ALPISTATIC ranges are the most widely used standard ranges

All these products can be made for other electrical characteristics (frequencies, voltages, powers, connections, etc.), and in particular:

- 60 Hz and other frequencies for a wide range of applications
- Single phase voltages
- Dual voltage with retained power
- Other standard voltages: 240 - 415 - 480 - 500 - 530 - 550 - 600 - 690 - 800 V, etc.
- Other power ratings on request (please consult us)



↓ **NETWORK AUDIT**

Your mains supplies are subject to interference from numerous electrical phenomena

A simple one-off check is no longer enough to give you a true image of your installation

The Legrand audit provides you with an analysis of the behaviour of your mains supply over one week

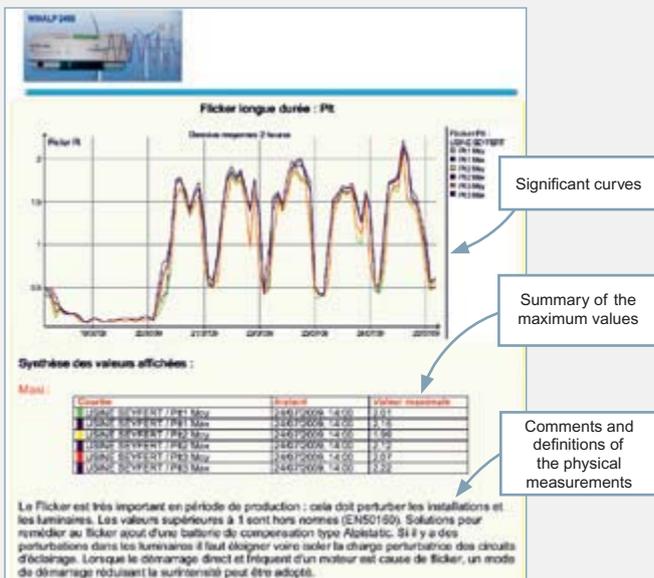
We take readings from the analyser installed in your company via a GSM modem

Our experts provide you with a report clearly setting out the essential phenomena of your electrical installation

The audit that is performed:

- Shows up faults on the mains supply
- Enables the reactive energy compensation to be sized
- Provides guidance on the selection of energy supply solutions (filtering, sizing of the transformer, capacitor banks)

Example of a report page:



↓ **DESIGN SOFTWARE**

LOGIALPES capacitor bank design software

This is very user-friendly and can be used to define the right capacitor bank for your installations in just few clicks



You can download it from: [www.alpestechnologies.com](http://www.alpestechnologies.com)

## network analysers Alptec 2444, Alptec 2333

On industrial sites, for renewable energies, energy suppliers



RBAA001.1



RBAD001.1



RDAB002

Alptec 2444 and Alptec 2333 network analysers are used for real-time, simultaneous monitoring of all electrical parameters:

- Dips, overvoltages and interruptions
- Flicker
- Waveforms (200 points per period) recorded on events
- Active, reactive and apparent powers
- Power factors, tangents and peak factors
- Static rms measurements
- 51 harmonic orders

Pack	Cat.Nos	Alptec 2444 quality analysers
		<p>Power supply: 190-264 V<math>\sim</math> / 240-360 V<math>\sim</math> (48 V<math>\sim</math> and 127 V<math>\sim</math> supply available on request)</p> <p>The following values are measured and recorded on a Compact Flash card:</p> <ul style="list-style-type: none"> <li>- Dips, overvoltages and distortions</li> <li>- Reports on quality of current</li> <li>- Flicker (Pst, Plt acc. to IEC 61000-4-7)</li> <li>- 51 harmonics and inter-harmonics (voltage and current)</li> <li>- Unbalance</li> <li>- Conventional values (U, I, P, Q, S, D, PF, THD U and THD I)</li> </ul> <p>Communication methods: USB, Ethernet and RTC modem (GSM and IP modem available on request)</p> <p>Supplied with:</p> <ul style="list-style-type: none"> <li>- Backup battery (standalone operation: 30 minutes minimum)</li> <li>- 512 Mb Flash memory card</li> <li>- RS 232 cable</li> <li>- USB cable</li> </ul>
1	RBAA001.1	<p><b>Alptec 2444d - For mounting on DIN rail</b></p> <p>For permanent installation Measurement: 4 voltages and 4 currents with galvanic insulation Input: screw terminal blocks</p>
1	RBAD001.1	<p><b>Alptec 2444i - portable</b></p> <p>For temporary installation Portable device Measurement: 4 voltages and 4 currents Quick connectors Supplied with:</p> <ul style="list-style-type: none"> <li>- Voltage clamps</li> <li>- Current clamps (100 A/1 Vrms)</li> <li>- Carrying case</li> </ul>

Pack	Cat.Nos	Alptec quality analysers - IP 54
1	RDAB002	<p>Power supply: 215-600 V<math>\sim</math> three-phase or 125-325 V<math>\sim</math> single phase Portable device The following values are measured and recorded:</p> <ul style="list-style-type: none"> <li>- Dips, overvoltages and distortions</li> <li>- Report on quality of current</li> <li>- Flicker (Pst, Plt acc. to IEC 61000-4-7)</li> <li>- 51 harmonics and inter-harmonics (voltage and current)</li> <li>- Symmetrical values, unbalance</li> <li>- Conventional values (U, I, P, Q, S, D, PF, THD U and THD I)</li> </ul> <p>Communication method: USB Measurement: 3 voltages and 3 currents Supplied with:</p> <ul style="list-style-type: none"> <li>- Backup battery (minimum standalone operation: 45 minutes)</li> <li>- Memory capacity 1 Gb</li> <li>- USB cable</li> <li>- 3 voltage clamps</li> <li>- 3 current clamps (100 A/1 Vrms)</li> <li>- Carrying case</li> </ul>
1	RBAT001	<p><b>Winalp 2400 software</b></p> <p>For downloading, storing and comparing data from the whole range of Alptec current quality analysers, so that the data can then be analysed and reports printed out Compatible with:</p> <ul style="list-style-type: none"> <li>- Win98</li> <li>- Win NT4</li> <li>- Windows millennium</li> <li>- Windows XP</li> <li>- Windows Vista</li> </ul>

Pack	Cat.Nos	Accessories
3	RBAE016	<p><b>Clamps</b></p> <p>10 A micro-clamps Supplied with a 2 m cable</p>
3	RBAG007	<p>Adjustable clamp: 10 A/100 A/1000 A Supplied with a 2 m cable</p>
3	RBAE017	<p><b>Alpflex flexible clamp</b></p> <p>Adjustable flexible clamp: 3 kA/1 kA/300 A Supplied with a 3 m cable</p>
3	RBAE006	<p><b>Novafax 56000 modem</b></p> <p>Modem for downloading data at 56 kbps</p>



48 V $\sim$  and 127 V $\sim$  electricity supply, GSM and IP modem: please consult us

# Medium voltage compensation



## MAIN ADVANTAGES OF THE MEDIUM VOLTAGE RANGE

> Synthetic **"all-film"** type dielectric capacitors have numerous advantages, the most important of which are: a long service life and excellent thermal stability linked to very low power losses. The remarkable chemical stability of the liquid dielectric gives a high transient overcurrent and overvoltage absorption capacity and a very low variation of capacitance as a function of temperature.

> The ranges of medium voltage capacitors and capacitor banks complete the offer, providing fixed or automatic solutions, with or without harmonic filters.

► **MEDIUM VOLTAGE CAPACITORS**

(See p. 52 - 59)



"All-film" medium voltage capacitors  
p. 52-54

Capacitors for induction furnaces  
p. 55

Protection of "all-film" MV capacitors  
p. 56-58

"All-film" MV capacitor installation conditions  
p. 58

Dimensions and weights of "all-film" MV capacitors  
p. 59

► **MEDIUM VOLTAGE CAPACITOR BANKS**

(See p. 60 - 63)



Medium voltage capacitor banks  
p. 60

Wiring medium voltage capacitor banks  
p. 61

Built-in electrical protection devices  
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Additional accessories, operating and protection devices  
p. 62-63

► **RACKS AND CUBICLES FOR MV CAPACITOR BANKS**

(See p. 64 - 68)



Racks and cubicles for capacitor banks  
p. 64

Installation examples:  
fixed type - delta configuration  
p. 65

Installation examples: fixed type with  
contactors - delta configuration  
p. 66

Installation examples: fixed type - double  
star configuration  
p. 67-68

**ENERGY COMPENSATION PRINCIPLES & OTHER RANGES**

**General information**  
See p. 4-19

**Low voltage energy compensation**  
See p. 20 - 49

# Electrical characteristics of medium voltage capacitors

## "ALL-FILM" MEDIUM VOLTAGE CAPACITORS

MEDIUM VOLTAGE RANGE



External view of an "all-film" MV capacitor

1. Connection
2. Porcelain terminal
3. Fixing lug
4. Stainless steel case
5. Active part

Medium voltage capacitors are composed of elementary or partial capacitances, generally connected in several series-parallel groups, providing the required electrical characteristics for the unit.

- The nominal voltage of a capacitor depends on the number of groups in series
- The nominal power of a capacitor depends on the number of partial capacitances in parallel per group

Each elementary capacitance is made of two sheets of aluminium foil forming the reinforcements or the electrodes and special high quality polypropylene film which is rough to assist impregnation, forming part of the insulation.

This wired capacitance assembly, referred to as the "active part", is positioned in a stainless steel case, which has insulated porcelain terminals or bushings at the top for connecting the device.

After the "active part" has been dried and treated, is impregnated under vacuum with a liquid dielectric of the following type:

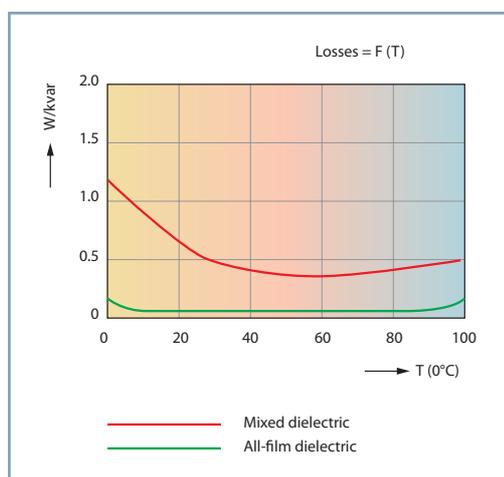
- Non-chlorinated
- Non-toxic
- Biodegradable

With the polypropylene film, this liquid dielectric, which has a remarkably high chemical stability, a high gas absorption capacity and a high partial discharge extinction capacity (discharges for which the flash point is approximately 150°C), ensures total insulation between electrodes. This "all-film" capacitor technology has the following main characteristics:

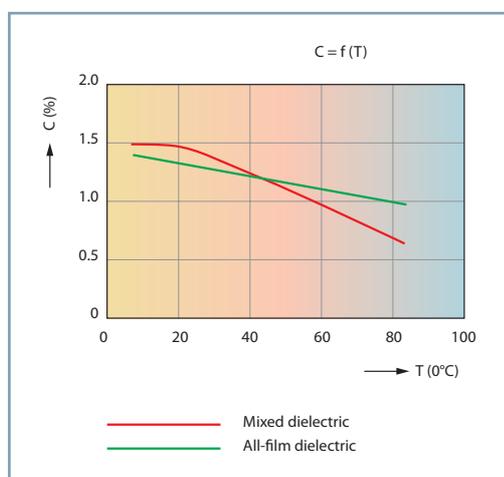
- Excellent resistance to strong electrical fields
- Very low power losses, leading to considerable savings for high power capacitor banks

## "ALL-FILM" MV CAPACITORS (CONTINUED)

### Variation of the W/kVAr losses as a function of the temperature



### Variation of the capacitance C (μF) as a function of the temperature



In comparison with the previous generation of "mixed" type dielectric (paper + film) capacitors, synthetic "all-film" type dielectric capacitors have a much longer service life, due to:

- Their excellent thermal stability related to very low power losses, due to the removal of the paper
- The remarkable chemical stability of the liquid dielectric, giving:
  - A high partial discharge absorption capacity
  - High dielectric resistance to transient overcurrents and overvoltages
  - A very low variation of capacitance as a function of temperature

- **Average loss factor:**

- 0.15 W/kVAr at power-up
- 0.1 W/kVAr after 500 hours' operation

- **Variation of the capacitance as a function of the temperature:**

- Average:  $2 \times 10^{-4}/^{\circ}\text{C}$ .

- **Internal discharge device:**

- Internal discharge resistors reducing the residual voltage to 75 V in 10 minutes after disconnection of the supply

- **Frequency:**

- Standard: 50 Hz (60 Hz on request)

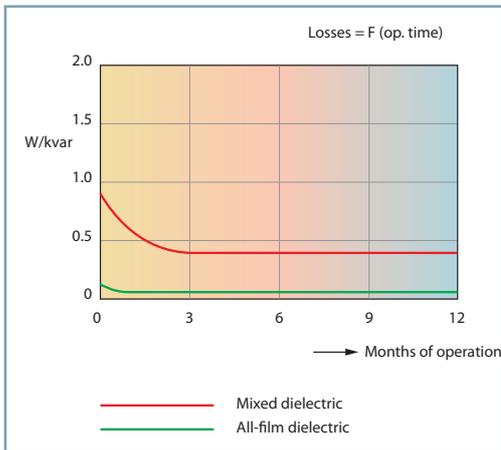
- **Reference standards:**

- French: C 54 102
- International:
  - \* IEC 60 871.1 and 2 (supply capacitors)
  - \* IEC 60 110 (capacitors for air or water cooled induction furnaces)
- German: VDE 0560/4, VDE 0560/9
- British: BS 1650
- Other standards on request

# Electrical characteristics of medium voltage capacitors (continued)

## "ALL-FILM" MEDIUM VOLTAGE CAPACITORS (CONTINUED)

Variation of the W/kVAr losses as a function of the operating time



### • Permissible overloads

- Current: 1.3 I nominal continuously
- Voltage (between terminals):
  - 1.1 U nominal, 12 hours in every 24 hours
  - 1.15 U nominal, 30 minutes in every 24 hours
  - 1.2 U nominal, 5 minutes in every 24 hours
  - 1.3 U nominal, 1 minute in every 24 hours

### • Standard insulation levels (phases/earth) for individual capacitors

- Highest voltage for equipment $U_m$ (rms) (kV)					
2.4	3.6	7.2	12	17.5	24

- Test voltage at industrial frequency (duration: 10 seconds) (kV)					
8	10	20	28	38	50

- Lightning impulse withstand voltage (peak value) (kV)					
35	40	60	75	95	125



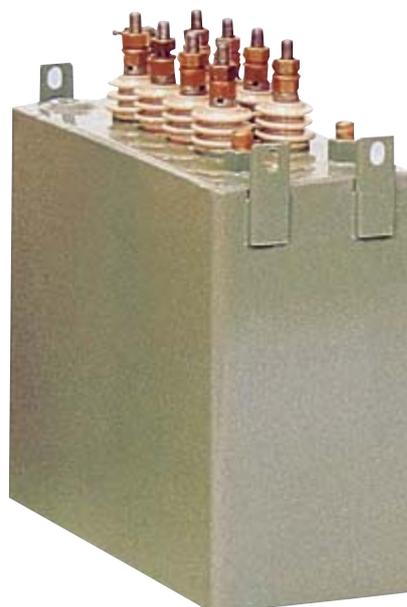
### • Individual tests

- Measurement of capacitance and losses
- Voltage test between terminals, i.e.:
  - 2 U nominal, 10 s. AC voltage
  - 4 U nominal, 10 s. DC voltage
- Voltage test between joined terminals and earth at industrial frequency
- Test of discharge device and seal-tightness of the case.

## CAPACITORS FOR INDUCTION FURNACES

Legrand offers a range of special capacitors for the compensation and balancing of induction furnaces. These capacitors are custom designed according to the requirements and characteristics of the installation.

- Capacitors complying with standard IEC 60110
- "All-film" dielectric
- Biodegradable impregnating agent
- With or without internal discharge resistor
- Possible internal protection devices:
  - Internal fuses
  - Pressure monitoring device
  - Thermostat
- Frequency range: 50 Hz to 200 kHz
- Voltage range: 50 V to 3000 V
- Air or water cooled according to frequency
- Multiple outputs possible



Water-cooled capacitor for medium frequency induction furnaces



Please consult us for a costed design

# Electrical characteristics of medium voltage capacitors (continued)

## PROTECTION DEVICES FOR "ALL-FILM" MV CAPACITORS

### > Protection using internal fuses

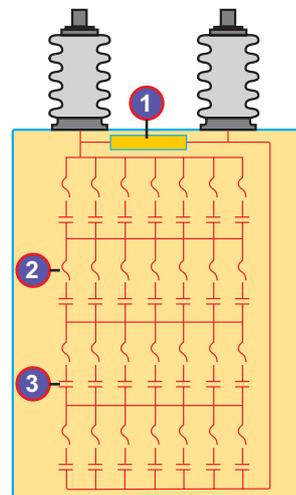
Due to the advantages they provide, internal fuses are the most frequently used means of protecting "all-film" MV capacitors.

In this technology, each elementary capacitance forming the capacitor is protected by its own internal fuse.

When there is a fault on an elementary capacitance, the internal fuse eliminates the corresponding capacitance and the continuity of service of the capacitor is assured.

Given the large number of elementary capacitances that make up the device, the loss of power resulting from the first fault is negligible (less than 2%). The external unbalance protection will only be activated if there is a large number of "broken down" elementary capacitances in one capacitor which will create an unbalance. The operation of an internal fuse is activated:

- When the voltage of the capacitor reaches its maximum value, and therefore the current reaches its minimum value, the voltage difference at the terminals of the "faulty" elementary capacitance will trigger the blow-out of the corresponding fuse.
- When the current reaches its maximum value, and therefore the voltage reaches its minimum value, the flow of the energy stored in the parallel operational capacitances in the "faulty" capacitance will trigger the blow-out of the corresponding fuse.



Internal view of an "all-film" MV capacitor with internal fuses

1. Discharge resistor
2. Internal fuse
3. Elementary capacitance

## PROTECTION DEVICES FOR "ALL-FILM" MV CAPACITORS (continued)

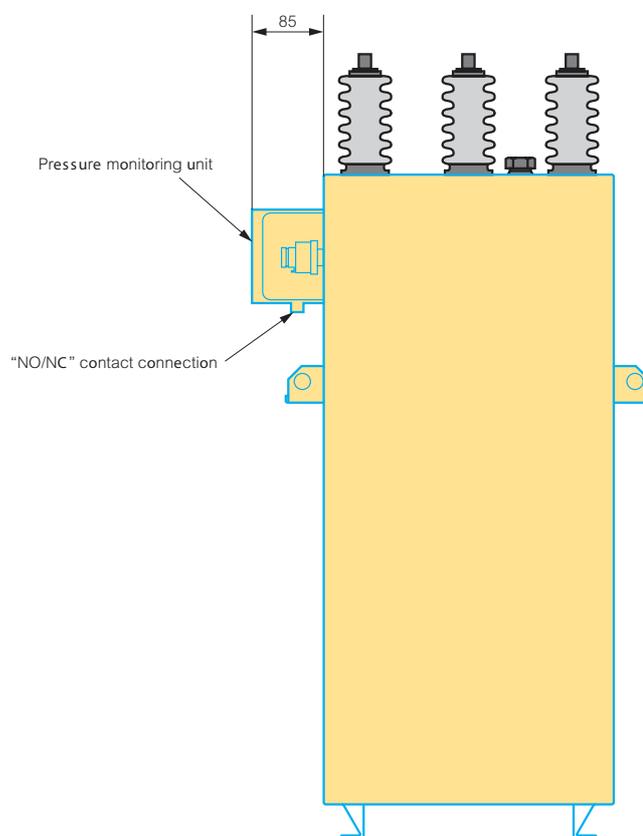
### > Protection by pressure monitoring device

Protection by means of a pressure monitoring device is useful if the capacitor cannot be protected correctly using internal fuses or by unbalance monitoring (due to electrical characteristics or cost problems).

This protection is individual to each capacitor.

It consists of a pressure switch that is hermetically sealed onto the capacitor case.

This pressure switch consists of a "membrane" that is sensitive to the increase in pressure generated in the case if there are breakdowns of the elementary capacitances, and an NC/NO contact which trips the banks's operating device (contactor - switch, etc.)



# Electrical characteristics of medium voltage capacitors (continued)

## PROTECTION DEVICES FOR "ALL-FILM" MV CAPACITORS (continued)

There are four protection options for "all-film" MV capacitors:

- **Without internal fuses** and external protection by unbalance monitoring
- **With internal fuses** and external protection by unbalance monitoring
- **Without pressure monitoring device** and external protection by HRC fuses
- **With pressure monitoring device** and external protection by HRC fuses

The choice between these four options is dependent on the following criteria:

- Electrical characteristics of the capacitor (power, voltage, connection)
- Customer's requirements concerning the sensitivity of the protection device

The following table gives the possible type of protection for the capacitor and its advantages, according to the above criteria.

Capacitor power and voltage	Capacitor connection	Capacitor protection	Associated external protection	Advantages
All powers and all voltages	Single phase	Without internal fuse	Unbalance	
$P \geq 200$ kVAr and $U \leq 13$ kV	Single phase	With internal fuses	Unbalance	<ul style="list-style-type: none"> <li>• Does not trip on 1st fault</li> <li>• Assured continuity of service</li> </ul>
All powers and $U \leq 12$ kV	Three-phase	Without pressure monitoring device	HRC fuses	
All powers and $U \leq 12$ kV	Three-phase	With pressure monitoring device	HRC fuses	<ul style="list-style-type: none"> <li>• No risk of rupture of case</li> </ul>

## INSTALLATION CONDITIONS FOR "ALL-FILM" MV CAPACITORS

### > Temperature class

- Standard: - 25/+ 45°C:
  - 45°C average over 1 hour
  - 40°C average over 24 hours
  - 30°C average over 1 year

### > Compatibility with the environment

- "All-film" capacitors are impregnated with a (PCB-free) biodegradable liquid dielectric. Their installation does not require any particular precautions with regard to the environment.

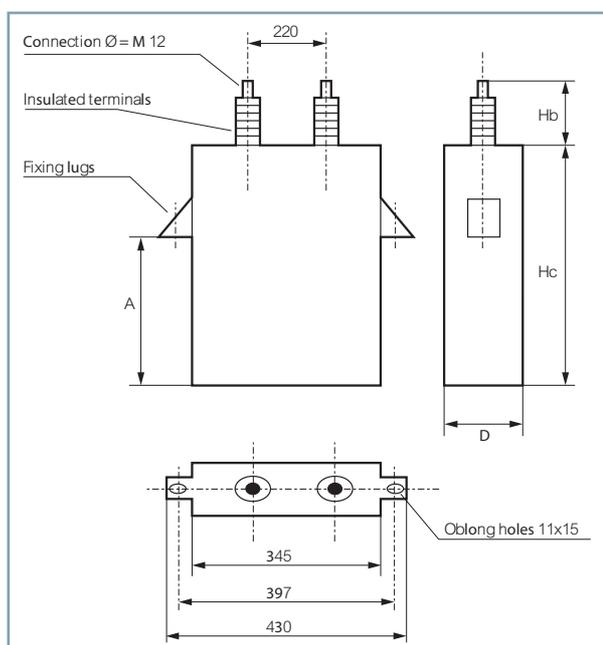
### > Protection against corrosion

- Installation possible: indoor or outdoor
- Stainless steel case, with one coat of primer and several top coats (RAL 7033)



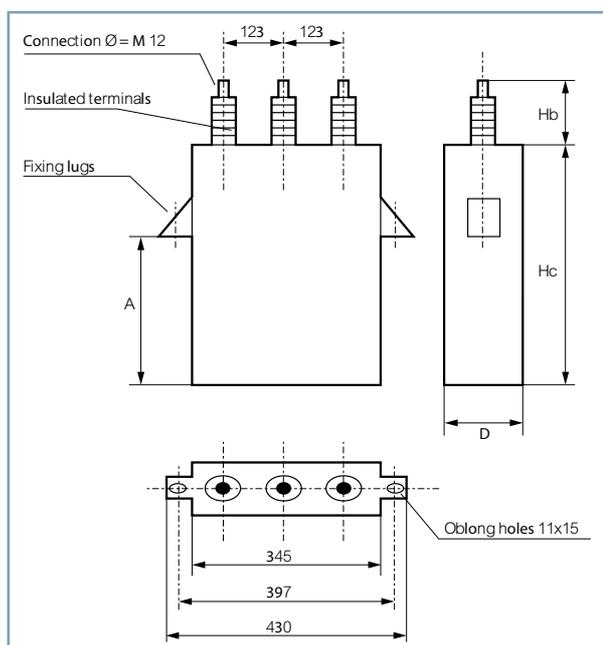
**Other temperature classes on request, please consult us**

## DIMENSIONS AND WEIGHTS OF "ALL-FILM" MV CAPACITORS



Power (standard) kVAr	Dimensions, for information purposes (mm)			Weight (kg)
	Hc	A	D	
50	190	40	135	17
75	250	100	135	21
100	280	130	135	23
125	350	200	135	27
150	370	220	135	30
175	450	300	135	33
200	460	310	135	35
250	460	310	135	42
300	510	360	175	46
350	590	440	175	53
400	650	400	175	60
450	730	480	175	65
500	790	540	175	70
550	880	630	175	76
600	950	700	175	82

Note: Given the multiplicity of MV capacitor voltages, these dimensions must be confirmed by our technical departments.



Hb Indoor type (mm)	Hb Outdoor type (mm)	Um rms kV
75	235	2.4
160	235	3.6
160	235	7.2
160	235	12
235	235	17.5
265	265	24

Note: The Um rms voltage to be taken into account is the voltage of the mains supply to which the capacitor is to be connected, and not the nominal voltage of the unit (applies in particular to single phase capacitors wired in star or double star configurations).

# Medium voltage capacitor banks

## TYPES OF CAPACITOR BANKS



A capacitor bank is generally made up of several individual single phase or three-phase capacitors, assembled together and interconnected to create high power assemblies called "capacitor banks".

LEGRAND designs and manufactures various different types of capacitor banks, defined by:

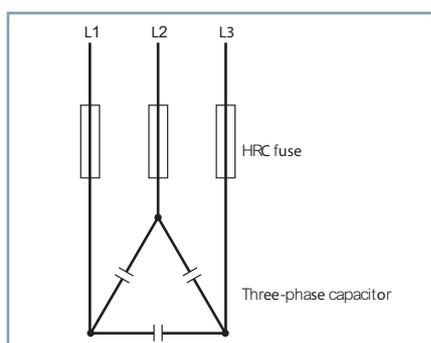
- The total reactive power to be installed
- The nominal supply voltage
- The electrical requirements:
  - Presence of harmonics
  - Automatic capacitor banks with power factor controller
- Installation
  - Indoor (in an electrical room)
  - Outdoor (in an electrical substation)
- Operator safety
  - IP 00 open rack
  - IP 21 - IK 05 cubicle (indoor installation)
  - IP 23 - IK 05 cubicle (outdoor installation)



## WIRING CAPACITOR BANKS

### Wiring MV capacitor banks

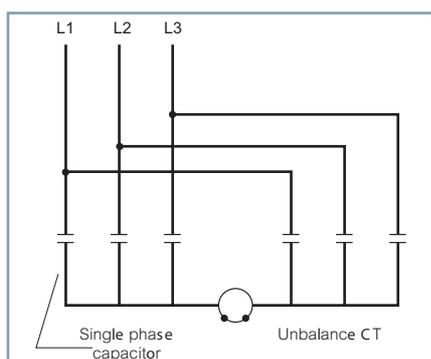
The "all-film" MV capacitor is generally a single phase unit (or three-phase for max. voltages of 12 kV). There are several wiring or connection methods for combining individual capacitors to create high power capacitor banks.



- Delta wiring

This type of wiring is used for low power capacitor banks and those with a nominal voltage of less than 12 kV.

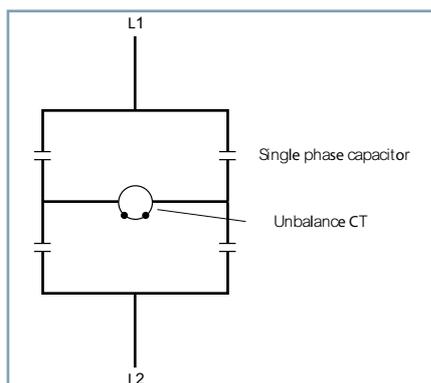
These capacitor banks are mainly intended for direct compensation at the terminals of MV motors. The capacitor(s) are generally three-phase.



- Double star wiring

The type of wiring is suitable for capacitor banks of all powers and voltages (in this case single phase capacitors are subject to phase-to-neutral voltage).

An unbalance protection device (transformer and current relay) continuously monitors the unbalance, between two neutral points, and if there is an internal fault in a capacitor it triggers the opening of the bank's operating device.



- H wiring

This type of wiring is intended for high power single phase MV capacitor banks and three-phase MV capacitor banks. For three-phase capacitor banks, the unbalance is monitored on each phase.

This unbalance monitoring system applies to both star and delta capacitor banks.

# Capacitor banks (continued)

## BUILT-IN ELECTRICAL PROTECTION DEVICES

In addition to the protection devices specific to each capacitor (internal fuses or pressure monitoring devices), other accessories must be used and an associated external protection device incorporated in the capacitor bank. The most commonly used external protection devices are:

- HRC fuses
- Unbalance or differential protection

### > HRC fuses

Protection using HRC fuses integrated in the capacitor bank is ideal (technically and economically) for capacitor banks with the following characteristics:

- Low power (< 1000 kVAr)
- Those equipped with three-phase connection capacitors (see delta wiring, p. 57)
- Supply voltage less than 12 kV

The rating of the HRC fuses will be selected to have a value between 1.7 and 2.2 times the nominal current of the capacitor bank.

HRC fuse blow-outs are generally caused by a short circuit inside the capacitor.

### > Unbalance or differential protection

This protection generally applies to capacitor banks with the following characteristics:

- Medium or high power (> 1000 kVAr)
- Those with single phase connection capacitors
- Supply voltage greater than 12 kV

Unbalance or differential protection is sensitive, capable of detecting and reacting to a partial fault in a capacitor.

It consists of a current transformer connected between two electrically balanced points, combined with a current relay. When there is a fault in a capacitor there is an unbalance and therefore a current circulating in the current transformer, which will cause, by means of the relay, the banks' operating device (circuit breaker, switch, contactor, etc.) to open.

## ADDITIONAL ACCESSORIES

### > Quick discharge reactors

Installing two quick discharge reactors or voltage transformers between the phases of the capacitor bank reduces the capacitor discharge time from 10 minutes to approximately 10 seconds.

This reduced discharge time:

- Provides safety for staff when carrying out work
- Reduces waiting time before earthing (closing of the earthing switch)
- Makes it possible to reactivate the capacitor banks in steps more quickly after breaking, although a minimum time of 30 minutes between two discharges is essential, to ensure correct cooling of the reactors.

### > Damping reactors

Installing single phase damping reactors in series on each phase of the capacitor bank makes it possible to reduce the switching currents to values that are acceptable for the corresponding operating device.

These are necessary in the following situations:

- Step capacitor banks
- Very high mains short-circuit power in relation to the power of the capacitor bank to be connected
- Frequent control operations of the capacitor bank

## ADDITIONAL ACCESSORIES (CONTINUED)

### > Detuned reactors

For mains supplies with a high level of harmonic interference, installing a detuned reactor, generally three-phase and connected in series with the capacitor bank, is the only effective protection.

The detuned reactor performs a dual role:

- Increasing the impedance of the capacitor in relation to the harmonic currents
- Shifting the parallel resonance frequency of the source and the capacitor to below the main frequencies of the harmonic currents that are causing interference

Note: The detuned reactor also performs the functions of a damping reactor.

### > Contactor

The installation of a contactor at the input of the capacitor bank enables it to be controlled by a PLC or a regulation system (for example a power factor controller).

This contactor is designed to switch capacitive currents and is generally of vacuum type.

A contactor must always be used with three damping reactors, or a detuned reactor in order to damp the inrush currents.

### > Other possible components:

- Earthing switch
- Switch (optionally motorised)
- Circuit switch (optionally motorised)
- Power factor controller to control automatic capacitor banks

## OPERATING AND PROTECTION DEVICES

The operating and protection equipment (circuit breaker, fuse, switch, contactor) of a medium voltage capacitor bank must take the following three requirements into account:

- Capacity to withstand high transient currents when activated
- Capacity to ensure breaking on opening without restrike (at the moment of breaking, the capacitor bank may be loaded at full voltage)

- Capacity to withstand a permanent rms current corresponding to at least 1.43 times the nominal 50 Hz current of the capacitor bank in steady state.

Vacuum switch operating devices, or those in the SF<sub>6</sub>, are ideal for operating and protecting capacitor banks.

The LEGRAND Technical Departments can advise you on the selection of a suitable operating and protection device for your capacitor bank.

# Racks and cubicles for capacitor banks

## COMPOSITION

Possible components of medium voltage capacitor banks:

- Capacitors
- Additional accessories (discharge reactors, damping reactors and detuned reactors)
- Built-in electrical protection devices (HRC fuses, unbalance protection devices, etc.)
- Operating devices (circuit breakers, switches, contactors, etc.)
- Power factor controllers for automatic capacitor banks

They can be fitted and wired:

- On open racks (IP 00)
- In cubicles (IP 21 or IP 23 - IK 05) (other degrees of protection on request).

These assemblies are designed for:

- **Indoor type** installation
- **Outdoor type** installation

LEGRAND offers various standard or specific equipment to meet your requirements.

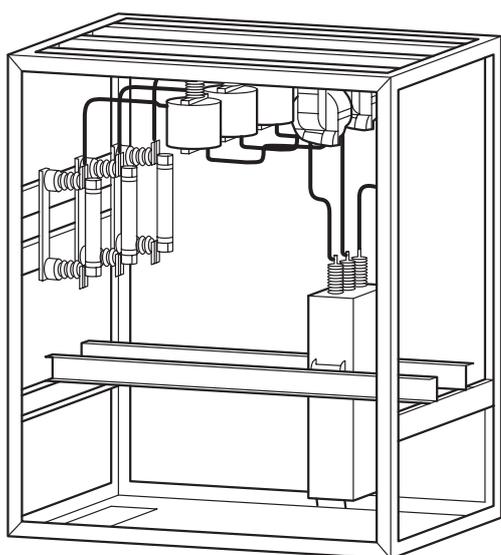


## INSTALLATION EXAMPLES

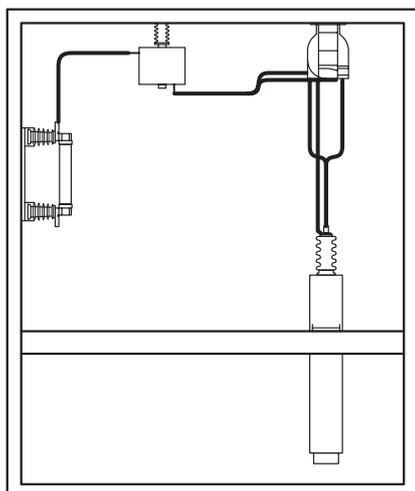
### > Fixed type - Delta configuration

- Max. voltage: 12 kV
- Max. power: 2500 kVAr
- Installation: indoor or outdoor

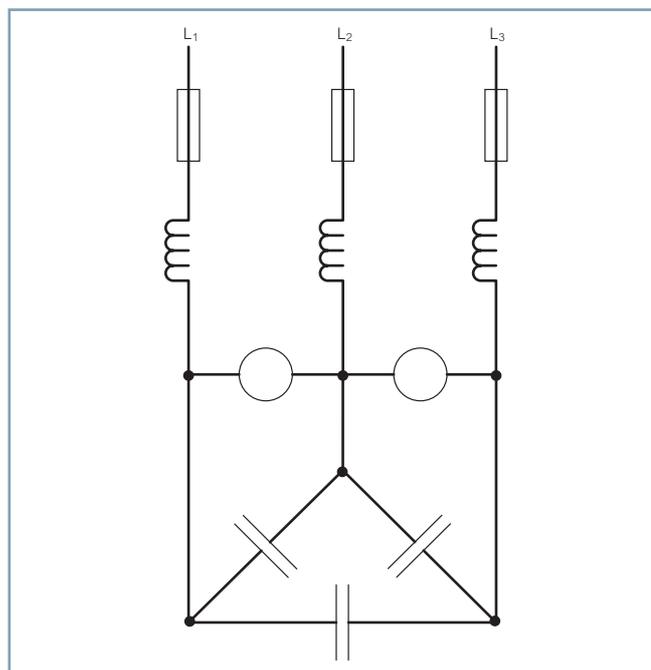
- Possible components: damping reactors, discharge reactors, HRC fuses, earthing switch, detuned reactor, etc.
- Max. dimensions (mm): 2000 x 2000 H = 2200



Example of assembly



Example of electrical diagram



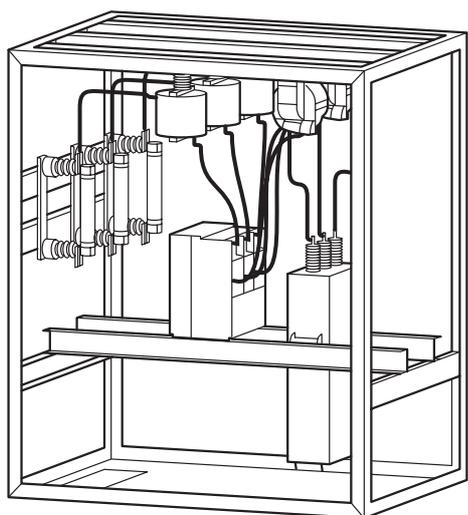
# Racks and cubicles for capacitor banks (continued)

## INSTALLATION EXAMPLES

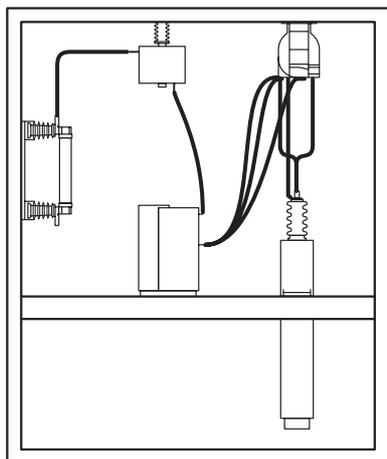
### > Fixed type with contactors – Delta configuration

- Max. voltage: 12 kV
- Max. power: 2500 kVAr
- Installation: indoor or outdoor

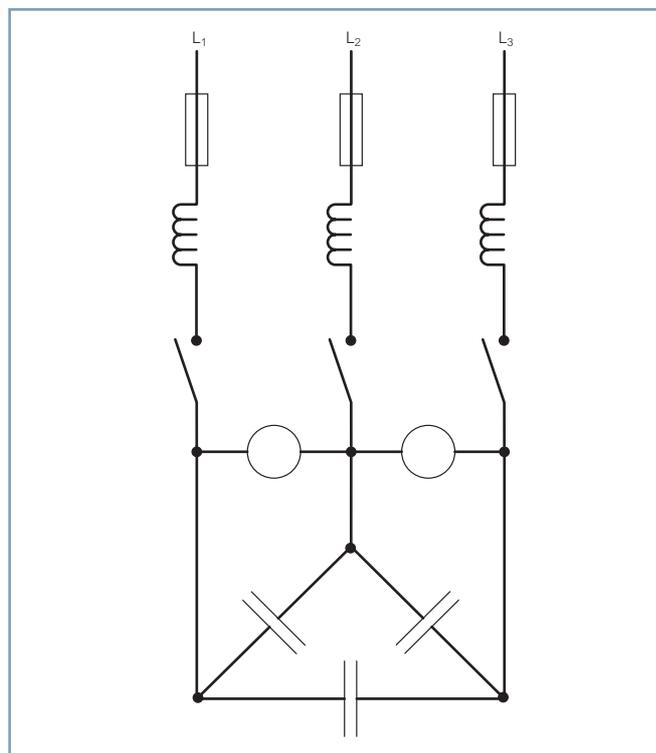
- Possible components: damping reactors, discharge reactors, contactors, HRC fuses, power factor relays, detuned reactor, etc.
- Max. dimensions (mm): 2000 x 2000 H = 2200



Example of assembly

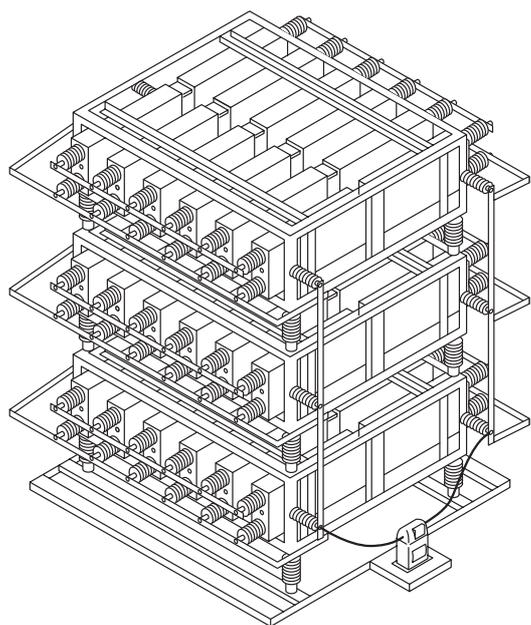


Example of electrical diagram



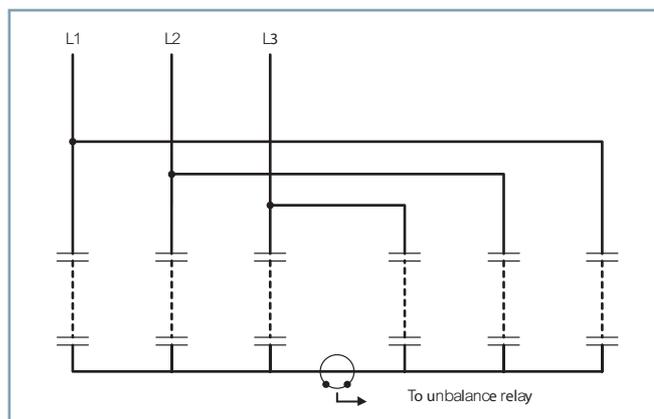
## > Fixed type - Double star configuration

- Max. voltage: 36 kV
- Max. power: 20,000 kVAr
- Installation: indoor or outdoor
- With or without serial group per branch

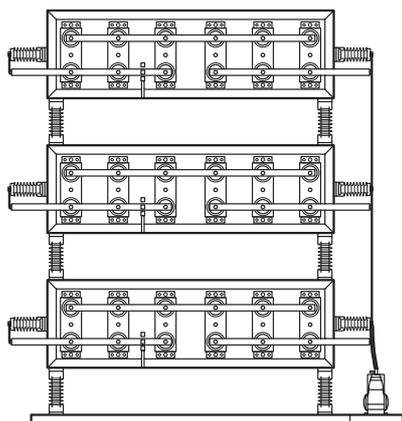


- Possible components: damping reactors, discharge reactors, unbalance relays, unbalance current transformers, etc.
- Max. dimensions (mm): 3500 x 2000 H = 4000

Example of electrical diagram



Example of assembly



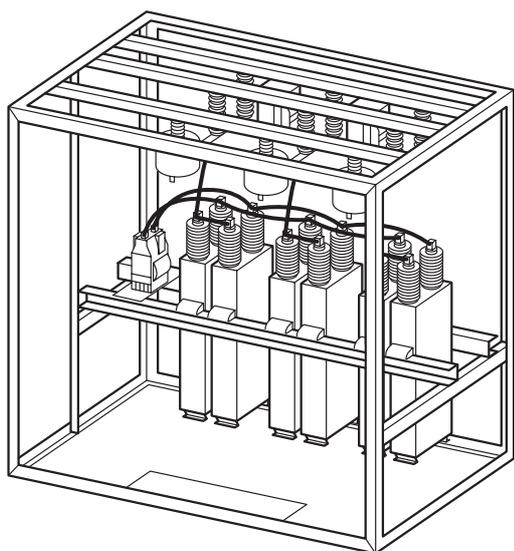
# Racks and cubicles for capacitor banks (continued)

## INSTALLATION EXAMPLES

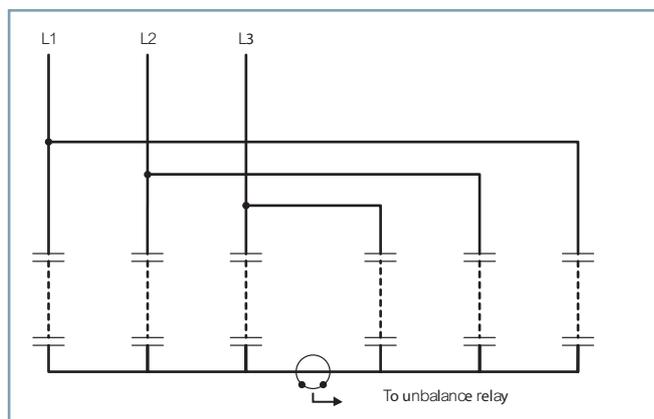
### > Fixed type - Double star configuration

- Max. voltage: 24 kV
- Max. power: 5000 kVAr
- Installation: indoor or outdoor

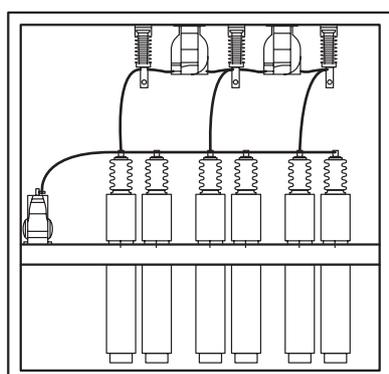
- Possible components: damping reactors, discharge reactors, unbalance current transformers, unbalance relays, etc.
- Max. dimensions (mm): 2500 x 2000 H = 2200



Example of electrical diagram



Example of assembly





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Energy performance of installations in commerce and industry



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