DUCATI energia

Medium & High Voltage Capacitors & Power Factor Correction Solutions

MANENS | PULSE | PULSE GUARD | PULSE SHIELD | QUANTUM

DUCATI energia
HISTORY DRIVES THE FUTURE

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CAPACITORS SINCE 1926

The history of **DUCATI energia** started **in 1926,** when the three brothers Adriano, Bruno and Marcello Cavalieri Ducati founded their company in Bologna, named ***Società Scientifica Radio-Brevetti Ducati: SSR.***

Building on the expertise and patents developed by co-founder and radio scientist **Adriano Cavalieri Ducati,** the Company initially specialised in the research and manufacture of radio communication technologies. Notably, they established both the first shortwave radio connection between Italy and the United States and the first simultaneous connection across all five continents.

This success was also driven by the quality of the capacitors patented by the Company. Its first model – **MANENS** – was initially produced in the cellar of the family home.

The first capacitors designed and produced were also used by the inventor **Guglielmo Marconi** in his radio prototypes, and it was within this environment of research and continuous experimentation that **Ducati energia** gradually built its technological identity.

Today, **DUCATI energia** is a benchmark in the design and manufacture of capacitors, for both medium-high and low-voltage applications, delivering innovative solutions for energy efficiency and power grid stability.

1926

This catalogue has been created to provide designers and operators with a portfolio of medium-voltage power factor correction solutions, developed with a clear objective: to deliver the highest standards of **reliability**, **safety**, and **operational value** throughout the entire life cycle of the electrical plant.

TODAY

2 QUALITY

The **QUALITY SYSTEM** of **Ducati energia S.p.A.** – Capacitor Division, as described in the Quality Manual, was among the first in Italy to be approved by BSI in accordance with **ISO 9002 (EN 29002)** procedures: Certificate of Registration No. FM22004.

Ducati energia is certified by CSQ in accordance with **ISO 9001, ISO 14001 and ISO 45001 standards.**

Ducati energia employs highly integrated manufacturing processes, advanced and innovative machinery and technologies, and production control methodologies based on precise specifications and operator accountability at every level.

3

MANENS
Power Capacitors

3.1 Introduction

The **MANENS** capacitor series is the result of extensive research into dielectric materials, dielectric oils and manufacturing processes.

3.2 Construction features

MANENS capacitors are manufactured using all-film technology, featuring low dielectric losses and a long service life.
Each capacitor consists of a number of capacitive **elements** 1 connected in series and parallel so as to achieve the rated voltage and power.
These elements consist of two ultra-pure aluminium electrodes separated by multiple layers of polypropylene film. The **impregnant** 6 is a synthetic oil that is biodegradable, non-toxic and has a chlorine content below 5 ppm.

Case 2

The active parts are housed inside a painted steel or stainless-steel enclosure with all joints welded. Its robust construction is designed to withstand the abnormal stresses that may result from a capacitor failure.
The total hermetic sealing of the enclosure provides reliable protection against material degradation, ensuring a long service life for the capacitor. At the same time, the mechanical flexibility of the enclosure surfaces compensates for variations in the volume of the impregnation fluid over the specified operating temperature range, keeping changes in internal pressure within modest limits.
To ensure that the rust protection is fully effective, including in highly aggressive environments, the enclosure surface is first sandblasted and then coated with multiple layers of single-component paint.
Upon request, capacitors intended for use in particularly aggressive environments can be supplied with a stainless-steel enclosure.

The two **handles** 3 welded to the case facilitate handling and ensure secure mounting on the metal frame.

Terminals 4

The capacitor terminals are mounted on glazed porcelain bushings, ensuring excellent resistance to weather conditions. The porcelain bushings are metallised both for fastening to the capacitor cover and for securing the threaded connection terminal. The bushings are perfectly hermetic and particularly robust.

Discharge devices 5

In accordance with applicable standards, the capacitors are internally equipped with discharge resistors designed to reduce the residual voltage to less than 75 V within 10 minutes after disconnection.
The discharge system is one of the most critical factors influencing the reliability and safety of the capacitor bank. However, overall performance also depends heavily on fuse technology and unbalance protection devices.

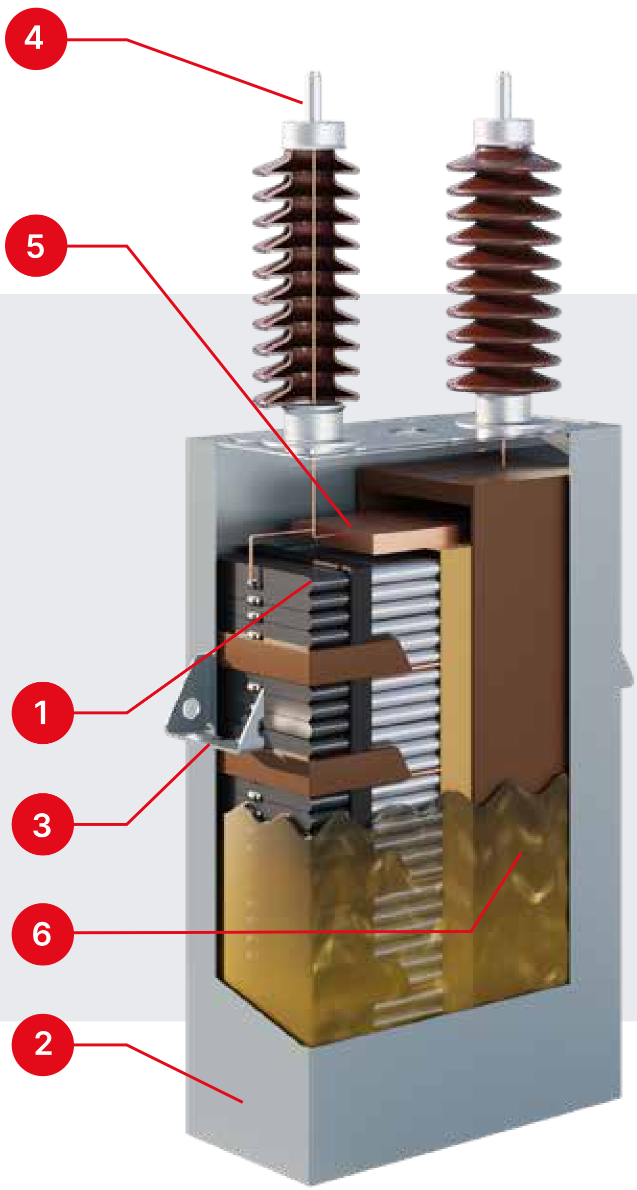


Fig. 1: Internal Construction

3.3 Applicable standards and tests

MANENS series capacitors are compliant with **IEC 60871 standards.**

Routine tests

- Capacitance measurement (IEC 60871-1, Cl. 7)
- Measurement of the loss angle tangent (tan δ) (IEC 60871-1, Cl. 7)
- Voltage test between terminals (IEC 60871-1, Cl. 9)
- Voltage test between terminals and container (IEC 60871-1, Cl. 10)
- Verification of discharge resistors (IEC 60871-1, Cl. 11)
- Verification of enclosure tightness (IEC 60871-1, Cl. 12)
- Discharge test on internal fuses (IEC 60871-4, Cl. 5.1.1), for capacitors with internal fuses only

Routine tests are performed on 100% of capacitors produced. In compliance with the applicable standards, all capacitors are manufactured according to a type-tested design, making it unnecessary to repeat type tests for each individual project.

3.4 Service conditions and proper use

The correct operation and long-term service life of a capacitor are decisively influenced by service conditions and operating conditions. Factors such as temperature, altitude, pollution level, supply voltage and overloads directly affect component performance and life cycle.
When used in full compliance with the technical specifications, the capacitor can ensure high reliability, reduce the risk of premature failure and fully meet the declared performance levels.

Temperature

According to IEC 60871-1, capacitors are classified under four temperature categories, as shown in the table below.

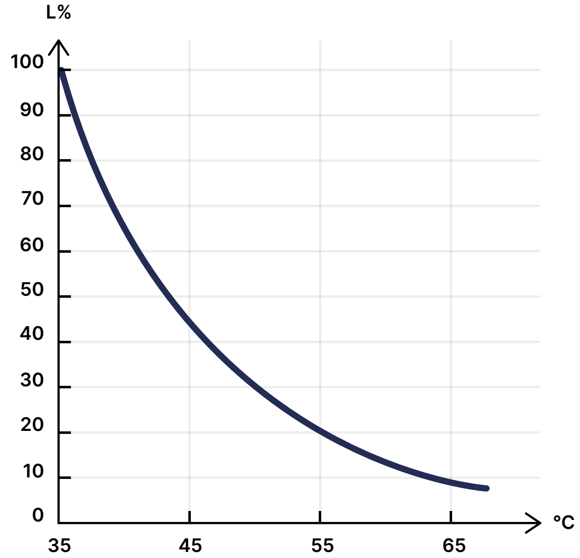


Fig. 2: Capacitor lifetime reduction as function of temperature

The upper temperature limit can significantly affect capacitor life. As shown in **Fig. 2**, a 10°C increase in temperature results in approximately a 50% reduction in service life.

Temperature category	Upper limit (°C)	Maximum ambient air temperature (°C)	
		Highest mean over any period	
		In one day	In one year
A	40°	30°	20°
B	45°	35°	25°
C	50°	40°	30°
D	55°	45°	35°

Table 1: Maximum temperature values for the different categories. (The values can be found in the meteorological temperature values covering the installation site)

If the capacitors influence the ambient air temperature the above values can be increased by 5°C (Ex. Internal Installation)

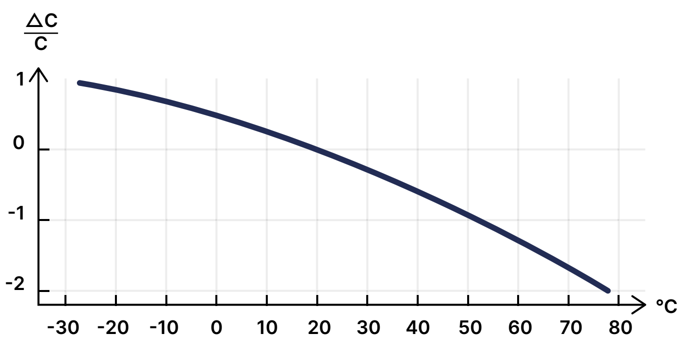


Fig. 3: Capacitance vs. temperature

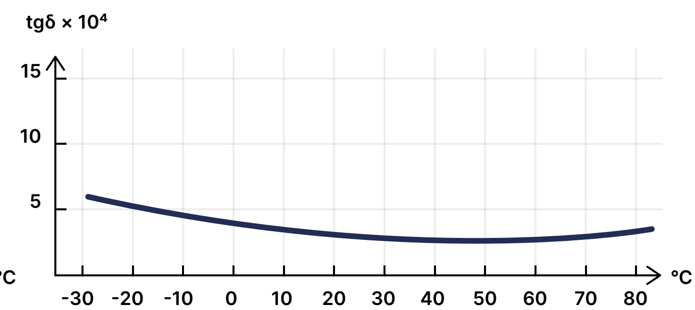


Fig. 4: All film dielectric, loss angle vs. temperature

Altitude

Normal service conditions require installation at an altitude no greater than 1000 m above sea level. For installations at altitudes above 1000 m, suitable correction factors must be applied.

Rated voltage and permissible overloads

In accordance with IEC 60871, capacitors are designed to withstand the overvoltages indicated in the relevant table. When choosing the rated voltage of a capacitor, it is important to consider that permanent overvoltages will reduce its service life.
For this reason, factors such as the increase in grid voltage following capacitor installation should be carefully evaluated.
Moreover, in electrical plants where harmonics are present, these can cause an increase in the operating voltage of the capacitors, especially under resonance conditions. The most appropriate rated voltage for the capacitor should therefore be determined for each situation.
The curve in **Fig. 5** illustrates the reduction in capacitor life as a function of the permanent overvoltage factor.

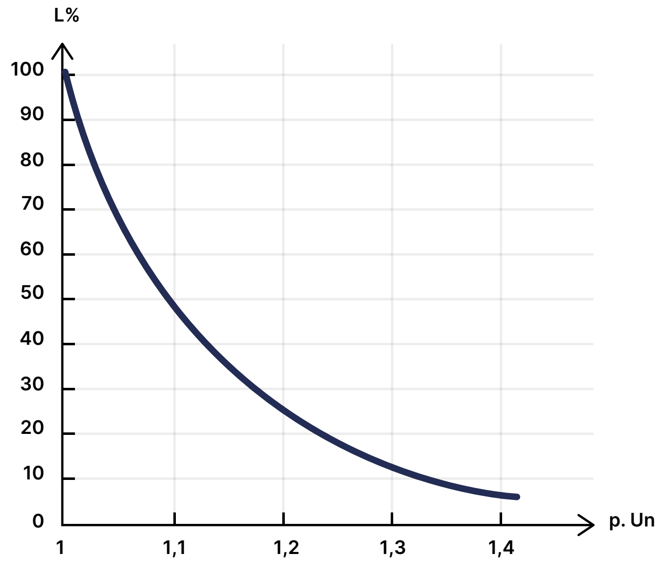


Fig. 5: Capacitor lifetime reduction as function of overvoltage factor

Overvoltage factor	Maximum Duration	Cause
1,10 Vn	12 h per day	Fluctuation in network voltage
1,15 Vn	30’ per day	
1,20 Vn*	5’	Voltage increase in periods of low load
1,30 Vn*	1’	

Table 2: Maximum overvoltage allowed

*Not more than 200 times in the life of the capacitor

Max overcurrent allowed

Regarding current overloads, the capacitor can withstand:

- 1.3 × In as a result of the simultaneous presence of overvoltages and harmonics
- 100 × In, considered as the peak inrush current value (for 0.5 cycle) for up to 1,000 switching operations per year

3.5 MANENS 1 single-phase capacitors

Single-phase capacitors are available in the following versions:

- with internal fuses
- fuseless
- with external fuses

Technical Data

MANENS-1	
Voltage range	2÷20 kV
Reactive power range	25÷800 kvar
Capacitance tolerance	-5+10%
Frequency	50÷60 Hz
Dielectric	All-film
Electrode	Aluminium folder foil
Impregnant	PCB-free
Temperature category	-25/B (+45°C) available on request up to -25D (+55°C)
Discharge resistors	Internal 75 V in 10 min
Dielectric losses	< 0.1 W/kvar
Stabilisation at Un 45 °C	100 h
Case material	Steel or Stainless Steel
Colour	RAL 7031
Number of insulators	1 or 2
Insulator creepage distance	See table
Terminals	M14
Dimensions	See table
Weight	See table

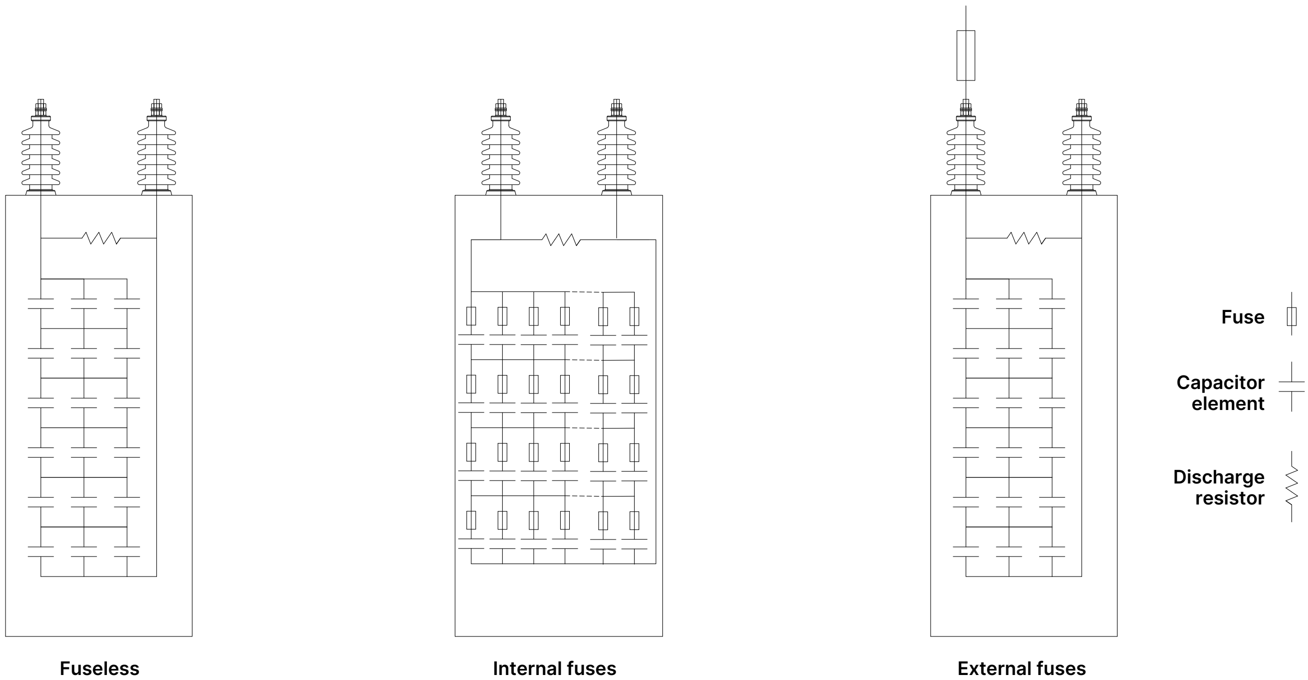


Fig. 6

Dimensions

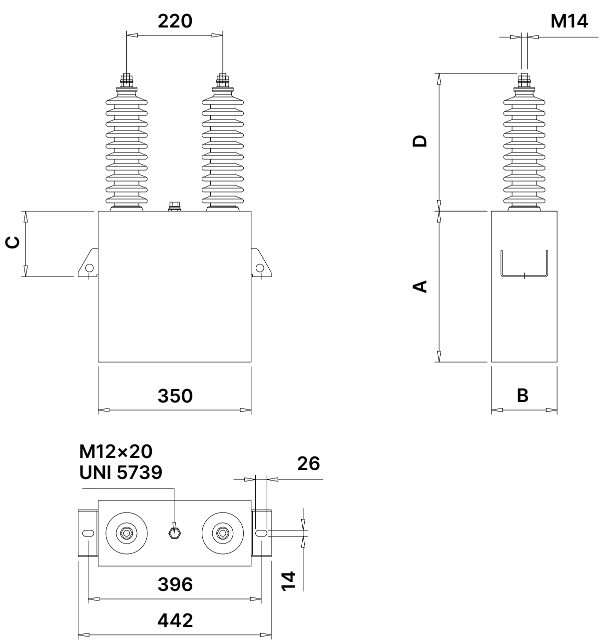


Fig. 7: Capacitor with 2 insulated terminals

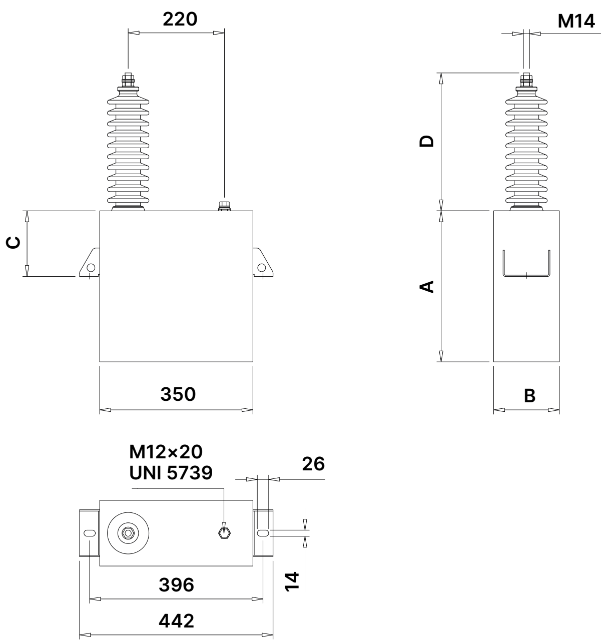


Fig. 8: Capacitor with 1 insulated terminals

Highest system voltage				12 kV 12/28/75 kV		24 kV 24/50/125 kV		36 kV 36/70/170 kV	
Bushing details			D (mm)	240		315		440	
			Creepage (mm)	300		600		900	
kvar	A (mm)	B (mm)	C (mm)	H tot (mm)	Weight (kg)	H tot (mm)	Weight (kg)	H tot (mm)	Weight (kg)
25	125	150	100	365	13	440	16	565	17
50	160	150	100	400	14	475	17	600	18
67	180	150	100	420	15	495	18	620	19
83	200	150	100	440	16	515	19	640	20
100	230	150	100	470	17	545	20	670	21
133	280	150	100	520	21	595	24	720	25
150	300	150	100	540	23	615	25	740	27
167	320	150	100	560	24	635	27	760	28
200	370	150	100	610	27	685	30	810	31
250	440	150	100	680	33	755	36	880	37
300	515	150	230	755	39	830	41	955	43
350	590	150	230	830	45	905	47	1030	48
400	560	175	230	800	49	875	51	1000	52
450	630	175	230	870	55	945	58	1070	59
500	690	175	230	930	61	1005	63	1130	64
550	750	175	320	990	66	1065	69	1190	70
600	810	175	320	1050	72	1125	74	1250	75
650	830	175	320	1070	73	1145	76	1270	77
700	870	190	320	1110	84	1185	87	1310	88
750	970	190	320	1210	94	1285	97	1410	98
800	1020	190	320	1260	99	1335	102	1460	103

Table 3: Dimensions, weights and voltage range

Capacitors with internal fuses

In capacitors with internal fuses, each capacitive element within a group is protected by its own dedicated internal fuse. If a capacitive element fails, the corresponding fuse operates, disconnecting the faulty element from service. After an internal fuse has operated, the capacitor may remain in service, since the group is made up of many capacitive elements connected in parallel, provided that the resulting capacitance variation remains within the tolerance specified for the component.

It is not possible to manufacture the entire capacitor range with internal fuses. This is mainly due to certain design and economic limitations.

Fig. 9 shows the feasible power/voltage combinations for single-phase capacitors with internal fuses.

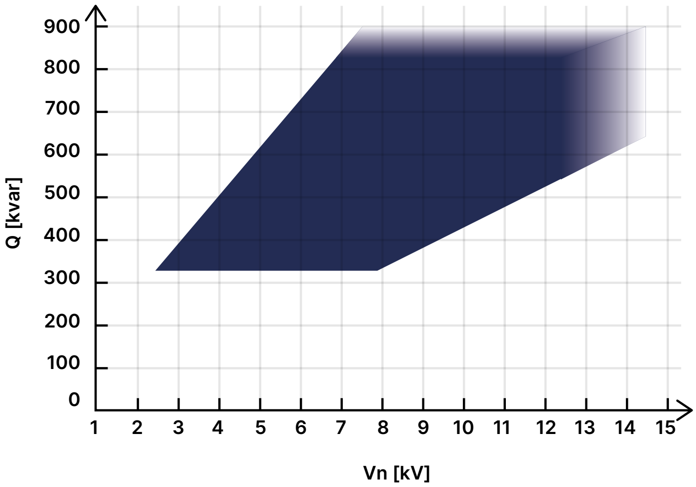


Fig. 9: Possible internal fuse capacitor kvar/kV configurations are in blue area. Capacitors with characteristics outside the blue area can be produced only after technical approval.

Operational advantages

- Immediate disconnection of the damaged element
- Minimal generation of gases inside the capacitor
- Continuity of service
  The elimination of the damaged unit enables the continuity of the connected unit.
- Possibility of planned battery maintenance
- Much simpler maintenance

Design advantages

- Optimisation of battery costs
- Fewer capacitors used per battery
- Reduced battery enclosure size
- Greater capacitor power

Fuseless capacitors

Standard execution capacitors are constructed from parallel capacitive elements called “groups,” which are in turn connected in series. A failure in a capacitive element causes a short circuit in the bank and an increase in voltage across the remaining banks of the capacitor. It is good practice to replace the faulty unit as soon as the first malfunction is detected.

Capacitors with external fuses (see also the section EXPULSION FUSES PROTECTION)

Capacitors with external fuses have the same construction as fuseless capacitors. Each capacitor is connected to the bank through an external fuse which, in case of activation, disconnects the capacitor from service.

Once the capacitor has been disconnected, a permanent voltage increase will occur across the capacitors connected in parallel.

This technology is particularly effective when banks are made up of a large number of low-power units connected in parallel. The main benefit of using external fuses is that the damaged unit can be visually identified.

3.6 MANENS 3 three-phase capacitors

Three-phase capacitors are specifically designed for compensation of transformers at no load operation and large medium-voltage motors.

They must be protected by HRC - High Rupturing Capacity - fuses and shall also be installed in segregated enclosed compartments.

Technical Data

MANENS-3	
Voltage range	3,3÷12 kV
Reactive power range	50÷600 kvar
Capacitance tolerance	-5+10%
Frequency	50÷60 Hz
Connection	Delta
Dielectric	All-film
Electrode	Aluminium folded foil
Impregnant	PCB-free
Temperature category	-25/C (+50°C) available on request -25/D (+55°C)
Discharge resistors	Internal 75V in 10 min
Dielectric losses	< 0.1 W/kvar
Stabilization at Un 45°C	100 h
Case material	Steel or Stainless Steel
Colour	RAL 7031
Number of insulators	3
Insulator creepage distance	See table
Terminals	M14
Dimensions	See table
Weight	See table
Internal fuses	To be checked for feasibility

Dimensions

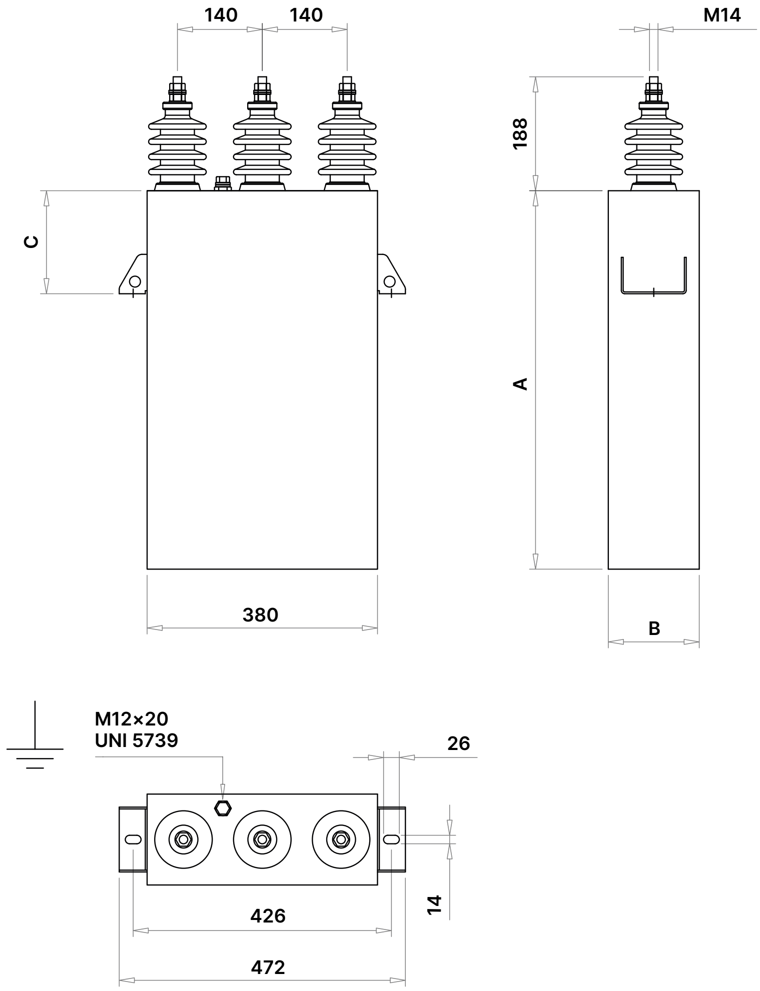


Fig. 10: Manens 3 7.2kV dimensions

POWER 50 Hz (kvar)	POWER 60 Hz (kvar)	Un 3,3 kV/6,6 kV			
		Dimension (mm)			Weight (kg)
		A	B	C	
50	60	210	150	100	28
100	120	310	150	100	33
150	180	410	150	100	42
200	240	510	150	100	50
250	300	610	150	230	57
300	360	620	175	230	66
350	420	710	175	230	75
400	480	790	175	230	80
450	540	800	190	230	87
500	600	880	190	320	97
550	660	960	190	320	102
600	720	1030	190	320	109

BIL	7,2/20/60 kV
Insulator creepage distance	190 mm

Table 4: MANENS 3: 7.2 kV dimensions and weight

Dimensions

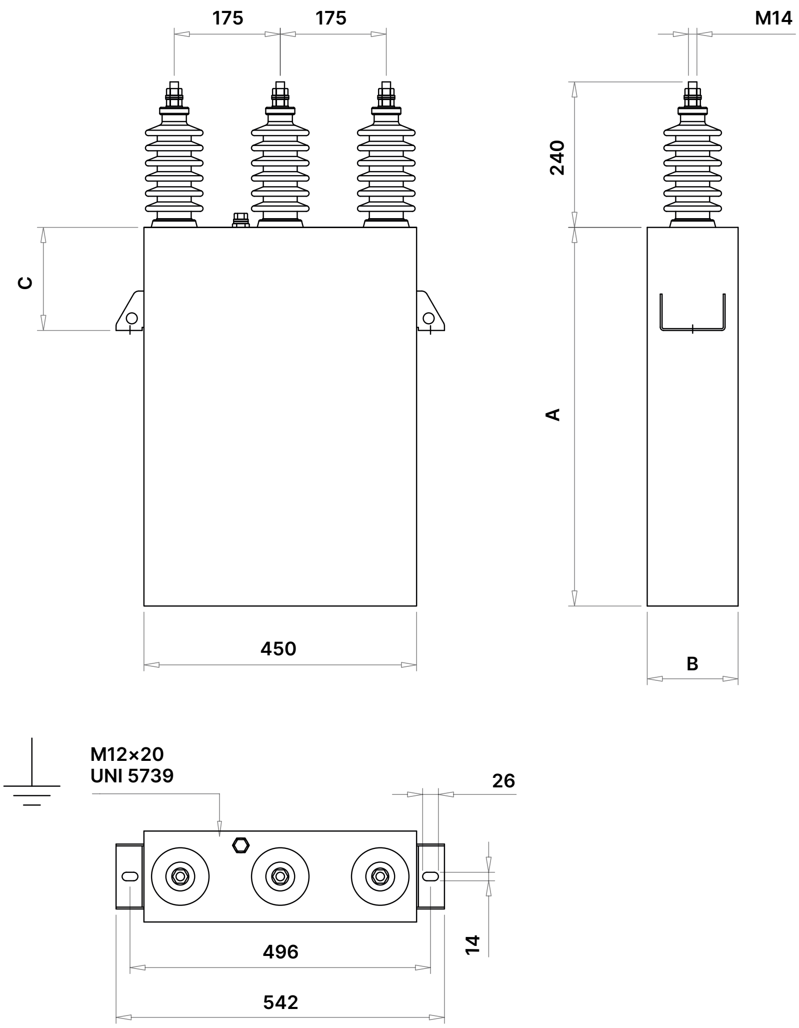


Fig. 11: Manens 3 12kV dimensions

POWER 50 Hz (kvar)	POWER 60 Hz (kvar)	Un 12 kV			
		Dimension (mm)			Weight (kg)
		A	B	C	
50	60	360	150	100	45
100	120	320	150	100	37
150	180	420	150	100	48
200	240	530	150	100	60
250	300	630	150	230	69
300	360	650	175	230	79
350	420	730	175	230	89
400	480	820	175	230	101
450	540	730	175	230	85
500	600	810	175	320	94
550	660	750	200	230	97
600	720	810	200	320	104

BIL	12/28/75 kV
Insulator creepage distance	300 mm

Table 5: MANENS 3: 12 kV dimensions and weight

3.7 MANENS BOX IP54 three-phase capacitors

MANENS BOX consists of a three-phase capacitor with live parts protection.

Technical Data

MANENS BOX IP54	
Insulation Voltage	7,2 or 12 kV
Reactive Power	50-600 kvar
Connection	Delta
Installation	Indoor/outdoor
Protection degree	IP54

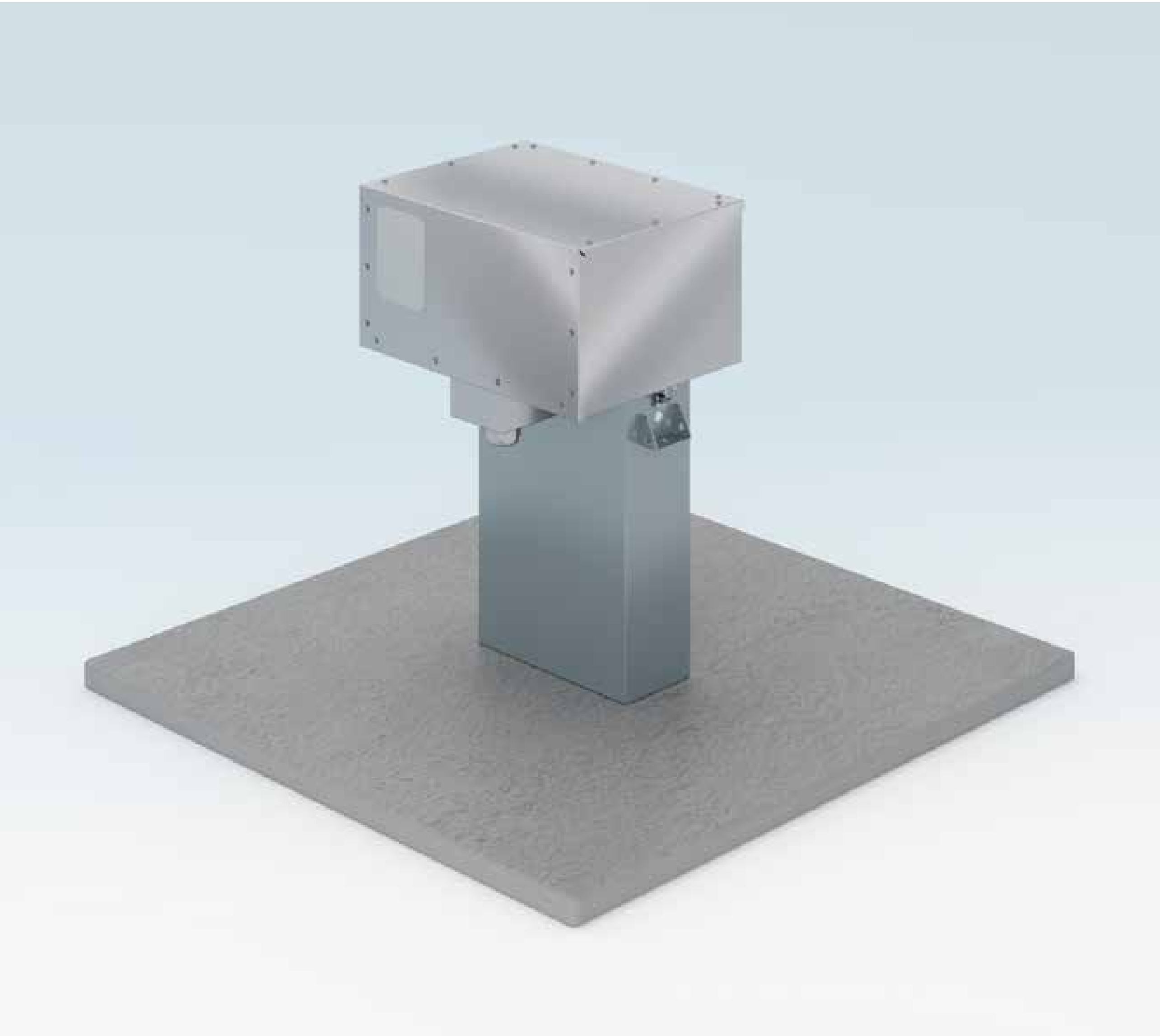


Fig. 12: Manens Box

4

POWER FACTOR CORRECTION

4.1 Why power factor correction matters

The use of **static capacitors** for reactive power generation is now an established requirement for both industrial users and electric power distribution companies.

Power factor correction is essential for the proper technical and economic management of an electrical system.
The main benefits are:
- Improved utilisation of electrical machines
- Improved utilisation of conductors and cables
- Reduction of losses
- Reduction of voltage drop
- Helps control voltage in distribution and transmission lines
- Elimination of penalty charges

4.2 How to perform power factor correction?

Power factor correction may be applied at any point in an electrical plant.
In order to achieve optimum power factor improvement, a power factor correction strategy should be defined according to the system configuration, load variability and the power grid quality at the installation point.

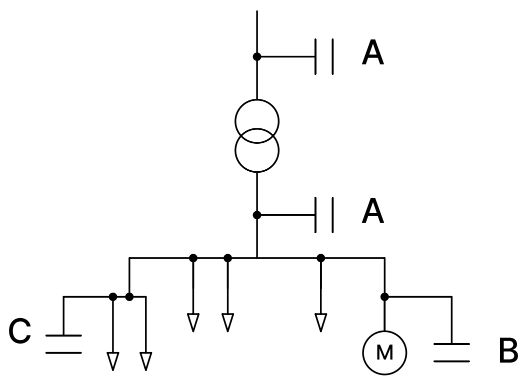


Fig. 13: Typical electric diagram with PFC system

Centralised power factor correction (A)
The compensation system is installed at the main power incoming point of the electrical plant (upstream of the distribution boards, typically in the substation or in the main switchboard).
Benefits: this is the most widely adopted solution when the main objective is to improve the power factor recorded by the utility and consequently reduce or eliminate reactive energy penalties on the electricity bill.

Individual power factor correction (B) at the load, e.g. motor "M"
Direct power factor correction of the equipment to be corrected is the optimum technical solution for reducing reactive power demand directly at the load.
Benefits: it minimises reactive current in the upstream circuits, resulting in lower I^2R losses, reduced voltage drop and improved utilisation of cables and conductors.
This solution is commonly applied to pumps, motors and transformers.

Group power factor correction (C) (on homogeneous lines/users)
Compensation is installed on a distribution line feeding several similar loads (department, local switchboard, feeder).
Benefits: It offers a good balance between technical effectiveness and installation simplicity, reducing reactive current on the main lines of that branch without increasing the number of installation points, while also optimising overall costs.

5

PFC SYSTEMS IN HARMONIC ENVIRONMENTS

In industrial installations with non-linear loads, the power factor correction system must be chosen with particular care.
The voltage distortion level of the electrical plant is expressed in terms of THDv, which is often specified as a contractual parameter between the utility and the customer.

What is meant by non-linear loads
Non-linear loads are loads that draw non-sinusoidal current and therefore generate harmonics.

Typical examples of non-linear loads include:

- Static converters (such as rectifiers, inverters, variable speed drives and UPS systems)
- Induction and arc furnaces
- Equipment with saturated magnetic circuits
- Electronic loads (computers, servers, etc.)

Non-linear loads, and consequently the harmonics they generate, are present at all voltage levels and propagate through the power grid depending on their magnitude and the characteristics of the grid itself.

Main system malfunctions caused by harmonics

- Higher losses and overheating in cables and circuit breakers, resulting in accelerated ageing; this effect may be particularly severe in the neutral conductor.
- Higher losses and overheating in MV/LV transformers, leading to premature ageing or the need for transformer oversizing.
- Irregular operation of electric motors (stalling, torque pulsations, additional losses and increased noise levels).
- Improper operation or nuisance tripping of protection relays and fuses.
- Malfunction of electronic equipment.
- Overloading of power factor correction capacitors, with a consequent reduction in service life.

The above issues may become critical (causing immediate damage) if resonance occurs between the capacitance of the power factor correction system and the equivalent inductance of the grid.

Each electrical plant requires a dedicated solution to ensure optimum performance and long-term reliability.

5.1 Harmonic filters in practice

To better illustrate the phenomena associated with harmonics, resonance and their impact on voltage distortion, the following two examples show the power factor correction of an electrical plant with non-linear loads, implemented using standard PFC capacitor banks: **(SCENARIO#1)** and harmonic filters **(SCENARIO#2)**.

HV network
Rated voltage =33 kV
Rated frequency =50 Hz
Short circuit power = 1400 MVA

Step down transformer
Rated power= 10 MVA
Voltage ratio= 33/11 kV
Vcc=10%

ELECTRIC DIAGRAM

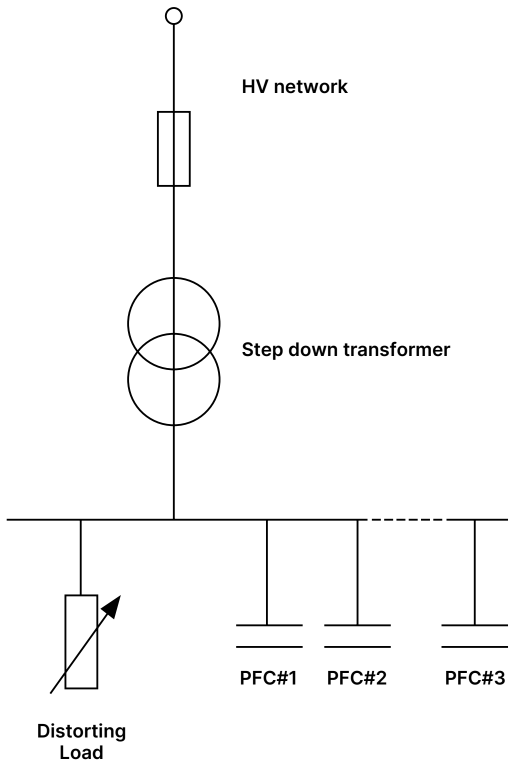


Fig. 14

Non-linear load harmonic spectrum

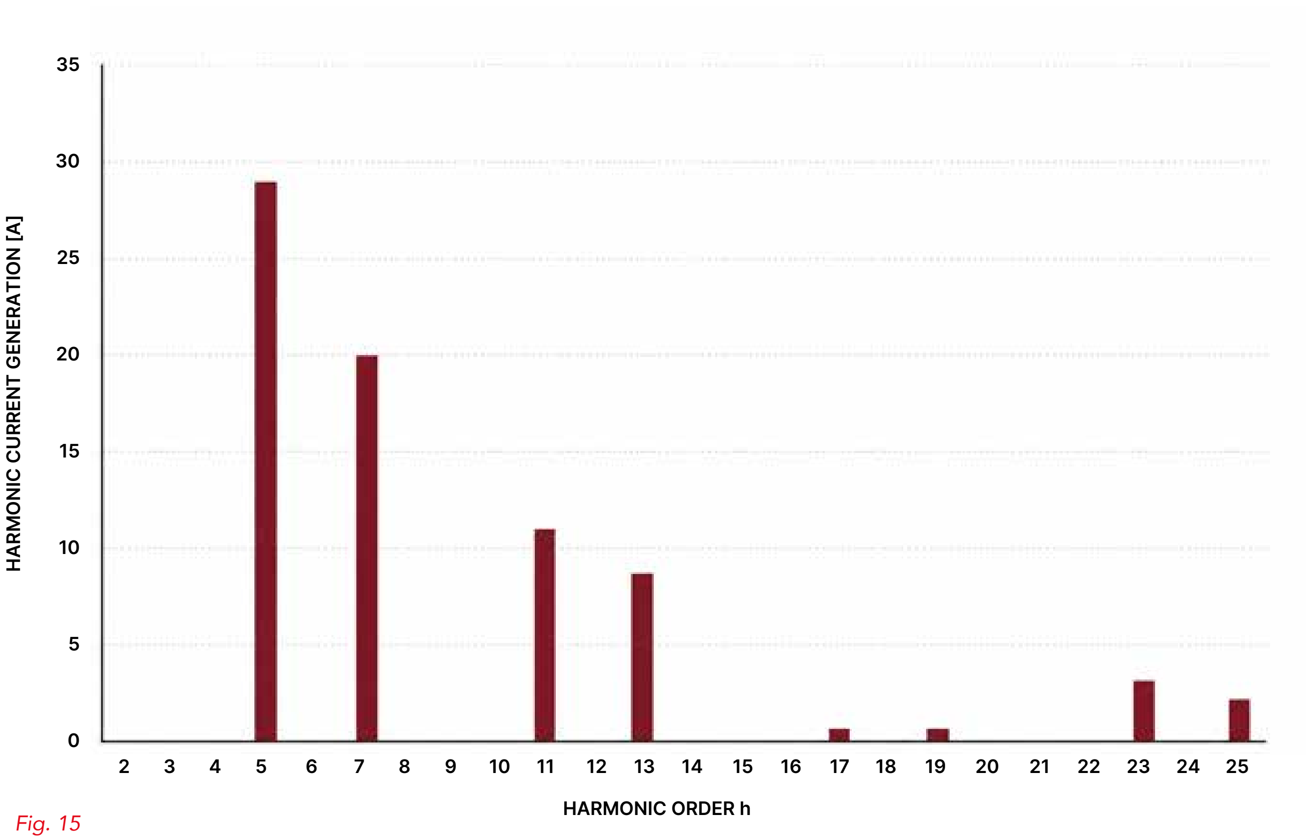


Fig. 15

SCENARIO #1

PFC installed in the plant

PFC	Tuning order h	Power [kvar]	Cn [uF]	L [mH]
PFC# 1	-	2000	52.6	-
Total Installed Power		**2000**		

Table 6

Harmonic current in MV network

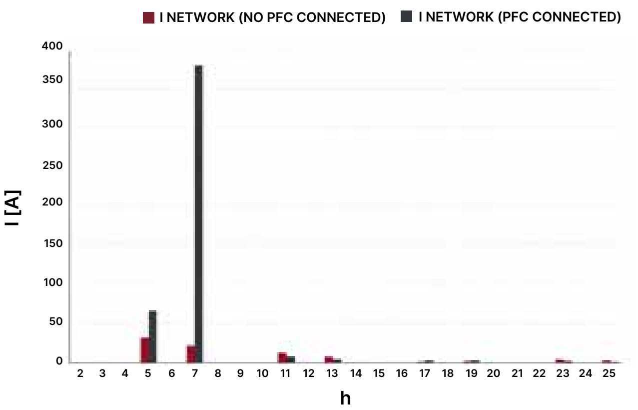


Fig. 16

Network impedance

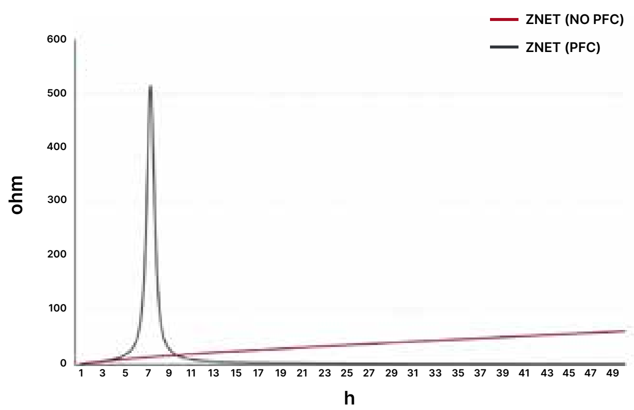


Fig. 17

THD EVALUATION

Order h	Harmonic distortion on MV side		Limit according to IEC 61000-3-6 (planning level) in MV networks
5	6.33	!!!	**5.00**
7	54.21	!!!	**4.00**
11	1.54	OK	**3.00**
13	0.87	OK	**2.50**
17	0.03	OK	**1.60**
19	0.02	OK	**1.20**
21	0.00	OK	**0.20**
23	0.14	OK	**1.20**
24	0.00	OK	**0.20**
25	0.10	OK	**1.20**
THDv	54.6%		**6.5**

Table 8

CONCLUSION

The simulation results indicate that the installation of a capacitor bank **(SCENARIO #1)** creates a resonance condition at the 7th harmonic, leading to amplification of the harmonics present in the grid and a THDv value of 54.5%.

SCENARIO #2

PFC installed in the plant

PFC	Tuning order h	Power [kvar]	Cn [uF]	L [mH]
PFC# 1	5.0	1000	25.3	16.0
PFC# 2	7.0	1000	25.8	8.0
Total Installed Power		**2000**		

Table 7

Harmonic current in MV network

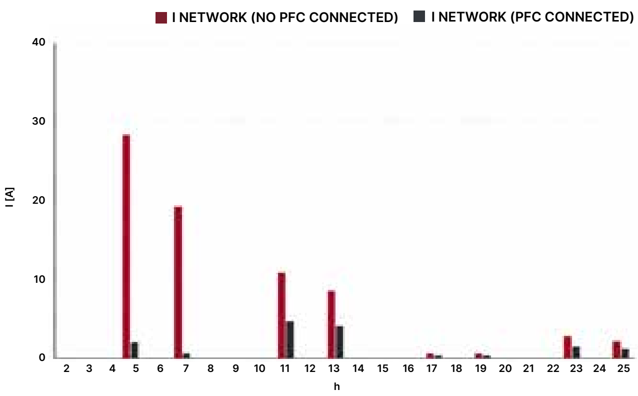


Fig. 18

Network impedance

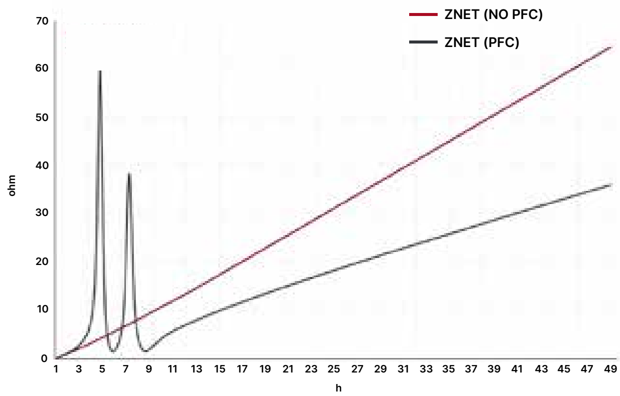


Fig. 19

THD EVALUATION

Order h	Harmonic distortion on MV side		Limit according to IEC 61000-3-6 (planning level) in MV networks
5	0.23	OK	**5.00**
7	0.08	OK	**4.00**
11	1.12	OK	**3.00**
13	1.12	OK	**2.50**
17	0.08	OK	**1.60**
19	0.06	OK	**1.20**
21	0.00	OK	**0.20**
23	0.77	OK	**1.20**
24	0.00	OK	**0.20**
25	0.67	OK	**1.20**
THDv	1.9		**6.5**

Table 9

CONCLUSION

To comply with THDv regulatory limits and improve the efficiency of the electrical plant, power factor correction should be implemented using filters tuned to the characteristic harmonic frequencies **(SCENARIO #2)**.

6

FILTER REACTORS

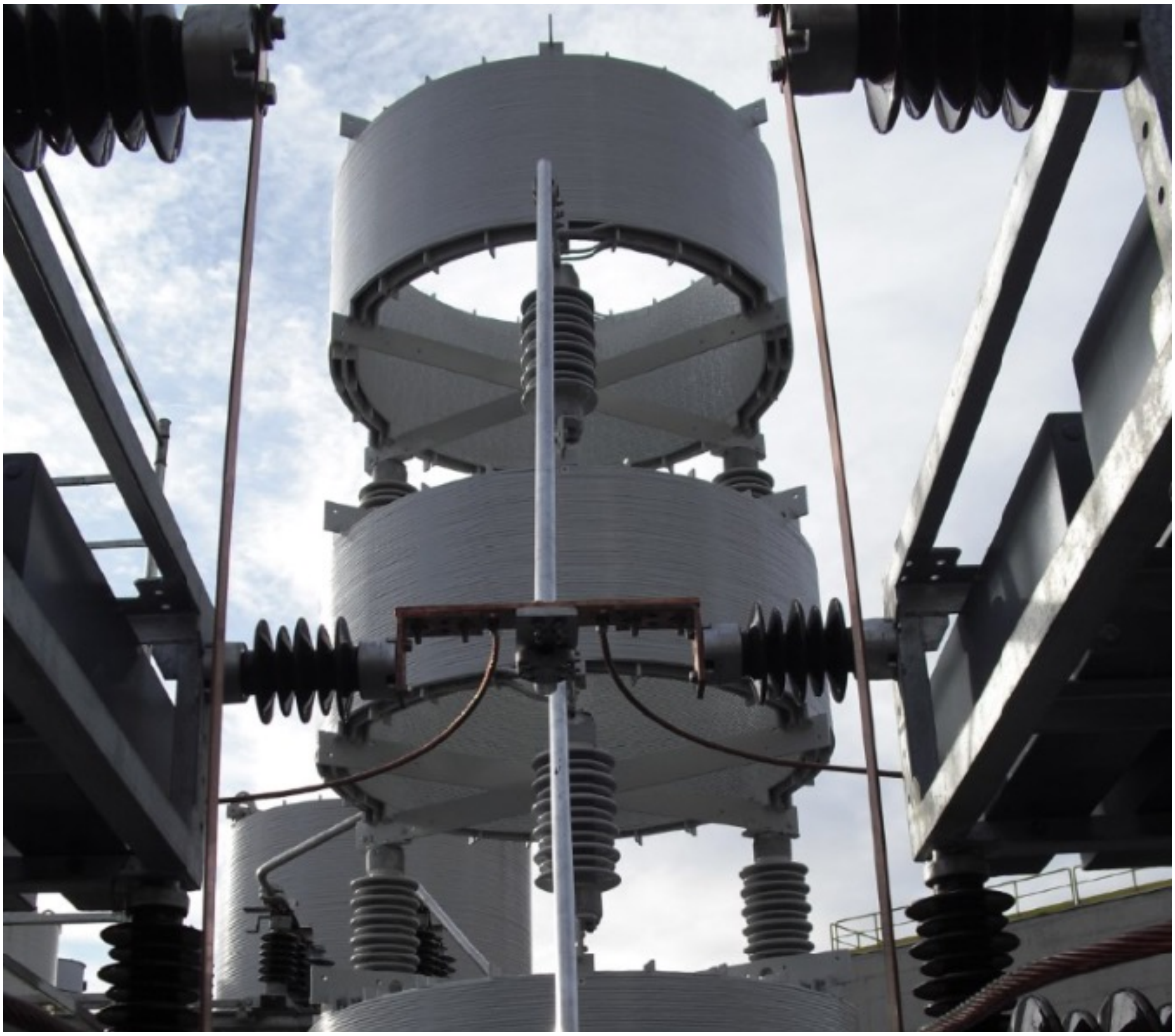


Fig. 20

Filter reactors used in detuned power factor correction systems or harmonic filter systems are custom-designed for each electrical plant, based on its specific requirements (application type, installation conditions, voltage level and harmonic spectrum).
Filter reactors can be manufactured with either an air core or iron magnetic core.

6.1 Air core reactors

Air Core Reactors have a cylindrical design and can be installed side by side or one above the other, according to layout requirements.

Although they require more space, they ensure high linearity, excellent behavior at high frequencies, low losses, good thermal stability, minimal maintenance and long operating life. Their suitability for both indoor and outdoor applications makes them an ideal solution for high-performance industrial systems.

The installation area must allow for the required magnetic clearances from adjacent metal parts (such as metal fences or foundation reinforcement bars), as illustrated in **Fig. 21** and **22.**

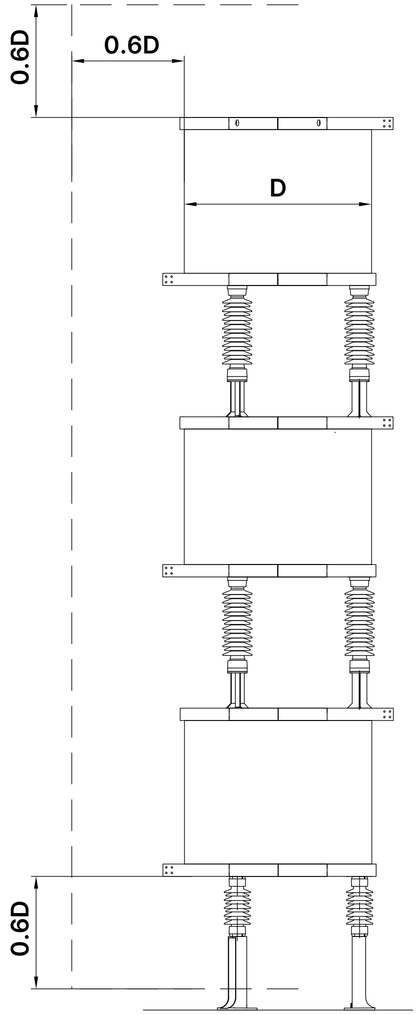


Fig. 21: Indicative value of Magnetic clearance for three-phase stacked arrangement

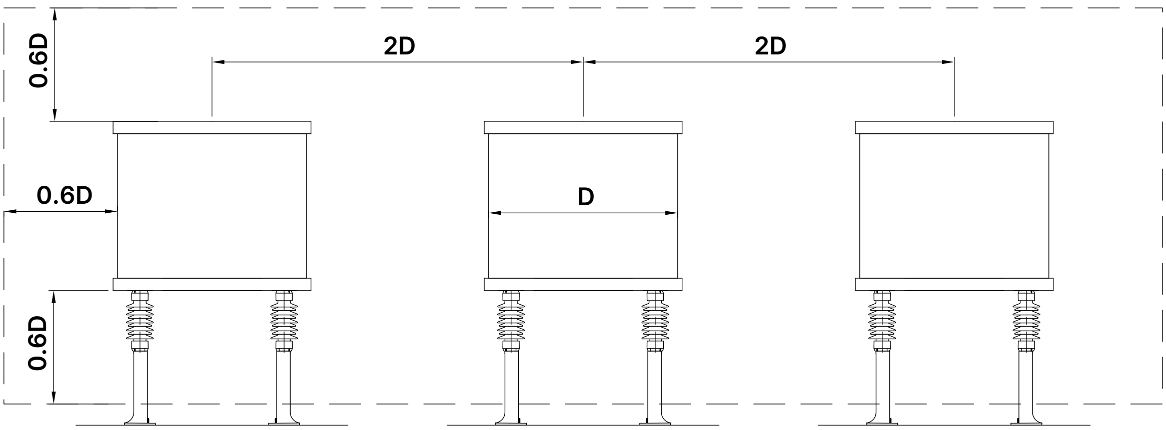


Fig. 22: Indicative value of Magnetic clearance for Air core reactors installed side by side

6.2 Iron core reactors

Iron Core Reactors offer a compact and economically efficient solution for a wide range of industrial applications. The high magnetic permeability of the core allows high inductance values to be achieved with limited dimensions and weight, making these reactors particularly suitable for integration into switchboards and indoor installations with restricted space.

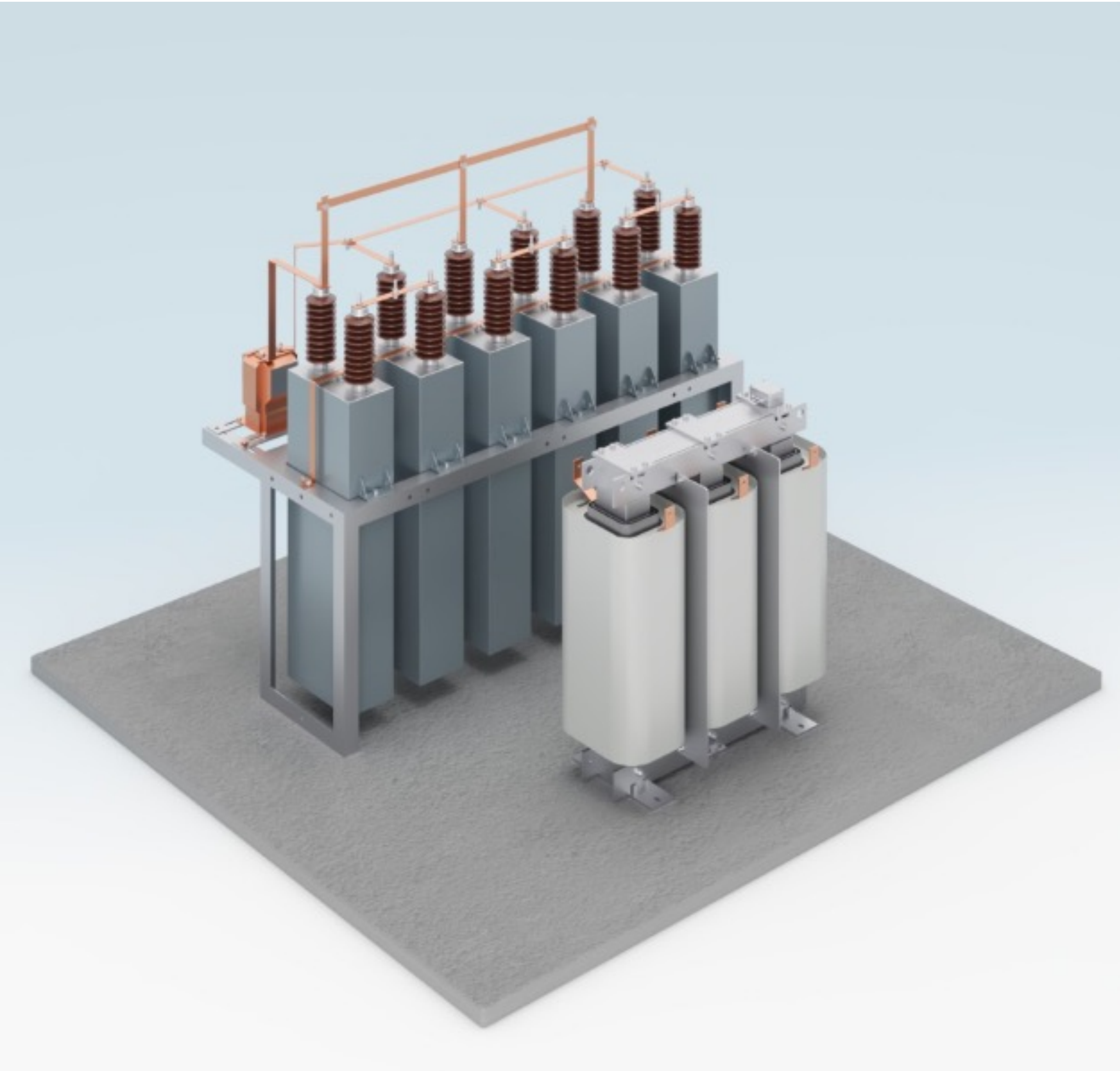


Fig. 23: Typical configuration of detuned system up to 2 Mvar, 12 kV

7

MEDIUM VOLTAGE PFC SOLUTIONS

Ducati energia designs and supplies custom-designed power factor correction systems up to 245 kV.

Series	Description	Insulation voltage	Protection degree
PULSE	Open-air PFC capacitor banks	Up to 245 kV	**IP00**
PULSE GUARD	PFC capacitor banks with inrush reactors	Up to 245 kV	**IP00**
PULSE SHIELD	Capacitor banks with blocking reactors or filter reactors	Up to 245 kV	**IP00**
QUANTUM	Metal-enclosed capacitor banks	Up to 17.5 kV	**IP31 – IP54**

Table 10

8

PULSE SERIES:
open-air capacitor banks

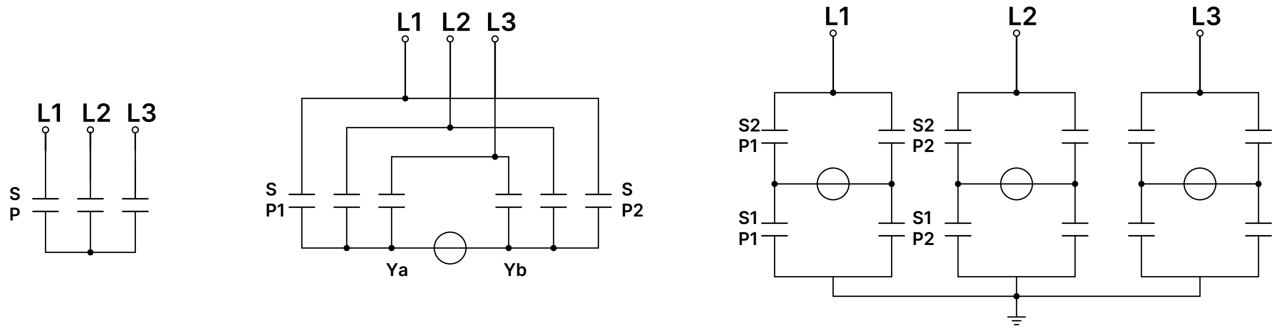
Fig. 24: Capacitor Bank 80 Mvar, 220 kV

The PULSE Series consists of highly flexible modular capacitor bank solutions suitable for a wide range of applications.
PULSE capacitor banks are manufactured using MANENS single-phase capacitors (with or without internal fuses, or with external fuses), mounted on galvanised steel structures.

The capacitors are connected in series and parallel combinations to achieve the required voltage and reactive power values.
The banks are made up of one or more properly insulated stacked frames. Depending on the space available at the installation site, the banks can be configured in either a vertical or horizontal layout.

Technical Data

Insulation voltage	up to 245kV
Reactive power	> 300 kvar
Fuses	Internal/External/Fuseless
Connection type	Y, Y-Y, H (Y = star; Y-Y = double star; H = bridge)
Installation	indoor/outdoor
Protection degree	IP00



Y STAR　　Y – Y DOUBLE STAR　　H BRIDGE

Fig. 25: Capacitor Bank Connection Type

S: *Number of capacitor connected in series*
P: *Number of capacitor connect in parallel*
Unbalance Current Transformer

The PULSE Series is supplied as standard with:

- Single-phase capacitors
- Installation kit (metal support frames, insulators and materials for electrical connections)
- 1 CT for unbalance protection

The following accessories are available on request:

- Line earthing switch
- Line current transformer for overload protection
- Surge arresters
- Protection relays
- Capacitor bank feeder – PULSE CONTROL

8.1 PULSE standard configuration up to 24 kV (PLB)

Technical Data

Insulation voltage	up to 24kV
Reactive power	from 500 kvar up to the values shown in the table 11
Fuses	Internal/External/Fuseless
Connection type	Y-Y
Installation	indoor/outdoor
Protection degree	IP00

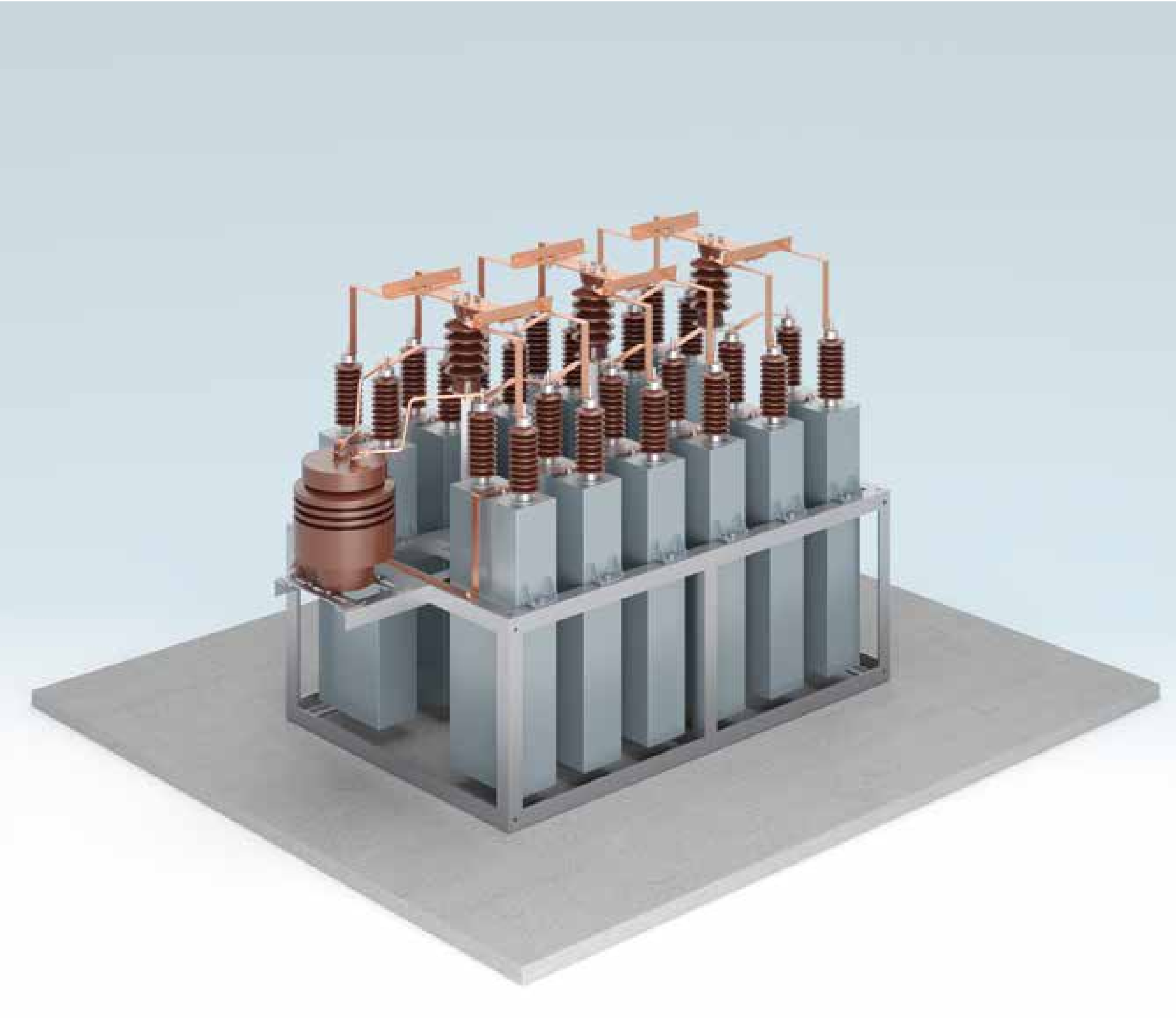


Fig. 26: Typical configuration of PULSE PLB12 24 kV Capacitor Banks

Overall dimensions

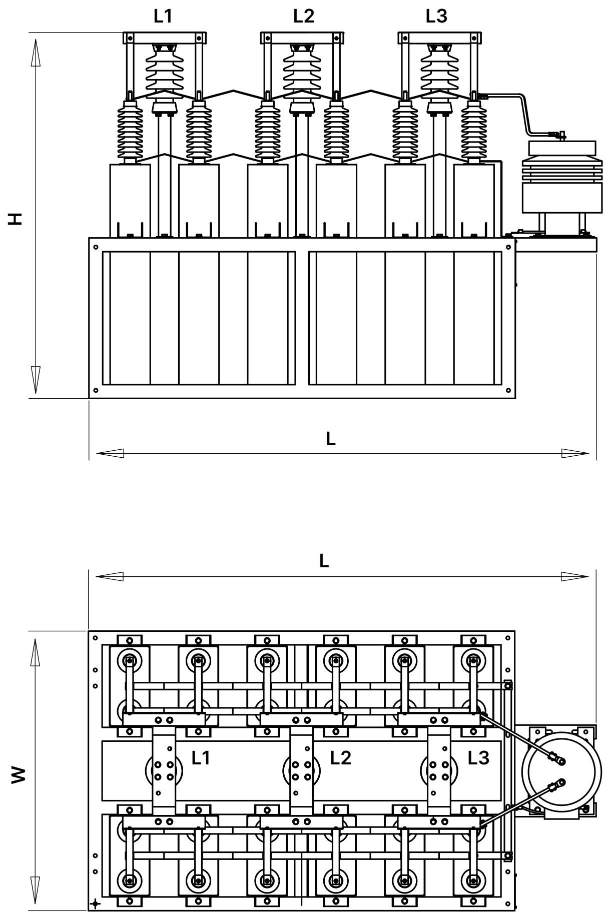


Fig. 27: PULSE Capacitor Bank drawing

PULSE 24 kV capacitor banks: dimension and power ratings

Execution	No. of Capacitors	Q max [Mvar]	L [mm]	W [mm]	H [mm]	Weight [kg]
PLB 6	6	4.8	1350	1220	1700	900
PLB 12	9-12	9.6	2250	1220	1700	1500
PLB 18	15-18	14.4	3150	1220	1700	2200
PLB 24	21-24	19.2	4100	1220	1700	2900

Table 11

8.2 PULSE standard configuration up to 52 kV

8.2.1 PULSE-STACKED capacitor banks (PLK)

Technical Data

Rated voltage	from 24 kV up to 52 kV
Reactive power	from 1,200 kvar up to the values shown in the table 12
Fuses	Internal/Fuseless
Connection type	Y-Y
Installation	indoor/outdoor
Protection degree	IP00
Terminal arrangement	stacked

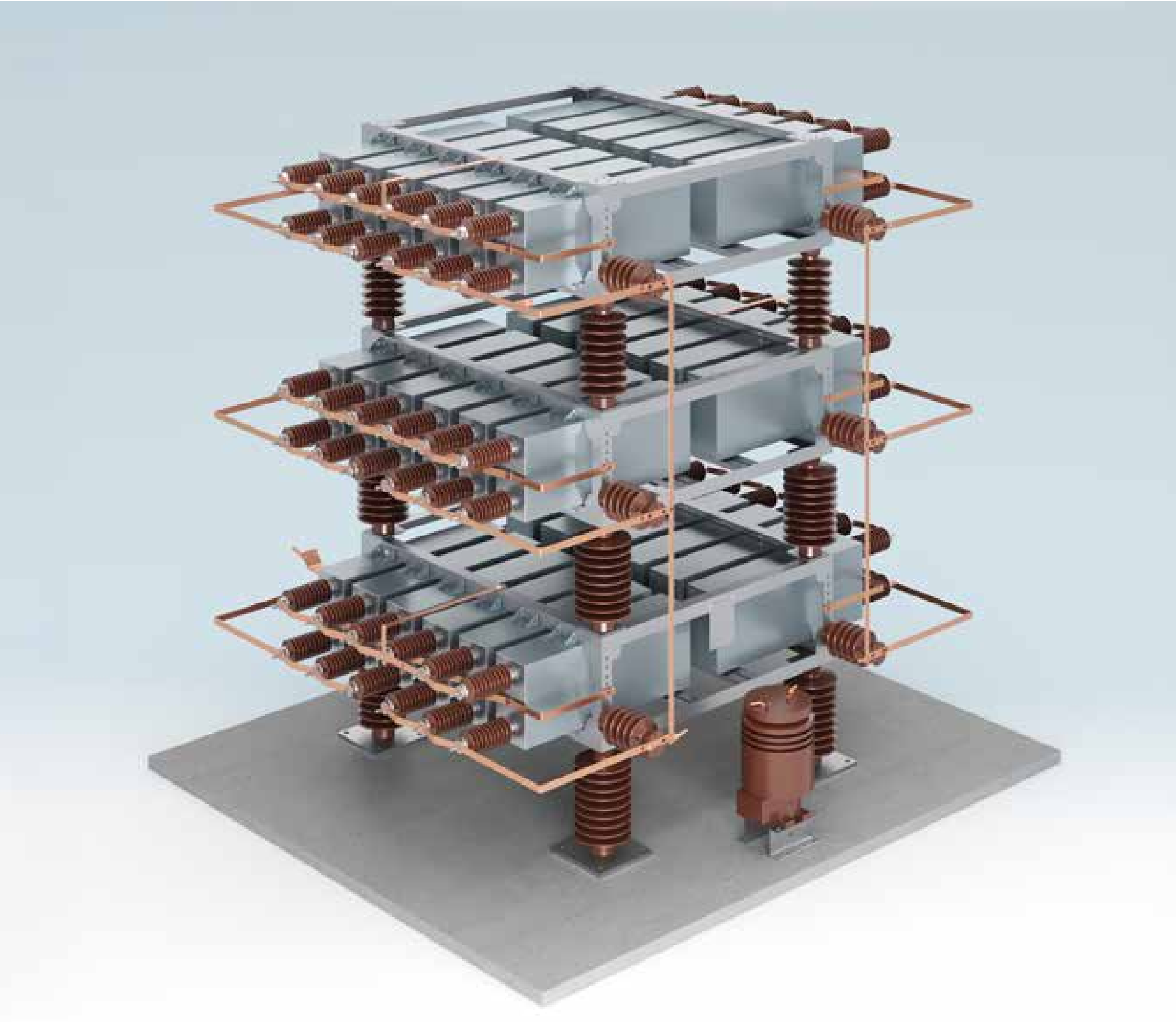


Fig. 28: Typical configuration of PULSE PLK36 36 kV Capacitor Bank

Overall dimensions

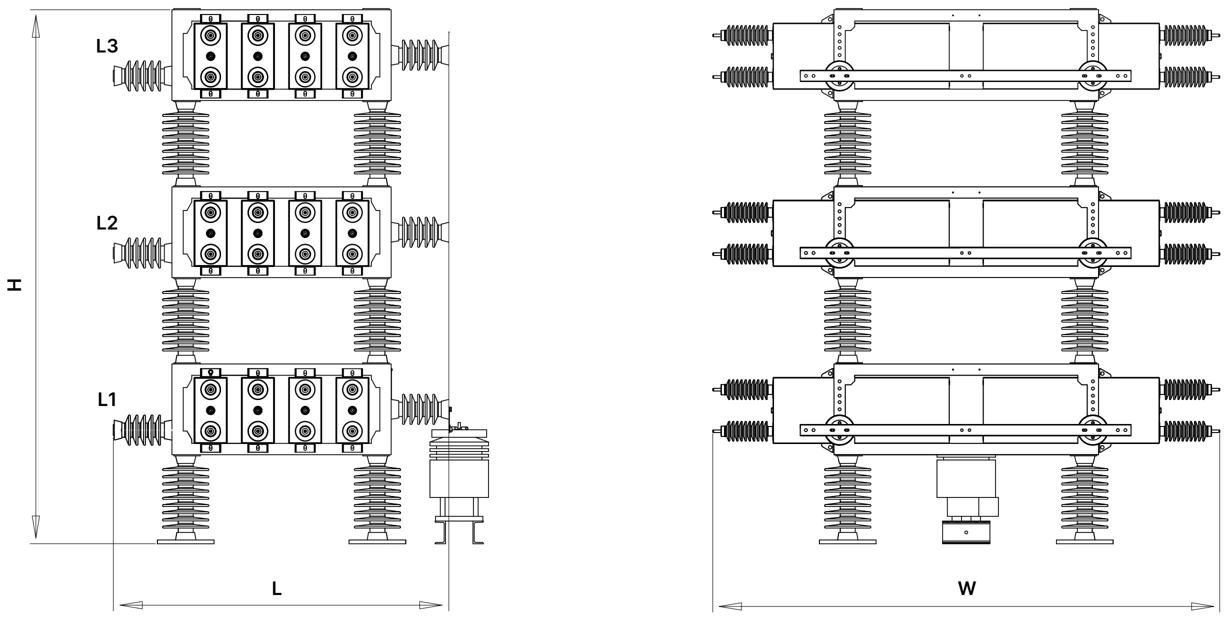


Fig. 29: PULSE PLK Capacitor Bank <52 kV drawing

PULSE PLK Capacitor Banks, dimension and power ratings

Type	No. of Capacitors	Q max [Mvar]	L [mm]	W [mm]	Weight [kg]
PLK 12	12	9.6	1320	2800	2200
PLK 18	18	14.4	1620	2800	2800
PLK 24	24	19.2	1920	2800	3500
PLK 30	30	24	2220	2800	4200
PLK 36	36	28.8	2520	2800	4800
PLK 48	48	38.4	3120	2800	6200
PLK 54	54	43.2	3420	2800	6800
PLK 60	60	48	3720	2800	7500

	24 kV	36 kV	52 kV
H [mm]	2450	2850	3200
W [mm]	2800	2800	2800

Table 12

8.2.2 PULSE SIDE-BY-SIDE capacitor banks (PLD)

Technical Data

Rated voltage	from 24 kV to 52 kV
Reactive power	from 30 Mvar up to the values shown in the table 13
Fuses	Internal/Fuseless
Connection type	Y-Y
Installation	indoor/outdoor
Protection degree	IP00
Terminal arrangement	side-by-side

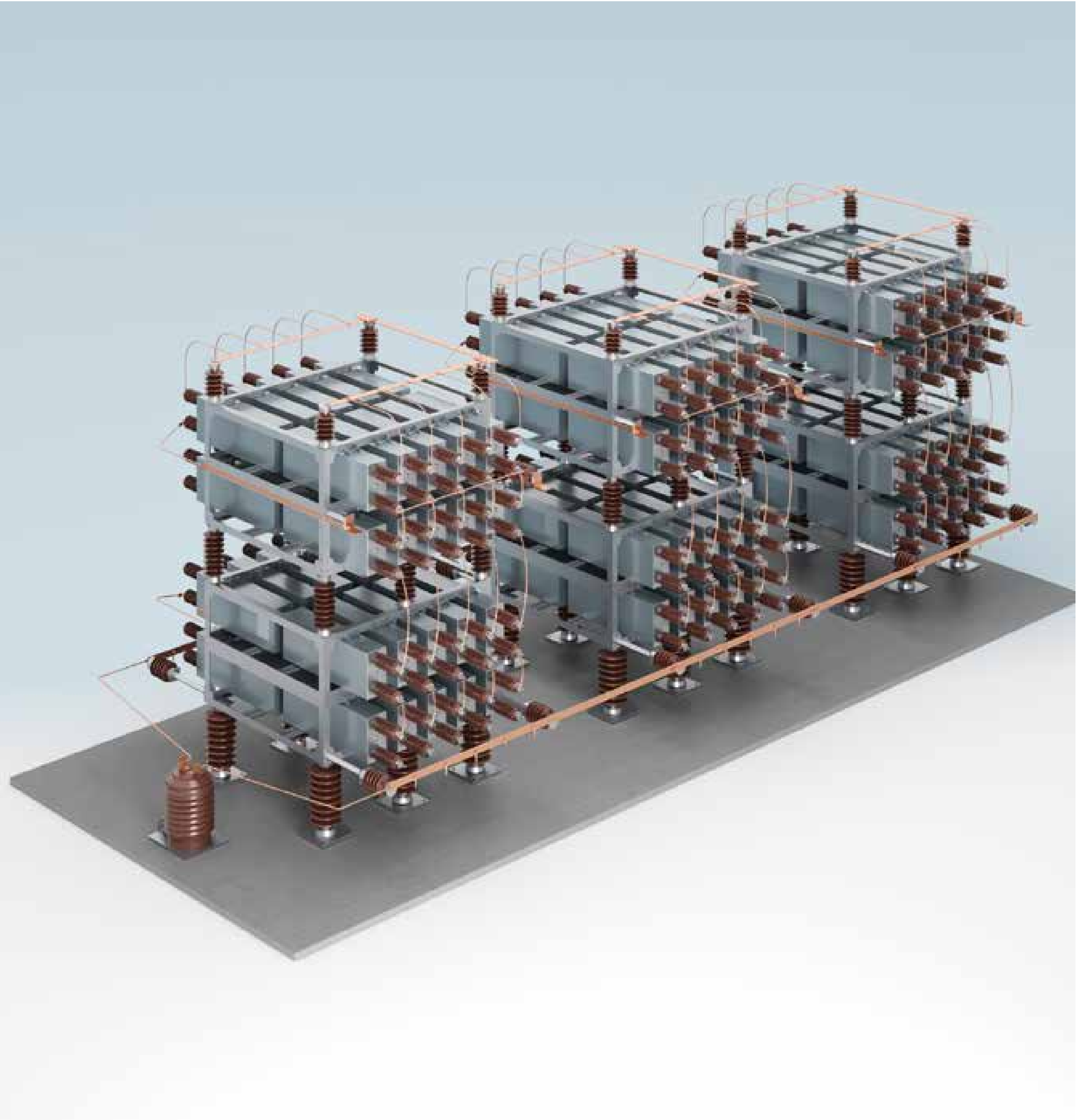


Fig. 30: Typical configuration of PULSE PLD4-12 Capacitor Banks

Overall dimensions

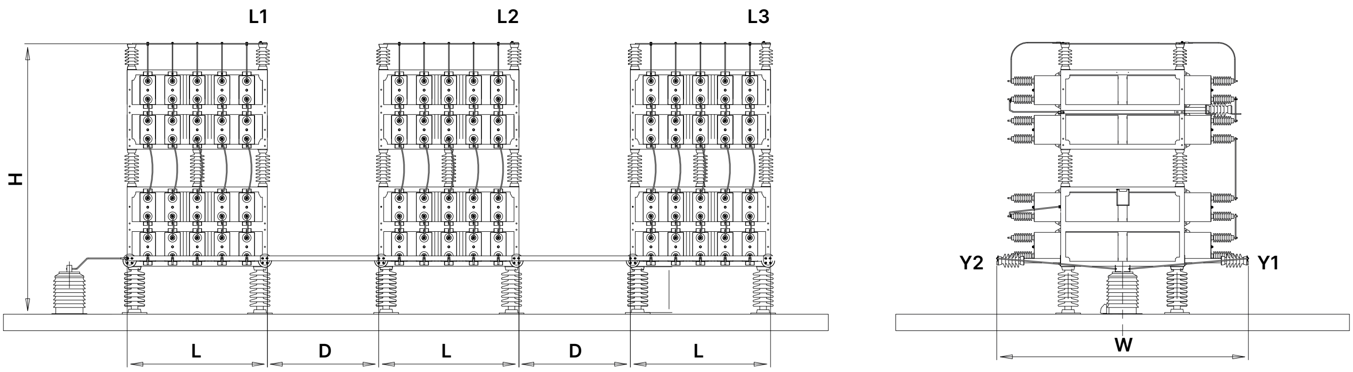


Fig. 31: PULSE PLD Capacitor bank drawing

Type	No. of Capacitors	Q max [Mvar]	L [mm]	H (mm) 36 kV	H (mm) 52 kV	D (mm)	W (mm)
PLD 3	54	43.2	1100	2560	2670	800	3100
PLD 3	72	57.6	1400	2560	2670	800	3100
PLD 4	72	57.6	1100	3100	3300	800	3100
PLD 3	90	72	1700	2560	2670	800	3100
PLD 4	96	76.8	1400	3100	3300	800	3100
PLD 3	108	86.4	2100	2560	2670	800	3100
PLD 4	120	96	1700	3100	3300	800	3100
PLD 3	126	100.8	2400	2560	2670	800	3100
PLD 3	144	115.2	2700	2560	2670	800	3100
PLD 4	144	115.2	2100	3100	3300	800	3100
PLD 4	168	134.4	2400	3100	3300	800	3100
PLD 4	192	153.6	2700	3100	3300	800	3100

Table 13: PULSE PLD Capacitor bank, dimension and power ratings

8.3 PULSE CAPACITOR BANKS for voltage higher than 52 kV

Technical Data

Rated voltage	from 52 kV up to 245 kV
Reactive power	from 10 Mvar
Fuses	Internal/Fuseless
Connection type	Y-Y, H
Installation	indoor/outdoor
Protection degree	IP00
Terminal arrangement	side-by-side

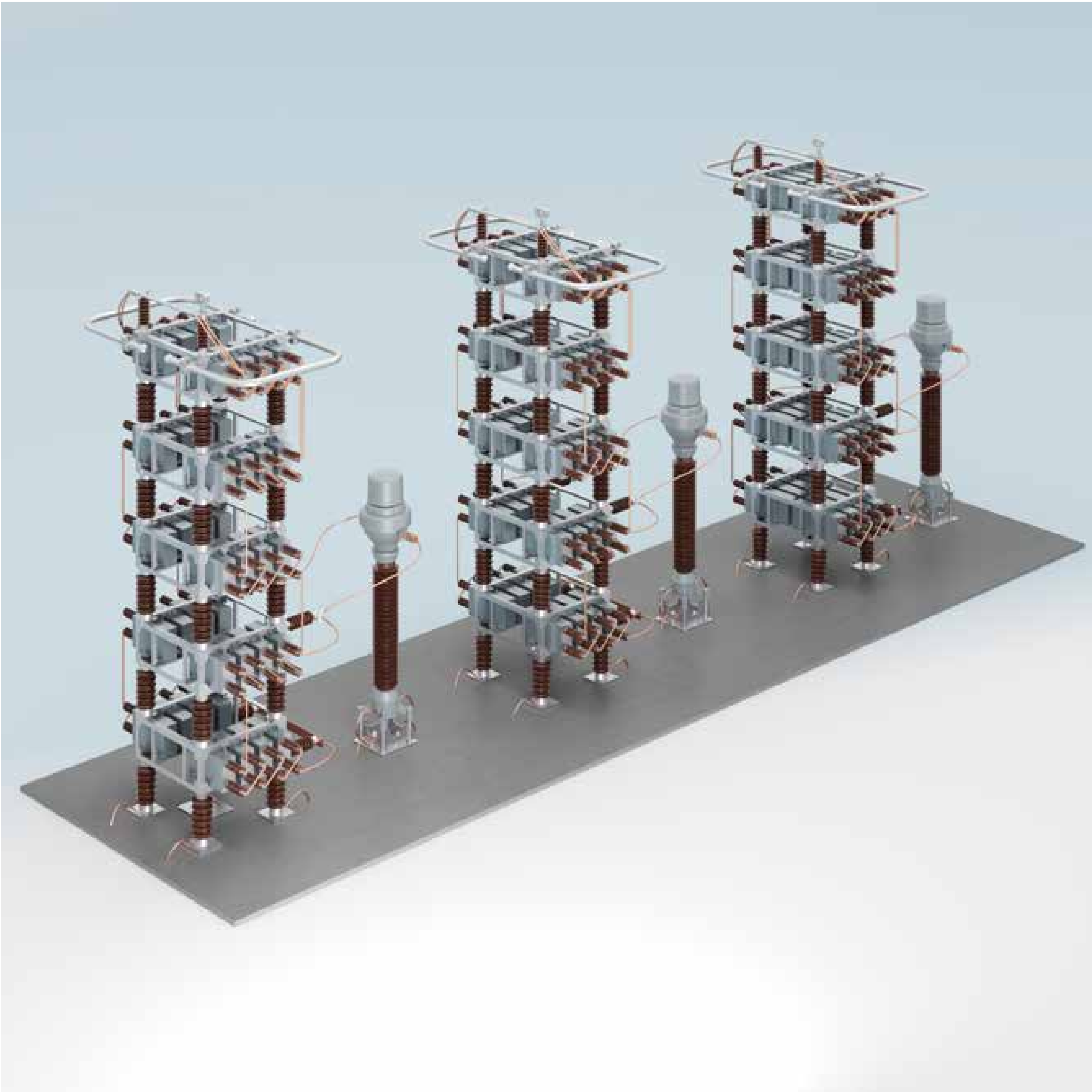


Fig. 32: Example of a 220 kV capacitor Bank

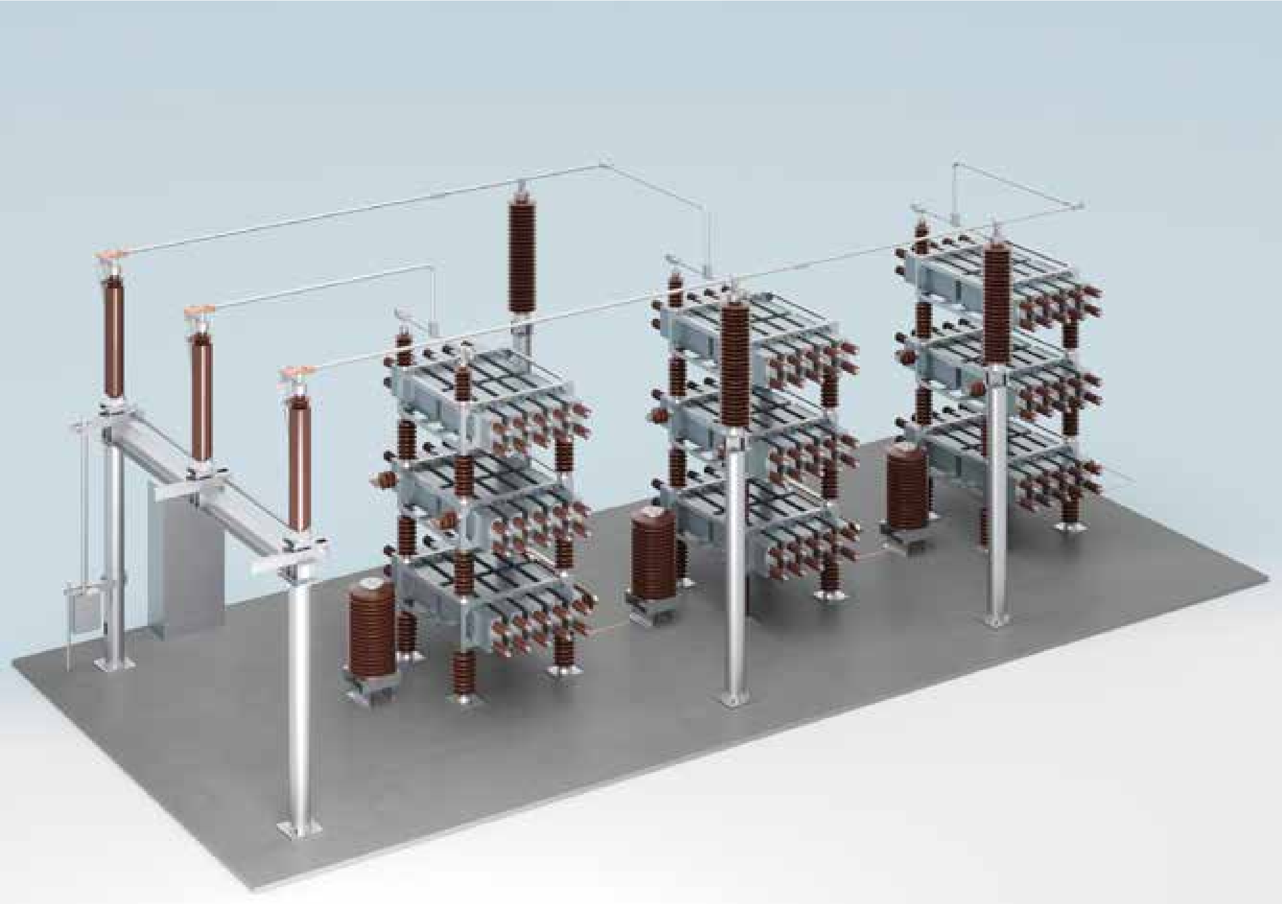


Fig. 33: Example of 132 kV 54Mvar Capacitor Bank

Fig. 34: 132 kV, 54 Mvar Capacitor Bank

9

PULSE GUARD SERIES:
capacitor banks with inrush reactors

When capacitor banks are operated in parallel on the same busbar, it is necessary to install inrush reactors, i.e. reactors that limit the peak current to the levels specified by the standards.

The following examples illustrate some bank configurations equipped with inrush reactors.

Technical Data

Voltage	up to 245kV
Power	from 300 kvar up to the values shown in the table 14
Fuses	Internal/External/Fuseless
Connection type	Y-Y
Protection degree	IP00
Installation	indoor/outdoor

9.1 Standard execution examples up to 24 kV

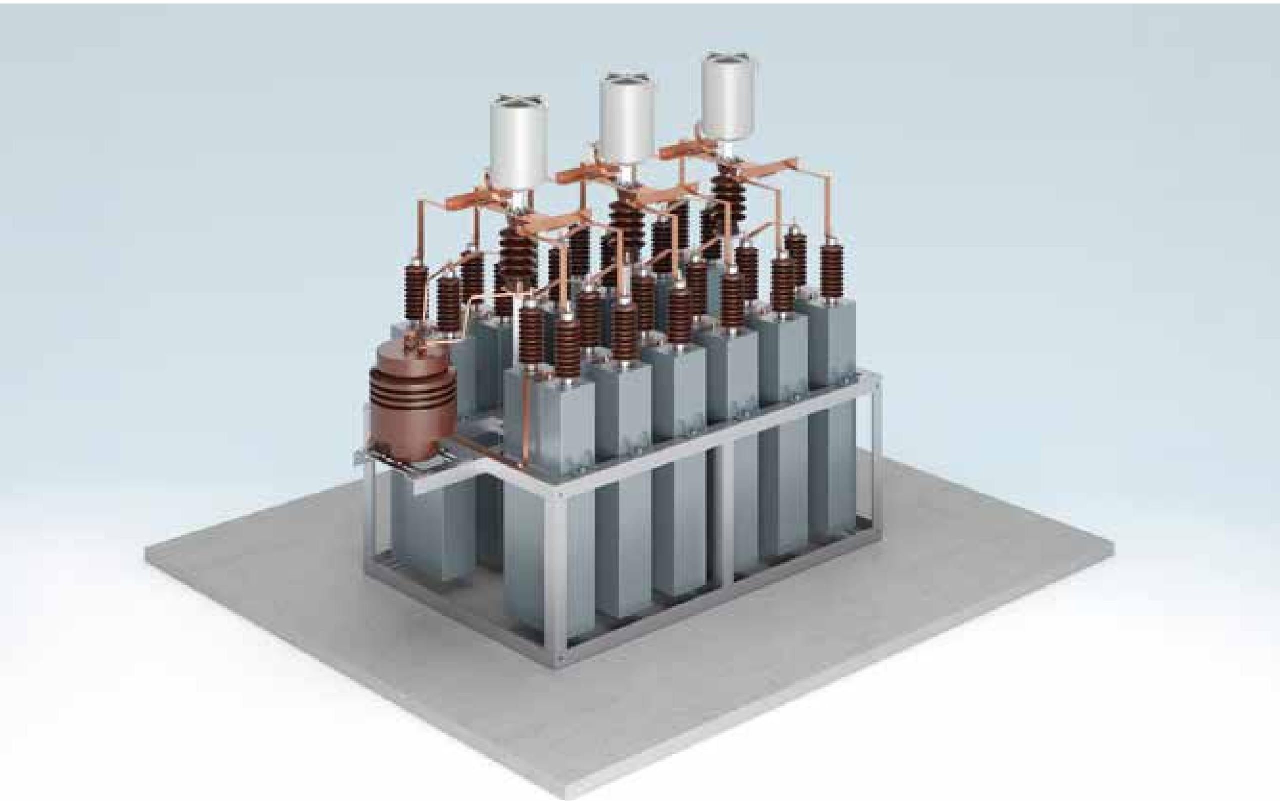


Fig. 35: Typical configuration of PULSE GUARD PDG12, 24 kV Capacitor Banks with inrush reactors

Overall dimensions

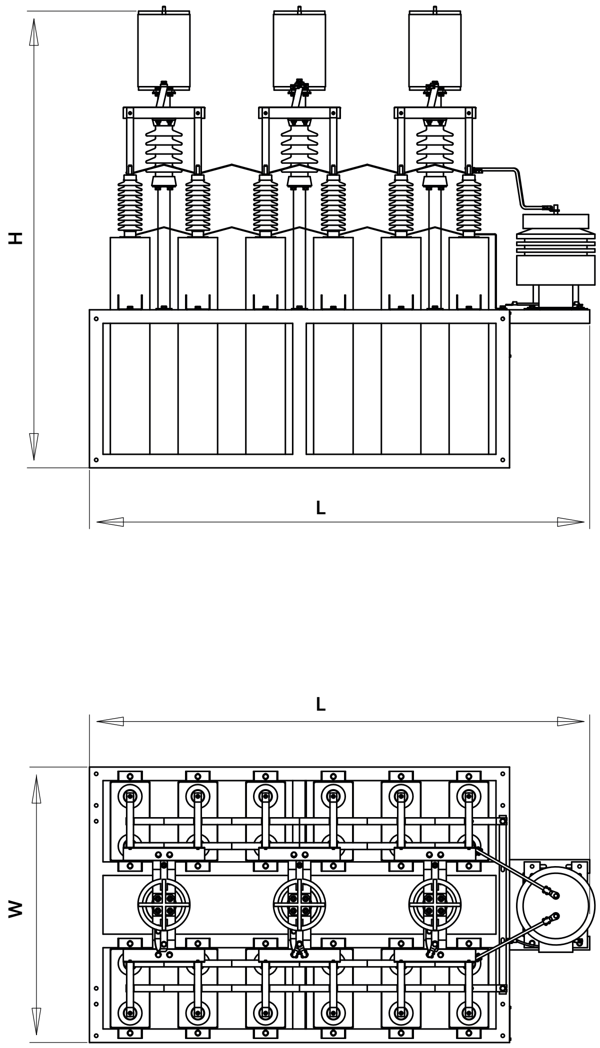


Fig. 36: PULSE GUARD Capacitor Bank drawing

Type	No. of Capaci-tors	Q[Mvar]	L [mm]	H[mm]	W[mm]	Weight [kg]
PDG 12	6-12	9.6	2250	2100	1220	1600
PDG 18	15-18	14.4	3150	2100	1220	2300
PDG 24	21-24	19.2	4100	2100	1220	3000

Table 14: PULSE PDG GUARD capacitor bank, dimensions and power ratings

9.2 Standard execution examples up to 52 kV

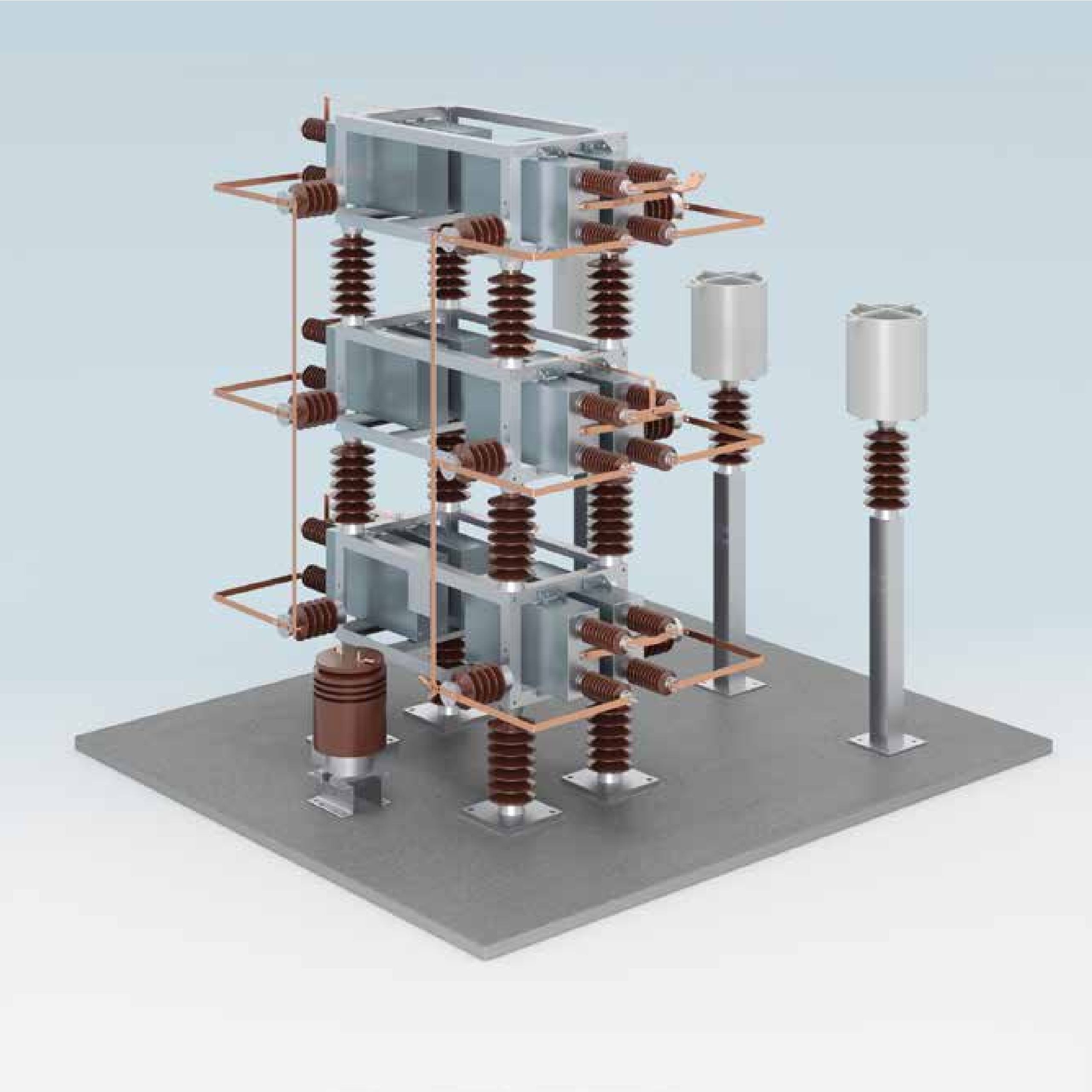


Fig. 37: Typical configuration of PULSE GUARD 36 kV Capacitor Banks with inrush reactors, installation area 5×5 m

10

PULSE SHIELD SERIES: capacitor banks with tuned/detuned reactors

10.1 Detuned systems

When the harmonic content is low or relatively low, detuned systems may be selected (i.e. power factor correction systems tuned to a non-characteristic harmonic).
This type of power factor correction allows the target power factor to be achieved without amplifying harmonic distortion.

A detuned system consists of a reactor connected in series with a capacitor bank.

Typical tuning frequencies for detuned systems are:

- 210 Hz (XL = 5.6% XC)
- 189 Hz (XL = 7% XC)

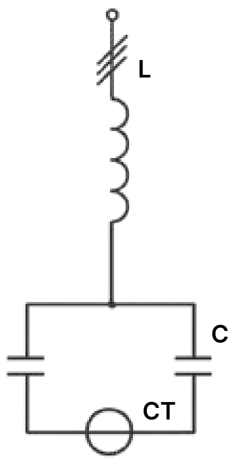


Fig. 38

Technical Data

Insulation voltage	up to 245 kV
Power	> 300 kvar
Fuses	Internal/External/Fuseless
Connection type	Y-Y, H
Protection degree	IP00
Installation	indoor*/outdoor

** For indoor applications up to 17.5 kV, iron-core reactors can be supplied, significantly reducing the required installation space.*

For outdoor applications, the design is similar to that of harmonic filters with Air Core Reactors.

10.2 Harmonic filters

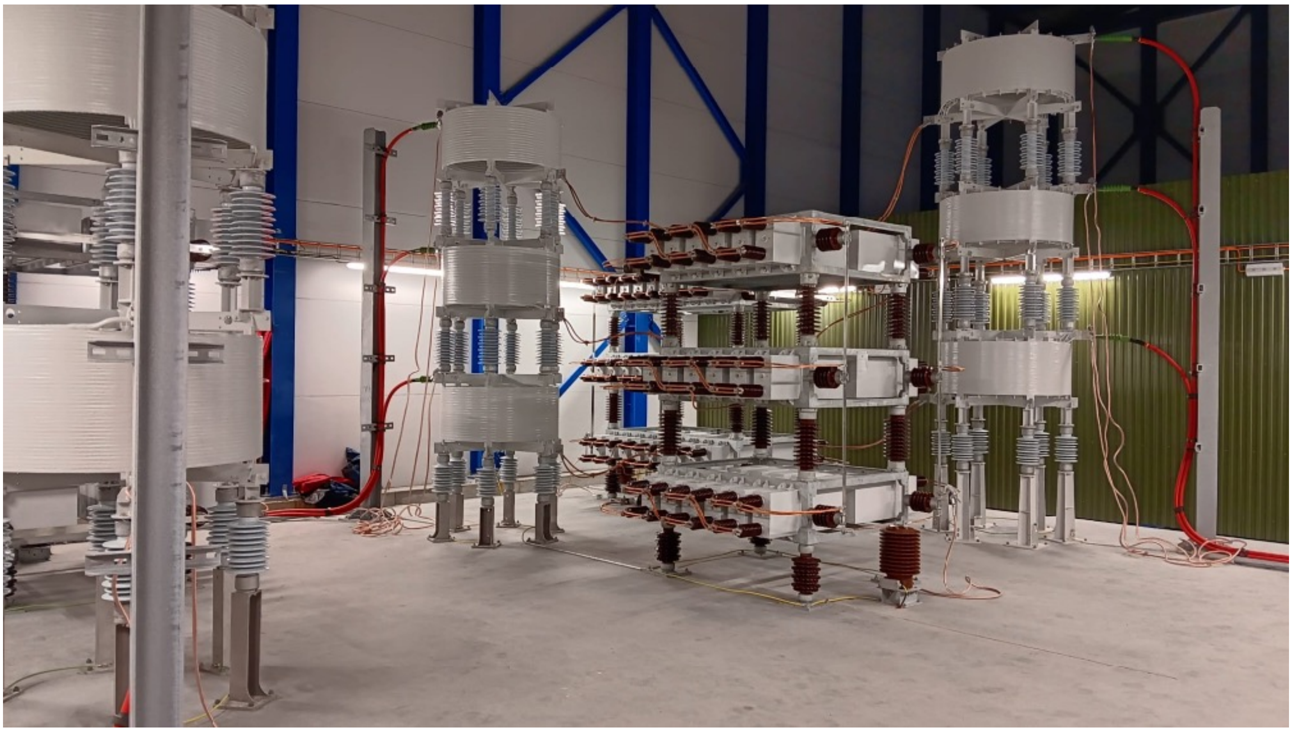


Fig. 39

When power quality improvement is required, and harmonic distortion (THD) must therefore be reduced, tuned harmonic filter systems must be used.

Harmonic filters are available in three types:

- ☑ LC filter **(1)**
- ☑ C-filter **(2)**
- ☑ High-pass filter **(3)**

Technical Data

Insulation voltage	up to 245 kV
Power	> 300 kvar
Fuses	Internal/External/Fuseless
Connection type	Y-Y, H
Protection degree	IP00
Installation	indoor/outdoor

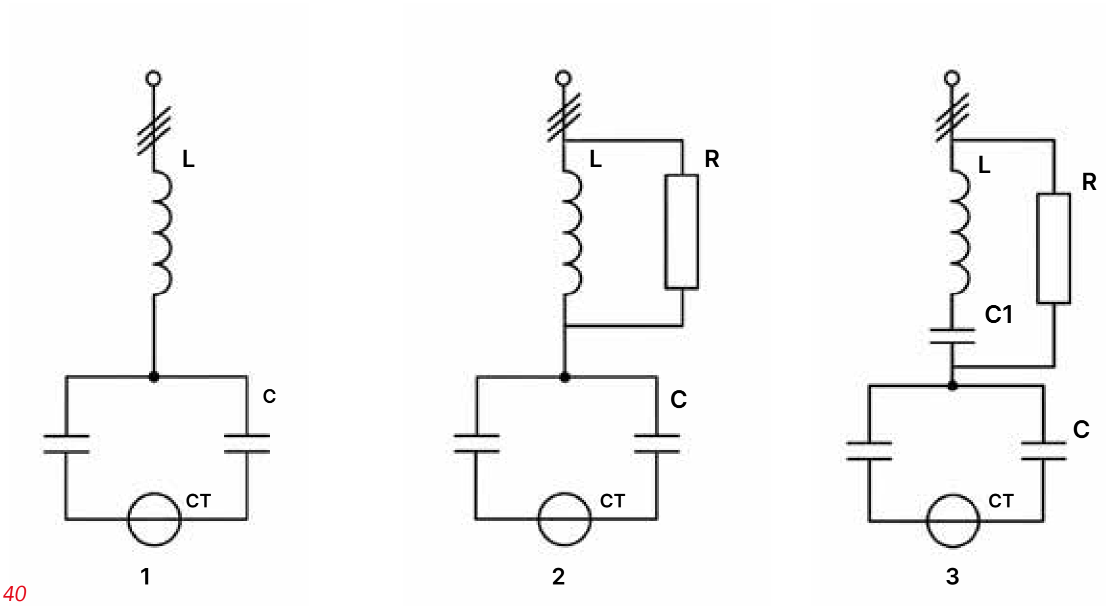


Fig. 40

Fig. 41: PULSE shield: 5th harmonic filter, 3 Mvar, 12 kV equipped with disconnector switch and phase CT, installation area: 6.5×6.5m

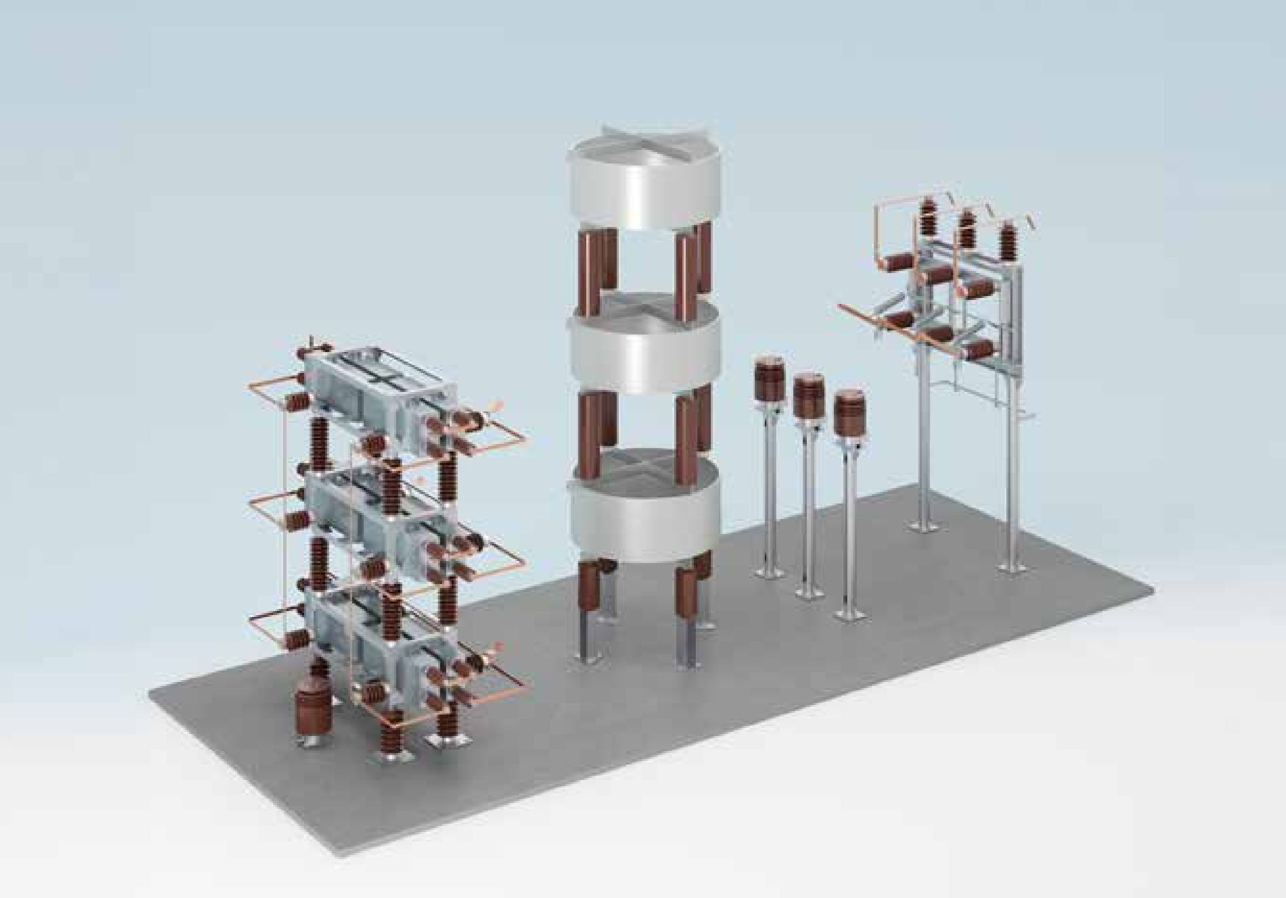


Fig. 42: PULSE shield: 11th harmonic filter, 6 Mvar, 33 kV equipped with disconnector switch and phase CT, installation area: 11.5×5m

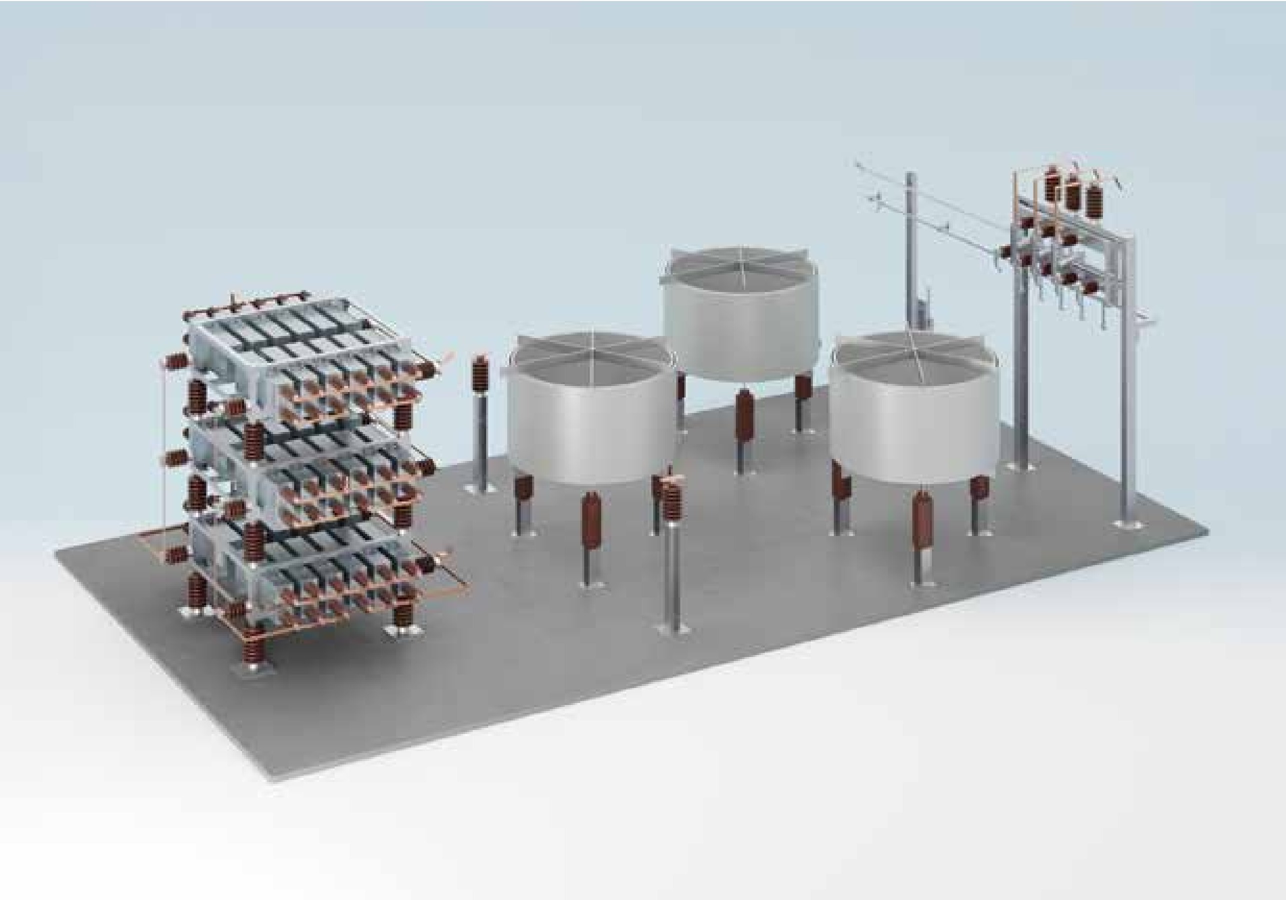


Fig. 43: PULSE shield: 3rd harmonic filter, 15 Mvar, 24 kV equipped with disconnector switch and phase CT, installation area: 12×8m

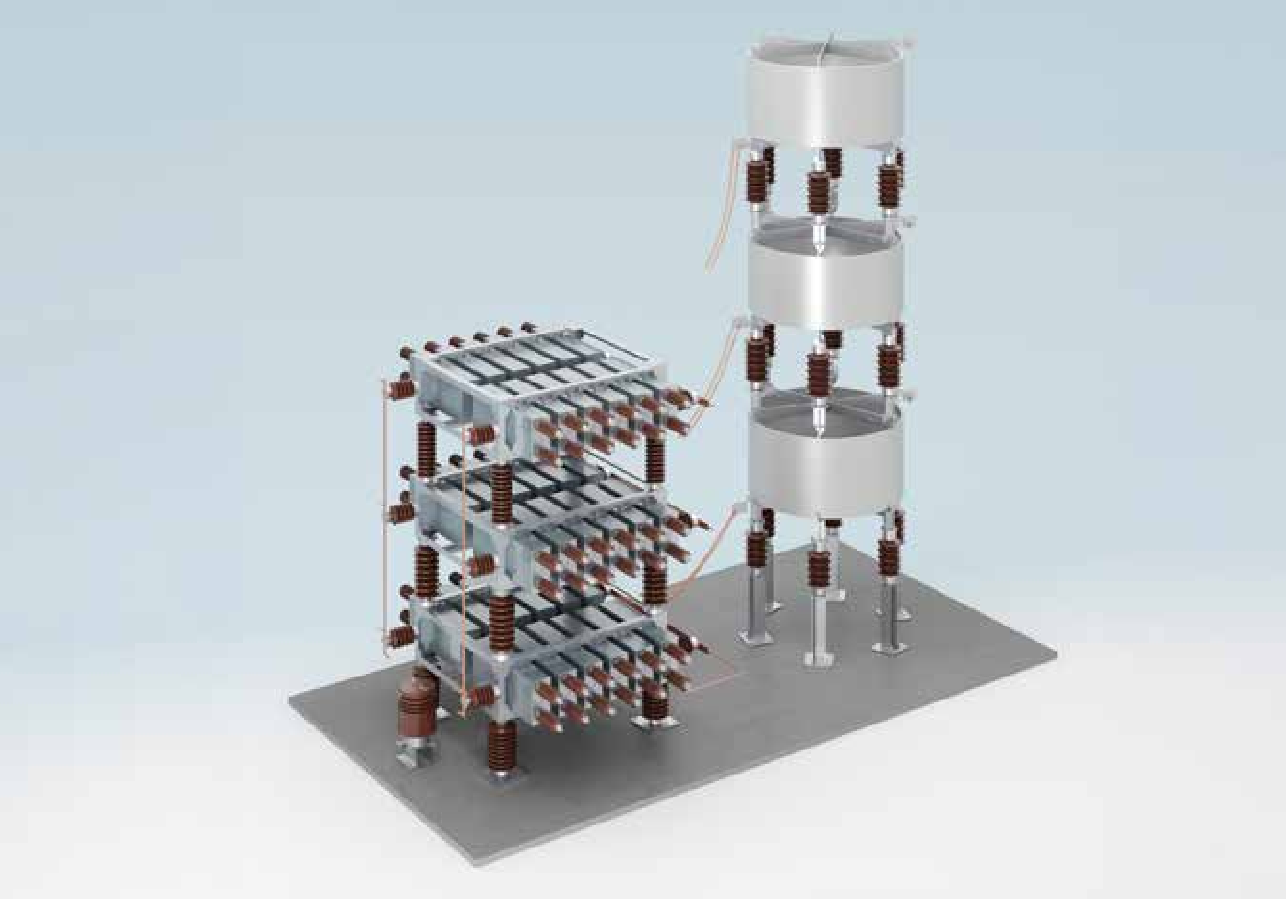


Fig. 44: PULSE shield: 11th harmonic filter, 12 Mvar, 33 kV installation area: 8×5

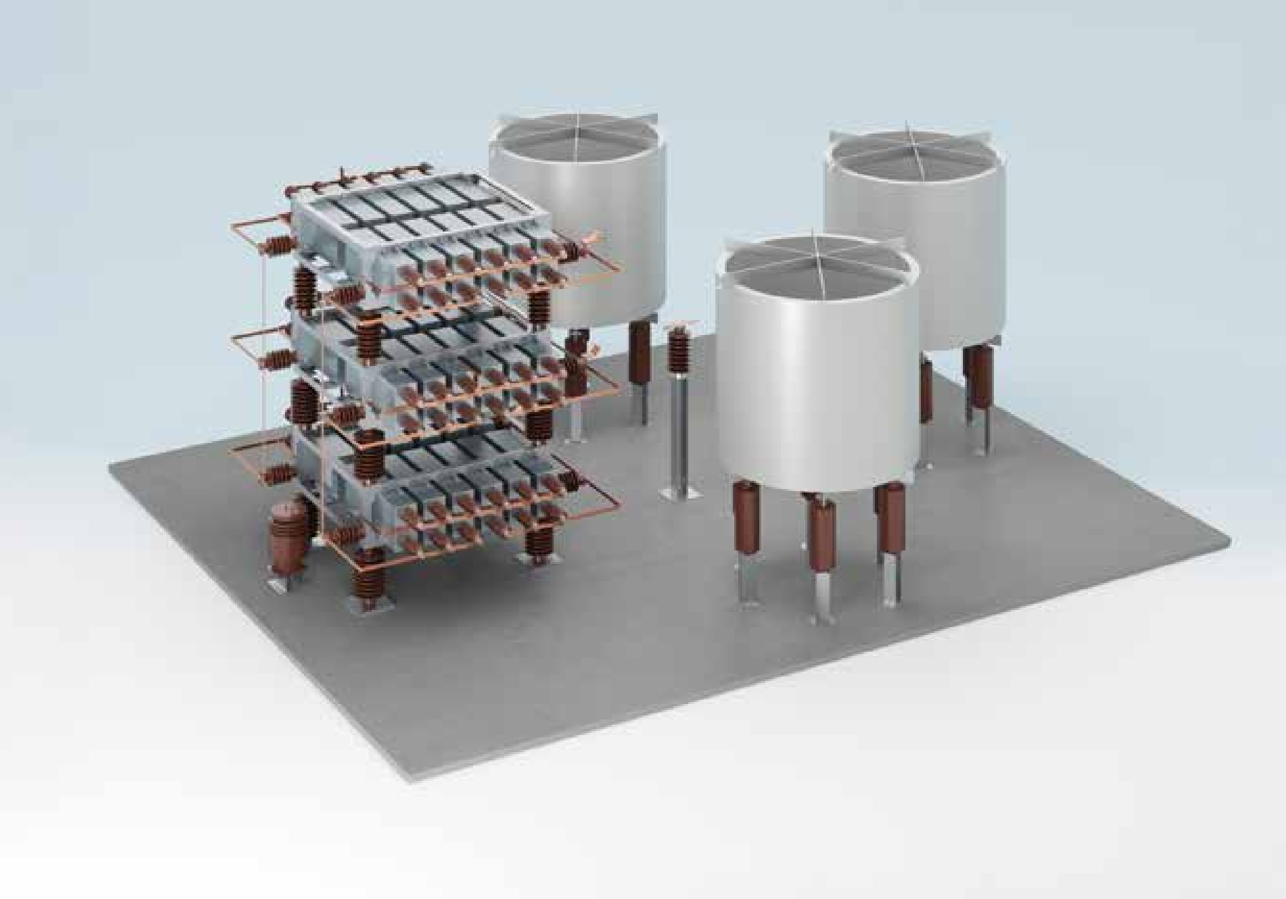


Fig. 45: PULSE shield: 3rd harmonic filter, 12 Mvar, 33 kV, installation area: 10×8m

Fig. 46: System filters 24 kV

11

QUANTUM SERIES:
metal-enclosed capacitor banks

Fig. 47

The QUANTUM Series is a compact and modular solution designed to ensure maximum application flexibility. Thanks to their versatile configuration, they can be easily integrated into a wide range of electrical systems and installation architectures.
Each unit is supplied fully assembled and factory tested, significantly reducing installation and commissioning activities at the customer's site.
The metal enclosure provides full protection of the live parts and a high level of operational safety, achieved through the use of mechanical interlocking systems and safety keys that prevent unauthorised operations and ensure maximum reliability during operation.

Type	Installation	Insulation voltage	Short circuit current	Auto/Fixed
QUANTUM FX (QFX)	Indoor	12/28/75	16 kA/1s	Fixed
QUANTUM CONTROL (QCT)	Indoor	12/28/75	31.5 kA/1s	Auto
QUANTUM FX PLUS (QFP)	Indoor/Outdoor	17.5/38/95	40 kA/1s	Fixed
QUANTUM CONTROL PLUS (QCP)	Indoor/Outdoor	12/28/75	40 kA/1s	Auto

Table 15

11.1 | QUANTUM FX (QFX)

QUANTUM FX is a fixed power factor correction system. It consists of a single-module panel containing capacitors, protection devices and any optional accessories.
It is particularly suitable for the local power factor correction of MV motors or no-load transformers.

The **QUANTUM FX** can be equipped with:

- HRC fuses
- Capacitor banks with Y or Δ connection
- Inrush reactors
- Anti-condensation heaters
- Internal lighting

Technical Data

Insulation voltage	up to 12 kV
Short-circuit withstand current	up to 16 kA/1s
Maximum reactive power	600 kvar
Installation	indoor
Degree of protection	IP31
Access	front
Cable incoming	bottom
Enclosure material	painted sheet steel

Overall dimensions

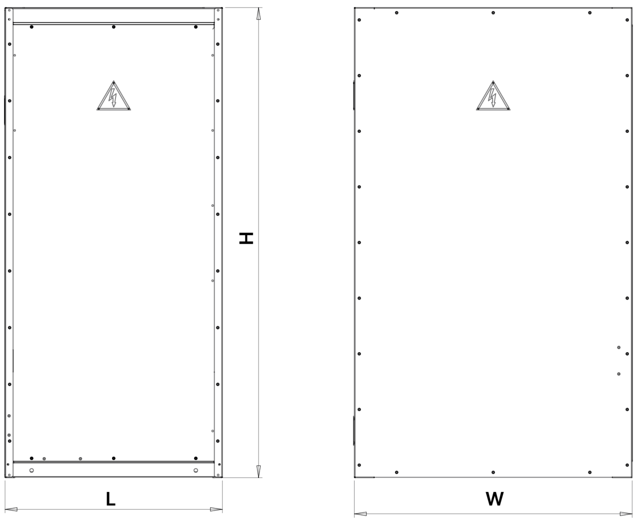


Fig. 48

Electrical diagram

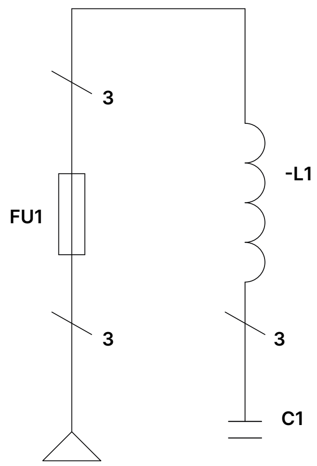


Fig. 49

Type	L [mm]	W[mm]	H[mm]
QFX	900	1150	1950

Table 16

11.2 QUANTUM CONTROL (QTC)

QUANTUM Control is an automatic power factor correction system with a compact modular design. It consists of a cable incoming unit and one or more capacitor bank units, complete with switching and protection devices, together with a wide range of optional accessories.

Fig. 50: Example of installation of QUANTUM Control

The **cable incoming** unit acts as the interface with the electrical plant and houses the connection of the MV power cables and auxiliary circuits.

The cable incoming unit can be equipped with:

- Line disconnector
- Earthing switch
- Voltage presence indicator lamps
- Power factor controller (cos φ regulator)

The **"capacitor bank"** units may include:

- Withdrawable vacuum contactor
- HRC fuses
- Y-Y capacitor bank
- Current transformers for unbalance protection
- Detuned/inrush reactors
- Earthing switch
- Current transformers for overload protection
- Surge arresters
- Ventilation system
- Temperature control
- Anti-condensation heaters
- Internal lighting
- Safety locks
- Protection relay

Technical Data

Insulation voltage	up to 12 kV
Short-circuit withstand current	up to 31.5 kA/1 s
Power per step/unit	up to 1200 kvar when combined with inrush reactors; 800 kvar when combined with detuned reactors
Installation	indoor
Degree of protection	IP31-IP42
Access	front
Cable incoming	bottom
Enclosure material	painted sheet steel

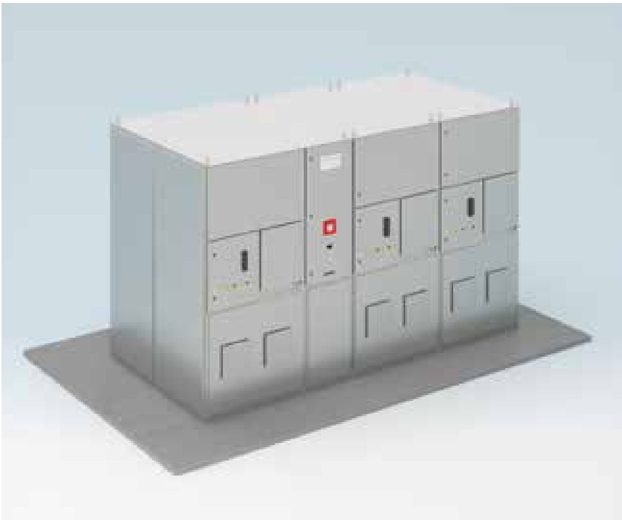


Fig. 51: Typical configuration of QUANTUM Control with three Capacitor Bank

Overall dimensions

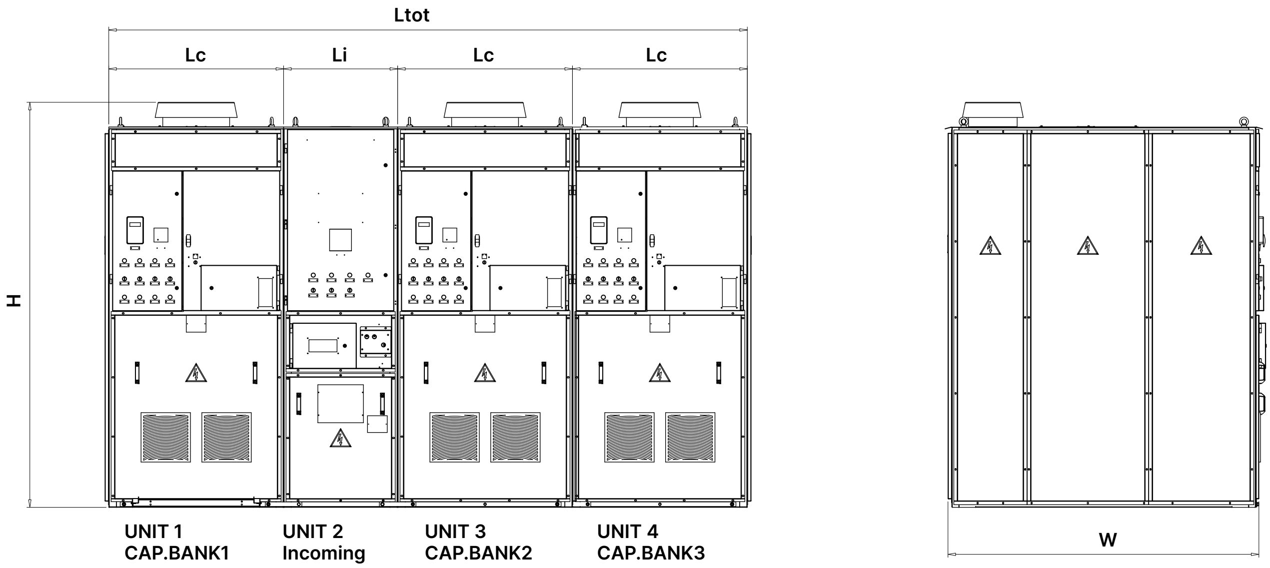


Fig. 52

Electrical diagram

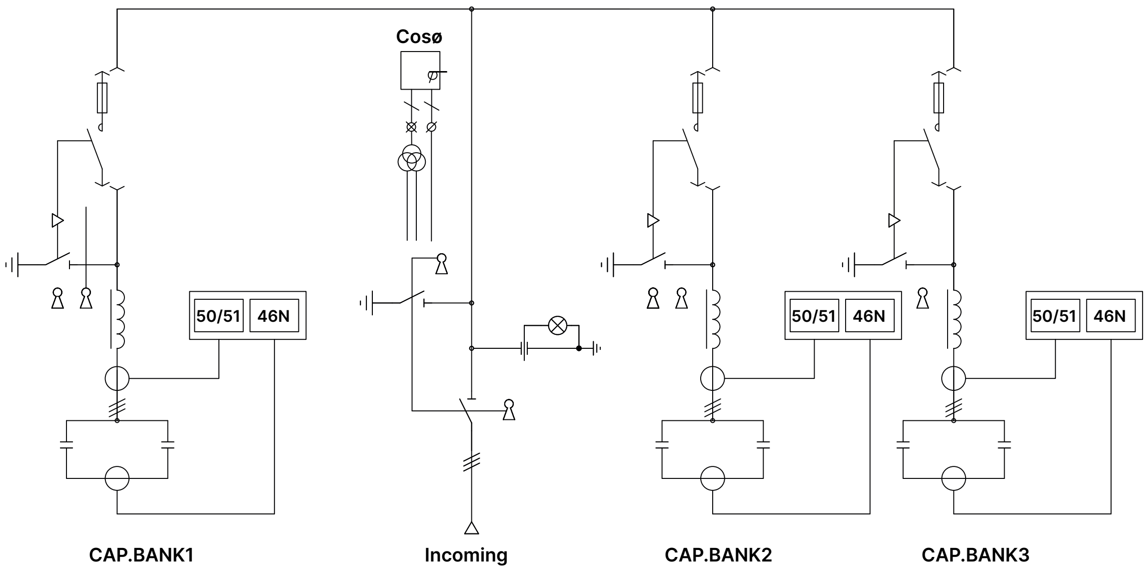


Fig. 53

Type	No. of capacitor banks.	Lc [mm]	Li [mm]	Ltot [mm]	W [mm]	H [mm]
QCT 1	1	1150	750	1900	2000	2665
QCT 2	2	1150	750	3050	2000	2665
QCT 3	3	1150	750	4200	2000	2665
QCT 4	4	1150	750	5350	2000	2665

Table 17

11.3 QUANTUM FX PLUS (QFP)

QUANTUM **FX PLUS** is a modular fixed power factor correction system. It consists of a cable incoming unit and a capacitor bank unit, complete with switching and protection devices, together with a wide range of optional accessories.

Technical Data

Insulation voltage	up to 17.5 kV
Short-circuit withstand current	up to 40 kA/1 s
Power per step/unit	up to 2,500 kvar
Installation	indoor/outdoor
Degree of protection	IP31-IP54
Access	front/rear
Cable incoming	bottom
Enclosure material	painted sheet steel
Basic frame	galvanised steel

The **cable incoming unit** acts as the interface with the electrical plant and houses the connection of the MV power cables and auxiliary circuits.
The cable incoming unit can be equipped with:

- Line disconnector
- Earthing switch
- Voltage presence indicator lamps
- Protection relay

The **"capacitor bank"** unit may include:

- HRC fuses
- Y-Y capacitor bank
- Current transformers for unbalance protection
- Detuned/inrush reactors
- Earthing switch
- Current transformers for overload protection
- Surge arresters
- Ventilation system
- Temperature control
- Anti-condensation heaters
- Internal lighting
- Safety locks

Fig. 54: Typical configuration of QUANTUM Capacitor Bank

Overall dimensions

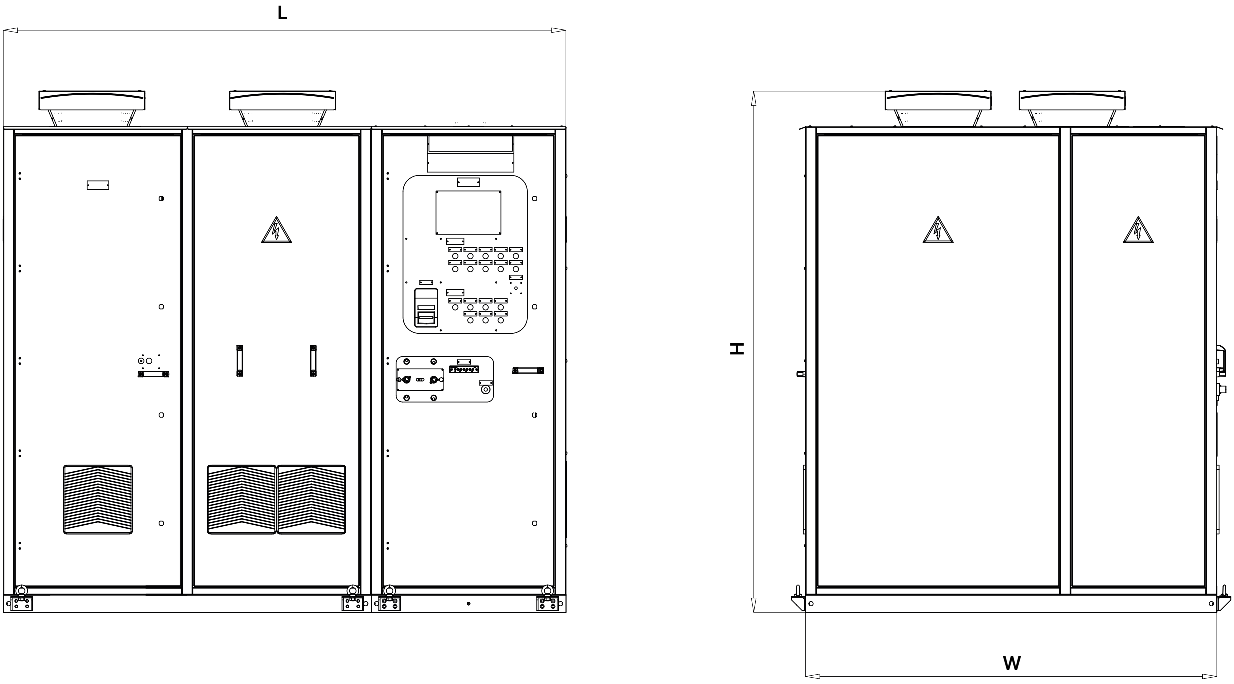


Fig. 55

Electrical diagram

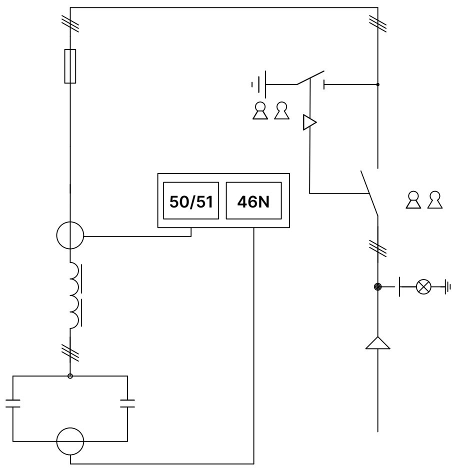


Fig. 56

Type	No. of capacitor banks.	Lc [mm]	Li [mm]	Ltot [mm]	W [mm]	H [mm]
QFP	1	1700	900	2600	1900	2410

Table 18

11.4 QUANTUM CONTROL PLUS (QCP)

QUANTUM Control Plus is a modular automatic power factor correction system. It consists of a cable incoming unit and one or more capacitor bank units, complete with switching and protection devices, together with a wide range of optional accessories.

Fig. 57

The **cable incoming unit** acts as the interface with the electrical plant and houses the connection of the MV power cables and auxiliary circuits.
The cable incoming unit can be equipped with:
- Line disconnector
- Earthing switch
- Voltage presence indicator lamps

The **"capacitor bank"** units may include:
- Vacuum contactor
- HRC fuses
- Y-Y capacitor bank
- Current transformers for unbalance protection
- Detuned/inrush reactors
- Earthing switch
- Current transformers for overload protection
- Surge arresters
- Ventilation system
- Temperature control
- Anti-condensation heaters
- Internal lighting
- Safety locks

The system is completed by a **control and protection panel,** either integrated into the cable incoming unit or supplied as a separate panel, including:
- Power factor controller (cos φ regulator)
- One protection relay for each capacitor bank

Technical Data

Insulation voltage	up to 12 kV
Short-circuit with-stand current	up to 40 kA/1 s
Power per step/unit	up to 2,500 kvar
Installation	indoor/outdoor
Degree of protection	IP31-IP54
Access	front/rear
Cable incoming	bottom
Enclosure material	painted sheet steel
Basic frame	galvanised steel

Overall dimensions

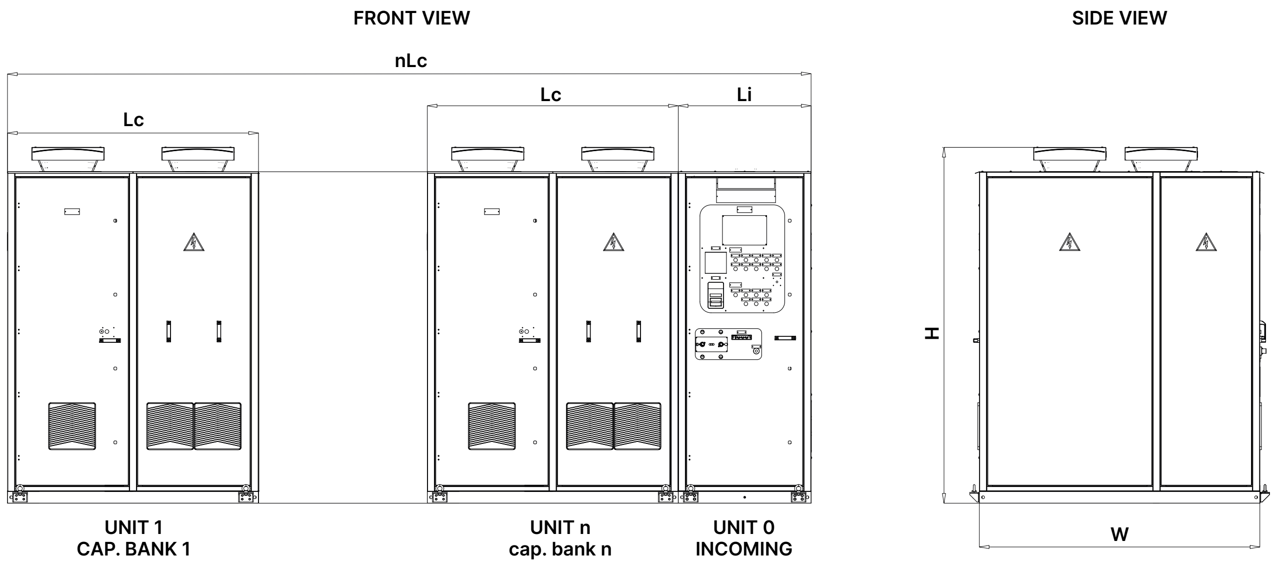


Fig. 58

Electrical diagram

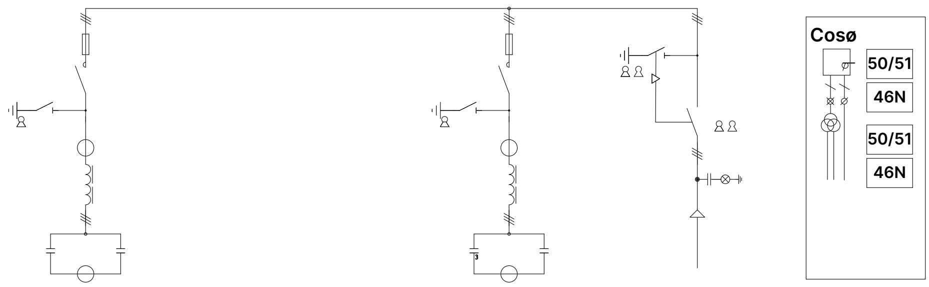


Fig. 59

Type	No. of capacitor banks.	Lc [mm]	Li [mm]	Ltot [mm]	W [mm]	H [mm]
QCP 1	1	1700	900	2600	1900	2410
QCP 2	2	1700	900	4300	1900	2410
QCP 3	3	1700	900	6000	1900	2410
QCP 4	4	1700	900	7700	1900	2410

Table 19

Fig. 60: example of special application in Container

12

CAPACITOR BANK PROTECTION SYSTEMS

The recommended protection systems for a capacitor bank are shown schematically in **Fig. 61.**

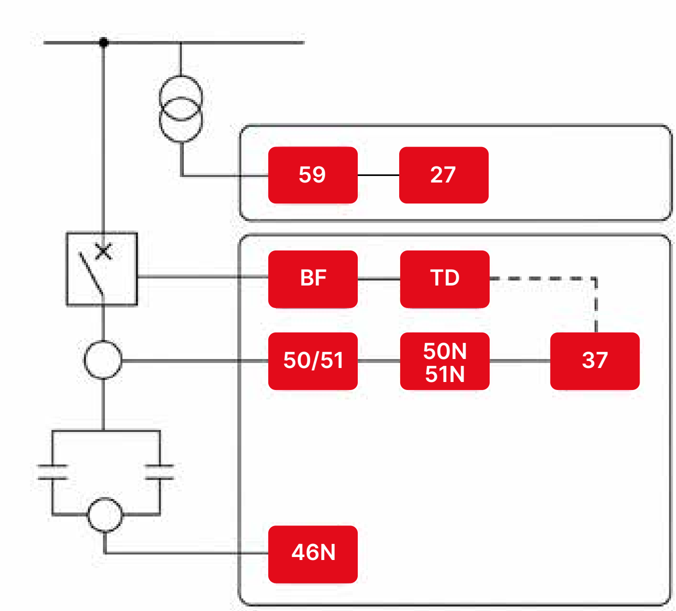


Fig. 61: Summary of possible protections for capacitor banks

27 – Undervoltage	
59 – Overvoltage	
BF – Breaker failure	
TD – Discharge time	
50/51 – Overcurrent	
50N/51N – Earth fault/ground fault current	
37 – Undercurrent	
46N – Current unbalance with offset compensation	

12.1 Current unbalance protection 46N

Current unbalance protection is the best method for monitoring the health status of a capacitor bank in the event of internal element failures.

Different methods can be used to detect capacitor bank unbalance; the most sensitive and reliable method is the current unbalance protection.

The protection is based on the balance principle: the bank is split into two star-connected sections, with a current transformer installed between the two neutral points.

Under normal conditions, the two sections are balanced and no current flows between the neutral points. In the event of an initial fault in one capacitor unit, the neutral point of the affected section shifts, generating a current between the two neutral points through the CT. This current is detected by a dedicated relay, which trips the main circuit breaker.

During commissioning, it may happen that, due to capacitance tolerances, the unbalance current is not exactly equal to 0 A. This condition is known as natural unbalance.

Modern protection relays for capacitor bank protection feature natural unbalance compensation. By enabling this function, the protection thresholds are applied to the compensated natural current, thus preserving sensitivity without the need to modify the threshold settings.

12.2 Phase over-current protection 50/51

Phase overcurrent protection should be provided to safeguard the capacitor bank against current exceeding the allowable limits, for example due to unexpected harmonic generation or resonance effects. This protection can be achieved by means of two or three current transformers (CTs), depending on whether the system is a three-wire system with insulated neutral or otherwise, together with a suitable phase overcurrent relay.

12.3 Overvoltage and undervoltage protection 59/27

This can be provided by means of two or three voltage transformers together with a suitable relay, in order to keep the overvoltage within the limits specified in **Section 3.4 tab.2**.

12.4 Discharge time TD

The capacitor bank nameplate specifies two timing parameters:

- the minimum time interval between de-energisation and subsequent re-energisation
- the discharge time required for the residual voltage to reach 75 V

If the first timing is not observed, this may cause capacitor failure as well as damage to a significant portion of the connected system, due to switching overvoltages.

The second time interval is related to personnel safety who may access the capacitor area for maintenance.

12.5 HRC fuse protection

This type of protection is particularly effective for capacitors connected in delta, and it can also be used to protect low-power capacitor banks in combination with other protection devices.

12.6 | Expulsion fuse protection

Expulsion fuses are particularly effective when the bank is configured with several capacitors connected in parallel for each series group. Each capacitor is protected by its own external fuse.
In the event of a fault, the fuse operates by isolating only the affected capacitor.

The main benefit of this type of protection is that the faulty unit can be identified by a visual check, minimising troubleshooting time.

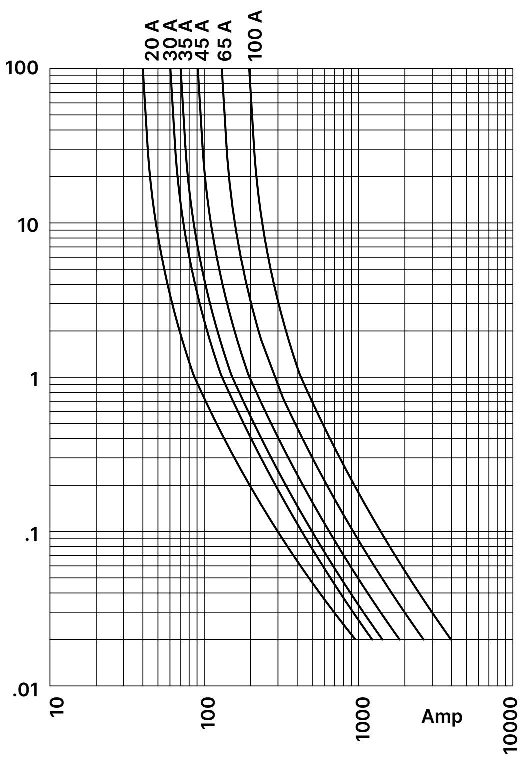


Fig. 62: Intervention curve

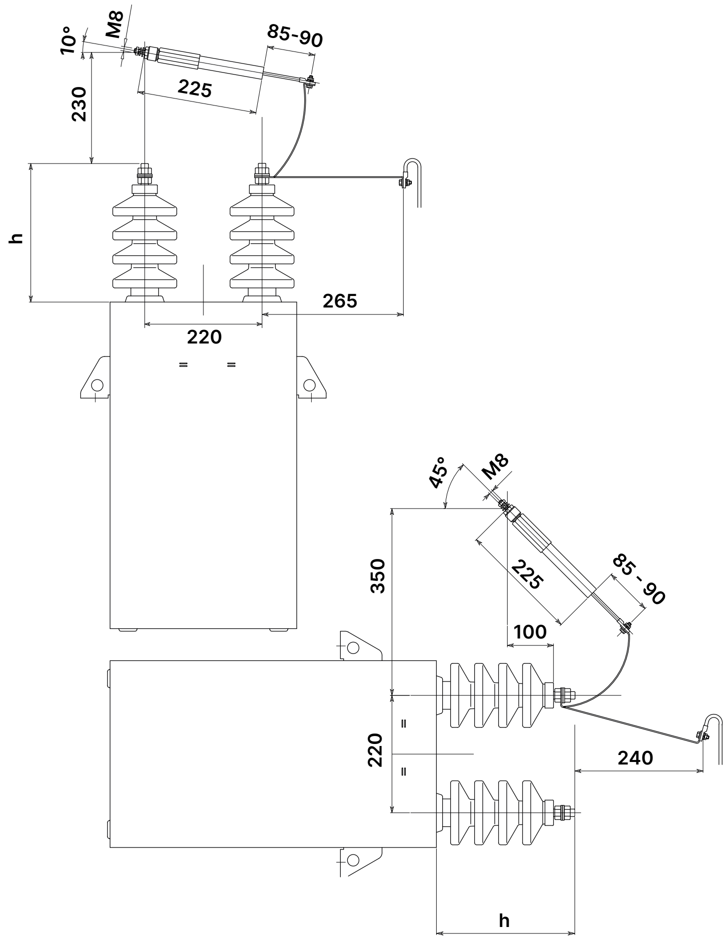


Fig. 63: Arrangement of expulsion fuse in the vertical and horizontal assembly of the capacitors.

Rated current A	Vertical cap. Part number	Horizontal cap. Part number
20	415.65.5010	415.65.0010
30	415.65.5020	415.65.0020
35	415.65.5030	415.65.0030
45	415.65.5040	415.65.0040
63	415.65.5050	415.65.0050
100	415.65.5060	415.65.0060
150	415.65.5070	415.65.0070

Table 20: Expulsion fuses (weight 400 gr)

Fig. 64

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INQUIRY FORM

PROJECT NAME:

COUNTRY:

Product type

	Series	Description – Protection degree
	PULSE	Open-air PFC capacitor banks – IP00
	PULSE GUARD	PFC capacitor banks with inrush reactors – IP00
	PULSE SHIELD	Capacitor banks with blocking or filter reactors – IP00
	QUANTUM	Metal-enclosed power factor correction capacitor banks – IP31 and IP54

QUANTITY:

RATED VOLTAGE Vn [kV]:

RATED POWER Qn [kvar]:

INSULATION LEVEL Um [kV]:

RATED FREQUENCY fn: [ ]50 Hz ; [ ]60 Hz

SHORT-CIRCUIT CURRENT: .....kA/1 s

ALTITUDE: [ ] < 1000 m above sea level ; [ ]

INSTALLATION : [ ] INDOOR, [ ] OUTDOOR

SPACE LIMITATION L×W×H [m]:

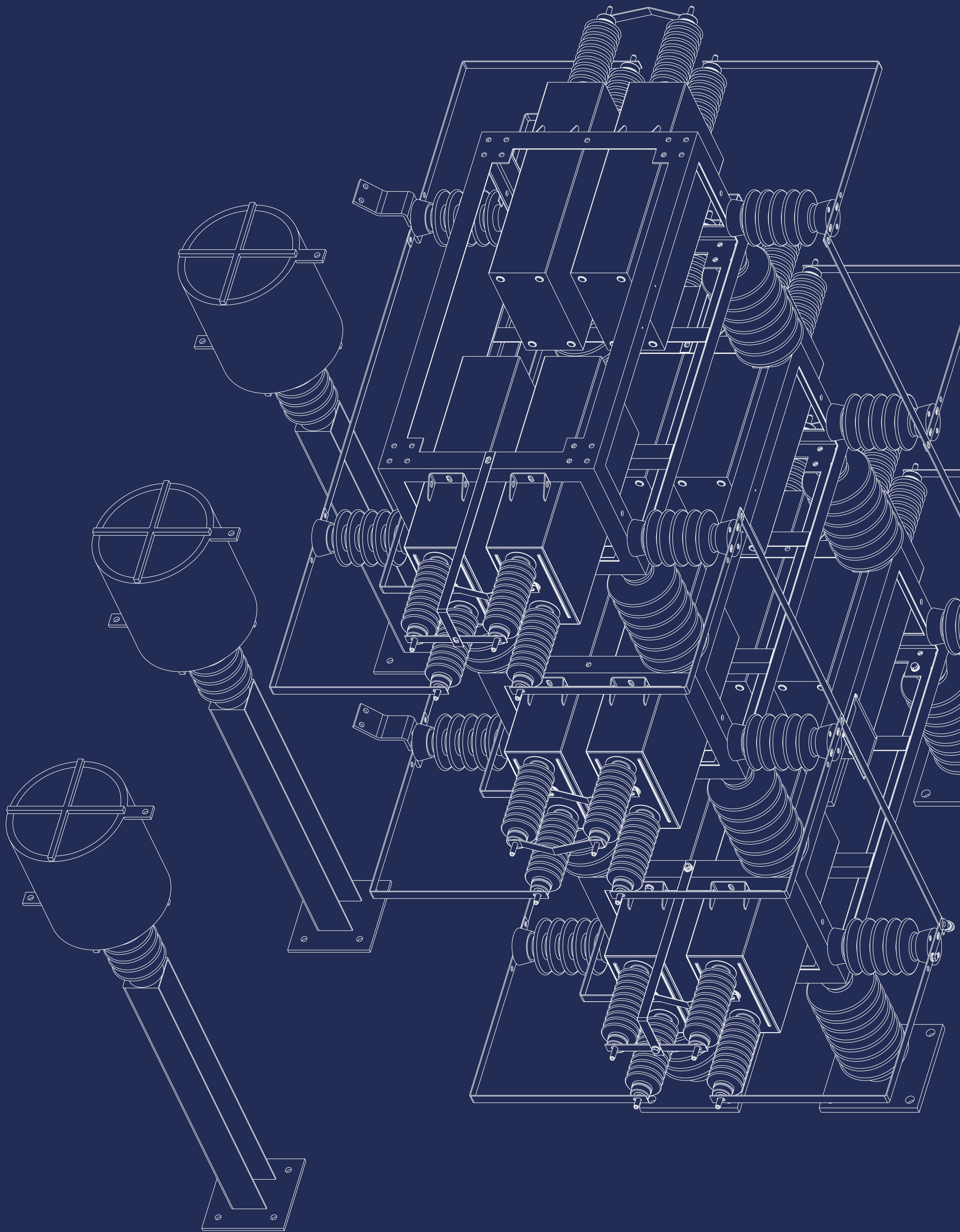
POLLUTION LEVEL: [ ] Light 16 mm/kV; [ ] Medium 20 mm/kV; [ ] heavy 25 mm/kV; [ ] very heavy 31 mm/kV

SERVICE TEMPERATURE min/max: ....°C/...........°C

SPECIAL REQUIREMENTS:

HARMONIC ABSORBED BY PFC SYSTEM (mandatory data for detuned and harmonic filters)

Harmonic order h	Harmonic value [A]
2	
3	
4	
5	
7	
11	
13	
17	
19	
23	
25	



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