ITM Capacitor

Company-Product-Service

Information

About ITM

Company Information:

ITM was founded in 2000, and signed a number of Distributorship Agreements with

- TDK Electronics AG, Germany (EPCOS Brand Name),
- Wöhner GmbH, Germany and

We offer our customers standard components, network analysis and solutions to save energy and to improve power quality by reactive power compensation and harmonic filtering.

Company Values:

Our ambition is to establish and run a quality-minded engineering company that you can trust and rely on. Much effort has been put to provide products, services and solutions that customers will receive the best value and highest quality.

Background of Presenter

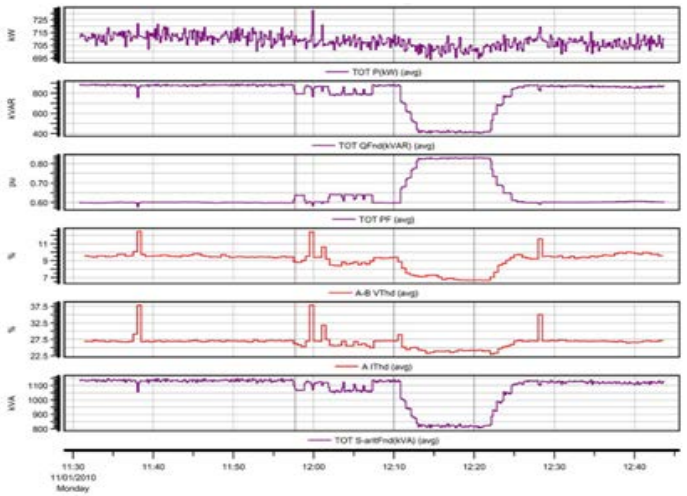
Thumrongdej Mungcharoen is the managing director and founder of ITM Capacitor Company Limited (ITM), the leading supplier of Capacitor Banks and Harmonic Filter Systems in Thailand and neighbor countries.
We have provided engineering, service and product support to Industrial, commercial, renewable and utility power systems by ITM for over 20 years.

Mr. Thumrongdej M received B.Eng. in electrical engineering from Chulalongkorn University and Master of Management from SASIN Thailand.

He used to work as an electrical engineer at Provincial Electricity Authority (PEA) and also worked as sales, design, Project engineer and managing director of ABB Distribution Co., Ltd. Thailand.

Organization Chart

ITM Services and Solutions



Insufficient power quality leads to:

- High energy consumption and costs
- Power losses in the network
- Higher transformer and cable losses
- Increased voltage drop
- Production failure
- Malfunction of electric controls
- Tripping of CBs and fuses
- Capacitors damaged

ITM has provided services and solutions to save energy and improve power quality by:

- Performing PQ measurements
- Performing Network analysis
- Performing Design system solutions
- Providing Reactive power compensations
- Renovating existing capacitor banks
- Providing harmonic filters

TDK–EPCOS–SIEMENS Company Information

1847 Establishment of Siemens in Berlin Germany

1947 Siemens invented MKK Capacitors in Heidenheim

Siemens Matsushita Components

1989 Establishment of Siemens Matsushita Components GmbH, Germany

1999 Establishment of EPCOS AG, Germany

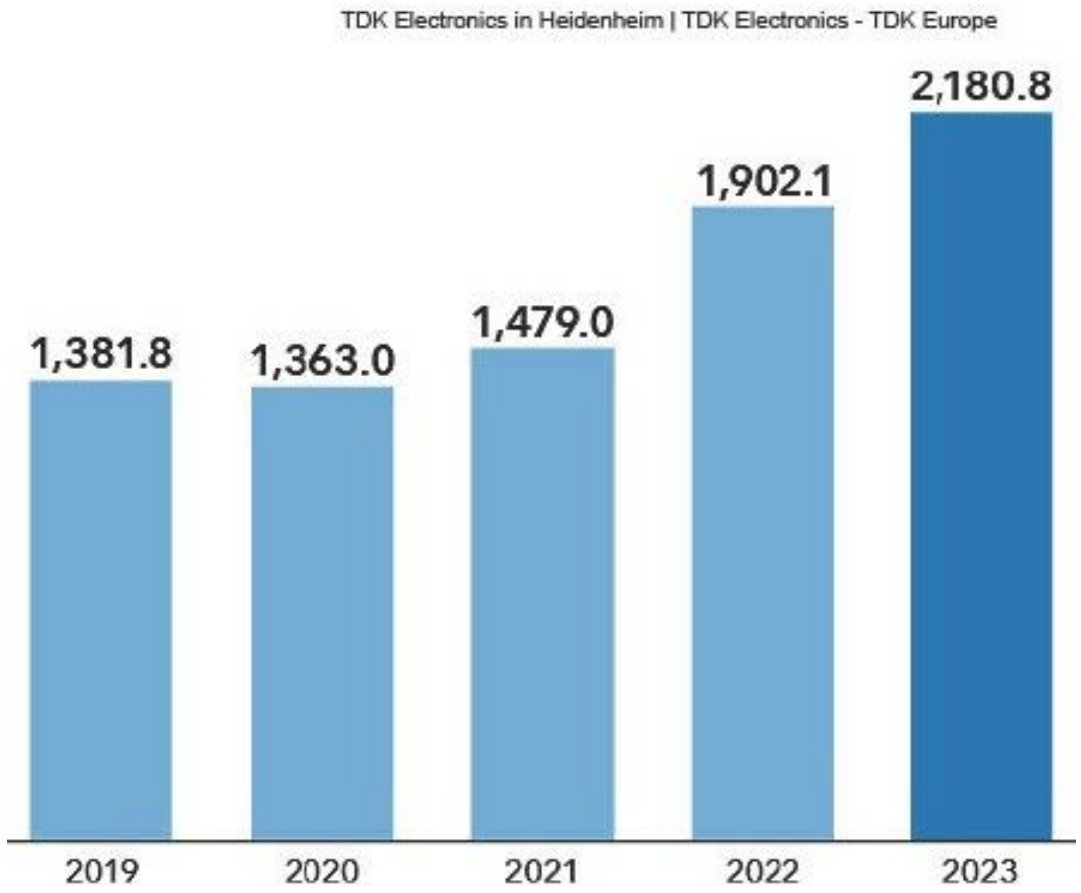
(EPCOS AG is the legal successor to Siemens Matsushita Components GmbH)

TDK is the parent company of EPCOS

2009 No change to the products that bear the EPCOS brand

2023

TDK-EPCOS Company Information



TDK – a Global Player

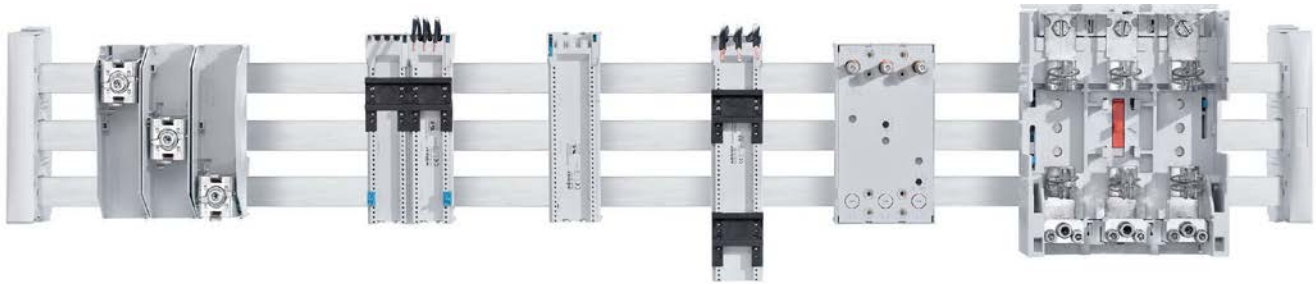
- Headquarter: Tokyo, Japan
- Product brands: TDK, EPCOS, InvenSense, Micronas, Tronics and TDK-Lambda
- Sales of about JPY 2,180 billion (USD 15.4 billion) in fiscal year 2023 (ending March 31)
- Extensive R&D, manufacturing and sales network

EPCOS Product Information

- PFC Capacitors
- Capacitor Contactors
- Thyristor Modules
- PF Controllers
- Detuned Reactors
- Static Var Generators (SVG)
- Active Harmonic Filters (AHF)

Wöhner Company Information

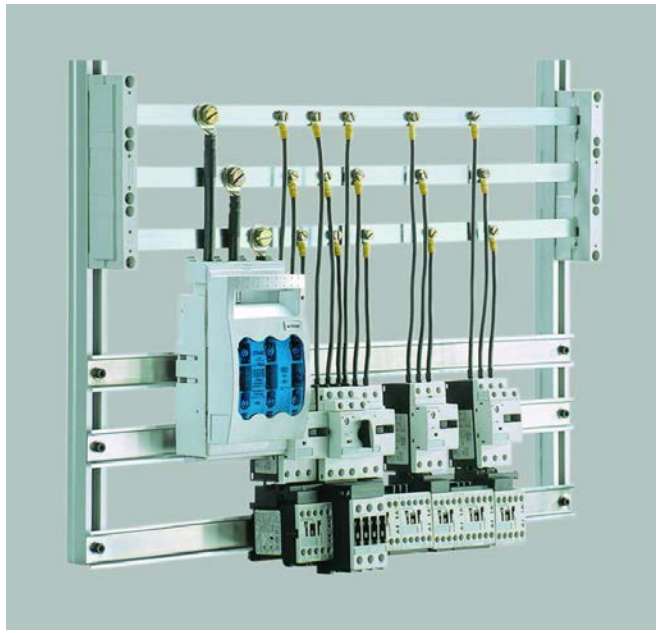
- Founded Founded in 1929 by Alfred Wöhner
- Head office in Rödental/Bavaria
- 12 subsidiaries/joint ventures
- Operations extend to 80 countries
- Over 100 registered patents
- Over 200 employees (worldwide)



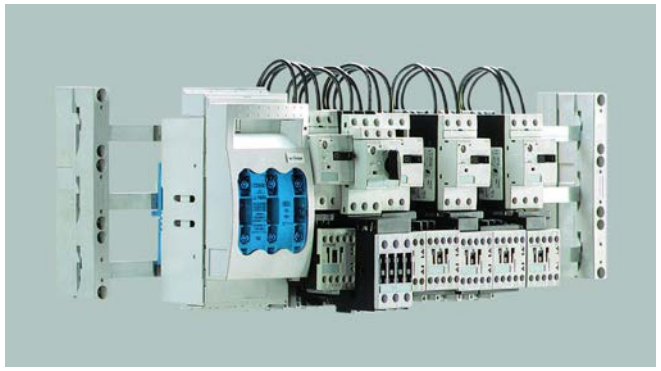
Wöhner Product Information

CrossLink Technology

- patented plug technology
- economic pre-assembling of units
- shock-protected universal adapter



Traditional installation with busbar drillings



Innovative busbar-mounting systems with Clip on mounting components without busbar drillings

Some Major References

MV and LV

Capacitor Banks and Components

Major Reference – LV Capacitors

- The Siam Cement (Kaeng Khoi) Co., Ltd.
- The Siam Cement (Ta Luang) Co., Ltd.
- The Siam Cement (Thung Song) Co., Ltd.
- The Siam Cement (Lampang) Co., Ltd.
- CPAC Construction Solution Co., Ltd.
- Sosuco Ceramic Co., Ltd.
- Siam Kraft Industry Co., Ltd.
- Thai Cane Paper Public Company Limited.
- Thai Containers Group Co., Ltd.
- Phoenix Pulp & Paper Public Company Limited.
- Thai Paper Co., Ltd.
- Thai Plastic and Chemicals Public Company Limited,
- Siam Nippon Industrial Paper Co., Ltd. (SNP)
- The Siam Pulp and Paper Public Company Limited
- Thai Kraft Paper Industry Co., Ltd.

Major Reference – LV Capacitors

- MRTA
- Thai Airways – TG Hangar
- MEA
- Central Rama 3
- Central Phuket Festival
- Big C, Carrefour, Lotus, Home Pro
- Bangkok Post
- Krung Thai Bank
- Bank of Thailand
- JW Marriott Bangkok Hotel
- Sofitel Hotel, Chedi Chiang Mai Hotel
- Intercontinental Bangkok Hotel
- King Power Suvarnabhumi Airport

Major Reference – LV Capacitors

- Siam City Cement PLC
- Thai Rayon PLC
- Thai Acrylic Fiber Co., Ltd.
- Asia Cement PLC.
- Thai Steel Profile PLC
- Asiapet Limited and Indorama Polymers Public Company Limited - Lopburi
- Thai Polyphosphate & Chemicals Co., Ltd.
- Bangkok Steel Industry Co., Ltd.
- Sang Som Co., Ltd.
- Thai Beverage PLC
- Lao Brewery Co Ltd.
- Boonrawd Brewery Co., Ltd.
- The Red Bull Beverage Co., Ltd. - Prachinburi

Major Reference – MV Capacitors

- Government Complex Commemorating His Majesty The King's 80th Birthday Anniversary, 5th December, B.E. 2550 (2007): MV Capacitors, Vacuum Contactors and Series Damping Reactors 2,100 kVAr 7.2 kV
- Forestias Project: MV Capacitors, Vacuum Contactors and Series Damping Reactors 3,600 kVAr 7.2 kV
- SCGP (Thai Cane Paper PLC – Prachinburi Plant): MV Capacitors (24 x 207 kVAr 2,500 V 1-ph 2-bushing and MV Detuned Reactors (4 x 775 kVAr 3300 V 7%)
- Double A (1991) PCL – Prachinburi Plant): MV Capacitors (4 x 550 kVAr 8,000 V 3-ph 3-bushing) and MV Detuned Reactors (4 x 400 kVAr 6,600 V 7%)

EPCOS

Film Foil Oil Impregnated Capacitors

- **MV** & LV **power capacitors**
- **MV surge capacitors**
- MV DC energy storage capacitors
- MV & LV AC filter capacitors

- Technology : Non Self Healing
- Dielectric : Hazy Polypropylene
- Impregnant : Synthetic oil (PXE / Jarylec)
- Electrode : EFE Aluminium foil
- Bushings : Ceramic / Non-ceramic
- Can : CRCA / SS

Detuned Capacitor Banks designed and supplied by ITM

SIW

(The Siam Industrial Wire Co., Ltd.)

Reactive Power Compensation 9,000 kVAr 400 V

- EPCOS Capacitor Contactors Type S….J230
- EPCOS Thyristor Modules Type TSM-LC-N1
- EPCOS PF Controllers Type BR6000
- EPCOS PFC Capacitors Type PhaseCap
- EPCOS Detuned Reactors 50 kVAr Detuning 7%
- Designed, supplied and energized by ITM in December 2009.

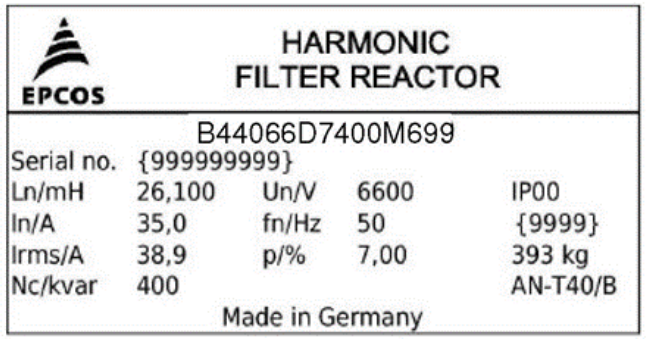
Detuned Capacitor Components supplied by ITM

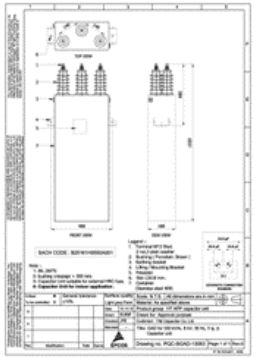
Double A Paper

(Double A (1991) Public Co Ltd.)

Reactive Power Compensation 6,675 kVAr 400 V and 690 V

- EPCOS Capacitor Contactors Type S9010J230
- EPCOS PF Controllers Type BR7000
- EPCOS PFC Capacitors Type PhaseCap Premium
- EPCOS Detuned Reactors 75 kVAr Detuning 7%
- Supplied and energized by ITM in 2014





Reactive Power Compensation 1,600 kVAr 400 V and 6,600 V

- EPCOS PF Controllers Type BR7000
- EPCOS PFC Capacitors 8 kV 3-ph 550 kVAr (4 units)
- EPCOS Detuned Reactors 6.6 kV 3-ph 400 kVAr 7% (4 units)
- Supplied and energized by ITM in 2014

PFC Capacitor Components supplied by ITM

Red Bull (T.C. Pharmaceutical Industries Co., Ltd.)

Reactive Power Compensation 3,000 kVAr 400 V

- EPCOS Capacitor Contactors Type S6210J230
- EPCOS PF Controllers Type BR6000-R12
- EPCOS PFC Capacitors Type PhaseCap Premium
- Supplied by ITM in December 2019.

Dynamic PFC designed and supplied by ITM

Thai Containers Group Co., Ltd. (Pathum Thani Plant)

Reactive Power Compensation 600 kVAr 400 V

- EPCOS Thyristor Modules Type TSM-LC-N1
- EPCOS PF Controller Type BR7000-T
- EPCOS PFC Capacitors Type PhaseCap
- Mangoldt Detuned Reactors 50 kVAr Detuning 7%
- Designed, supplied, installed and energized by ITM in May 2020.

MV PFC Capacitors designed and supplied by ITM

Forestias Project

Reactive Power Compensation 3,600 kVAr 7.2 kV

- EPCOS MV Vacuum Contactors
- EPCOS MV Capacitors
- EPCOS MV Damping Series Reactors
- ETI MV Fuses
- Delivered in April 2022.

Dry type, Air Core Reactor

Inrush current ratio with inductance value; µH								
Step #	50	75	100	200	250	500	1,000	2,200
1	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9
2	104.4	85.3	73.9	52.2	46.7	33.0	23.4	15.7
3	139.3	113.7	98.5	69.6	62.3	44.0	31.1	21.0
4	156.7	127.9	110.8	78.3	70.1	49.5	35.0	23.6
5	167.1	136.5	118.2	83.6	74.7	52.8	37.4	25.2
6	174.1	142.1	123.1	87.0	77.9	55.0	38.9	26.2
7	179.1	146.2	126.6	89.5	80.1	56.6	40.0	27.0
8	182.8	149.2	129.2	91.4	81.7	57.8	40.9	27.6
9	185.7	151.6	131.3	92.8	83.0	58.7	41.5	28.0
10	188.0	153.5	132.9	94.0	84.1	59.5	42.0	28.3
11	189.9	155.1	134.3	95.0	84.9	60.1	42.5	28.6
12	191.5	156.3	135.4	95.7	85.6	60.6	42.8	28.9
XL / XC	0.0046	0.0068	0.0091	0.0182	0.0228	0.0455	0.0911	0.2004	%

MV PFC Capacitors designed and supplied by ITM

Government Complex Project

Reactive Power Compensation 2,100 kVAr 7.2 kV

- EPCOS MV Vacuum Contactors
- EPCOS MV Capacitors
- EPCOS MV Damping Series Reactors
- ETI MV Fuses
- Delivered in January 2024.

Dry type, Air Core Reactor

Inrush current ratio with inductance value; µH								
Step #	50	75	100	200	250	500	1,000	2,200
1	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9
2	104.4	85.3	73.9	52.2	46.7	33.0	23.4	15.7
3	139.3	113.7	98.5	69.6	62.3	44.0	31.1	21.0
4	156.7	127.9	110.8	78.3	70.1	49.5	35.0	23.6
5	167.1	136.5	118.2	83.6	74.7	52.8	37.4	25.2
6	174.1	142.1	123.1	87.0	77.9	55.0	38.9	26.2
7	179.1	146.2	126.6	89.5	80.1	56.6	40.0	27.0
8	182.8	149.2	129.2	91.4	81.7	57.8	40.9	27.6
9	185.7	151.6	131.3	92.8	83.0	58.7	41.5	28.0
10	188.0	153.5	132.9	94.0	84.1	59.5	42.0	28.3
11	189.9	155.1	134.3	95.0	84.9	60.1	42.5	28.6
12	191.5	156.3	135.4	95.7	85.6	60.6	42.8	28.9
XL / XC	0.0046	0.0068	0.0091	0.0182	0.0228	0.0455	0.0911	0.2004	%

Technical Presentation

Power Quality

Problems and Solutions

Power Quality Problems and Solutions

Technical Presentation

- Basic Capacitor Bank
- Detuned Capacitor Bank
- Dynamic Detuned Capacitor Bank
- Static Var Generator – SVG
- Active Harmonic Filter - AHF

Power Quality Problems and Solutions

Power Quality Problems

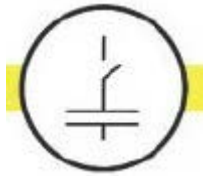
- Reactive Power
- Harmonics
- Dynamic Load
- Voltage dips
- Flicker

Possible Solutions

- Basic capacitor banks without reactors
- Detuned capacitor banks with reactors
- Dynamic power factor correction
- Static Var Generator – SVG
- Active Harmonic Filter - AHF

Power Quality Issues and Solutions

How to select reactive power compensation and harmonic filter systems



- Use Basic capacitor banks without reactors in case of high reactive load, non-linear load ≤ 15% (mainly linear load) and static load.

- Use Detuned capacitor banks with detuned reactors in case of high reactive load, non-linear load > 15%, ≤ 50% and static load.

- Use Dynamic power factor correction in case of high reactive load, voltage dip, dynamic load or frequent load changes (mostly high harmonic current) e.g. welding, arc furnace, cranes, winding process, rolling mill, etc.

- Use Static Var Generator – SVG in case of high reactive load, non-linear load ≤ 15% (mainly linear load) and flickers.

- Use Active Harmonic Filter – AHF in case of low reactive load, non-linear load > 15% and flickers.

How to Design

Basic Capacitor Bank

Basic Capacitor Bank

Scope of work:

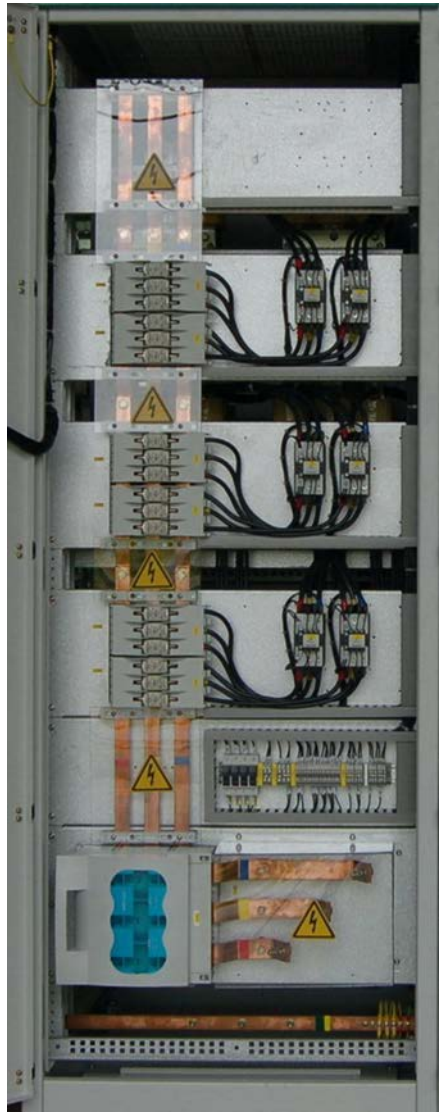
The Contractor shall supply and install the Automatic Basic Capacitor Bank ready for connection and use in low voltage systems.

Electrical environment:

The connection of a capacitor bank onto a system containing harmonics may reduce its life time.
The damaging effects of harmonics can be mitigated by the use of a suitable detuning reactor in series with each capacitor step.

The basic capacitor bank without detuning reactor shall be used in case of

- Non-linear loads < 15% or
- THDv < 3% or
- THDi < 10%.



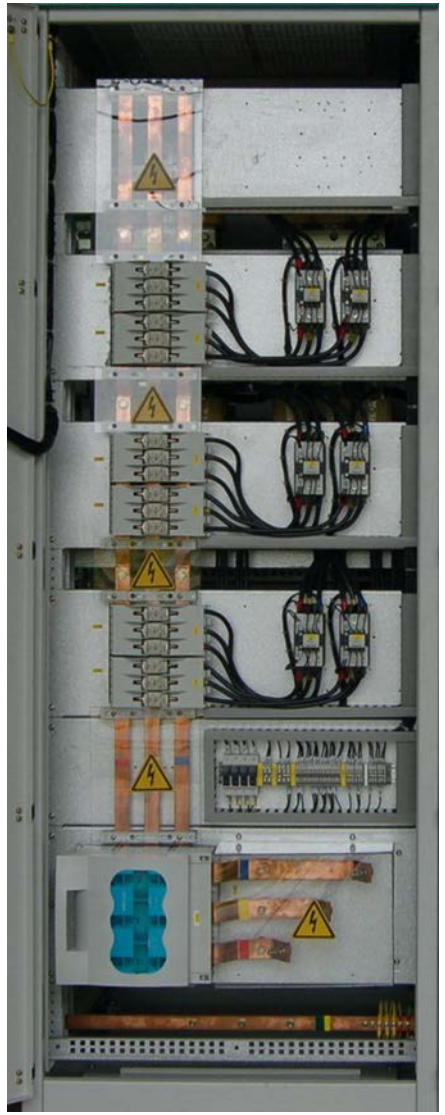
Basic Capacitor Bank

Design:

The modules on a galvanized sheet-steel chassis are fitted with busbar mounting fuse bases including shock protection cover, capacitor contactors with damping resistors, discharge reactors for fast discharges of capacitors, and dry-type capacitors. For connecting the modules together and for the connection to the power system via cable, each module has a 60 mm busbar support system and 30x10 mm copper busbars with insulation cover mounted at the front.

The connection of the module on the control side to the pf controller and to the control voltage is made by control cables via terminal blocks. This control cables shall be routed in cable ducts.

The maximum effective power per section (cubicle) shall not be higher than 400 kvar. For higher power ratings, capacitor section(s) shall be added. The dimension of each 400 kvar section should not be less than HxWxD 2250x800x600 mm. and each section shall have ventilation slots (louver) and axial fan(s).



Basic Capacitor Bank

Cooling fans 230 V, 50 Hz, air flow not less than 800 cubic meter per hour per 400 kvar section. The operating fans shall be controlled by aux. contacts (NO Contacts) of capacitor contactors.

PF Controller, contactor coils and fans shall be protected by control fuse size 10x38, 500 V, 2 - 6 A mounted in fuse switch holder size 10x38, 690 V, 32 A, AC-22B.

The Capacitor bank shall be installed in a separate cubicle from MDB and designed so that alteration or addition of the capacitor in future will not affect the systems. The unit shall be installed as recommended by the manufacturer.

Basic Capacitor Bank

Main components:

- Power Factor Controller
- Fuse-switch or Fuse-base with HRC fuses
- Contactor with damping device for capacitor switching
- Power Factor Correction Capacitor
- Ventilation fans
- LV PFC Banks.

Basic Capacitor Bank

Technical Data:

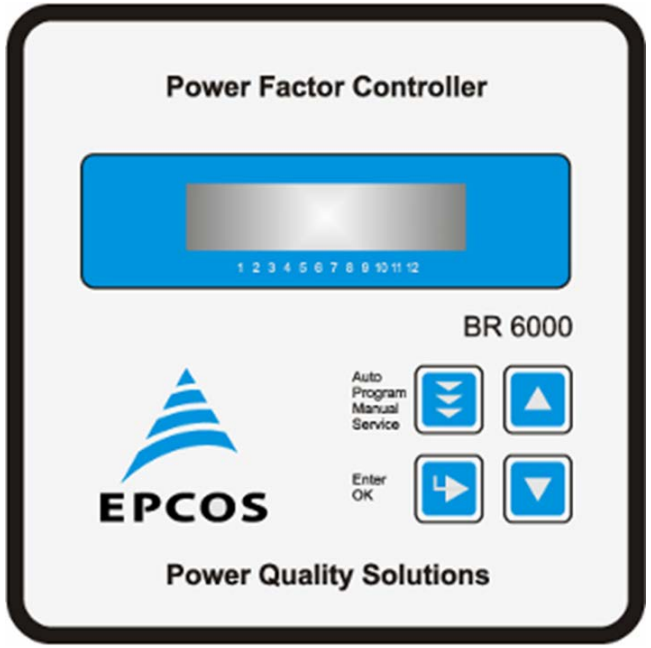
- Low-voltage power factor correction banks

Comply with the requirements of IEC 61921, IEC 61439-1 and IEC 61439-2.
Sheet steel cubicle shall have door and panel thickness 2 mm
Ambient temperature –20 to +35 degree C, 24 h average
Degree of protection IP 21
Short circuit strength of busbars Ipk = 75 kA, Icw = 42 kA, 1 sec.

Basic Capacitor Bank

o Power Factor Controllers

Comply with the requirements of IEC 61000-4-2, IEC 61000-4-4 and IEC 61010-1.
Continuous LCD Display, Operating temp up to +60 degree C
Humidity class up to 95 %, Protection class IP 54 (Front)
Measurement current: x / 5 A, Target Power Factor : 0.3 ind – 0.3 cap
Power Factor display: 0.1 ind – 0.1 cap, Switching
and discharge time: 1-1200 sec, Control mode: LIFO, FIFO,
Intelligent mode, Minimum operating current or Sensitivity: 50 mA
Frequency: 50 Hz, Zero voltage release: < 15 ms
Switching outputs: 6 or 12 steps according to the drawing
Alarm relay: 1 NO Contact (250 V, 1000 W)
Display of V, A, W, VAR, KVA, Frequency, THDv, THDi,
individual harmonics up to 19th, individual capacitor current, temp,
real time cos phi, target cos phi, kvar value to target cos phi
Alarm output of under/over compensation, under/over current, over temp,
harmonics exceeded Recall reorded values of number of contactor switching operations,
Vmax, KVAmax, THDmax, KWmax, KVARmax, TEMPmax, operation time of all capacitors.



Basic Capacitor Bank

- Capacitor Contactors

Comply with the requirements of IEC 60947-4-1 / -5-1.
The capacitor contactor shall be equipped with Aux contact (1 NO) and damping resistors to reduce peak inrush current
Rated Insulation Voltage: 690 V
Utilization categories AC-6b according to IEC 60947-4-1 for switching of capacitor bank
Rated power: according to the drawing.

Basic Capacitor Bank

- Discharge reactors

Rated voltage up to 690 V
Internal configuration: 2 winding in V arrangement
Discharge time: 400-690 V up to 25 kVAr < 5 s /
up to 50 kVAr < 10 s / up to 100 kVAr < 20 s
Power losses: < 1.8 W
Insulation class T40/B
Ambient temp -5 +55^{o} C (24 h mean)

Basic Capacitor Bank

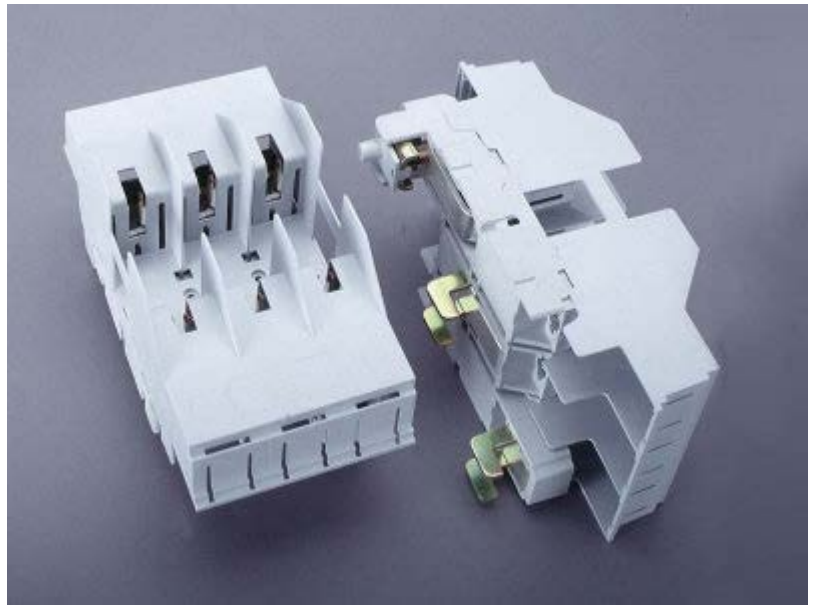
- PFC Capacitors

Comply with the requirements of IEC 60831-1+2
Indoor Dry Type, Inert gas (Nitrogen) impregnation
Rated voltage: not less than the system voltage
230/400/440/480/525/690/800/1000 VAC 50 Hz,
3-phase delta connection
Power output: according to the drawing
Safety: self healing, 3-phase overpressure disconnector and dry type
Overcurrent: up to 1.6 · Ir including combined effects of harmonics, overvoltages and capacitance tolerance
Inrush current: up to 300 x Ir
Losses: dielectric ≤ 0.2 W / kVAr, total ≤ 0.45 W / kVAr
Mean life expectancy: up to 130,000 hours
Humidity: max 95 %
Ambient temp: –40/D; max. temp. +55 °C; max. mean 24 h = +45 °C; max. mean 1 year = +35 °C; lowest temperature = –40 °C

Basic Capacitor Bank

- NH Bus-mounting fuse bases

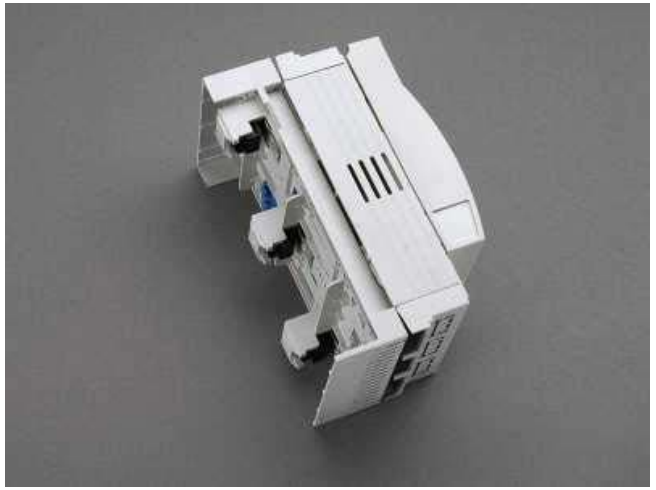
Comply with the requirements of IEC 60269-1/-2
For mounting on busbars 30x10 mm.
Rated Voltage: 690 V 3-Pole
Rated Current: 00/160 A for capacitor up to 60 kVAr 400 V
Rated Current: 1/250 A for capacitor up to 100 kVAr 400 V
Short-circuit strength when protected by fuses: 50 kA
Safety: Shock protection cover



Basic Capacitor Bank

- NH Bus-mounting fuse switch-disconnector

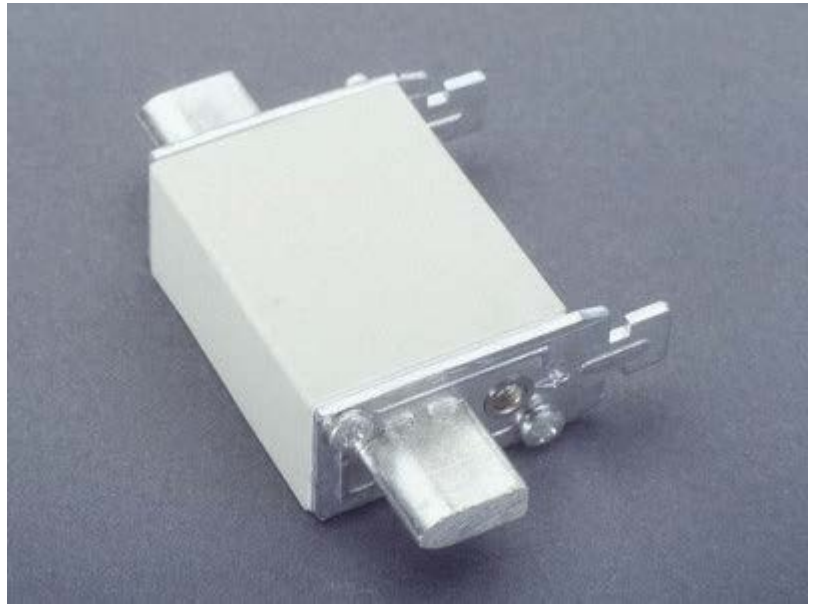
Comply with the requirements of IEC 60947-1/-3
For mounting on busbars 30x10 mm.
Rated Voltage: 690 V 3-Pole
Rated Current: 00/160 A for capacitor up to 60 kVAr 400 V
Rated Current: 1/250 A for capacitor up to 100 kVAr 400 V
Short-circuit strength when protected by fuses: 50 kA
Safety: Shock protection cover



Basic Capacitor Bank

- NH HRC fuse links type gG

Comply with the requirements of IEC 60269-1/-2
Rated Voltage: ≥ 500 V
Size 00 for rated current up to 125 A
Size 1 for rated current up to 250 A
Rated Current: according to the drawing
Rated short-circuit breaking capacity AC 120 kA
Indicator version: double indicator at top and middle

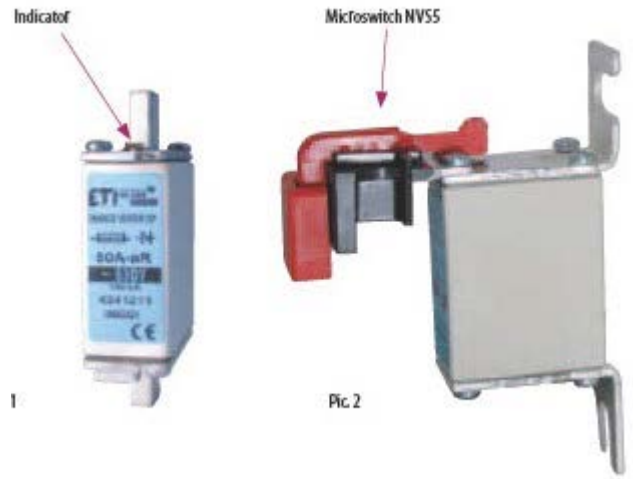


Basic Capacitor Bank

- Micro switch or Remote monitoring

The micro switch is used for signaling of interruption of Fuse-links of the NH size 00 to size 3.
This micro switch is activated through the indicator spring of NH Fuses. The NC contact of this micro switch shall be connected in series with the control coil of the capacitor contactor.
In case of one fuse blown, the capacitor contactor will be switched off to disconnect the 3-phase capacitor unit.

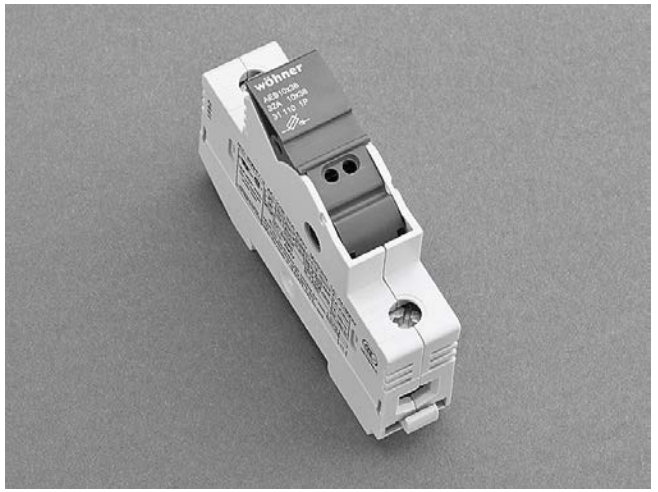
Rated Voltage: 250 V AC
Rated Current: 5 A
Contact: 1 NC



Basic Capacitor Bank

- Holder for cylindrical fuses

Comply with the requirements of IEC 60947-1/-3
Size 10 x 38 mm., 1-pole, AC-22B, DIN rail system
Rated Voltage: 690 V AC Rated Current: 32 A
rated isolation voltage Ui AC or DC: 800 V
rated surge voltage Uimp : 6 kV
short-circuit current with fuses (AC): 100 kA / 400 V (32A)
degree of protection: IP20

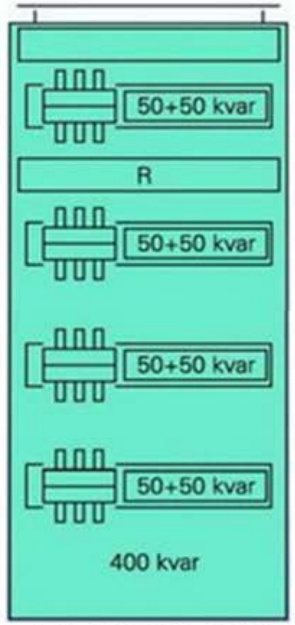


- Cylindrical fuse link type gG

Comply with the requirements of IEC 60269-1/-2
Size 10 x 38 mm.
Rated Voltage: 500 V AC Rated Current: 4 A and 6 A
Rated short-circuit breaking capacity AC 120 kA

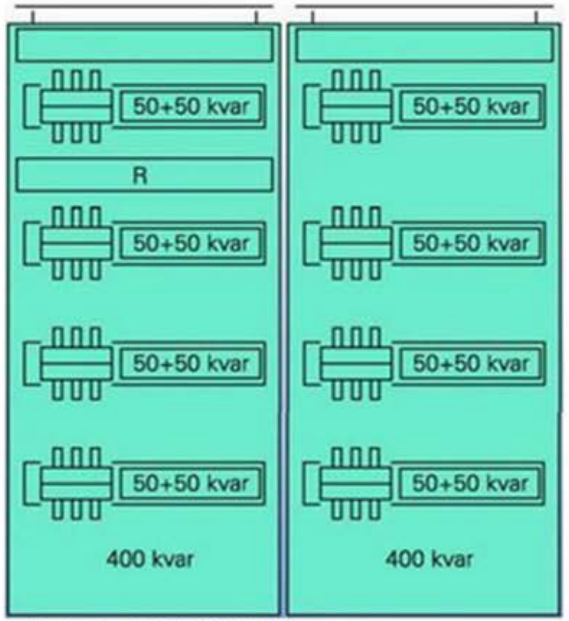
Basic Capacitor Bank

Dimension and Ventilation fans of basic capacitor bank



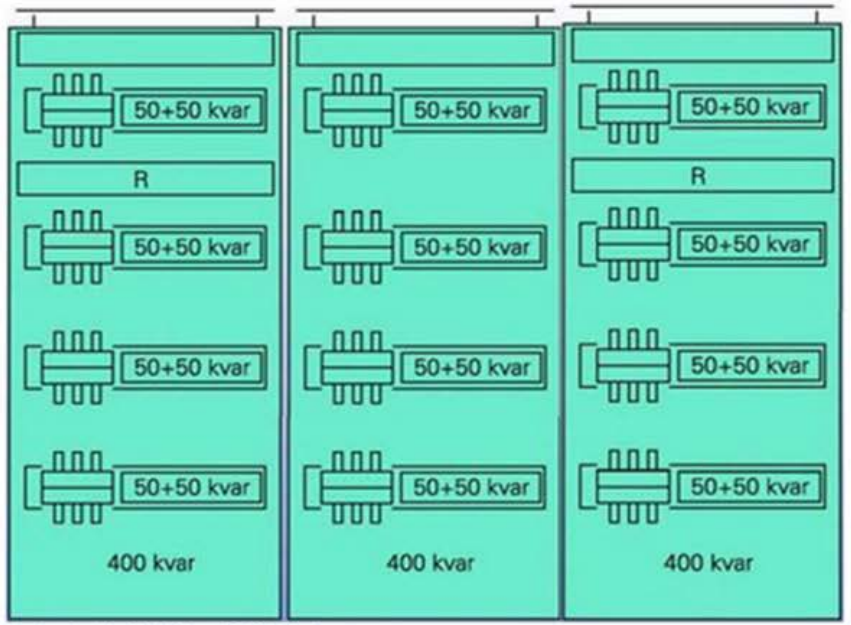
Total 300-400 kvar

2200x800x600 mm.
2x400 M³/hr



Total 450-800 kvar

2200x1600x600 mm.
4x400 M³/hr



Total 850-1200 kvar

2200x2400x600 mm.
6x400 M³/hr

HxWxD

Basic Capacitor Bank

Scope of Supply: Example of 12 x 50 kVAr 400 V

Item	Qty	Descriptions
1	1	'"EPCOS" P.F. Controller type BR6000-R12, 12 steps, 400 V, 50 Hz, Measuring current 5 A, Measurement voltage range 30 ... 525 V AC (L–L / L–N), Supply voltage 110…230 V AC, 50 Hz, Target cos phi 0.3 ind. - 0.3 cap. with indication of U, I, Q, P, S, Cos-phi, temperature and harmonics, Standards EN 55082-2, EN 55011, IEC 61010-1.
2	12	"EPCOS" Type MKK400D25-03 x 2, PhaseCap Energy Plus PFC dry gas filled (N2) Capacitors, 3-ph, 50 kVAr, 400 V, 50 Hz., Ultra long life expectancy up to 240 000 hours at temperature class –40/D, inrush current capability of up to 500 · I_R, Self-healing, 3 phase overpressure disconnector, Total loss excluding discharge resistors ≤ 0.45 W/kVAr, Standards IEC 60831-1+2, UL 810.
3	12	"EPCOS" B44066S6210J230 Capacitor Contactor with damping device 50 kVAr, 400 V with 230 V coil, Auxiliary contact 1 NO, Rated insulation voltage Vi 690 V AC, Contact life 0.12 million operations, Standards IEC 947-4-1, IEC 947-5-1, VDE 0660.

Basic Capacitor Bank

Scope of Supply: Example of 12 x 50 kVAr 400 V

Item	Qty	Descriptions
4	12	"Wöhner" 03654 Busbar Mounting Fuse Base 3-pole, 00/160 A, 690 V
5	36	"Wöhner" 03533 NH HRC fuse links size 00 / 125 A, 500 V AC.
6	36	"ETI" Type NVS 5 Micro switches on each fuse puller leg to disconnect 3-phase in case of one fuse blown.
7	4	"Wöhner" 31110 Switch for cylindrical fuse 10x38 mm, 32 A.
8	2	"Wöhner" 31182 Cylindrical fuse 10x38 mm, 2 A.
9	2	"Wöhner" 31184 Cylindrical fuse 10x38 mm, 4 A.
10	2	"EBM" M4Q 045 -CA01-A Ventilation fans Air flow 400 m^3 / h from inside cubicle to outside cubicle 7/31 W, 230 V, 50 Hz., 0.2 A, 1300 RPM.

Basic Capacitor Bank

Scope of Supply: Example of 12 x 50 kVAr 400 V

Item	Qty	Descriptions
11	2	"Wöhner" 33603 Busbar Mounting Fuse Switch 3-pole, 3/630 A, 690 V
12	6	"Wöhner" 03582 NH HRC fuse links size 3 / 630 A, 500 V AC.
13	2	Capacitor bank cubicle dimension HWD 2200x800x600 mm. with front doors, panels, base plates, copper busbars 3//30x10 mm., power cables, control cables, terminal blocks and accessories, galvanized steel plate 2 mm. thickness, IP21, RAL 7032 Color.

How to Design

Detuned Capacitor Bank

Detuned Capacitor Bank

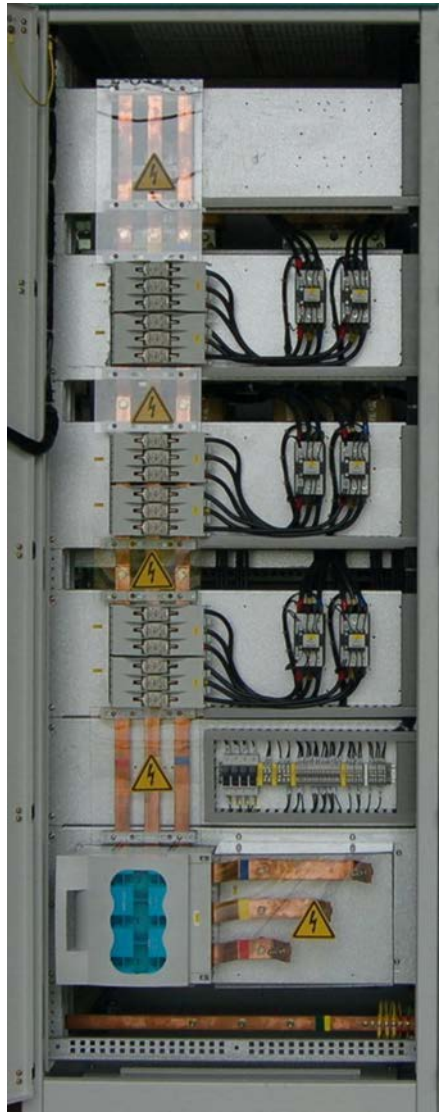
Scope of work:

The Contractor shall supply and install the Automatic Basic Capacitor Bank ready for connection and use in low voltage systems.

Electrical environment:

The connection of a capacitor bank onto a system containing harmonics may reduce its life time.
The damaging effects of harmonics can be mitigated by the use of a suitable detuning reactor in series with each capacitor step.
The detuned capacitor bank shall be used in case of

- Non-linear loads ≥ 15% or
- THDv ≥ 3% or
- THDi ≥ 10%.



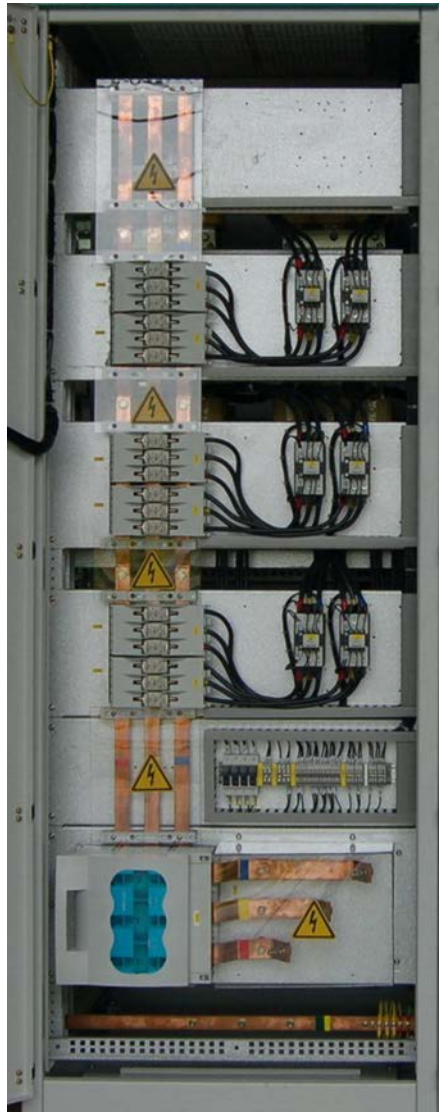
Detuned Capacitor Bank

Design:

The modules on a galvanized sheet-steel chassis are fitted with busbar mounting fuse bases including shock protection cover, capacitor contactors with damping resistors, discharge reactors for fast discharges of capacitors, and dry-type capacitors. For connecting the modules together and for the connection to the power system via cable, each module has a 60 mm busbar support system and 30x10 mm copper busbars with insulation cover mounted at the front.

The connection of the module on the control side to the pf controller and to the control voltage is made by control cable via terminal blocks. This control cables shall be routed in cable ducts.

The maximum effective power per section (cubicle) shall not be higher than 400 kvar. For higher power ratings, capacitor section(s) shall be added. The dimension of each 400 kvar section should not be less than HxWxD 2250x800x1200 mm. and each section shall have ventilation slots (louver) and axial fan(s).



Detuned Capacitor Bank

Cooling fans 230 V, 50 Hz, air flow not less than 800 cubic meter per hour per 400 kvar section. The operating fans shall be controlled by aux. contacts (NO Contacts) of capacitor contactors.

PF Controller, contactor coils and fans shall be protected by control fuse size 10x38, 500 V, 2 - 6 A mounted in fuse switch holder size 10x38, 690 V, 32 A, AC-22B.

The Capacitor bank shall be installed in a separate cubicle from MDB and designed so that alteration or addition of the capacitor in future will not affect the systems. The unit shall be installed as recommended by the manufacturer.

Detuned Capacitor Bank

Main components:

- Power Factor Controller
- Fuse-switch or Fuse-base with HRC fuses
- Contactor with damping device for capacitor switching
- Detuned Reactor 7% detuning factor
- Power Factor Correction Capacitor
- Ventilation fans
- LV PFC Banks.

Detuned Capacitor Bank

Technical Data:

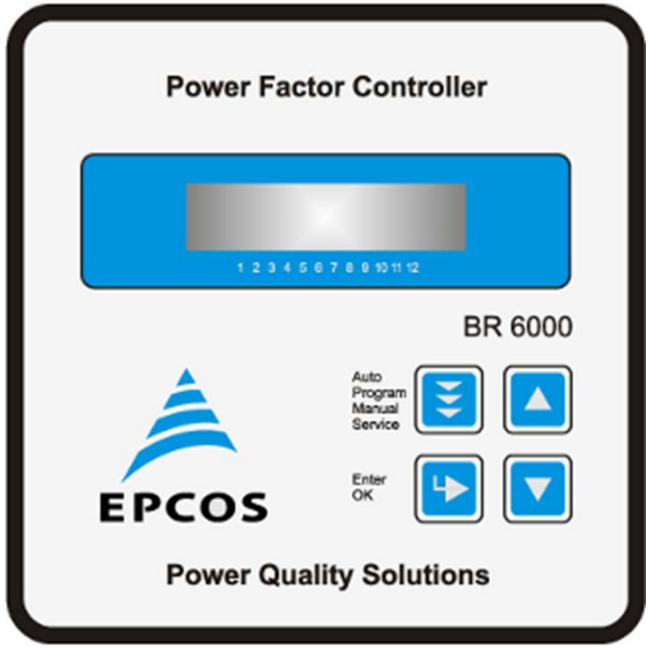
- Low-voltage power factor correction banks

Comply with the requirements of IEC 61439-1 and IEC 61439-2.
Sheet steel cubicle shall have door and panel thickness 2 mm
Ambient temperature –20 to +35 degree C, 24 h average
Degree of protection IP 21
Short circuit strength of busbars Ipk = 75 kA, Icw = 42 kA, 1 sec.

Detuned Capacitor Bank

o Power Factor Controllers

Comply with the requirements of IEC 61000-4-2, IEC 61000-4-4 and IEC 61010-1.
Continuous LCD Display, Operating temp up to +60 degree C
Humidity class up to 95 %, Protection class IP 54 (Front)
Measurement current: x / 5 A, Target Power Factor : 0.3 ind – 0.3 cap
Power Factor display: 0.1 ind – 0.1 cap, Switching
and discharge time: 1-1200 sec, Control mode: LIFO, FIFO,
Intelligent mode, Minimum operating current or Sensitivity: 50 mA
Frequency: 50 Hz, Zero voltage release: < 15 ms
Switching outputs: 6 or 12 steps according to the drawing
Alarm relay: 1 NO Contact (250 V, 1000 W)
Display of V, A, W, VAR, KVA, Frequency, THDv, THDi,
individual harmonics up to 19th, individual capacitor current, temp,
real time cos phi, target cos phi, kvar value to target cos phi
Alarm output of under/over compensation, under/over current, over temp,
harmonics exceeded Recall reorded values of number of contactor switching operations,
Vmax, KVAmax, THDmax, KWmax, KVARmax, TEMPmax, operation time of all capacitors.



Detuned Capacitor Bank

- Capacitor Contactors

Comply with the requirements of IEC 60947-4-1 / -5-1.
The capacitor contactor shall be equipped with Aux contact (1 NO) and damping resistors to reduce peak inrush current
Rated Insulation Voltage: 690 V
Utilization categories AC-6b according to IEC 60947-4-1 for switching of capacitor bank
Rated power: according to the drawing.

Detuned Capacitor Bank

- Discharge reactors

Rated voltage up to 690 V
Internal configuration: 2 winding in V arrangement
Discharge time: 400-690 V up to 25 kVAr < 5 s /
up to 50 kVAr < 10 s / up to 100 kVAr < 20 s
Power losses: < 1.8 W
Insulation class T40/B
Ambient temp -5 +55^{o} C (24 h mean)

Detuned Capacitor Bank

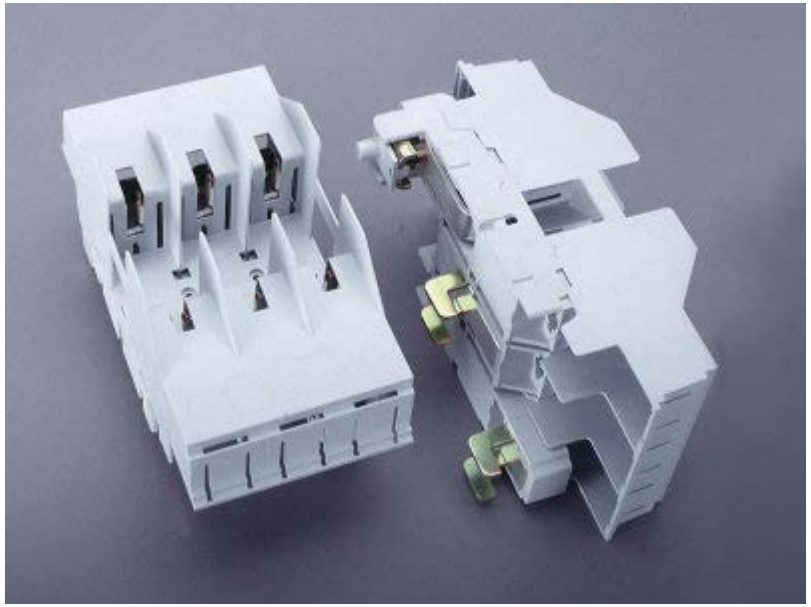
o PFC Capacitors

Comply with the requirements of IEC 60831-1+2
Indoor Dry Type, Inert gas (Nitrogen) impregnation
Rated voltage: not less than the system voltage
230/400/440/480/525/690/800/1000 VAC 50 Hz,
3-phase delta connection
Power output: according to the drawing
Safety: self healing, 3-phase overpressure disconnector and dry type
Overcurrent: up to 1.6 · Ir including combined effects of harmonics,
Over voltages and capacitance tolerance
Inrush current: up to 300 x Ir
Losses: dielectric ≤ 0.2 W / kVAr, total ≤ 0.45 W / kVAr
Mean life expectancy: up to 130,000 hours
Humidity: max 95 %
Ambient temp: –40/D; max. temp. +55 ◦C; max. mean 24 h = +45 ◦C;
max. mean 1 year = +35 ◦C; lowest temperature = –40 ◦C

Detuned Capacitor Bank

- NH Bus-mounting fuse bases

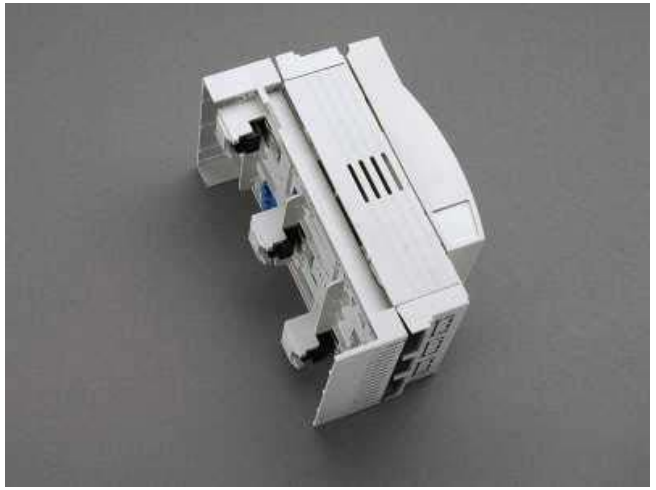
Comply with the requirements of IEC 60269-1/-2
For mounting on busbars 30x10 mm.
Rated Voltage: 690 V 3-Pole
Rated Current: 00/160 A for capacitor up to 60 kVAr 400 V
Rated Current: 1/250 A for capacitor up to 100 kVAr 400 V
Short-circuit strength when protected by fuses: 50 kA
Safety: Shock protection cover



Detuned Capacitor Bank

- NH Bus-mounting fuse switch-disconnector

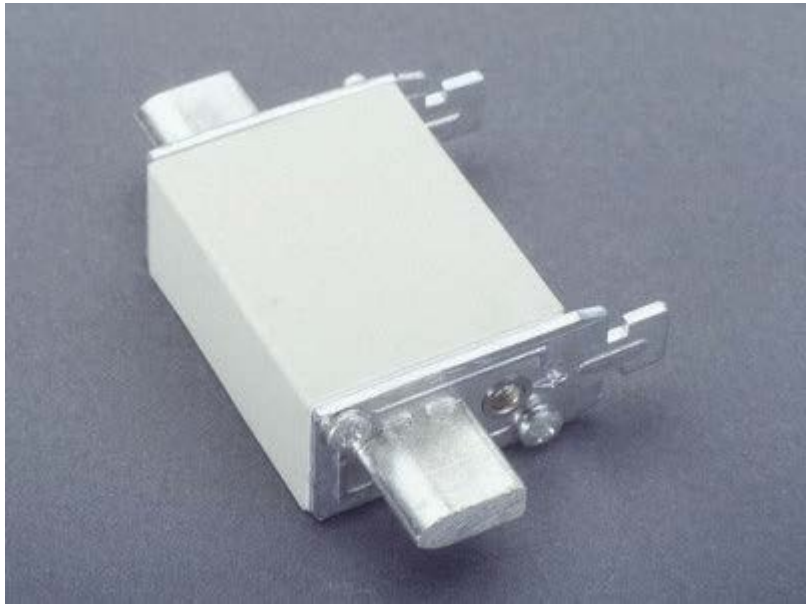
Comply with the requirements of IEC 60947-1/-3
For mounting on busbars 30x10 mm.
Rated Voltage: 690 V 3-Pole
Rated Current: 00/160 A for capacitor up to 60 kVAr 400 V
Rated Current: 1/250 A for capacitor up to 100 kVAr 400 V
Short-circuit strength when protected by fuses: 50 kA
Safety: Shock protection cover



Detuned Capacitor Bank

- NH HRC fuse links type gG

Comply with the requirements of IEC 60269-1/-2
Rated Voltage: ≥ 500 V
Size 00 for rated current up to 125 A
Size 1 for rated current up to 250 A
Rated Current: according to the drawing
Rated short-circuit breaking capacity AC 120 kA
Indicator version: double indicator at top and middle

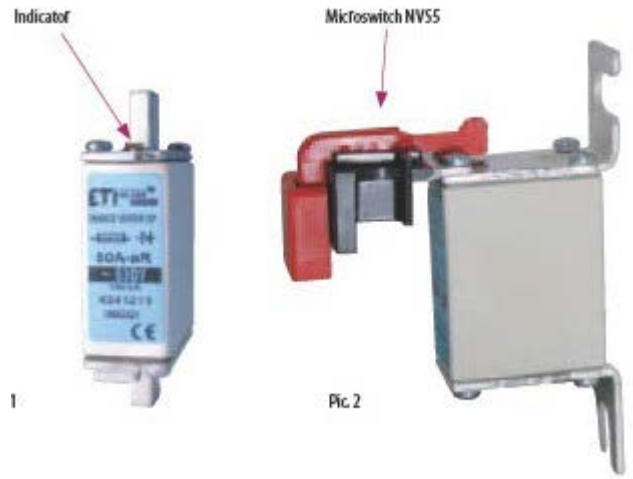


Detuned Capacitor Bank

- Micro switch or Remote monitoring

The micro switch is used for signaling of interruption of Fuse-links of the NH size 00 to size 3.
This micro switch is activated through the indicator spring of NH Fuses. The NC contact of this micro switch shall be connected in series with the control coil of the capacitor contactor.
In case of one fuse blown, the capacitor contactor will be switched off to disconnect the 3-phase capacitor unit.

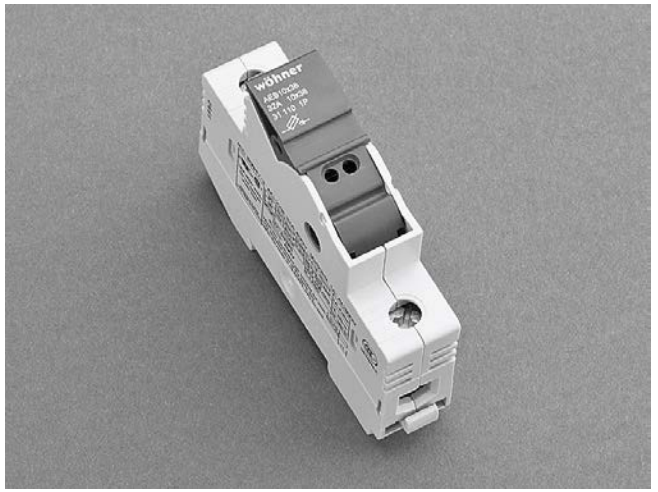
Rated Voltage: 250 V AC
Rated Current: 5 A
Contact: 1 NC



Detuned Capacitor Bank

- Holder for cylindrical fuses

Comply with the requirements of IEC 60947-1/-3
Size 10 x 38 mm., 1-pole, AC-22B, DIN rail system
Rated Voltage: 690 V AC Rated Current: 32 A
rated isolation voltage Ui AC or DC: 800 V
rated surge voltage Uimp : 6 kV
short-circuit current with fuses (AC): 100 kA / 400 V (32A)
degree of protection: IP20

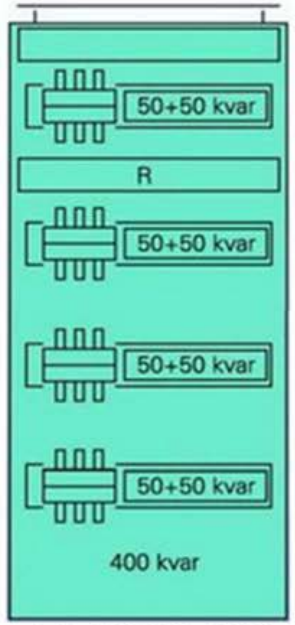


- Cylindrical fuse link type gG

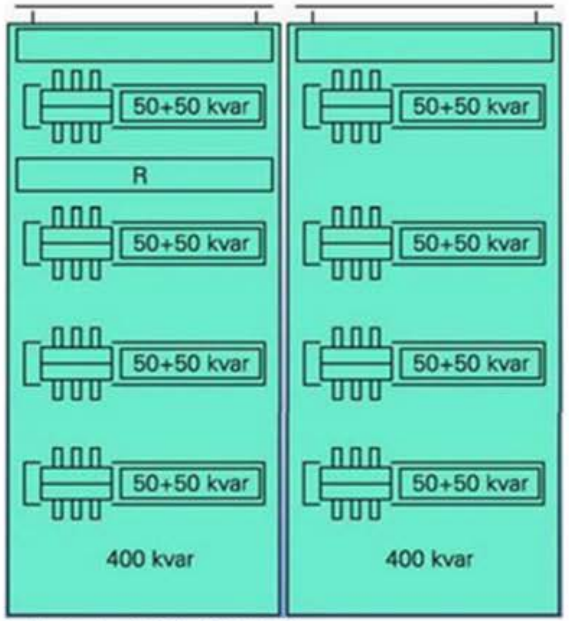
Comply with the requirements of IEC 60269-1/-2
Size 10 x 38 mm.
Rated Voltage: 500 V AC Rated Current: 4 A and 6 A
Rated short-circuit breaking capacity AC 120 kA

Detuned Capacitor Bank

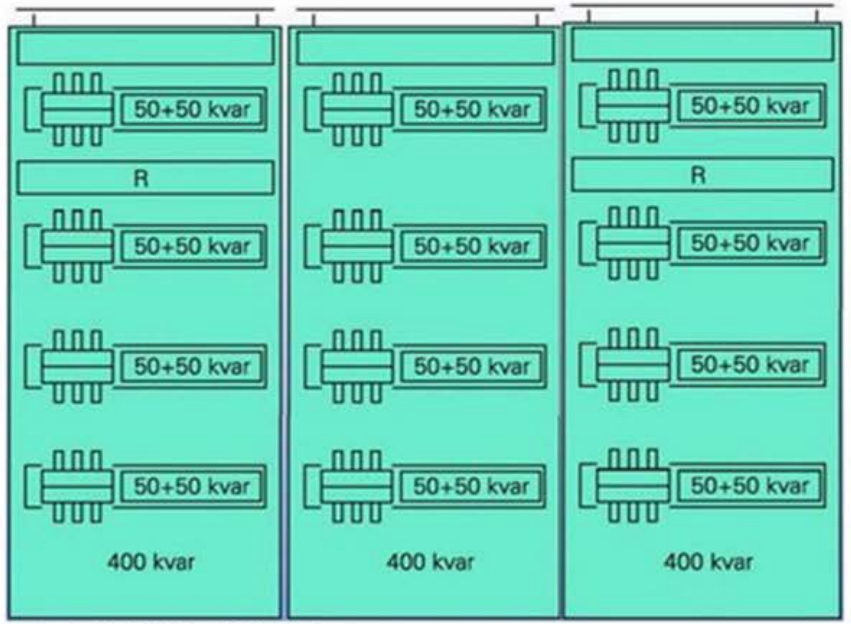
Dimension and Ventilation fans of basic capacitor bank



Total 300-400 kvar



Total 450-800 kvar



Total 850-1200 kvar

2200x800x1200 mm. 2200x1600x1200 mm. 2200x2400x1200 mm. HxWxD

2x800 M^3/hr 4x800 M^3/hr 6x800 M^3/hr

Detuned Capacitor Bank

Scope of Supply: Example of 12 x 50 kVAr 400 V

Item	Qty	Descriptions
1	1	'"EPCOS" P.F. Controller type BR6000-R12, 12 steps, 400 V, 50 Hz, Measuring current 5 A, Measurement voltage range 30 ... 525 V AC (L–L / L–N), Supply voltage 110…230 V AC, 50 Hz, Target cos phi 0.3 ind. - 0.3 cap. with indication of U, I, Q, P, S, Cos-phi, temperature and harmonics, Standards EN 55082-2, EN 55011, IEC 61010-1.
2	12	"EPCOS" Type MKK525D20-03 x 4, PhaseCap Energy Plus PFC dry gas filled (N2) Capacitors, 3-ph, 80 kVAr, 525 V, 50 Hz., Ultra long life expectancy up to 240,000 hours at temperature class –40/D, inrush current capability of up to 500 · I_R, Self-healing, 3 phase overpressure disconnector, Total loss excluding discharge resistors ≤ 0.45 W/kVAr, Standards IEC 60831-1+2, UL 810.
3	12	"EPCOS" B44066S6210J230 Capacitor Contactor with damping device 50 kVAr, 400 V with 230 V coil, Auxiliary contact 1 NO, Rated insulation voltage Vi 690 V AC, Contact life 0.12 million operations, Standards IEC 947-4-1, IEC 947-5-1, VDE 0660.

Detuned Capacitor Bank

Scope of Supply: Example of 12 x 50 kVAr 400 V

Item	Qty	Descriptions
4	12	"Wöhner" 03654 Busbar Mounting Fuse Base 3-pole, 00/160 A, 690 V
5	36	"Wöhner" 03533 NH HRC fuse links size 00 / 125 A, 500 V AC.
6	36	"ETI" Type NVS 5 Micro switches on each fuse puller leg to disconnect 3-phase in case of one fuse blown.
7	4	"Wöhner" 31110 Switch for cylindrical fuse 10x38 mm, 32 A.
8	2	"Wöhner" 31182 Cylindrical fuse 10x38 mm, 2 A.
9	2	"Wöhner" 31184 Cylindrical fuse 10x38 mm, 4 A.
10	2	"EBM" M4Q 045 -CA03-A Ventilation fans Air flow 800 m^3 / h from inside cubicle to outside cubicle 10/36 W, 230 V, 50 Hz., 0.25 A, 1300 RPM.

Detuned Capacitor Bank

Scope of Supply: Example of 12 x 50 kVAr 400 V

Item	Qty	Descriptions
11	2	"Wöhner" 33603 Busbar Mounting Fuse Switch 3-pole, 3/630 A, 690 V
12	6	"Wöhner" 03582 NH HRC fuse links size 3 / 630 A, 500 V AC.
13	2	Capacitor bank cubicle dimension HWD 2200x800x1200 mm. with front doors, panels, base plates, copper busbars 3//30x10 mm., power cables, control cables, terminal blocks and accessories, galvanized steel plate 2 mm. thickness, IP21, RAL 7032 Color.
14	12	"EPCOS" B44066D7050E400 Detuned Reactors 400 V 50 Hz 50 kVAr detuning factor 7%.

Selection Tables and Basic Calculation

for

Capacitor Banks

Capacitor Reactive Power Calculation Table

Current (ACTUAL) tan φ	cos φ	Achievable (TARGET) cos φ 0.80	0.82	0.85	0.88	0.90	0.92	0.94	TARGET cos φ = 0.96 Qc	cos φ ≤ 1 0.96	0.98	1.00
		Faktor F							Qc = Pmot · F (0.96) = ... [kvar] 100 · 1.01 = 101.0 kvar			
3.18	0.30	2.43	2.48	2.56	2.64	2.70	2.75	2.82		2.89	2.98	3.18
2.96	0.32	2.21	2.26	2.34	2.42	2.48	2.53	2.60		2.67	2.76	2.96
2.77	0.34	2.02	2.07	2.15	2.23	2.28	2.34	2.41		2.48	2.56	2.77
2.59	0.36	1.84	1.89	1.97	2.05	2.10	2.17	2.23		2.30	2.39	2.59
2.43	0.38	1.68	1.73	1.81	1.89	1.95	2.01	2.07		2.14	2.23	2.43
2.29	0.40	1.54	1.59	1.67	1.75	1.81	1.87	1.93		2.00	2.09	2.29
2.16	0.42	1.41	1.46	1.54	1.62	1.68	1.73	1.80		1.87	1.96	2.16
2.04	0.44	1.29	1.34	1.42	1.50	1.56	1.61	1.68		1.75	1.84	2.04
1.93	0.46	1.18	1.23	1.31	1.39	1.45	1.50	1.57		1.64	1.73	1.93
1.83	0.48	1.08	1.13	1.21	1.29	1.34	1.40	1.47		1.54	1.62	1.83
1.73	0.50	0.98	1.03	1.11	1.19	1.25	1.31	1.37		1.45	1.63	1.73
1.64	0.52	0.89	0.94	1.02	1.10	1.16	1.22	1.28		1.35	1.44	1.64
1.56	0.54	0.81	0.86	0.94	1.02	1.07	1.13	1.20		1.27	1.36	1.56
1.48	0.56	0.73	0.78	0.86	0.94	1.00	1.05	1.12		1.19	1.28	1.48
1.40	0.58	0.65	0.70	0.78	0.86	0.92	0.98	1.04		1.11	1.20	1.40
1.33	0.60	0.58	0.63	0.71	0.79	0.85	0.91	0.97		1.04	1.13	1.33
1.30	0.61	0.55	0.60	0.68	0.76	0.81	0.87	0.94		1.01	1.10	1.30
1.27	0.62	0.52	0.57	0.65	0.73	0.78	0.84	0.91		0.99	1.06	1.27

Capacitor reactive power Qc Calculation Table for System Active Power KW and PF

Example 1:

- Total active power 1,000 kW
- Actual PF = 0.61
- Target PF = 0.96
- Factor F from the table 1.01

- Capacitor reactive power
  Qc = 1000x1.01 = 1,010 kVAr

Capacitor Reactive Power Calculation Table

1.23	0.63	0.48	0.53	0.61	0.69	0.75	0.81	0.87	0.94	1.03	1.23
1.20	0.64	0.45	0.50	0.58	0.66	0.72	0.77	0.84	0.91	1.00	1.20
1.17	0.65	0.42	0.47	0.55	0.63	0.68	0.74	0.81	0.88	0.97	1.17
1.14	0.66	0.39	0.44	0.52	0.60	0.65	0.71	0.78	0.85	0.94	1.14
1.11	0.67	0.36	0.41	0.49	0.57	0.63	0.68	0.75	0.82	0.90	1.11
1.08	0.68	0.33	0.38	0.46	0.54	0.59	0.65	0.72	0.79	0.88	1.08
1.05	0.69	0.30	0.35	0.43	0.51	0.56	0.62	0.69	0.76	0.85	1.05
1.02	0.70	0.27	0.32	0.40	0.48	0.54	0.59	0.66	0.73	0.82	1.02
0.99	0.71	0.24	0.29	0.37	0.45	0.51	0.57	0.63	0.70	0.79	0.99
0.96	0.72	0.21	0.26	0.34	0.42	0.48	0.54	0.60	0.67	0.76	0.96
0.94	0.73	0.19	0.24	0.32	0.40	0.45	0.51	0.58	0.65	0.73	0.94
0.91	0.74	0.16	0.21	0.29	0.37	0.42	0.48	0.55	0.62	0.71	0.91
0.88	0.75	0.13	0.18	0.26	0.34	0.40	0.46	0.52	0.59	0.68	0.88
0.86	0.76	0.11	0.16	0.24	0.32	0.37	0.43	0.50	0.57	0.65	0.86
0.83	0.77	0.08	0.13	0.21	0.29	0.34	0.40	0.47	0.54	0.63	0.83
0.80	0.78	0.05	0.10	0.18	0.26	0.32	0.38	0.44	0.51	0.60	0.80
0.78	0.79	0.03	0.08	0.16	0.24	0.29	0.35	0.42	0.49	0.57	0.78
0.75	0.80		0.05	0.13	0.21	0.27	0.32	0.39	0.46	0.55	0.75
0.72	0.81			0.10	0.18	0.24	0.30	0.36	0.43	0.52	0.72
0.70	0.82			0.08	0.16	0.21	0.27	0.34	0.41	0.49	0.70
0.67	0.83			0.05	0.13	0.19	0.25	0.31	0.38	0.47	0.67
0.65	0.84			0.03	0.11	0.16	0.22	0.29	0.36	0.44	0.65
0.62	0.85				0.08	0.14	0.19	0.26	0.33	0.42	0.62
0.59	0.86				0.05	0.11	0.17	0.23	0.30	0.39	0.59
0.57	0.87					0.08	0.14	0.21	0.28	0.36	0.57
0.54	0.88					0.06	0.11	0.18	0.25	0.34	0.54
0.51	0.89					0.03	0.09	0.15	0.22	0.31	0.51
0.48	0.90						0.06	0.12	0.19	0.28	0.48

Capacitor reactive power Qc Calculation Table for System Active Power KW and PF

Example 2:

- Total active power 1,000 kW
- Actual PF = 0.8
- Target PF = 0.98
- Factor F from the table 0.6

- Capacitor reactive power
  Qc = 1000x0.6 = 600 kVAr

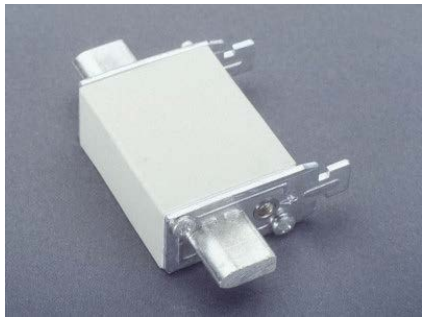
Capacitor Power Selection Table for Transformer

If the total active power is unknown,
the capacitor reactive power can be estimated from the
transformer kVA ratings, i.e. Qc ≈ 30% of transformer kVA ratings:

Transformer apparent power ratings	Capacitor reactive power ratings	Designed numbers of cubicles
o 500 kVA	o 150 kVAr (10 x 15 kVAr)	o 1x150 kVAr
o 630 kVA	o 200 kVAr (10 x 20 kVAr)	o 1x200 kVAr
o 800 kVA	o 240 kVAr (12 x 20 kVAr)	o 1x240 kVAr
o 1000 kVA	o 300 kVAr (12 x 25 kVAr)	o 1x300 kVAr
o 1250 kVA	o 400 kVAr (10 x 40 kVAr)	o 1x400 kVAr
o 1500 kVA	o 450 kVAr (9 x 50 kVAr)	o 1x250 + 1x200 kVAr
o 1600 kVA	o 480 kVAr (12 x 40 kVAr)	o 1x240 + 1x240 kVAr
o 2000 kVA	o 600 kVAr (12x 50 kVAr)	o 1x300 + 1x300 kVAr
o 2500 kVA	o 750 kVAr (15 x 50 kVAr)	o 1x400 + 1x350 kVAr

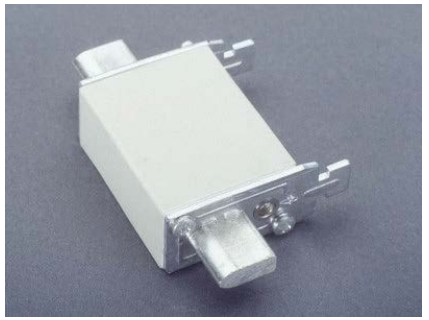
Fuse Selection Table for Capacitor Step

Selection Table for NH HRC Fuse Links type gG			
Capacitor Step power kVAr	Capacitor and system voltage V	Capacitor current A	Fuse current A
12.5	400	18.04	35
15	400	21.65	35
20	400	28.87	50
25	400	36.08	63
30	400	43.30	80
40	400	57.74	100
50	400	72.17	125
60	400	86.60	160
75	400	108.25	160
100	400	144.34	250



Fuse-CB Selection Table of Capacitor Bank

Selection Table for NH HRC Fuse Links type gG or CB			
Capacitor Bank power kVAr	Capacitor and system voltage V	Capacitor current A	Fuse or CB current A
200	400	289	400
250	400	361	500
300	400	433	630
350	400	505	700
400	400	577	800
450	400	650	1000
500	400	722	1000
600	400	866	1200
700	400	1010	1600
800	400	1155	1600



Component Selection Table for Detuned PFC

Component Selection for system voltage 400 V 50 Hz Detuning factor 7%					
Effective Filter Output	Capacitor Ratings	Reactor Ratings	Contactor Ratings	Fuse Base Ratings	Fuse Ratings
25 kVAr	40 kVar 525 V	25 kVAr 400 V	25 kVAr 400 V	160 A 690 V	36 A 525 V
30 kVAr	50 kVar 525 V	30 kVAr 400 V	33 kVAr 400 V	160 A 690 V	80 A 525 V
40 kVAr	65 kVar 525 V	40 kVAr 400 V	50 kVAr 400 V	160 A 690 V	100 A 525 V
50 kVAr	80 kVar 525 V	50 kVAr 400 V	50 kVAr 400 V	160 A 690 V	125 A 525 V
60 kVAr	100 kVar 525 V	60 kVAr 400 V	60 kVAr 400 V	160 A 690 V	160 A 525 V
75 kVAr	120 kVar 525 V	75 kVAr 400 V	80 kVAr 400 V	160 A 690 V	160 A 525 V
100 kVAr	160 kVar 525 V	100 kVAr 400 V	100 kVAr 400 V	250 A 690 V	250 A 525 V

ITM Literatures

For further technical information concerning capacitor designs and harmonics,

Please refer to the literatures in our website:

www.itm.co.th