POWER CAPACITORS

C-Series Low Voltage Power Capacitors

FECSAKP1 (Three-Phase 400V)

40 kVAr - 50 kVAr

K-Series Low Voltage Power Capacitors

FEK-13 (Three-Phase 400V)

5 kVAr ... 30 kVAr

FEK-13 (Three-Phase 450V)

10 kVAr ... 30 kVAr

M-Series Low Voltage Power Capacitors

FEKM (Mono-Phase 400V)

1,67 kVAr ... 5 kVAr

CONTENTS

TS EN 60831-1, TS EN 60831-2
EN 60831-1, EN 60831-2
IEC 60831-1, IEC 60831-2
CE

Assembly Position : Vertical (can be connected in horizontal position by supporting)
Altitude : 2000 m (max)
Ambient Temperature : between -25°C and +55°C
Protection Class : IP00 (IP40 when plastic connector cover is used)

POWER CAPACITORS

Loads of large networks mainly have inductive characteristics. Since asynchronous motors, induction furnaces, ballast lamps draw inductive currents, they decrease power coefficients of the network they are connected to. The decrease in power coefficient results in voltage reductions and power losses in energy transmission and distribution lines. This case leads to decrease in efficiency. Loads with low power coefficient result in unnecessarily high capacities of alternators, transformer and circuit elements. In this case, it is not possible to utilize the system in an economical manner. Federal low voltage power capacitors utilized to compensate power coefficient are manufactured in accordance with CE.

Power Factor :
Power factor of the load is described as proportion of active power to apparent power. The closer it is to Cos_, 1.00, the less power is drawn from the network. If Cos_=1, transmission of 500 kW in 400 V tri-phase main lines requires a current of 722A. Transmission of the same effective power at Cos_=0,6 shall require a higher current, that is 1203A. Therefore, distribution and transmission equipments such as supply transformers should be sized for this high load.
- For systems with low power factor, transmission of electrical power appropriate with the current standards is more costly both for the consumers and the network distribution. Another reason of higher costs is the losses caused by the heat in conductors due to the entire current of the system, as well as transformer and power plant coils. Under general conditions, while power factor of a tri-phase system is going down, current goes up. Heat loss in the system increases proportional to square of current increase.

As a result:
Decrease in electrical losses is ensured via compensation of power factor.
The network shall be capable of supporting the additional load to be advantageous for an expanding system.
Load in distribution shall decrease with compensation of the power factor and this case shall allow life extension of the devices in this system.

Power Factor Compensation Methods
Counter-capacity reactive power supplied by the capacitor to the system may compensated the inductive reactive power needed by the electrical load. It ensures a decrease in reactive power drawn from the network and is called Power Factor Compensation (PFC).
Most common methods of power-factor compensation;

Single or fixed PFC:
Compensation of reactive power of each load or decrease of load at supply end (for fixed and/or large-power single receiver powers). (Figure-2)

Group PFC:
Connection of the capacitor to a group of simultaneous-operating inductive load. (Example: Motor group, discharge lamps) (Şekil-3)

Central PFC:
It is used for wide electrical systems with variable load, where a particular number of capacitors are usually connected to a primary power distribution station or secondary station. Capacitors are controlled via microprocessor based reactive power control relay, which continuously monitors the reactive power demand in the network. (Figure-4)

Over-stimulus synchronous motors are also employed in compensation of reactive power, as well as capacitors; however, employment of capacitors is more common than synchronous motors.

MKP:
MKP type consists of low power loss dielectric shaped with pure polypropylene folio. Zinc metallized film is obtained by having polypropylene film subject to zinc steam under vacuum. This guarantees long service life of the capacitor. Capacitor elements are dried under vacuum. After the capacitor is placed in the housing, adhesive polyurethane resin or dried insulation gas is inserted.

Advantages of MKP Technology:
As a result of the simple composition technology, MKP capacitors are manufactured with low costs by using less material; as a result, clients pay less.
Although they have thicker dielectric, MKP capacitors are usually smaller than their equivalents.
MKP capacitors have special high capacitance and high AC load capacity. As composition and high-quality material is used as mentioned below, reliability and long-term service life is guaranteed. Furthermore, Federal capacitors occupy a smaller space in compensation panels thanks to their small sizes.

Self-Repair:
Federal capacitors self-repair punctures caused by sudden voltage in low voltage switch facilities. Arcs caused by punctures melt the metal plate and these arcs insulate the puncture part in the insulator. In this way, capacitor reaches full voltage strength and continues operating without any problem. Capacity loss arising from this is too less, so it can be neglected.

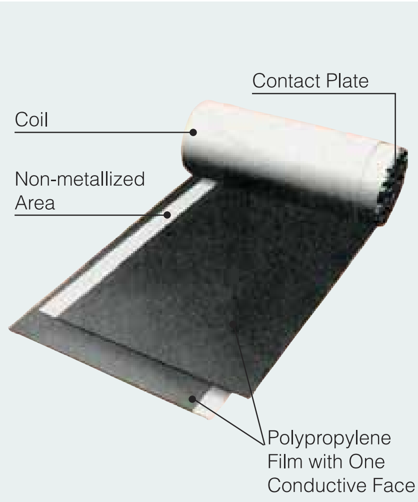


Fig-1: Zinc Metallized Polypropylene Film

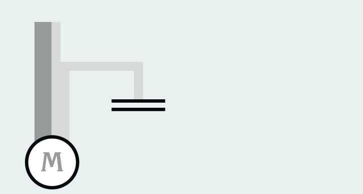


Fig-2: Fixed PFC

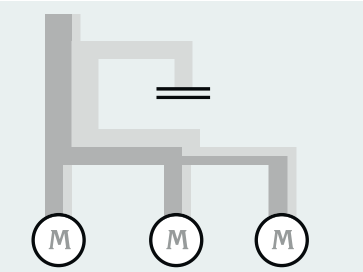


Fig-3: Group PFC

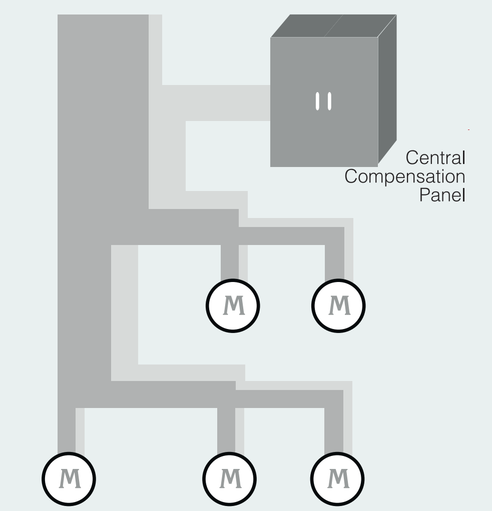


Fig-4: Central PFC

Active Energy   Reactive Energy

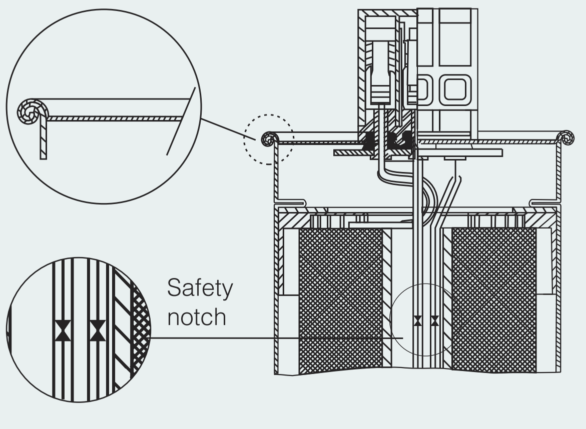


Fig-5 Before Failure

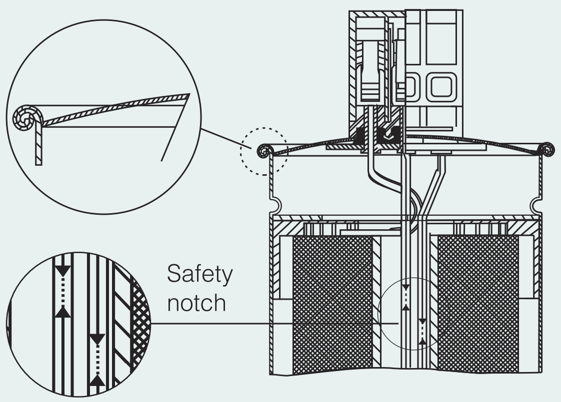


Fig-6 After Failure

Multiplier Factor		Target cosφ2				
		0,980	0,985	0,990	0,995	1,000
Original cosφ1	0,20	4,696	4,724	4,756	4,799	4,899
	0,25	3,670	3,698	3,730	3,773	3,873
	0,30	2,977	3,005	3,037	3,079	3,180
	0,35	2,473	2,501	2,534	2,576	2,676
	0,40	2,088	2,116	2,149	2,191	2,291
	0,45	1,781	1,809	1,842	1,884	1,985
	0,50	1,529	1,557	1,590	1,632	1,732
	0,55	1,315	1,343	1,376	1,418	1,518
	0,60	1,130	1,158	1,191	1,233	1,333
	0,65	0,966	0,994	1,027	1,069	1,169
	0,70	0,817	0,845	0,878	0,920	1,020
	0,75	0,679	0,707	0,739	0,782	0,882
	0,80	0,547	0,575	0,608	0,650	0,750
	0,85	0,417	0,445	0,477	0,519	0,620
	0,90	0,281	0,309	0,342	0,384	0,484
	0,95	0,126	0,154	0,186	0,228	0,329

Tablo-1

Environmental temperature category :

			Highest average value in periods	
Symbol	Minimum	Maximum	24 hours	1 year
25/C	25 °C	50 °C	40 °C	30 °C
25/D	25 °C	55 °C	45 °C	35 °C

Protection Against Overloads:
Protection has been ensured against overloading with a separator fuse system integrated into Federal power capacitors. Gas arising from frequent self-repair causes high pressure in body of the device and as a result, cables between winding and connector break off from safety notch as the capacitor body bends lengthwise. In this way, capacitor is separated from the network. Protection against overload and failures for safety of the capacitor and the system is shown in Figure-5 and Figure-6.

Calculation of Required Capacitor Capacity for Compensation of Power Coefficient:
Reactive power required to acquire the desired power factor is calculated as follows.

Qc= P x (tanφ1-tanφ2)

P = Active power
S = Apparent power
Qc = Reactive power
Cosφ1 = Current power coefficient
Cosφ2 = Desired power coefficient
(tanφ1-tanφ2) = Multiplier factor is shown in Table-1.

Example :
Let's calculate the required capacitor power to have a system with active power : P=500 kW
cosφ1=0,7 as cosφ2=0,98.

Solution with use of the table:
In order to increase power factor from 0,7 to 0,98, when we cross rows and columns corresponding to cosφ1=0,7 and cosφ2=0,98 in the multiplier factor table, we find the multiplier factor as 0,817.
Qc=500 x 0,817
Qc=408,5 kVAr

Solution with use of formulas:

$$S_1 \frac{P_1}{\cos\varphi} = \frac{500}{0,7} = 714kVA$$

$$Q_1 = \sqrt{S_1^2 - P_1^2} = \sqrt{714^2 - 500^2} = 510kVAr$$

$$S_2 = \frac{P_1}{\cos\varphi} = \frac{500}{0,98} = 510,2kVA$$

$$Q_2 = \sqrt{S_2^2 - P_1^2} = \sqrt{510,2^2 - 500^2} = 101,5kVAr$$

$$Q_c = Q_1 - Q_2 = 510 - 101,5 = 408,5kVAr$$

Note: While facility materials of the compensation facilities are selected, effects of incidents occurring during opening and closing should be taken into consideration. While capacitors are enabled or connected parallel, they draw huge currents like short circuit current during temporary regime. Value and duration of these currents depend on capacitor power, inductive resistance and specific frequency of the subject network section. If switch is closed at the highest value of the voltage, current impacts reach the highest value. Effective period of this current is rarely longer than 1 or 2 periods.

In the meanwhile, in order to have the capacitors resist the connection over voltages, insulation against capacitor housing of the metal folio is anticipated to be 3.5 times more than maximum value of the nominal voltage. While capacitors are disabled, large arcs occur as it is more difficult to break the capacitive current. Therefore, these characteristics are taken into consideration in selection of connection elements such as switches, fuses and lines used in compensation facilities. Therefore, connection elements used in compensation facilities

are a bit different than the ones used in normal facilities and they are selected for higher currents than the nominal current corresponding to capacitor power.
It is recommended to use special compensation contactors, which are manufactured by our company, for the compensating switching systems. Contactors limit the start-up currents of the capacitors, thanks to their current-limiting contact blocks. In this way, service life of both capacitors and circuit protective devices is extended. Difference of Federal compensation contactors from normal contactors is that there is a transition block having a current limiting resistances connected parallel to main contacts on the contactor. In this way, service life of the contactor and the capacitor shall be doubled.

Assembly Instructions :
Capacitors can be easily mounted by using M12 screws. Assembly screws are used as the grounding connection at the same time. Maximum tightening torque is 5 Nm. Connectors are connected with 5 mm screw and maximum 2Nm torque. Cable connections should be made in a way to allow the body length to bend for 20 mm minimum, in order to allow the capacitor to provide protection easily in case of over pressure.

Attention! Only copper cables should be utilized in connection of capacitors.

Transformer Power (kVA)	Capacitor Power for Oil Type Transformers (kVAr)	Capacitor Power for Dry Type Transformers (kVAr)
10	1	1,5
20	2	1,7
50	4	2
75	5	2,5
100	5	2,5
160	7	4
200	7,5	5
250	8	7,5
315	10	7,5
400	12,5	8
500	15	10
630	17,5	12,5
800	20	15
1000	25	17,5
1250	30	20
1600	35	22
2000	40	25
2500	50	35
3150	60	50

Compensation of MV Transformers
MV transformers draw reactive energy from the network as long as they operate idle. This reactive energy is compensated by (fixed) capacitors permanently connected to the transformer. Powers of these capacitors are calculated with the formula below.

Q = Io% x Pn / 100

Io = no load transformer current
Pn = transformer power

Required capacitor value can easily be determined with used of the table abover.

Capacitor Power for Tri-Phase Squirrel Cage Asynchronous Motors (kVAr)					
Motor Power		Motor Speed (s/m)			
(kW)	(Hp)	3000	1500	1000	750
22	30	6	8	9	10
30	40	7,5	10	11	12,5
37	50	9	11	12,5	16
45	60	11	13	14	17
55	75	13	17	18	21
75	100	17	22	25	28
80	125	20	25	27	30
110	150	24	29	33	37
132	180	31	36	38	43
160	218	35	41	44	52
200	274	43	47	53	61
250	340	52	57	63	71
280	385	57	63	70	79
355	482	67	76	86	98
400	544	78	82	97	106
450	610	87	93	107	117

Compensation of Tri-Phase Asynchronous Motors:
The most common reactive power consumers are tri-phase motors. You may see the required capacitor powers for compensation of squirrel cage motors in the table above. Add 5 to values in the table for motors with winding rotor.

Determination of Capacitor Voltage:
Voltages of the power capacitors to be used in compensation are determined according to harmonic currents in the network to be connected.

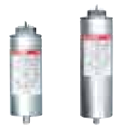
Capacitor voltages are given in the table below according to total harmonic distortion.

THD < 12%	THD < 20%	THD < 27%
400V	450V	525V

Technical Features:

Type	FEKM	FEK13	FEC
Rated Voltage	230/400 V	400/450 V	400 V
Frequency	50 Hz	50 Hz	50 Hz
Standards	TS EN 60831-1/2, IEC 831-1/2	TS EN 60831-1/2, IEC 831-1/2	TS EN 60831-1/2, IEC 831-1/2
Maximum over voltage	Un + 10% up to 8 hours a day Un + 15% up to 30 minutes a day Un + 20% up to 5 minutes a day Un + 30% up to 1 minute a day Voltages exceeding 15% should not be more than 200 times for the service life of capacitor.	Un + 10% up to 8 hours a day Un + 15% up to 30 minutes a day Un + 20% up to 5 minutes a day Un + 30% up to 1 minute a day Voltages exceeding 15% should not be more than 200 times for the service life of capacitor.	Un + 10% up to 8 hours a day Un + 15% up to 30 minutes a day Un + 20% up to 5 minutes a day Un + 30% up to 1 minute a day Voltages exceeding 15% should not be more than 200 times for the service life of capacitor.
Over Current	4xIn	2xIn	2xIn
Capacity tolerance	- 5%+10%	- 5%+10%	- 5%+10%
Test Voltage, terminal / terminal	2.15xUn AC 2 sec	2.15xUn AC 2 sec	2.15xUn AC 2 sec
Test Voltage, terminal / body	3 kV AC 10 sec	3 kV AC 10 sec	3 kV 10 sec
Sudden discharge current	Max. 200 x In	Max. 100 x In	Max. 200 x In
Dielectric losses	0.2 W/kVAr	0.3 W/kVAr	0.25 W/kVAr
Expected statistical life-time	130.000 hours .... (class -25/C) 110.000 hours.............(class -25/D)	100.000 hours........... (class -25/C) 80.000 hours.............(class -25/D)	100.000 hour.............(class -25/D)
Protection Class	IP 00	With standard terminal protector : IP 30 With special protecor : IP 54	With standard terminal protector : IP 20 With special protecor : IP 54
Ambient temperature capacity	-25/D	-25/D	-25/D
Cooling	Natural ventilated	Natural ventilated	Natural ventilated
Allowed relative humidity	Max 95%	Max % 95	Max % 95
Permitted max.Altitude	2000 m above sea level	2000 m above sea level	2000 m above sea level
Assembly position	Any position possible	Any position possible	Any position possible
Assembly	Threaded M12 stud at the bottom of the case	Threaded M12 stud at the bottom of the case	Threaded M12 stud at the bottom of the case
Safety	Over pressure fear-off fuse	Over pressure fear-off fuse	Over pressure fear-off fuse
Dielectric	MKP - metalizedpolypropylene film self heating	MKP - metalizedpolypropylene film self heating	MKP - metalizedpolypropylene film self heating
Filling	Resin - without PCB	Resin - without PCB	Resin - without PCB
Discharge resistances	-	- 75 V in 3 minutes	- 50 V in 1 minutes

M Series Mono-Phase



MKP technologies

Type	Voltage (V)	Power (kVAr)	Current (A)	Capacity (μF)	Dimensions Ø(D)xH (mm)	Order Code
FEKM 0,4/1.67	230/400	0,55 / 1.67	4,2	33,2	45 x 115	9SF-AA000-0001
FEKM 0,4/2.50	230/400	0,82 / 2.50	6,3	49,8	50 x 115	9SF-AA000-0002
FEKM 0,4/3.33	230/400	1,10 / 3.33	8,3	66,3	50 x 150	9SF-AA000-0003
FEKM 0,4/4.17	230/400	1,37 / 4.17	10,4	83,0	55 x 150	9SF-AA000-0004
FEKM 0,4/5	230/400	1,65 / 5	12,5	99,5	60 x 150	9SF-AA000-0005

K Series Three-Phase

MKP technologies

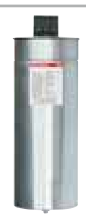
Type	Voltage (V)	Power (kVAr)	Current (A)	Capacity (μF)	Dimensions Ø(D)xH (mm)	Order Code
FEK13 0,4/5	400	5	7,2	3x33,2	65 x 200	9SD-BA000-0500
FEK13 0,4/10	400	10	16,0	3x66	75 x 260	9SD-BA000-1000
FEK13 0,4/12,5	400	12,5	18,0	3x83	85 x 235	9SE-BA000-1250
FEK13 0,4/15	400	15	22,0	3x100	90 x 260	9SE-BA000-1500
FEK13 0,4/20	400	20	29,0	3x133	100 x 260	9SE-BA000-2000
FEK13 0,4/25	400	25	36,0	3x166	100 x 300	9SE-BA000-2500
FEK13 0,4/30	400	30	43,0	3x199	100 x 370	9SE-BA000-3000

K Series Three-Phase

MKP technologies

Type	Voltage (V)	Power (kVAr)	Current (A)	Capacity (μF)	Dimensions Ø(D)xH (mm)	Order Code
FEK13 0,45/10	450	10	12,8	3x52	75 x 260	9SD-BB000-1000
FEK13 0,45/12,5	450	12,5	16,0	3x66	85 x 235	9SE-BB000-1250
FEK13 0,45/15	450	15	19,0	3x79	90 x 260	9SE-BB000-1500
FEK13 0,45/20	450	20	25,6	3x104	100 x 260	9SE-BB000-2000
FEK13 0,45/25	450	25	32,0	3x131	100 x 300	9SE-BB000-2500
FEK13 0,45/30	450	30	39,5	3x157	100 x 370	9SE-BB000-3000

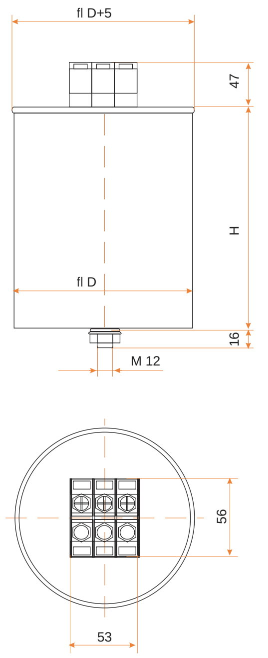
C Series Three-Phase



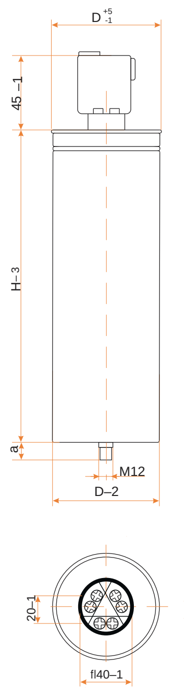
MKP technologies

Type	Voltage (V)	Power (kVAr)	Current (A)	Capacity (μF)	Dimensions Ø(D)xH (mm)	Order Code
FECSAKP1 0,4/40	400	40	57,7	3x265	146 x 260	9SC-BA000-4000
FECSAKP1 0,4/50	400	50	72,0	3x332	146 x 355	9SC-BA000-5000

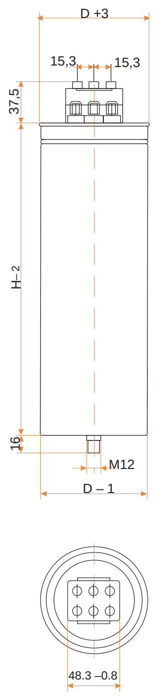
C Series:



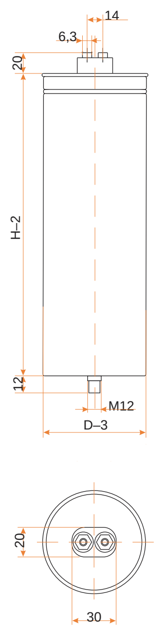
K Series:
400V, Q=5 ve 10 kVAr



K Series:
400V, 10 < Q ≤ 30 kVAr
450V, 10 ≤ Q ≤ 30 kVAr



M Series:



Power (kVar)	a (mm)
5	12
10	16

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