

High Reliable Components for



Power Factor Correction and Power Quality



It's all about saving your money!

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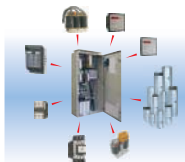
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Power Factor Correction Capacitors Type LKT



// Features that matter:

- Overcurrent up to 2.2 times rated current
- Inrush current up to 300 times rated current
- Self-healing type, segmented film technology plus overpressure disconnecter
- Environment-friendly, dry type
- CO₂ emission reduction
- Safes energy costs

Power Factor Correction Capacitors

Type LKT



// General Remarks

FRAKO Power Factor Correction Capacitors are produced in unique advanced technology and incorporate a triple safety feature. **FRAKO** is the first capacitor manufacturer who succeeded to combine self-healing capacitor film with segmented film and overpressure disconnection. This manufacturing technique guarantees significantly improved operational reliability of capacitors on power factor correction. We reserve the right to make alterations which are based on newly acquired knowledge or which contribute to an improvement in our products.

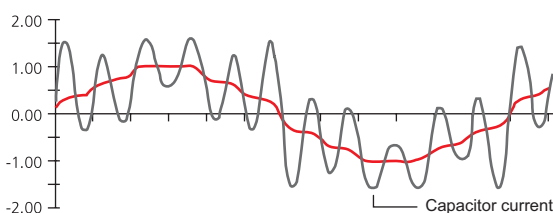
// Technical Remarks

For the operation of Power Factor Correction Capacitors three aspects are of utmost importance:

- High overload capacity
- Long life expectancy
- Safe reaction at overload

// Overload Capacity

In networks where the pollution with harmonics is permanently increasing, surplus loads in capacitors have to be reckoned with. Apart from the higher voltage load it is especially the higher effective current during network resonances, that can considerably further stress the capacitors:



If, for example, the 11th harmonic is present with 8% of the rated network voltage, the r.m.s. value of the rated voltage is only increased by some 0.3%, but the current in the capacitors will exceed its rated value by 33%. It becomes clear that the ability of a capacitor to withstand excessive current is significantly greater than the ability to withstand excessive voltage.

Therefore **FRAKO** designs its capacitors as follows:

- **Max. overcurrent up to 2.2 times rated current**
- **Max. inrush current up to 300 times rated current**

// Life Expectancy

The use of thoroughly tested material as well as careful processing ensures quality and a long life expectancy of the products. **FRAKO** produces its capacitors according to own specifications, which surpass by far the requirements of EN 60831-1/2. Quality tests following each single manufacturing step, verify an outstanding manufacturing quality. Combined with a unique capacitor manufacturing technology, **FRAKO** achieves a worldwide leading durability.

For example, the consistently low power loss over many years is achieved by using a special mineral filler and stabilizer which can avoid permanent partial discharges within the dielectric. Vacuum drying and temperature storage over several days avoid oxygen inclusion, which would accelerate the aging process of a capacitor. This means an extra effort in our production which, however, pays-off with a longer life expectancy.

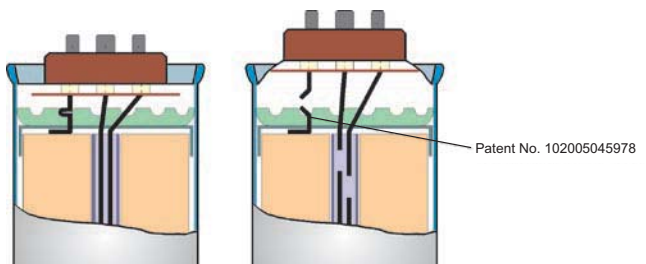
// Safty Features

FRAKO Power Factor Correction Capacitors operate with triple safety:

- Self-healing at over-voltage
- Reliable in operation because of segmented film
- An overpressure disconnector disconnects the capacitors from the mains at the end of their lifetime or at dangerous overload



Self-healing segmented capacitor film



The principle of the overpressure disconnector

To verify the correct functioning of the integrated safety systems, **FRAKO** regularly draws sample capacitors from the production line. A constantly outstanding quality can be achieved and maintained only this way.

Power Factor Correction Capacitors

Type LKT



Voltage Load Capacity

FRAKO Power Factor Correction Capacitors have a load capacity in accordance with EN 60831-1 and -2 as well as IEC 831-1 and -2.

Rated voltage (in VAC)	300	400	440	480	525	615
8 hours daily	330	440	484	528	578	677
30 min. daily	345	460	506	552	604	707
5 min.	360	480	528	576	630	738
1 min.	390	520	572	624	683	800

Application

FRAKO manufactures three series of Power Factor Correction Capacitors: Basic, Standard and Premium. We recommend Basic Capacitors for networks with low harmonic content and normal ambient temperature. Standard Capacitors are recommended for networks with higher harmonic levels and/or high ambient temperature. Premium Capacitors should be used for demanding networks (i. e. networks with very high harmonic levels and/or very high ambient temperature). All three series of capacitors are of excellent FRAKO quality. FRAKO holds the Management System Certificate ISO 9001 and the Environmental Management System ISO 14001.

Mechanical Construction

Cylindrical aluminium case with mounting stud M12 × 12, low loss self-healing dielectric made from segmented metallized polypropylene film. Filled with a PCB-free, flame inhibiting, mineral filler with adhesive stabilizer and integrated mechanical overpressure disconnecter. Permanently connected external discharge resistors at the terminals. The connecting terminal, which is available as an accessory, protects against direct contact of the fast-on terminals and meets the protection class IP 20.

Design

FRAKO Power Factor Correction Capacitors are available as three-phase capacitors in 3 versions: Basic, Standard and Premium. The single-phase capacitors are available as Standard version.

Rating

1.1-30 kvar; 300-615 V; 50/60 Hz (higher voltages on request!)

Capacitance and Rating Tolerance

+/- 5%

Power Loss

Approx. 0.5 Watt/kvar measured at the connecting terminal including discharge resistors.

Approx. 0.2 Watt/kvar measured at the capacitor coils.

Temperature Class

up to - 40 °C; + 65 °C

Discharging

According to EN 60831, every power capacitor must have a discharge device which guarantees a discharge to 75 V within three minutes. FRAKO capacitors have integrated discharge resistors which guarantee a discharge to 50 V within one minute.

Accessories for Power Factor Correction Capacitors

Article-No.	Description	Type
31-08000	Plug-in type connecting terminal for capacitors with Ø 60 mm and Ø 70 mm, 3-phase	AKD 25/3
31-08002	Plug-in type connecting terminal for capacitors with Ø 60 mm and Ø 70 mm, single-phase	AKD 25/2
31-08003	Plug-in type connecting terminal for capacitors with Ø 85 mm, 3-phase	AKD 30/3
69-00352	Plastic caps for LKT with Ø 60 mm	LKK 60
69-00350	Plastic caps for LKT with Ø 70 mm	LKK 70
69-00353	Rubber sleeve	LKK

Power Factor Correction Capacitors

Type LKT

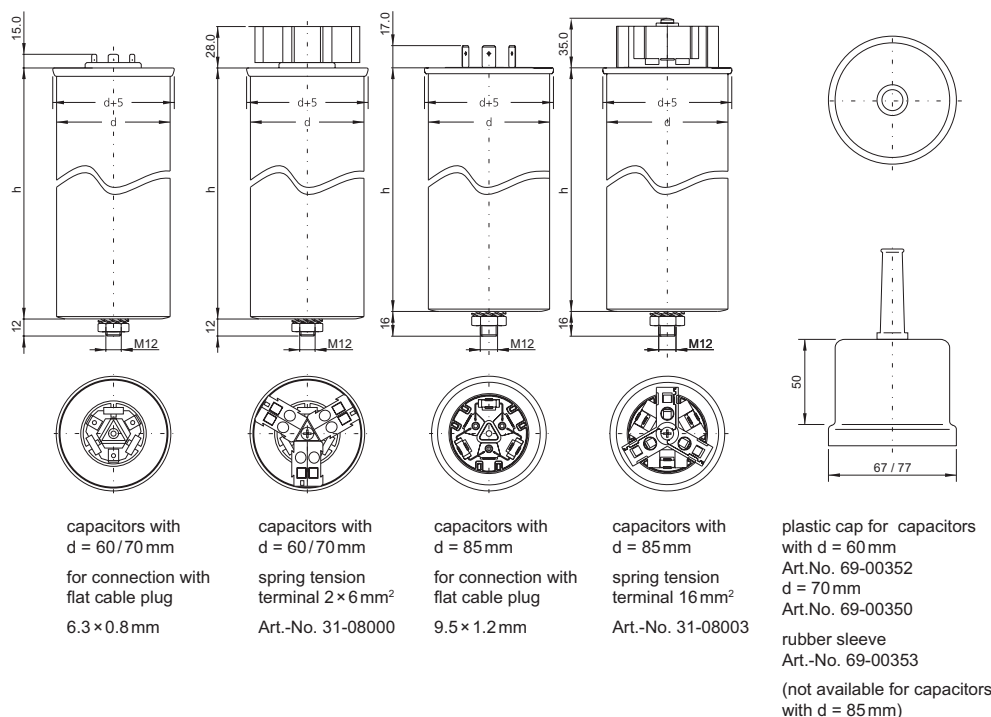


Technical Data

Technical Data	Basic Capacitor	Standard Capacitor	Premium Capacitor	
			operated with DL-specification	operated with DP-specification
Type	LKT...-DB	LKT...-DP	LKT...-DL	LKT...-DL
Rated reactive power	1.7 - 30 kvar	1.1 - 30 kvar	1.4 - 20 kvar	1.4 - 24.2 kvar
Rated voltage	230 - 525 V	230 - 525 V	400 - 525 V	400 - 615 V
Rated frequency	50 - 60 Hz	50 - 60 Hz	50 - 60 Hz	50 - 60 Hz
Max. overcurrent	$1.5 \times I_N$ (at rated voltage, 50 Hz)	$1.8 \times I_N$ (at rated voltage, 50 Hz)	$2.2 \times I_N$ (at rated voltage, 50 Hz)	$2.0 \times I_N$ (at rated voltage, 50 Hz)
Max. inrush current	$200 \times I_N$ (at rated voltage, 50 Hz)	$250 \times I_N$ (at rated voltage, 50 Hz)	$300 \times I_N$ (at rated voltage, 50 Hz)	$300 \times I_N$ (at rated voltage, 50 Hz)
Temperature class	-25/D	-40/+60°C continuous	-40/+65°C continuous	-40/+60°C continuous
Max./min. temperature	+55°C/-25°C	+60°C/-40°C	+65°C/-40°C	+60°C/-40°C
Max. case temperature	+70°C	+75°C	+78°C	+75°C
Test voltage terminal/terminal	$2.15 \times U_N$ for 2 sec. $1.85 \times U_N$ for 18 sec.	$2.15 \times U_N$ for 2 sec. $1.85 \times U_N$ for 18 sec.	$2.15 \times U_N$ for 2 sec. $1.85 \times U_N$ for 18 sec.	$2.15 \times U_N$ for 2 sec. $1.85 \times U_N$ for 18 sec.
Test voltage terminal/case	3,900 V, 2 sec.	3,900 V, 2 sec.	3,900 V, 2 sec.	3,900 V, 2 sec.
Isolation level	3/8 kV	3/8 kV	3/8 kV	3/8 kV
Mean Life expectancy	100,000 h	130,000 h	170,000 h	130,000 h
Max. humidity	95%	95%	95%	95%
Max. altitude	4,000 m	4,000 m	4,000 m	4,000 m
Number of annual switching operations	20,000	40,000	60,000	60,000
Discharging level in 60 sec.	≤50 V	≤50 V	≤50 V	≤50 V
Recommended for	Networks with low harmonic content and normal ambient temperature	Networks with higher harmonic levels and/or high ambient temperature	Demanding networks (i.e. very high harmonic levels and/or very high ambient temperature)	Networks with higher harmonic levels and/or high ambient temperature

Temperature class	admissible ambient temperature		
	maximum	mean over 24 h	highest mean over 1 year
D	55°C	45°C	35°C

Dimensions



Power Factor Correction Capacitors

Type LKT...-DB for 50Hz and 60Hz



Basic Capacitors

Capacitor Type	Dimensions mm	Article-No.	Rated Reactive Power in kvar at Rated Voltage 50Hz								
			230V	250V	300V	400V	415V	440V	460V	480V	525V
Three-phase capacitors											
LKT 5.0-400-DB	60×150	31-10414	1.7	2.0	2.8	5.0					
LKT 6.25-400-DB	60×150	31-10400	2.1	2.4	3.5	6.25					
LKT 7.5-400-DB	60×150	31-10415	2.5	2.9	4.2	7.5					
LKT 10.0-400-DB	60×225	31-10416	3.3	3.9	5.6	10.0					
LKT 12.5-400-DB	60×225	31-10401	4.2	4.9	7.0	12.5					
LKT 15.0-400-DB	70×225	31-10417	5.0	5.9	8.4	15.0					
LKT 20.0-400-DB	85×215	31-10418	6.7	7.8	11.3	20.0					
LKT 25.0-400-DB	85×278	31-10402	8.3	9.8	14.1	25.0					
LKT 30.0-400-DB	85×320	31-10403	9.9	11.7	16.9	30.0					
LKT 6.25-440-DB	60×150	31-10404	1.7			5.2	5.6	6.25			
LKT 10.0-440-DB	60×225	31-10412	2.7			8.3	8.9	10.0			
LKT 12.5-440-DB	60×225	31-10405	3.4			10.3	11.1	12.5			
LKT 15.0-440-DB	70×225	31-10406	4.1			12.4	13.3	15.0			
LKT 20.0-440-DB	85×278	31-10413	5.5			16.5	17.8	20.0			
LKT 25.0-440-DB	85×278	31-10407	6.8			20.7	22.2	25.0			
LKT 30.0-440-DB	85×278	31-10408	8.2			24.8	26.7	30.0			
LKT 6.25-525-DB	60×225	31-10409				3.6	3.9	4.4	5.2	6.25	
LKT 12.5-525-DB	70×225	31-10410				7.3	7.8	8.8	10.4	12.5	
LKT 15.0-525-DB	70×225	31-10419				8.7	9.4	10.5	12.5	15.0	
LKT 20.0-525-DB	70×265	31-10420				11.6	12.5	14.1	16.7	20.0	
LKT 25.0-525-DB	85×278	31-10411				14.5	15.6	17.6	20.9	25.0	

Capacitor Type	Dimensions mm	Article-No.	Rated Reactive Power in kvar at Rated Voltage 60Hz								
			230V	250V	300V	400V	415V	440V	460V	480V	525V
Three-phase capacitors											
LKT 5.0-400-DB	60×150	31-10414	2.0	2.3	3.4	6.0					
LKT 6.25-400-DB	60×150	31-10400	2.5	2.9	4.2	7.5					
LKT 7.5-400-DB	60×150	31-10415	3.0	3.5	5.0	9.0					
LKT 10.0-400-DB	60×225	31-10416	4.0	4.7	6.8	12.0					
LKT 12.5-400-DB	60×225	31-10401	5.0	5.9	8.4	15.0					
LKT 15.0-400-DB	70×225	31-10417	6.0	7.0	10.1	18.0					
LKT 20.0-400-DB	85×215	31-10418	7.9	9.4	13.5	24.0					
LKT 25.0-400-DB	85×278	31-10402	9.9	11.7	16.9	30.0					
LKT 30.0-400-DB	85×320	31-10403	11.9	14.1	20.3	36.0					
LKT 6.25-440-DB	60×150	31-10404	2.0			6.25	6.7	7.5			
LKT 10.0-440-DB	60×225	31-10412	3.3			9.9	10.7	12.0			
LKT 12.5-440-DB	60×225	31-10405	4.1			12.4	13.3	15.0			
LKT 15.0-440-DB	70×225	31-10406	4.9			14.9	16.0	18.0			
LKT 20.0-440-DB	85×278	31-10413	6.7			19.8	21.4	24.0			
LKT 25.0-440-DB	85×278	31-10407	8.2			24.8	26.7	30.0			
LKT 30.0-440-DB	85×278	31-10408	9.8			29.8	32.0	36.0			
LKT 6.25-525-DB	60×225	31-10409				4.4		5.3	5.8	6.3	7.5
LKT 12.5-525-DB	70×225	31-10410				8.7		10.5	11.5	12.5	15.0
LKT 15.0-525-DB	70×225	31-10419				10.5		12.6	13.8	15.1	18.0
LKT 20.0-525-DB	70×265	31-10420				13.9		16.9	18.4	20.1	24.0
LKT 25.0-525-DB	85×278	31-10411				17.4		21.1	23.0	25.1	30.0

Power Factor Correction Capacitors

Type LKT...-DP/...-EP for 50Hz



Standard Capacitors

Capacitor Type	Dimensions mm	Article-No.	Rated Reactive Power in kvar at Rated Voltage 50 Hz							
			230V	250V	300V	400V	415V	440V	480V	525V
Three-phase capacitors										
LKT 7.1-300-DP	60×225	31-10523	4.2	4.9	7.1					
LKT 14.2-300-DP	70×265	31-10524	8.3	9.9	14.2					
LKT 21.3-300-DP	85×278	31-10525	12.5	14.8	21.3					
LKT 5.0-400-DP	60×150	31-10500	1.7	2.0	2.8	5.0				
LKT 10.0-400-DP	60×225	31-10501	3.3	3.9	5.6	10.0				
LKT 12.5-400-DP	70×225	31-10502	4.2	4.9	7.0	12.5				
LKT 15.0-400-DP	70×265	31-10503	5.0	5.9	8.4	15.0				
LKT 20.0-400-DP	85×278	31-10504	6.7	7.8	11.3	20.0				
LKT 25.0-400-DP	85×278	31-10505	8.3	9.8	14.1	25.0				
LKT 3.8-440-DP	60×150	31-10534	1.0			3.1	3.4	3.8		
LKT 10.0-440-DP	60×225	31-10508	2.7			8.3	8.9	10.0		
LKT 12.5-440-DP	70×225	31-10507	3.4			10.3	11.1	12.5		
LKT 15.0-440-DP	70×225	31-10506	4.1			12.4	13.3	15.0		
LKT 20.0-440-DP	85×278	31-10512	5.5			16.5	17.8	20.0		
LKT 25.0-440-DP	85×278	31-10510	6.8			20.7	22.2	25.0		
LKT 28.2-440-DP	85×320	31-10535	7.7			23.3	25.0	28.2		
LKT 30.0-440-DP	85×320	31-10509	8.2			24.8	26.7	30.0		
LKT 15.5-480-DP	70×225	31-10513	3.6			10.8	11.6	13.1	15.5	
LKT 18.0-480-DP	70×265	31-10522	4.2			12.5	13.5	15.1	18.0	
LKT 10.0-525-DP	70×225	31-10517				5.8	6.3	7.0	8.3	10.0
LKT 12.5-525-DP	70×225	31-10516				7.3	7.8	8.8	10.4	12.5
LKT 15.0-525-DP	70×265	31-10520				8.7	9.4	10.5	12.5	15.0
LKT 20.0-525-DP	85×278	31-10521				11.6	12.5	14.1	16.7	20.0
LKT 25.0-525-DP	85×278	31-10519				14.5	15.6	17.6	20.9	25.0

Single-phase capacitors										
LKT 3.33-440-EP	60×90	31-10526	0.9			2.8	3.0	3.3		
LKT 4.17-440-EP	60×138	31-10527	1.1			3.4	3.7	4.2		
LKT 5.0-440-EP	60×138	31-10528	1.4			4.1	4.4	5.0		
LKT 9.4-440-EP	70×138	31-10511	2.6			7.8	8.4	9.4		
LKT 2.4-480-EP	60×90	31-10529	0.6			1.7	1.8	2.0	2.4	
LKT 3.33-480-EP	60×90	31-10530	0.8			2.3	2.5	2.8	3.3	
LKT 3.6-480-EP	60×138	31-10531	0.8			2.5	2.7	3.0	3.6	
LKT 4.8-480-EP	60×138	31-10515	1.1			3.3	3.6	4.0	4.8	
LKT 6.0-480-EP	60×138	31-10514	1.4			4.2	4.5	5.0	6.0	
LKT 2.8-525-EP	60×90	31-10532				1.6	1.8	2.0	2.3	2.8
LKT 3.33-525-EP	60×138	31-10533				1.9	2.1	2.3	2.8	3.4
LKT 8.33-525-EP	70×138	31-10518				4.8	5.2	5.9	7.0	8.3

Power Factor Correction Capacitors

Type LKT...-DP/...-EP for 60 Hz



Standard Capacitors

Capacitor Type	Dimensions mm	Article-No.	Rated Reactive Power in kvar at Rated Voltage 60 Hz								
			230V	250V	300V	400V	415V	440V	460V	480V	525V
Three-phase capacitors											
LKT 7.1-300-DP	60×225	31-10523	5.0	5.9	8.5						
LKT 14.2-300-DP	70×265	31-10524	10.0	11.8	17.0						
LKT 21.3-300-DP	85×278	31-10525	15.0	17.7	25.5						
LKT 5.0-400-DP	60×150	31-10500	2.0	2.3	3.3	6.0					
LKT 10.0-400-DP	60×225	31-10501	4.0	4.7	6.8	12.0					
LKT 12.5-400-DP	70×225	31-10502	5.0	5.9	8.4	15.0					
LKT 15.0-400-DP	70×265	31-10503	6.0	7.0	10.1	18.0					
LKT 20.0-400-DP	85×278	31-10504	8.0	9.4	13.5	24.0					
LKT 25.0-400-DP	85×278	31-10505	9.9	11.7	16.9	30.0					
LKT 3.8-440-DP	60×150	31-10534	1.3			3.8	4.1	4.6			
LKT 10.0-440-DP	60×225	31-10508	3.3			9.9	10.7	12.0			
LKT 12.5-440-DP	70×225	31-10507	4.1			12.4	13.3	15.0			
LKT 15.0-440-DP	70×225	31-10506	4.9			14.9	16.0	18.0			
LKT 20.0-440-DP	85×278	31-10512	6.7			19.8	21.4	24.0			
LKT 25.0-440-DP	85×278	31-10510	8.2			24.8	26.7	30.0			
LKT 28.2-440-DP	85×320	31-10535	9.2			27.9	30.0	33.8			
LKT 30.0-440-DP	85×320	31-10509	9.8			29.8	32.0	36.0			
LKT 15.5-480-DP	70×225	31-10513	4.3			13.0	13.9	15.7		18.6	
LKT 18.0-480-DP	70×265	31-10522	5.0			15.0	16.2	18.2		21.6	
LKT 10.0-525-DP	70×225	31-10517				7.0	7.5	8.3	9.2	10.0	12.0
LKT 12.5-525-DP	70×225	31-10516				8.7	9.4	10.5	11.5	12.5	15.0
LKT 15.0-525-DP	70×265	31-10520				10.4	11.3	12.6	13.8	15.0	18.0
LKT 20.0-525-DP	85×278	31-10521				13.9	15.0	16.9	18.4	20.1	24.0
LKT 25.0-525-DP	85×278	31-10519				17.4	18.8	21.1	23.0	25.1	30.0
Single-phase capacitors											
LKT 3.33-440-EP	60×90	31-10526	1.1			3.3	3.6	4.0			
LKT 4.17-440-EP	60×138	31-10527	1.4			4.1	4.5	5.0			
LKT 5.0-440-EP	60×138	31-10528	1.6			5.0	5.3	6.0			
LKT 9.4-440-EP	70×138	31-10511	3.1			9.3	10.0	11.3			
LKT 2.4-480-EP	60×90	31-10529	0.7			2.0	2.2	2.4		2.9	
LKT 3.33-480-EP	60×90	31-10530	0.9			2.8	3.0	3.4		4.0	
LKT 3.6-480-EP	60×138	31-10531	1.0			3.0	3.2	3.7		4.3	
LKT 4.8-480-EP	60×138	31-10515	1.3			4.0	4.3	4.8		5.8	
LKT 6.0-480-EP	60×138	31-10514	1.7			5.0	5.4	6.0		7.2	
LKT 2.8-525-EP	60×90	31-10532				1.9	2.0	2.4	2.6	2.8	3.4
LKT 3.33-525-EP	60×138	31-10533				2.3	2.5	2.8	3.1	3.3	4.0
LKT 8.33-525-EP	70×138	31-10518				5.8	6.3	7.0	7.7	8.3	10.0

Power Factor Correction Capacitors

Type LKT...-DL for 50Hz and 60Hz



Premium Capacitors

Capacitor Type	Dimensions mm	Article-No.	Rated Reactive Power in kvar at Rated Voltage 50 Hz						
			230V	400V	415V	440V	480V	525V	615V
Three-phase capacitors									
LKT 5.0-400-DL	60×225	31-10600	1.7	5.0	5.4*	6.1*			
LKT 6.25-400-DL	60×225	31-10601	2.1	6.25	6.7*	7.6*			
LKT 9.3-400-DL	70×225	31-10602	3.0	9.3	10.0*	11.3*			
LKT 10.0-400-DL	70×225	31-10603	3.3	10.0	10.8*	12.1*			
LKT 11.7-400-DL	70×225	31-10604	3.9	11.7	12.6*	14.2*			
LKT 12.5-400-DL	70×225	31-10605	4.2	12.5	13.5*	15.1*			
LKT 20.0-400-DL	85×278	31-10606	6.7	20.0	21.5*	24.2*			
LKT 5.0-440-DL	60×225	31-10607	1.4	4.2	4.5	5.0	6.0*		
LKT 7.6-440-DL	60×225	31-10608	2.1	6.25	6.8	7.6	9.0*		
LKT 9.1-440-DL	60×225	31-10609	2.5	7.5	8.1	9.1	10.8*		
LKT 12.1-440-DL	70×225	31-10610	3.3	10.0	10.8	12.1	14.4*		
LKT 17.6-440-DL	85×278	31-10612	4.8	14.5	15.6	17.6	21.0*		
LKT 3.6-480-DL	60×150	31-10613		2.5	2.7	3.0	3.6	4.3*	
LKT 4.5-480-DL	60×150	31-10614		3.1	3.4	3.8	4.5	5.4*	
LKT 7.2-480-DL	60×225	31-10615		5.0	5.4	6.0	7.2	8.6*	
LKT 7.8-480-DL	60×225	31-10616		5.4	5.8	6.5	7.8	9.3*	
LKT 10.4-480-DL	70×225	31-10617		7.3	7.8	8.8	10.4	12.4*	
LKT 12.5-480-DL	70×265	31-10618		8.7	9.4	10.5	12.5	15.0*	
LKT 4.17-525-DL	60×225	31-10619				2.9	3.5	4.2	5.7*
LKT 5.9-525-DL	60×225	31-10620				4.2	5.0	5.9	8.1*
LKT 7.7-525-DL	70×225	31-10621				5.4	6.5	7.7	10.6*
LKT 8.3-525-DL	70×225	31-10622				5.8	7.0	8.3	11.4*

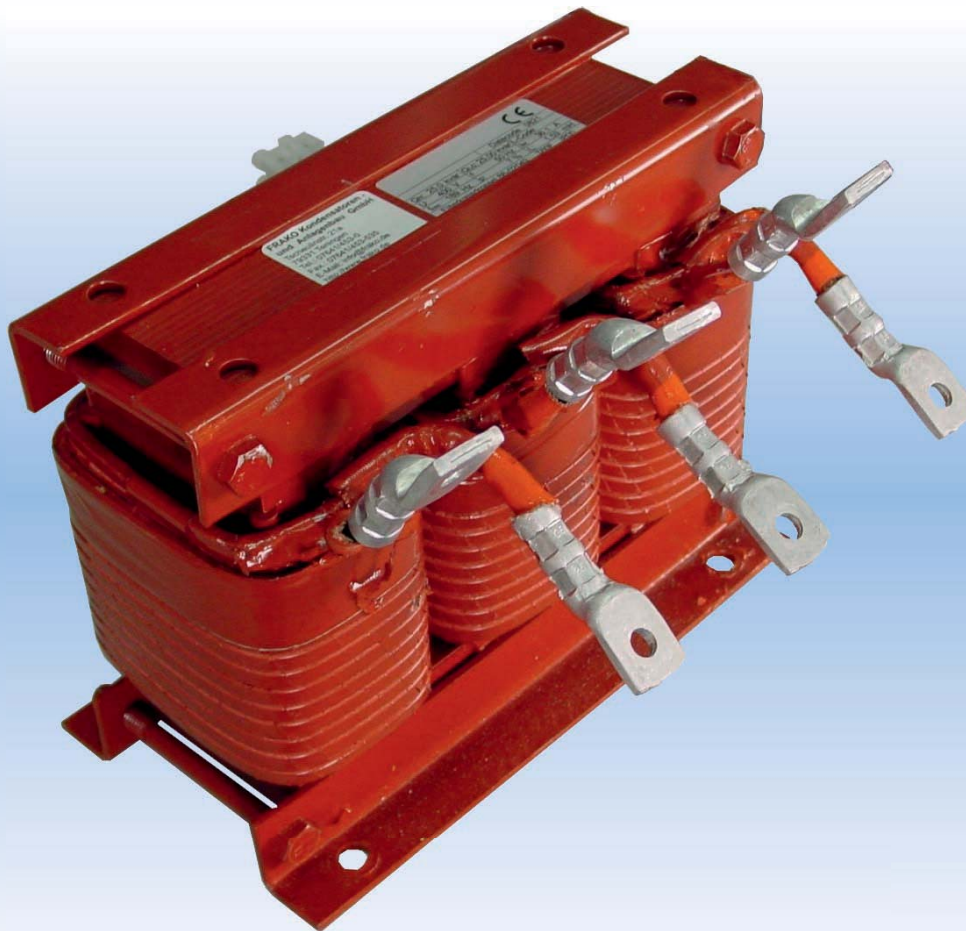
Capacitor Type	Dimensions mm	Article-No.	Rated Reactive Power in kvar at Rated Voltage 60 Hz							
			230V	400V	415V	440V	460V	480V	525V	615V
Three-phase capacitors										
LKT 5.0-400-DL	60×225	31-10600	2.0	6.0	6.5*	7.3*				
LKT 6.25-400-DL	60×225	31-10601	2.5	7.5	8.1*	9.1*				
LKT 9.3-400-DL	70×225	31-10602	3.7	11.1	12.0*	13.5*				
LKT 10.0-400-DL	70×225	31-10603	4.0	12.0	12.9*	14.5*				
LKT 11.7-400-DL	70×225	31-10604	4.6	14.0	15.1*	17.0*				
LKT 12.5-400-DL	70×225	31-10605	5.0	15.0	16.2*	18.2*				
LKT 20.0-400-DL	85×278	31-10606	7.9	24.0	25.8*	29.0*				
LKT 5.0-440-DL	60×225	31-10607	1.7	5.0	5.4	6.0	6.6*	7.1*		
LKT 7.6-440-DL	60×225	31-10608	2.5	7.5	8.1	9.1	9.9*	10.9*		
LKT 9.1-440-DL	60×225	31-10609	3.0	9.0	9.7	10.9	11.9*	13.0*		
LKT 12.1-440-DL	70×225	31-10610	4.0	12.0	12.9	14.5	15.8*	17.3*		
LKT 17.6-440-DL	85×278	31-10612	5.8	17.4	18.8	21.1	23.1*	25.1*		
LKT 3.6-480-DL	60×150	31-10613		3.0		3.6	4.0	4.3	5.2*	
LKT 4.5-480-DL	60×150	31-10614		3.8		4.6	5.0	5.4	6.5*	
LKT 7.2-480-DL	60×225	31-10615		6.0		7.2	7.9	8.6	10.3*	
LKT 7.8-480-DL	60×225	31-10616		6.5		7.9	8.6	9.3	11.2*	
LKT 10.4-480-DL	70×225	31-10617		8.7		10.5	11.5	12.5	14.9*	
LKT 12.5-480-DL	70×265	31-10618		10.4		12.6	13.8	15.0	18.0*	
LKT 4.17-525-DL	60×225	31-10619					3.8	4.2	5.0	6.9*
LKT 5.9-525-DL	60×225	31-10620					5.5	5.9	7.1	9.7*
LKT 7.7-525-DL	70×225	31-10621					7.1	7.8	9.3	12.7*
LKT 8.3-525-DL	70×225	31-10622					7.6	8.3	10.0	13.7*

Generally, DL-type capacitors can also be operated at higher voltages with the DP-type specification.

Please note that the DP values in the chart are marked with *

Basic Harmonic Filter Reactors

Type FDK



// Features that matter:

- Low losses
- Complete with mounting brackets and connecting clamps
- Temperature range up to +60°C
- Temperature switches available as option

Basic Harmonic Filter Reactors

Type FDK



Application

Used in conjunction with LKT type power capacitors, harmonic filter reactors (blocking reactors) make it possible to install detuned versions of fixed capacitor banks and power factor correction systems.

This enables users installing distribution boards to construct customized systems themselves.

Design

Low-loss, three-phase assembly complete with mounting brackets.

Series Resonance Frequency

Version	Series resonance frequency	Detuning factor	For networks with utility company AF remote control ¹⁾
P7	189 Hz	$\rho=7\%$	> 228 Hz

Please refer also to the design notes given in our Manual of Power Factor Correction. (other series resonance frequencies on request)

¹⁾ Utility company specifications inconsistent with the above must be taken into account.

Mounting

The reactor must be mounted in a suitable enclosure ensuring an ambient temperature within the specified range.

Connections

The coil line-side (U, V, W) and load-side (X, Y, Z) can be connected to the switchgear directly or via terminals.

Available Types

Type	Article-no.	Q kvar	Dimensions in mm								Weight kg	Al kg
			A	B	C	D	E	F	G	H		
FDK 12.5-400-P7	88-02044	12.5	180	112	155	-	120	90	8x16	190	8	1.14
FDK 25-400-P7	88-02042	25	220	152	176	185	176	121	8x16	210	16	1.59
FDK 50-400-P7	88-02043	50	283	145	220	170	200	115	11x20	250	26	2.21

Technical Specification

Q kvar	Net V/Hz	Inductance mH	f_{res} Hz	I_{50} A	I_{150} A	I_{250} A	I_{350} A	I_{RMS} A	max.loss power W
12.5	400V, 50Hz	3.067	189	19.8	7.0	6.7	2.4	21.1	74
25	400V, 50Hz	1.533	189	39.7	1.4	13.4	4.8	42.2	150
50	400V, 50Hz	0.767	189	79.4	2.7	26.8	9.7	84.4	230

We reserve the right to make changes to the dimensions and design of the products in this data sheet.

Standards

IEC 60289, IEC 60076, VDE 0532

Applicable Standards

When installing and connecting power capacitors in Germany, the standards VDE 0100 IEC 60364, VDE 0105 IEC 60050, IEC 60529, VDE 0560 Part 46 IEC 60831 and VDE 0106 Part 100 must be complied with. In other countries the equivalent local regulations must be observed.

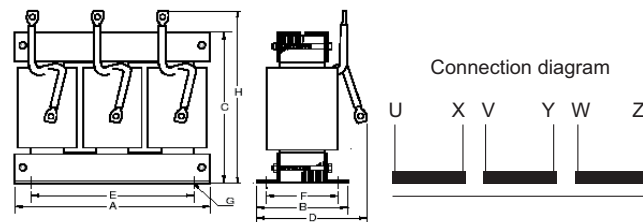
Technical Data

Tolerance of inductance:	+/- 5 %
Max. ambient temperature:	+ 60 °C
Temperature class:	H 180 °C
Insulation level:	3 kVac
Winding material:	Al
Color:	red or light brown

Option

Temperature switch 130 °C +/- 5 °C,
Voltage 250 VAC (type FDKT)

Mechanical Data



Standard Harmonic Filter Reactors

Type FDR/FKD



// Features that matter:

- Low losses
- Complete with mounting brackets and connecting cables
- Including temperature switches
- Temperature range up to +60°C

Harmonic Filter Reactors

Type FDR / FKD



// Application

Used in conjunction with LKT type Power Factor Correction Capacitors, harmonic filter reactors (blocking reactors) make it possible to install detuned versions of fixed capacitor banks and power factor correction systems. This enables users installing distribution boards to construct customized systems themselves.

// Design

Low-loss, three-phase assembly complete with mounting brackets, connecting cables and thermal trip.

// Series Resonance Frequency

Version	Series resonance frequency	Detuning factor	For networks with utility company AF remote control ¹⁾
P1	134 Hz	p=14 %	> 166 Hz
P7	189 Hz	p= 7 %	> 228 Hz

¹⁾Utility company specifications inconsistent with the above must be taken into account.

Please refer also to the design notes given in our Manual of Power Factor Correction. (other series resonance frequencies on request)

// Mounting

The reactor must be mounted in a suitable enclosure ensuring an ambient temperature within the specified range.

// Connections

The coil line-side (U1, V1, W1) and load-side (U2, V2, W2) cables can be connected to the switchgear directly or via terminals. The temperature switch (contacts open at 140°C) must be connected to a trip/alarm circuit in the control system.

// Applicable Standards

When installing and connecting power capacitors in Germany, the standards VDE 0100 IEC 60364, VDE 0105 IEC 60050, IEC 60529, VDE 0560 part 46 IEC 60831 and VDE 0106 part 100 must be complied with. In other countries the equivalent local regulations must be observed.

// Load Capacity

Version	Power loss W/kvar	Permissible harmonic voltage	
		250 Hz	350 Hz
P1	4-6	6%	6%
P7	3.5-6	6%	6%

// Power Loss

3.5 – 6 W/kvar (depending on version and level of harmonics)

// Temperature Range

-10 to +60°C

// Ingress Protection

IP00 to IEC 60529 for mounting within an enclosure

// Important Note

Please use only the correct number of the appropriate power capacitors as stated in the table for each individual harmonic filter reactor. If this requirement is not adhered to, the resulting series resonance frequency can under certain circumstances move into a critical range. Apart from possibly overloading the installed components, the utility company's remote control systems could also be adversely affected.

// Technical Data

Specimen order 1

P.F. correction stage with 7 % detuning factor 25 kvar at 400V/50 Hz supply voltage

2 power capacitors		
Type	LKT 11.7 – 400 – DL	Art.-No. 31-10604
2 terminal blocks		
Type	AKD 25/3	Art.-No. 31-08000
1 low-loss harmonic filter reactor with temperature switch		
Type	FDR 25 – 400 – P7	Art.-No. 88-01768

Specimen order 2

P.F. correction stage with 14 % detuning factor 12.5 kvar at 400V/50 Hz supply voltage

1 power capacitor		
Type	LKT 15.5 – 480 – DP	Art.-No. 31-10513
1 terminal block		
Type	AKD 25/3	Art.-No. 31-08000
1 low-loss harmonic filter reactor with temperature switch		
Type	FKD 12.5 – 400 – P1	Art.-No. 88-01168

Specimen order 3

P.F. correction stage with 14 % detuning factor 20 kvar at 400V/50 Hz supply voltage

1 power capacitor		
Type	LKT 7.6 – 440 – DL	Art.-No. 31-10608
1 power capacitor		
Type	LKT 15.5 – 480 – DP	Art.-No. 31-10513
2 terminal blocks		
Type	AKD 25/3	Art.-No. 31-08000
1 low-loss harmonic filter reactor with temperature switch		
Type	FKD 20 – 400 – P1	Art.-No. 88-01038

Harmonic Filter Reactors

Type FDR / FKD

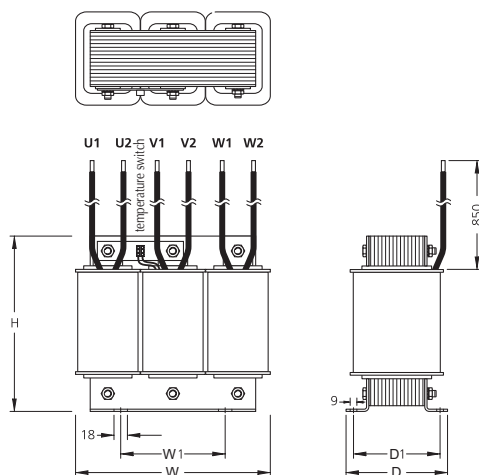


Capacitors and Harmonic Filter Reactors for 230 V/50 Hz – mains network

Resonance frequency		fres: 189 Hz, detuning factor p= 7%												
Rated power of Capacitor Reactor combination	Rated current of Capacitor Reactor combination	Type and Quantity of the required capacitors					Dimensions in mm					Weight	Harmonic Filter Reactors	
		LKT 10.0-400-DP Art.-No.31-10501	LKT 12.5-400-DP Art.-No.31-10502	LKT 10.0-440-DP Art.-No.31-10508	LKT 10.0-525-DP Art.-No.31-10517		W	W1	H	D	D1		kg	Art.-No.
5.0	12.6			1	1		150	80	132	109	75.5	5	88-01980	FDR 5-230-P7
10.0	26.9	3					178	100	156	95	66	9	88-01575	FKD 10-230-P7
12.5	31.3	1	2				178	100	156	115.5	85.5	9	88-01974	FDR 12.5-230-P7
16.7	44.9		4				178	100	156	128	98	10	88-01583	FKD 16.7-230-P7
20.0	53.8	1	4				202	100	177	121	91	15	88-01576	FKD 20-230-P7
25.0	62.5	2	4				202	100	177	121	91	16	88-01943	FDR 25-230-P7
33.0	89.9		8				226	100	197	128	98	21	88-01568	FKD 33-230-P7

Capacitors and Harmonic Filter Reactors for 230 V/60 Hz – mains network

Resonance frequency		fres: 227 Hz, detuning factor p= 7%												
Rated power of Capacitor Reactor combination	Rated current of Capacitor Reactor combination	Type and Quantity of the required capacitors					Dimensions in mm					Weight	Harmonic Filter Reactors	
		LKT 10.0-400-DP Art.-No.31-10501	LKT 7.1-300-DP Art.-No.31-10523				W	W1	H	D	D1		kg	Art.-No.
17.0	43.1	4					178	100	156	115	86	10	88-01809	FKD 17-230-60Hz-P7
25.0	62.2	2	3				202	100	177	121	91	21	88-01892	FDR 25-230-60Hz-P7



FDR/FKD dimensions

Harmonic Filter Reactors

Type FDR / FKD



Capacitors and Harmonic Filter Reactors for 400 V/50 Hz – mains network

Resonance frequency		fres: 189 Hz, detuning factor p= 7%												
Rated power of Capacitor Reactor combination	Rated current of Capacitor Reactor combination	Type and Quantity of the required capacitors					Dimensions in mm			Weight	Harmonic Filter Reactors			
		LKT 7.6-440-DL Art.-No.31-10608	LKT 9.1-440-DL Art.-No.31-10609	LKT 12.5-440-DP Art.-No.31-10507	LKT 11.7-400-DL Art.-No.31-10604	LKT 15.0-440-DP Art.-No.31-10506	W	W1	H		D	D1	kg	Art.-No.
Q_{LC} [kvar]	In [A]						W	W1	H	D	D1	kg	Art.-No.	Type
6.25	9.0	1					150	80	130	109	75.5	7	88-01410	FKD 6.25-400-P7
7.5	10.8	1					150	80	130	109	75.5	7	88-01482	FKD 7.5-400-P7
10.0	14.4	1					178	100	156	115.5	85.5	10	88-01479	FKD 10-400-P7
12.5	18.0	1					178	100	156	115.5	85.5	10	88-01767	FDR 12.5-400-P7
15.0	21.6	2					202	100	177	121	91	15	88-01362	FKD 15-400-P7
20.0	29.0	2					202	100	177	121	91	19	88-01363	FKD 20-400-P7
25.0	36.0	2					202	100	177	121	91	21	88-01768	FDR 25-400-P7
30.0	43.0	3					261	140	229	110	80	21	88-01484	FKD 30-400-P7
40.0	58.0	3					261	140	228	110	80	21	88-01782	FDR 40-400-P7
50.0	72.0	4					261	140	235	136	106	27	88-01769	FDR 50-400-P7

Resonance frequency		fres: 134 Hz, detuning factor p= 14%												
Rated power of Capacitor Reactor combination	Rated current of Capacitor Reactor combination	Type and Quantity of the required capacitors					Dimensions in mm			Weight	Harmonic Filter Reactors			
		LKT 7.8-480-DL Art.-No.31-10616	LKT 7.7-525-DL Art.-No.31-10621	LKT 7.6-440-DL Art.-No.31-10608	LKT 15.5-480-DP Art.-No.31-10513	LKT 12.1-440-DL Art.-No.31-10610	LKT 9.1-440-DL Art.-No.31-10609	W	W1		H	D	D1	kg
Q_{LC} [kvar]	In [A]						W	W1	H	D	D1	kg	Art.-No.	Type
6.25	9.0	1					178	100	156	115	86	10	88-01505	FKD 6.25-400-P1
10.0	14.4	2					178	100	156	115	86	10	88-01695	FKD 10-400-P1
12.5	18.0	1					202	100	177	121	91	15	88-01168	FKD 12.5-400-P1
20.0	28.8	1					226	100	197	128	98	21	88-01038	FKD 20-400-P1
25.0	36.0	2					261	140	230	136	106	27	88-01171	FKD 25-400-P1
40.0	57.6	2					295	225	265	155	125	33	88-01779	FDR 40-400-P1
50.0	72.0	4					295	225	265	155	125	33	88-01780	FDR 50-400-P1

Harmonic Filter Reactors

Type FDR / FKD



Capacitors and Harmonic Filter Reactors for 415 V/50 Hz – mains network

Resonance frequency		fres: 189 Hz, detuning factor p= 7%									
Rated power of Capacitor Reactor combination	Rated current of Capacitor Reactor combination	Type and Quantity of the required capacitors		Dimensions in mm					Weight	Harmonic Filter Reactors	
		LKT 15.5-480-DP Art.-No.31-10513	LKT 12.5-525-DP Art.-No.31-10516	W	W1	H	D	D1		kg	Art.-No.
12.5	17.3	1		178	100	156	115	86	10	88-01937	FDR 12.5-415-P7
16.8	23.4	2		178	100	156	115	86	11	88-01977	FDR 16.8-415-P7
25.0	34.7	2		202	100	177	121	91	15	88-01938	FDR 25-415-P7
33.6	46.7	4		226	100	197	128	98	19	88-01978	FDR 33.6-415-P7
50.0	69.3	4		261	140	235	136	106	27	88-01930	FDR 50-415-P7

Capacitors and Harmonic Filter Reactors for 440 V/50 Hz – mains network

Resonance frequency		fres: 189 Hz, detuning factor p= 7%									
Rated power of Capacitor Reactor combination	Rated current of Capacitor Reactor combination	Type and Quantity of the required capacitors		Dimensions in mm					Weight	Harmonic Filter Reactors	
		LKT 12.1-440-DL Art.-No.31-10610		W	W1	H	D	D1		kg	Art.-No.
25.0	34.2	2		226	100	197	128	98	21	88-01008	FKD 25-440-P7
50.0	68.4	4		261	140	235	136	106	28	88-01124	FKD 50-440-P7

Harmonic Filter Reactors

Type FDR / FKD



Capacitors and Harmonic Filter Reactors for 440 V/60 Hz – mains network

Resonance frequency		fres: 227Hz, detuning factor p= 7%															
Rated power of Capacitor Reactor combination	Rated current of Capacitor Reactor combination	Type and Quantity of the required capacitors								Dimensions in mm		Weight	Harmonic Filter Reactors				
		LKT 8.33-525-DL Art.-No.31-10622	LKT 15.5-480-DP Art.-No.31-10513	LKT 12.1-440-DL Art.-No.31-10610	LKT 7.7-525-DL Art.-No.31-10621	LKT 5.9-525-DL Art.-No.31-10620	LKT 7.8-480-DL Art.-No.31-10616	W	W1	H	D		D1	kg	Art.-No.	Type	
Q_{LC} [kvar]	In [A]									W	W1	H	D	D1	kg	Art.-No.	Type
6.25	9.2	1								150	80	132	109	75.5	6	88-01914	FKD 6.25-440-60Hz-P7
7.5	9.9	1								150	80	132	109	75.5	6	88-01795	FKD 7.5-440-60Hz-P7
12.5	16.9	1				1				178	100	156	95	66	21	88-01883	FKD 12.5-440-60Hz-P7
15.0	19.8	1								178	100	156	115.5	85.5	10	88-01796	FKD 15-440-60Hz-P7
25.0	33.1	1				1				202	100	177	121	91	11	88-01884	FKD 25-440-60Hz-P7
50.0	66.2	3								261	140	235	110	80	29	88-01875	FDR 50-440-60Hz-P7

Capacitors and Harmonic Filter Reactors for 460 V/60 Hz – mains network

Resonance frequency		fres: 227 Hz, detuning factor p= 7%															
Rated power of Capacitor Reactor combination	Rated current of Capacitor Reactor combination	Type and Quantity of the required capacitors								Dimensions in mm		Weight	Harmonic Filter Reactors				
		LKT 12.5-525-DP Art.-No.31-10516								W	W1		H	D	D1	kg	Art.-No.
Q_{LC} [kvar]	In [A]									W	W1	H	D	D1	kg	Art.-No.	Type
12.5	15.5	1								178	100	156	115.5	85.5	10	88-01854	FDR 12.5-460-60Hz-P7
25.0	31.1	2								202	100	177	121	91	21	88-01855	FDR 25-460-60Hz-P7
50.0	62.1	4								261	140	235	136	106	27	88-01856	FDR 50-460-60Hz-P7

Harmonic Filter Reactors

Type FDR / FKD



Capacitors and Harmonic Filter Reactors for 480 V/60 Hz – mains network

Resonance frequency		fres: 227 Hz, detuning factor p= 7%												
Rated power of Capacitor Reactor combination	Rated current of Capacitor Reactor combination	Type and Quantity of the required capacitors					Dimensions in mm					Weight	Harmonic Filter Reactors	
		LKT 12.5-525-DP Art.-No.31-10516	LKT 7.7-525-DL Art.-No.31-10621	LKT 4.17-525-DL Art.-No.31-10619	LKT 8.33-525-DL Art.-No.31-10622		W	W1	H	D	D1		kg	Art.-No.
33.3	43.1	2			1		261	140	229	110	80	21	88-01736	FKD 33.3-480-60Hz-P7
41.6	53.9	3		1			261	140	229	110	80	21	88-01737	FKD 41.6-480-60Hz-P7
50.0	60.5		6				261	140	235	136	106	27	88-01858	FDR 50-480-60Hz-P7

Capacitors and Harmonic Filter Reactors for 525 V/50 Hz – mains network

Resonance frequency		fres: 189 Hz, detuning factor p= 7%												
Rated power of Capacitor Reactor combination	Rated current of Capacitor Reactor combination	Type and Quantity of the required capacitors					Dimensions in mm					Weight	Harmonic Filter Reactors	
		LKT 4.17-525-DL Art.-No.31-10619	LKT 5.9-525-DL Art.-No.31-10620	LKT 7.7-525-DL Art.-No.31-10621	LKT 8.33-525-DL Art.-No.31-10622		W	W1	H	D	D1		kg	Art.-No.
6.25	7.0		1				150	80	130	109	75.5	7	88-01801	FKD 6.25-525-P7
12.5	14.1		2				178	100	156	115.5	85.5	10	88-01802	FKD 12.5-525-P7
20.0	24.7	1			2		226	100	198	104	74	19	88-01080	FKD 20-525-P7
25.0	29.6			3			226	100	197	128	98	21	88-01838	FDR 25-525-P7
30.0	34.6	1			3		226	100	197	128	98	21	88-01533	FKD 30-525-P7
50.0	55.0			6			261	140	235	136	106	29	88-01872	FDR 50-525-P7

Resonance frequency		fres: 134 Hz, detuning factor p= 14%												
Rated power of Capacitor Reactor combination	Rated current of Capacitor Reactor combination	Type and Quantity of the required capacitors					Dimensions in mm					Weight	Harmonic Filter Reactors	
		LKT 4.17-525-DL Art.-No.31-10616	LKT 5.9-525-DL Art.-No.31-10620				W	W1	H	D	D1		kg	Art.-No.
25.0	27.9	1	3				261	140	230	136	106	25	88-01960	FDR 25-525-P1
50.0	55.8	2	6				295	225	265	155	125	52	88-01900	FDR 50-525-P1

Harmonic Filter Reactors

Type FDR / FKD



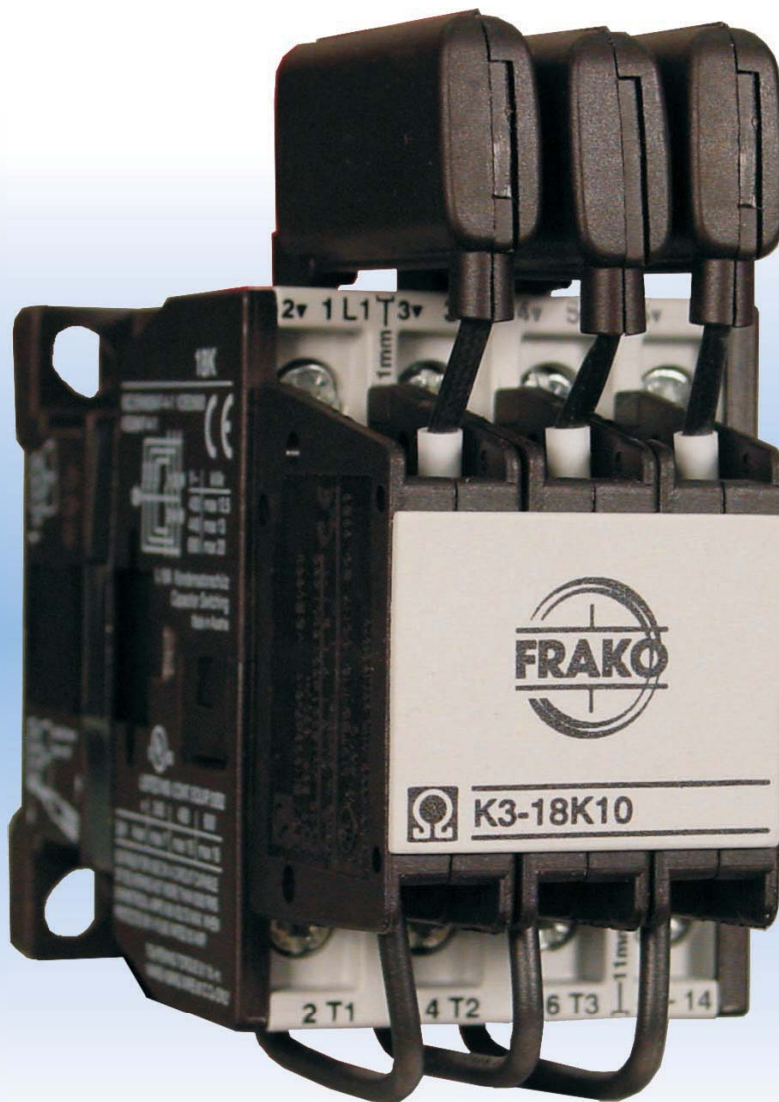
Capacitors and Harmonic Filter Reactors for 690 V/50 Hz – mains network

Resonance frequency		fres: 189 Hz, detuning factor p= 7%												
Rated power of Capacitor Reactor combination	Rated current of Capacitor Reactor combination	Type and Quantity of the required capacitors					Dimensions in mm	Weight	Harmonic Filter Reactors					
		LKT 9.4-440-EP Art.-No.31-10511							Art.-No.	Type				
Q_{LC} [kvar]	I_n [A]						W	W1	H	D	D1	kg	Art.-No.	Type
25.0	22.6	3					202	100	177	121	91	19	88-01932	FDR 25-690-P7
50.0	45.2	6					261	140	235	136	106	27	88-01933	FDR 50-690-P7

Resonance frequency		fres: 134 Hz, detuning factor p= 14%												
Rated power of Capacitor Reactor combination	Rated current of Capacitor Reactor combination	Type and Quantity of the required capacitors					Dimensions in mm	Weight	Harmonic Filter Reactors					
		LKT 4.8-480-EP Art.-No.31-10515	LKT 6.0-480-EP Art.-No.31-10514	LKT 8.33-525-EP Art.-No.31-10518					Art.-No.	Type				
Q_{LC} [kvar]	I_n [A]						W	W1	H	D	D1	kg	Art.-No.	Type
25.0	21.7	3	3			261	140	230	136	106	27	88-01842	FKD 25-690-P1	
50.0	43.4			9			295	225	265	155	125	33	88-01843	FKD 50-690-P1

Capacitor Switching Contactors

Type K3...-A, K3...-K



// Features that matter:

- Patented design with significant damping on inrush-current
- Long-life contactors tested by FRAKO up to 100,000 switching operations
- Suitable for unchoked and choked Power Factor Correction Systems
- Very high operational reliability

Capacitor Switching Contactors

for unchoked and choked PFC Systems



// Description

Capacitor contactors for unchoked power factor correction systems

During the switching of unchoked power factor correction capacitors a peak-switching current of 200 times of the nominal current can occur. This load is stressing the capacitors and the switching contacts of the contactors immensely. This can lead to welded main contacts of contactors.

Therefore modern power factor correction systems are currently equipped with special capacitor contactors switching the capacitors first with leading contacts and additionally with resistance wires. The in-rush current will be damped strongly by the resistors. After approximately 5 ms the main contacts of the contactor are switching in and taking over the current supply to the capacitors. Further to this the leading contacts open up and no current can flow during permanent operation. This is also to avoid an additional power loss.

Capacitor contactors with leading transition contact and additional resistance wires offer the following advantages to power factor correction system applications:

- Significant damping of in-rush current
- Improvement of the voltage quality during the switching process
- Long life of the contactors
- High operational reliability of the power factor correction system
- Extension of the maintenance periods of the power factor correction systems
- Suitable for choked and unchoked power factor correction systems due to leading transition contacts opening during permanent operation.

Capacitor contactors for choked power factor correction systems

When choked power factor correction systems are switched, the peak-switching current is essentially lower because of the high inductivity of the harmonic filter reactor as with unchoked power factor correction systems.

By using special wear-resistant contact material for these applications it is possible to use capacitor contactors without series resistors.

These special capacitor contactors offer the following advantages for choked power factor correction systems:

- Safe switching on and off of choked capacitor steps
- Improved voltage quality through chatter-proofed switching operations
- Long-life of the contactors (> 100,000 switching operations)
- High operational reliability of the power factor correction system



Capacitor Switching Contactors

for unchoked and choked PFC Systems



Technical Data

Rated operational power at 50/60 Hz Ambient temperature:						Aux. contacts built-in add.		Type	Article-No.	Weight	
50° C			60° C			NO NC		Coil voltage 220–240 V 50 Hz		kg/pc.	
380 V 400 V kvar	415 V 440 V kvar	660 V 690 V kvar	380 V 400 V kvar	415 V 440 V kvar	660 V 690 V kvar	1	–				pcs.
0-12.5	0-13	0-20	0-12.5	0-13	0-20	1	–	1 ¹⁾	K3-18K10 230	89-00280	0.34
10-20	10.5-22	17-33	10-20	10.5-22	17-33	–	–	3 ²⁾	K3-24K00 230	89-00279	0.62
10-25	10.5-27	17-41	10-25	10.5-27	17-41	–	–	3 ²⁾	K3-32K00 230	89-00278	0.62
20-33.3	23-36	36-55	20-33.3	23-36	36-55	–	–	3 ²⁾	K3-50K00 230	89-00277	1.0
20-50	23-53	36-82	20-50	23-53	36-82	–	–	3 ²⁾	K3-62K00 230	89-00276	1.0
20-75 ³⁾	23-75 ³⁾	36-120 ³⁾	20-60	23-64	36-100	–	–	3 ²⁾	K3-74K00 230	89-00286	1.0
33-80	36-82	57-120	33-75	36-77	57-120	–	–	6 ⁴⁾	K3-90K00230	89-00356	2.3
33-100 ⁵⁾	36-103 ⁵⁾	57-148 ⁵⁾	33-90 ⁵⁾	36-93 ⁵⁾	57-148 ⁵⁾	–	–	6 ⁴⁾	K3-115K00230	89-00357	2.3

¹⁾ 1HN.. or HA.. snap-on

²⁾ 2HB.. for side mounting and 1HN.. or HA.. snap-on

³⁾ Consider the max. thermal current of the contactor K3-74 A: $I_{th} 130 A$

⁴⁾ 2HB.. on the left or right side and 4 HN.. or HA.. snap-on

⁵⁾ Consider the min. cross-section of conductor at max. load

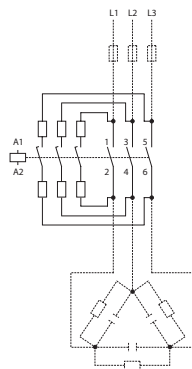
Specification: Contactors K3-..K are suitable for switching low-inductive and low loss capacitors in capacitor banks (IEC70 and 831, VDE 0560) without and with reactors. Capacitor switching contactors are fitted with early make contacts and damping resistors, to reduce the value of make current <70 x I_e.

Operating Conditions: Capacitor switching contactors are protected against contact welding for a prospective making current of 200 x I_e.

Technical Data acc. to IEC 947-4-1, IEC 947-5-1, EN 60947-4-1, EN 60947-5-1, VDE 0660

Type		K3-18K	K3-24K	K3-32K	K3-50K	K3-62K	K3-74K	K3-90K	K3-115K	
Max. frequency of operations z	1/h	120	120	120	120	120	80	80	80	
Contact life: unchoked capacitor banks	S x 10 ³	250	150	150	150	150	120	100	75	
Contact life: choked banks	S x 10 ³	400	300	300	300	300	200	200	200	
Rated operational current I _e	at 50 °C	A	0-18	14-28	14-36	30-48	30-72	30-108	50-115	50-144
	at 60 °C	A	0-18	14-28	14-36	30-48	30-72	30-87	50-108	50-130
Fuses gL (gG)	from/to	A	35/63	50/80	63/100	80/160	125/160	160/200	160/200	160/250

Typical Circuit Diagram



Mounting Instructions

In the area of capacitor switching contactors, difficulty inflammable and self-extinguishing materials may be used only, because abnormal temperatures within the area of the resistor spirals cannot be excluded.

Auxiliary Contact Blocks

Rated operational current			Contacts	Type	Article-No.	Weight	
AC15 230 V A	AC1 400 V A	AC1 690 V A					
3	2	10	NO NC	For contactors		kg/pc.	
3	2	10	1 1	K3-24... to K3-115... for side mounting	HB11	89-00294	0.02
3	2	10	1 –	K3-18... to K3-115...	HN10	89-00281	0.02

Capacitor Switching Contactors

for unchoked and choked PFC Systems



Technical Data

Rated operational power at 50/60 Hz						Aux. contacts built-in add.			Type	Article-No.	Weight
Ambient temperature: 50° C									Coil voltage 220–240 V 50 Hz		kg/pc.
380 V	415 V	660 V	380 V	415 V	660 V	NO	NC	pcs.			
400 V	440 V	690 V	400 V	440 V	690 V	–	–	6 ²⁾	K3-18A10 230	89-00288	0.23
kvar	kvar	kvar	kvar	kvar	kvar	–	–	6 ²⁾	K3-24A00 230	89-00289	0.48
12.5	13	20	12.5	13	20	–	–	6 ²⁾	K3-32A00 230	89-00290	0.48
20	22	33	20	22	33	–	–	6 ²⁾	K3-50A00 230	89-00291	0.85
25	27	41	25	27	41	–	–	6 ²⁾	K3-62A00 230	89-00292	0.85
33.3	36	55	33.3	36	55	–	–	6 ²⁾	K3-74A00 230	89-00293	0.85
50	53	82	50	53	82	–	–	9 ⁴⁾	K3-90A00 230	89-00358	2.2
75 ³⁾	75 ³⁾	100	60	64	100	–	–	9 ⁴⁾	K3-115A00 230	89-00359	2.2
80	82	120	75	77	120	–	–				
100 ⁵⁾	103 ⁵⁾	148 ⁵⁾	90 ⁵⁾	93 ⁵⁾	148 ⁵⁾	–	–				

¹⁾ 4HN.. or HA.. snap-on

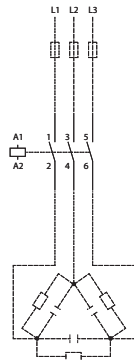
²⁾ 2HB11 on the left or right side and 4HN.. or HA.. snap-on

³⁾ Consider the max. thermal current: I_{th} 130 A

⁴⁾ 2HB.. on the left or right side and 7 HN.. or HA.. snap-on

⁵⁾ Consider the min. cross-section of conductor at max. load

Typical Circuit Diagram

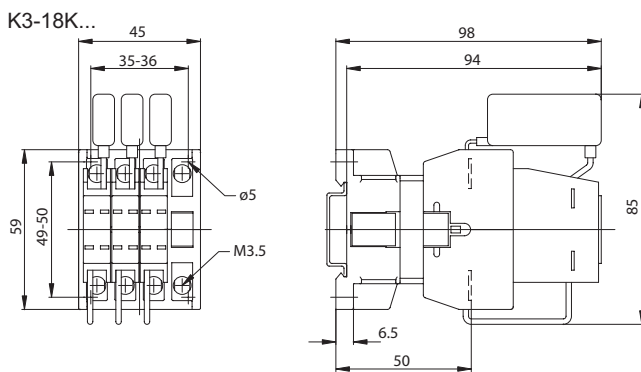


Mounting Instructions

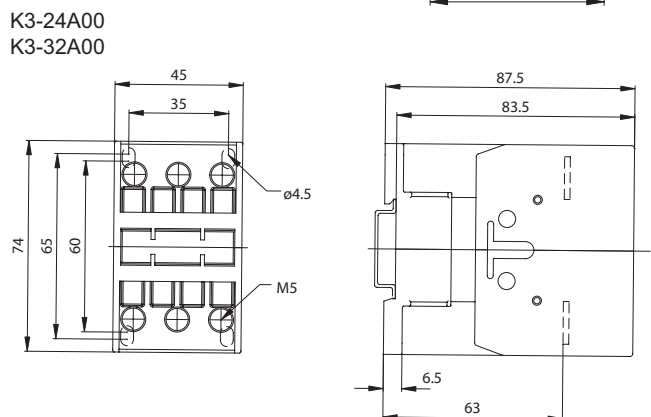
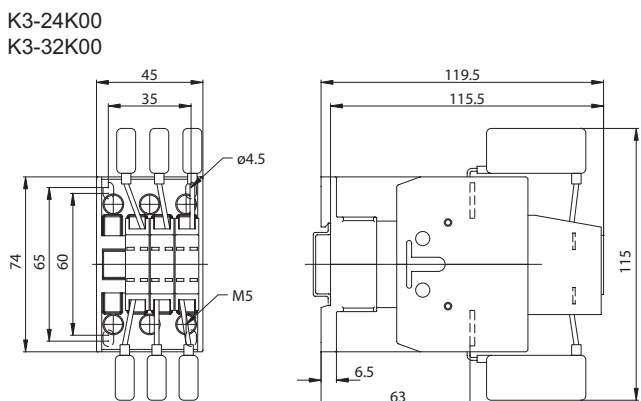
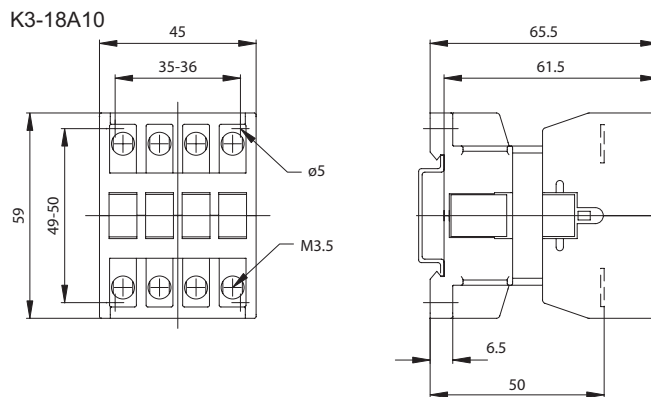
In the area of capacitor switching contactors, difficulty inflammable and self-extinguishing materials may be used only, because abnormal temperatures within the area of the resistor spirals cannot be excluded.

Dimensions

Capacitor switching contactors, AC-operated



Contactors, AC-operated



Capacitor Switching Contactors

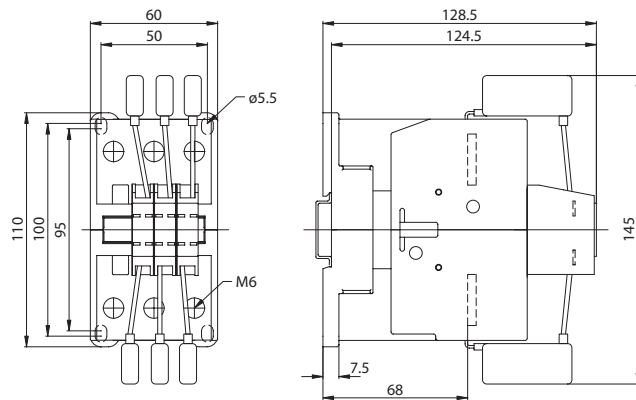
for unchoked and choked PFC Systems



Dimensions

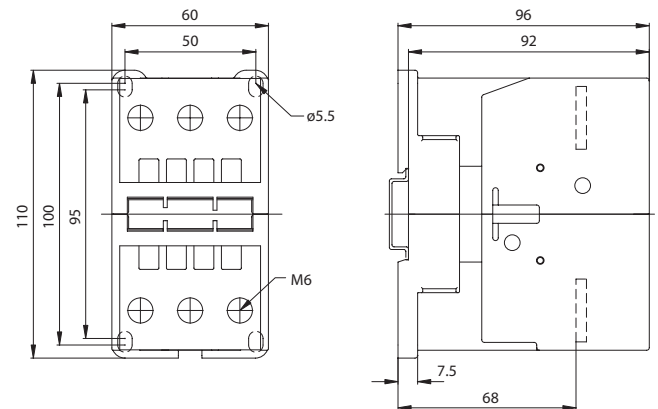
Capacitor switching contactors, AC-operated

K3-50K00
K3-62K00
K3-74K00

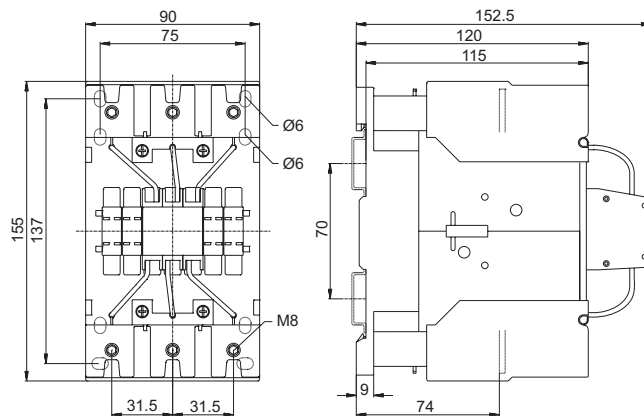


Contactors, AC-operated

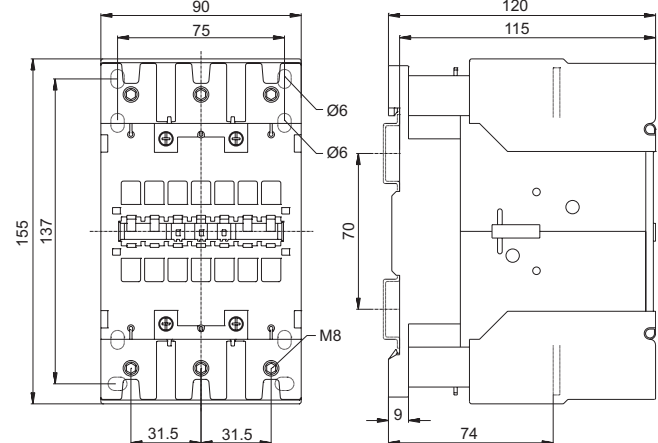
K3-50A00
K3-62A00
K3-74A00



K3-90K00
K3-115K00



K3-90A00
K3-115A00



Technical Data

Main Contacts	Type	K3-18K	K3-24K	K3-32K	K3-50K	K3-62K	K3-74K	K3-90K	K3-115K	
Switching of three-phase current pfc-systems										
Ambient temperature $\leq 50^\circ\text{C}$										
Rated operational current I_e	690 V	A	0–18	14–28	14–36	30–48	30–72	30–108 ¹⁾	50–115	50–144 ²⁾
Rated operational power	220–240V	kvar	0–7	5–11	5–14	12–20	12–28	12–33	20–45	20–55 ²⁾
	380–400 V	kvar	0–12.5	10–20	10–25	20–33.3	20–50	20–75 ¹⁾	33–80	33–100 ²⁾
	415–440 V	kvar	0–13	10.5–22	10.5–27	23–36	23–53	23–75 ¹⁾	36–82	36–103 ²⁾
Rated operational power	500 V	kvar	0–15	12–25	12–30	26–40	26–60	26–75	43–100	43–120 ²⁾
	525 V	kvar	0–15	12–25	12–32	26–43	26–64	26–80	45–105	45–125 ²⁾
	660–690 V	kvar	0–20	17–33	17–41	36–55	36–82	36–120	57–120	57–148 ²⁾
	1000 V	kvar	–	–	–	–	–	–	85–160	85–200 ²⁾
Ambient temperature $\leq 60^\circ\text{C}$										
Rated operational current I_e	690 V	A	0–18	14–28	14–36	30–48	30–72	30–87	50–108	50–130 ²⁾
Rated operational power	220–240 V	kvar	0–7	5–11	5–14	12–20	12–28	12–30	20–40	20–50 ²⁾
	380–400 V	kvar	0–12.5	10–20	10–25	20–33.3	20–50	20–60	33–75	33–90 ²⁾
	415–440 V	kvar	0–13	10.5–22	10.5–27	23–36	23–53	23–64	36–77	36–93 ²⁾
Rated operational power	500 V	kvar	0–15	12–25	12–30	26–40	26–60	26–70	43–90	43–110 ²⁾
	525 V	kvar	0–15	12–25	12–32	26–43	26–64	26–75	45–95	45–115 ²⁾
	660–690 V	kvar	0–20	17–33	17–41	36–55	36–82	36–100	57–120	57–148 ²⁾
	1000 V	kvar	–	–	–	–	–	–	85–150	85–180 ²⁾

¹⁾ Consider the max. thermal current: I_{th} 130 A

²⁾ Consider the min. cross-section of conductor at max. load

Capacitor Switching Contactors

Data according to IEC 947-4-1, EN 60947-4-1, VDE 0660



Technical Data

Main Contacts		Type	K3-18A	K3-24A	K3-32A	K3-50A	K3-62A	K3-74A	K3-90A	K3-115A
Switching of three-phase current pfc-systems										
Ambient temperature ≤ 50 °C										
Rated operational current I_e	690 V	A	18	28	36	48	72	108 ¹⁾	115	144 ²⁾
Rated operational power	220–240V	kvar	7	11	14	20	28	33	45	55 ²⁾
	380–400 V	kvar	12.5	20	25	33.3	50	75 ¹⁾	80	100 ²⁾
	415–440 V	kvar	13	22	27	36	53	75 ¹⁾	82	103 ²⁾
	500 V	kvar	15	25	30	40	60	75	100	120 ²⁾
	525 V	kvar	15	25	32	43	64	80	105	125 ²⁾
	660–690 V	kvar	20	33	41	55	82	120	120	148 ²⁾
	1000 V	kvar	–	–	–	–	–	–	160	200 ²⁾
Ambient temperature ≤ 60 °C										
Rated operational current I_e	690 V	A	18	28	36	48	72	87	108	130 ²⁾
Rated operational power	220–240 V	kvar	7	11	14	20	28	30	40	50 ²⁾
	380–400 V	kvar	12.5	20	25	33.3	50	60	75	90 ²⁾
	415–440 V	kvar	13	22	27	36	53	64	77	93 ²⁾
	500 V	kvar	15	25	30	40	60	70	90	110 ²⁾
	525 V	kvar	15	25	32	43	64	75	95	115 ²⁾
	660–690 V	kvar	20	33	41	55	82	100	120	148 ²⁾
	1000 V	kvar	–	–	–	–	–	–	150	180 ²⁾

¹⁾ Consider the max. thermal current: I_n 130 A

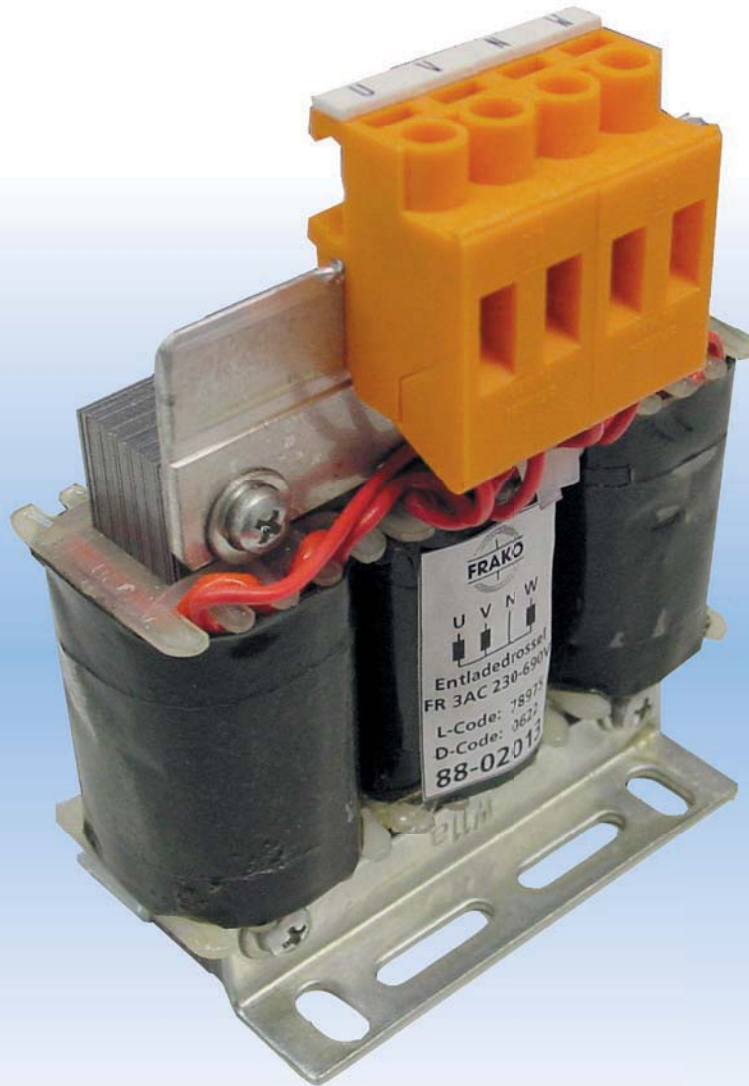
²⁾ Consider the min. cross-section of conductor at max. load

Main Contacts		Type	K3-18	K3-24	K3-32	K3-50	K3-62	K3-74	K3-90	K3-115
Maximum ambient temperature										
Operation	open	°C	–40 to +60 (+90) ¹⁾							
	enclosed	°C	–40 to +40							
Storage		°C	–50 to +90							
Short circuit protection										
for contactors without thermal overload relay										
Coordination-type "1" according to IEC 947-4-1										
Contact welding without Hazard of persons										
Max. fuse size	gL (gG)	A	100	100	100	160	160	160	200	250
Mechanical life										
AC-operated	S x 10 ⁶		10	10	10	10	10	10	5	5
DC-operated	S x 10 ⁶		10	10	10	10	10	10	5	5
Short time current	10s-current	A	144	184	240	360	504	592	680	880
Power loss per pole	At $I_g/AC3$ 400 V	W	0.5	0.7	1.3	2.2	3.9	5.5	4.3	6.0

¹⁾ With reduced control voltage range 0.9 up to 1.0 x U_c and with reduced rated current $I_g/AC1$ according to $I_g/AC3$

Discharge Reactors

Type FR 3AC



// Features that matter:

- One type for every application in Power Factor Correction Systems
- Low operating losses
- Ambient temperature up to +60°C
- Allows very fast re-switching of the same capacitor step

Discharge Reactors

Type FR 3AC



Description

Discharge reactors have lower losses than discharging resistors.

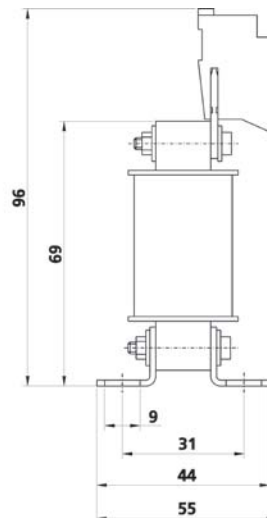
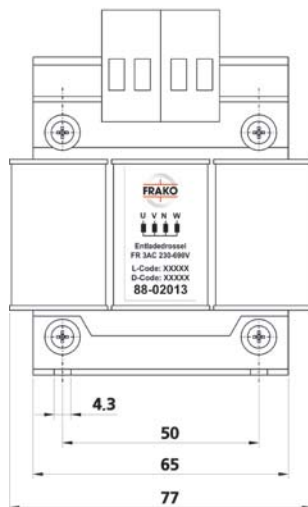
This could be an important fact in modern power factor correction systems if ambient temperature is a topic to solve.

The high AC resistance of the discharge reactors generates very small losses, also when capacitors were permanently connected to the network.

In the moment when capacitors are switched off, the low DC resistance of the discharge reactor is responsible for a very fast discharging time of the capacitors. It will only take a few seconds. This fast discharging also allows a very fast re-switching of the same capacitor.

Technical Data

Discharge reactor, type:	
FR3AC230-690V – Article-No. 88-02013	
Ordering code	88-02013
Rated operating voltage:	3AC 230 V – 690 V
Frequency:	50 – 60 Hz
Operating losses:	< 5 W
No-load current:	< 4.5 mA
Inductance:	70 H
Time of discharge:	230 V 25 kvar < 5 sec. 50 kvar < 10 sec. 400 V 50 kvar < 5 sec. 100 kvar < 10 sec. 690 V 100 kvar < 5 sec.
Permissible discharges:	3 / min
Temperature class:	T40 / E
Ambient temperature:	-25 ... +60 °C
Protection class:	IP 00
Abutting cross section:	0.75 mm ² – 2.5 mm ²
Fixing torque:	0.5 Nm
Total weight:	0.5 kg
Testing voltage:	4 kVAC
Standards:	EN 61558-2-20
Dimensions in mm:	
WxHxD	77 x 96 x 55



Power Factor Control Relays

Type EMR1100 / EMR1100S / RM9606 / RM2106 / RM2112



// Features that matter:

- Fully automatic and simple commissioning
- Patented control characteristic – no overcompensation during low load
- Measurement and monitoring of harmonics
- Overcurrent trip function – protection for capacitors
- Four-quadrant regulation

Power Factor Control Relays

Type EMR 1100S / EMR 1100



Description

Microprocessor-based control relay for intelligent control of capacitor banks with 12 control contacts.

Simple Commissioning

By automatic identification of threshold current (c/k value), phase angle, connected capacitor stages and switching sequences.

Operator Overview

Through clear digital display of key momentary values and operating parameters.

- Power factor ($\cos \varphi$)
- Apparent (RMS), active and reactive currents
- 5th, 7th, 11th and 13th voltage harmonics
- Total capacitive power required to meet target power factor setting

Monitoring of Harmonic Levels

By continuous monitoring and display of harmonic voltage levels. In the event of harmonic levels exceeding programmable limits, all capacitors will be switched off through overcurrent alarm.

Prolongs Switchgear Life

The EMR 1100 counts, stores and displays the number of switching operations for each individual capacitor stage. An alarm is triggered if the switching counters exceed programmable limits.

Additional Protection for Capacitors

The RMS current monitoring function provides excellent protection for capacitor banks without harmonic filters, especially when resonance causes an increase in harmonic levels.

Intelligent Control for Increased Equipment Life

- Cyclic switching for capacitor stages of the same rating.
- Accurate switching of capacitor stages prevents unnecessary switchings for responsive control.
- Continuous optimisation of switching delay according to required reactive current.

Features

- Potential-free alarm contact.
- Programmable over-current alarm threshold limit (from 1.05 to $3.0 \times I_{rms}$).
- Continuous monitoring for defective capacitor stages through self adjustment of control program.
- Zero voltage and zero current tripping with alarm signal.
- Patented "kinked" control curve characteristics avoid overcompensation under light load.
- Four-quadrant power control with LED display when active power is generated into mains.
- Manual/automatic operation with ability to switch each individual capacitor stage ON or OFF.
- Target power factor setting adjustable from 0.80 inductive to 0.90 capacitive in steps of 0.01 .
- Preset up to three fixed capacitor stages which will be excluded from normal automatic operation.
- Independent setting of capacitor switching time to match discharge time of capacitor stages.
- Suitable for current transformers with rated secondary current of 1 A or 5 A .



Alarm Signals for

- Undercompensation
- High harmonic levels
- Overcurrent
- Switching counters
- Fault in voltage circuit ($U = 0$ alarm)
- Fault in current circuit ($I = 0$ alarm)
- Fault in capacitor stages ($C = 0$ alarm)

Optional extension of the EMR 1100S to EMR 1100 full version by means of software upgrading

- Potential-free tariff switching contact to select two independent target power factor settings.
- Remote indication of the measuring values and historical data (daily curves, monthly and annual evaluation).
- Communication with Building control systems.
- Configuration and remote indication of the measuring values with software EMR-SW via the RS232 interface.

Power Factor Control Relays

Type RM 9606



Description

Microprocessor-based control relay for intelligent control of capacitor banks with 6 control contacts.

Simple Commissioning

By automatic identification of threshold current (c/k value), phase angle, connected capacitor stages and switching sequences.

Operator Overview

Through clear digital display of key momentary values and operating parameters.

- Power factor (cos φ)
- Apparent (RMS), active and reactive currents
- 5th, 7th, 11th and 13th voltage harmonics
- Total capacitive power required to meet target power factor setting

Monitoring of Harmonic Levels

By continuous monitoring and display of harmonic voltage levels. In the event of harmonic levels exceeding programmable limits, all capacitors will be switched off through overcurrent alarm.

Prolongs Switchgear Life

The RM 9606 counts, stores and displays the number of switching operations for each individual capacitor stage. An alarm is triggered if the switching counters exceed programmable limits.

Additional Protection for Capacitors

The RMS current monitoring function provides excellent protection for capacitor banks without harmonic filters, especially when resonance causes an increase in harmonic levels.

Power factor		Capacitor stages				Residual
Actual	Ind. 0.991	State	Stage power	Operation cycles	Manual switching	
Target	Ind. 0.987	S1	OFF 12.30 kvar	435 Cycles	<input type="checkbox"/>	<input type="checkbox"/>
Current		S2	ON 12.60 kvar	432 Cycles	<input type="checkbox"/>	<input type="checkbox"/>
I appr.	248.9 A	S3	ON 12.50 kvar	429 Cycles	<input type="checkbox"/>	<input type="checkbox"/>
I act.	248.2 A	S4	OFF 12.50 kvar	426 Cycles	<input type="checkbox"/>	<input type="checkbox"/>
I react.	31.60 A	S5	OFF 12.20 kvar	426 Cycles	<input type="checkbox"/>	<input type="checkbox"/>
Voltage		S6	OFF 12.30 kvar	425 Cycles	<input type="checkbox"/>	<input type="checkbox"/>
V Ph-Ph	401 V	S7	Zero 0.000 kvar	174 Cycles	<input type="checkbox"/>	<input type="checkbox"/>
Capacitor bank		S8	Zero 0.000 kvar	172 Cycles	<input type="checkbox"/>	<input type="checkbox"/>
Power	74 kvar	S9	Zero 0.000 kvar	170 Cycles	<input type="checkbox"/>	<input type="checkbox"/>
Utilization	33 %	S10	Zero 0.000 kvar	170 Cycles	<input type="checkbox"/>	<input type="checkbox"/>
Tariff switching		S11	Zero 0.000 kvar	170 Cycles	<input type="checkbox"/>	<input type="checkbox"/>
Tariff	1	S12	Zero 0.000 kvar	170 Cycles	<input type="checkbox"/>	<input type="checkbox"/>

Configuration and remote indication of the measuring values via RS232 interface with EMR 1100.

Intelligent Control for Increased Equipment Life

- Cyclic switching for capacitor stages of the same rating.
- Accurate switching of capacitor stages prevents unnecessary switchings for responsive control.
- Continuous optimisation of switching delay according to required reactive current.



Features

- Potential-free alarm contact.
- Programmable overcurrent alarm threshold limit (from 1.05 to $3.0 \times I_{rms}$).
- Continuous monitoring for defective capacitor stages through self adjustment of control program.
- Zero voltage and zero current tripping with alarm signal.
- Patented "kinked" control curve characteristics avoid overcompensation under light load.
- Four-quadrant power control with LED display when active power is generated into mains.
- Manual/automatic operation with ability to switch each individual capacitor stage ON or OFF.
- Target power factor setting adjustable from 0.80 inductive to 0.90 capacitive in steps of 0.01.
- Preset up to three fixed capacitor stages which will be excluded from normal automatic operation.
- Independent setting of capacitor switching time to match discharge time of capacitor stages.
- Suitable for current transformers with rated secondary current of 1 A or 5 A.

Alarm Signals for

- Undercompensation
- High harmonic levels
- Overcurrent
- Switching counters
- Fault in voltage circuit (U = 0 alarm)
- Fault in current circuit (I = 0 alarm)
- Fault in capacitor stages (C = 0 alarm)

Power Factor Control Relays

Type RM 2106 / RM 2112



Description

Microprocessor-based control relay for intelligent control of capacitor banks with 6 or 12 control contacts.

Simple Commissioning

By automatic identification of threshold current (c/k value), phase angle, connected capacitor stages and switching sequences.

Operator Overview

Through clear digital display of key momentary values and operating parameters.

- Power factor ($\cos \varphi$)
- Total harmonic voltage distortion factor (% THVD)
- Number of active capacitor steps

Extensive Analysis Record

When in automatic mode, display of:

- Connection faults
- Capacity step faults
- Recognized step sequence

Protection for Capacitors

The optional RMS current monitoring function provides excellent protection for capacitor banks without harmonic filters, especially when resonance causes an increase in harmonic levels. The threshold can be set between 1.05 to $1.95 \times I_{rms}$.

Intelligent Control for Increased Equipment Life

- Cyclic switching for capacitor stages of the same rating.
- Accurate switching of capacitor stages prevents unnecessary switchings for responsive control.
- Continuous optimisation of switching delay according to required reactive current.

Features

- Potential-free alarm contact.
- Programmable overcurrent alarm threshold limit.
- Continuous monitoring for defective capacitor stages through self adjustment of control program.
- Zero voltage and zero current tripping with alarm signal.
- Two control curves characteristics:
 - to avoid overcompensation under light load.
 - to avoid inductive reactive power under regeneration conditions.
- Four-quadrant power control with LED display when active power is generated into mains.
- Manual/automatic operation with ability to switch each individual capacitor stage ON or OFF.
- Target power factor setting adjustable from 0.85 inductive to 1.00 capacitive.
- Independent setting of capacitor switching time to match discharge time of capacitor stages.
- Suitable for current transformers with rated secondary current of 1 A or 5 A.
- Protection class terminals IP 20, housing IP 54 (when sealing ring is used).

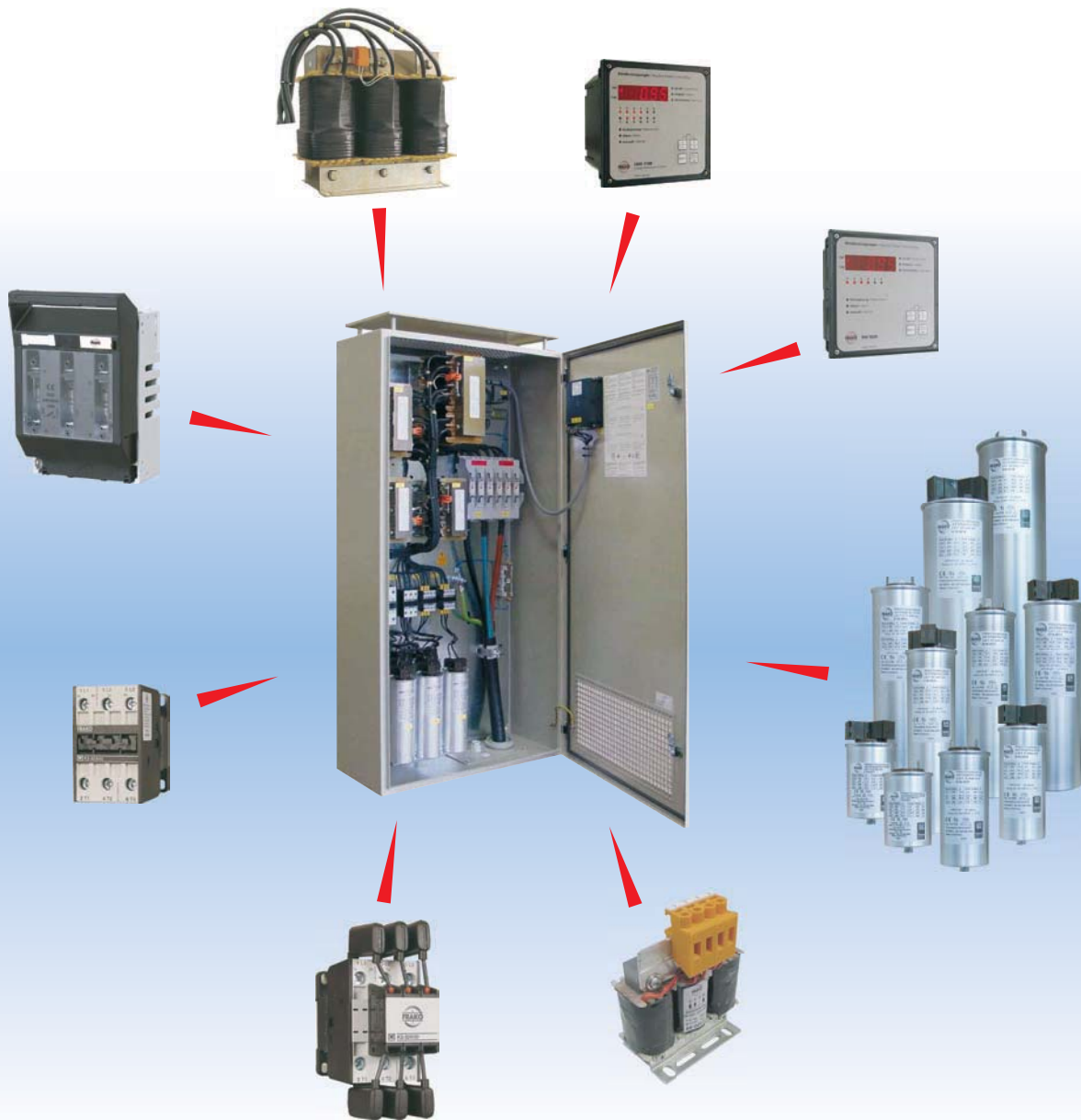


Alarm Signals for

- Overcurrent
- Fault in voltage circuit (U = 0 alarm)
- Fault in capacitor stages

Article-No.	Power Factor Control Relay	Type
38-00320	With 6 control contacts	RM 2106
38-00340	With 12 control contacts	RM 2112
38-00103	With 6 control contacts	RM 9606
38-00301	With 12 control contacts	EMR 1100 S
20-50008	With 12 control contacts and bus interface to FRAKO Energy-Management-System	EMR 1100
20-50013	Software-Upgrade EMR 1100 S to full version EMR 1100	EMR-Upgrade
20-10312	EMR-Software for EMR 1100 for configuraton and online-view	EMR-Software
20-50014	Protection kit for protection class IP 54	

Modular Construction System MCS System



// These components fit together

- Design your own high quality Power Factor Correction System
- Type-tested components
- High operational reliability of Power Factor Correction Systems
- Gain from 80 years experience in Power Factor Correction technologies

Modular Construction System

MCS System



Description

The **FRAKO** MCS System is a modular system, with which a skilled switchgear manufacturer can design a technically high-quality power factor correction system. However, knowing our “manual of power factor correction” is absolutely important to design such a power factor correction system. In this manual one will find all the necessary planning information as well as all the important technical data. You can download the manual free of charge from our website or order it free of charge from your local **FRAKO** partner.

The **FRAKO** MCS System consists of selected and tested components for the design of power factor correction systems. **FRAKO** uses these components in its own production of power factor correction systems in Teningen. This way the skilled switchgear manufacturer can gain from an experience and application know-how of almost 80 years.

The FRAKO MCS System contains the following components:

- Power factor control relay
- Control terminal strip for power factor control relay and Power Factor Correction Systems
- Control wires
- Busbar holders
- NH-fuse base and NH-isolating switch
- NH-fuse links
- Contactors
- Discharge reactors
- Harmonic filter reactors
- Power factor correction capacitors
- Thyristor switches (see page 52)

Page 37 Specimen order 1 shows the combination of all **FRAKO** components for a power factor correction system with no harmonic filter reactors with a total power of 350 kvar at 400 V, 50 Hz and a step rating of 25 kvar at a switching sequence of the capacitor steps of: 1:1:2:2:2:2:2:2.

Page 38 Specimen order 2 shows the combination of all **FRAKO** components for a choked power factor correction system with a total power of 375 kvar at 400 V, 50 Hz, a series resonance frequency of 189 Hz ($p = 7\%$) and a step rating of 25 kvar at a switching sequence of the capacitor steps of: 1:2:2:2:2:2:2:2.

Technical Data

Power Factor Control Relays and accessories

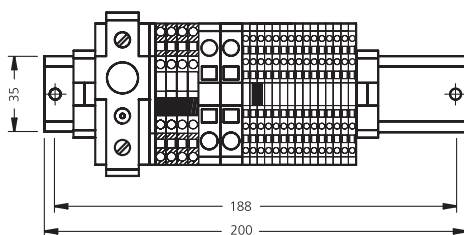
For technical details on our power factor control relays we would like to refer you to our catalogue (page 29 to 32).

For the relays, **FRAKO** recommend to use the suitable control terminal strips, the thermal trip contact for the monitoring of the cabinet temperature as well as the pre-

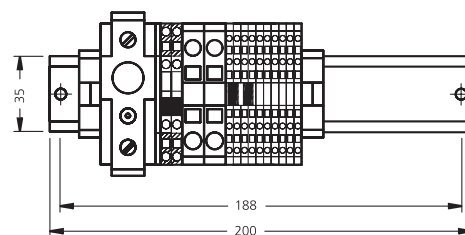
pared control cables. All items can be ordered as single components or as a complete control relay package.

The following chart shows the different types of relays as well as the suitable accessories for the assembly and the connection of the devices.

Article number:	Description:	Order Code:
Power factor control relay		
38-00320	with 6 control contacts	RM 2106
38-00103	with 6 control contacts	RM 9606
38-00340	with 12 control contacts	RM 2112
38-00301	with 12 control contacts	EMR 1100 S
20-50008	with 12 control contacts and bus interface to FRAKO Energy-Management-System	EMR 1100
20-50013	Software-Upgrade EMR 1100 S to full version EMR 1100	
Control terminal strip with thermal trip contact, pre-mounted		
34-80002	suitable for RM 9606	RKL-RM 9606
34-80003	suitable for EMR 1100 / EMR 1100 S	RKL-EMR 1100
34-80027	for extension units (only 12 control contacts)	RKL-Z-cabinet
Control cable, prepared		
89-20557	for connection of RM 9606 with control terminal strip (length: 1000 mm, 6 control contacts)	RK RM 9606-1150
89-20558	for connection of RM 9606 with control terminal strip (length: 1500 mm, 6 control contacts)	RK RM 9606-1500
89-20555	for connection of EMR 1100 / EMR 1100 S with control terminal strip (length: 1150 mm, 12 control contacts)	RK EMR 1100-1150
89-20556	for connection of EMR 1100 / EMR 1100 S with control terminal strip (length: 1500 mm, 12 control contacts)	RK EMR 1100-1500
89-20559	for connection of the "basic unit" with the "extension unit" (length: 6 m, 12 control contacts)	SS 12-6000
Reactive power factor control relay package		
Completely assembled and tested units comprising: Power factor control relay with control terminal strip, thermal trip contact and relay cable, length: 1150 mm		
34-72016	RM 9606, control terminal strip with thermal trip contact, cable length: 1150 mm	STR-RM 9606
34-72024	EMR 1100 S, control terminal strip with thermal trip contact, cable length: 1150 mm	STR-EMR 1100 S
34-72002	EMR 1100, control terminal strip with thermal trip contact, cable length: 1150 mm	STR-EMR 1100



RKL-EMR 1100



RKL-RM 9606

Modular Construction System MCS System



Technical Data

Copper busbar holders, NH-fuses

For the design of power factor correction systems **FRAKO** recommend to use the below-mentioned devices and fuses.

The busbar holders have a centre to centre distance of 60 mm to the single copper busbars. The copper busbars have either dimensions of 30 × 5 mm or 30 × 10 mm, depending on the total power of the power factor correction system.

Article-No.	Description
90-00046	Busbar holder with a bar centre to centre distance of 60 mm, Cu 30x10mm

90-00046



NH-isolating switch size 00. Applicable up to a mains rated voltage of 690 VAC. Available as NH-bus-mounting isolating switches for direct mounting on a busbar system with 60 mm bar centre to centre distance, or for mounting on mounting plates.

Article-No.	Description
90-00167	NH-isolating switch for plate mounting size 00, 160 A, 690 VAC
34-80282	NH-isolating switch for plate mounting size 00, 160 A, 690 VAC
90-00166	NH-bus-mounting isolating switch size 00, 160 A, 690 VAC
34-80281	NH-bus-mounting isolating switch size 00, 160A, 690 VAC



34-80281



34-80282



90-00166



90-00167

To assemble reasonably priced power factor correction systems, NH-fuse holders size 00 up to a mains rated

voltage of 690 VAC, can be used. These NH-fuse holders are also available as bus-mounting fuse holders for direct mounting on a busbar system with a bar centre to centre distance of 60 mm, or for mounting on mounting plates.

Article-No.	Description
90-00043	NH-bus-mounting fuse base size 00, 160 A, 690 VAC
34-80280	NH-bus-mounting fuse base size 00, 160 A, 690 VAC
90-00162	NH-fuse base for plate mounting size 00, 160 A, 690 VAC
34-80283	NH-fuse base for plate mounting size 00, 160 A, 690 VAC
90-00142	Cover for NH-fuses with nonisolated grip lugs



34-80283



34-80280



90-00162



90-00043

When operating the above mentioned devices, please note that special attention has to be paid to the corresponding safety regulations, especially the regulations concerning accident prevention!

Article-No.	Description
90-00061	D0-fuse NEOZED 2A, E14
90-00041	D0-fuse NEOZED 4A, E14
90-00092	D0-fuse NEOZED 6A, E14
90-00229	Fuse link with nonisolated metal grip lugs 25A, 500 VAC
90-00062	Fuse link with isolated metal grip lugs 25A, 500 VAC
90-00131	Fuse link with nonisolated metal grip lugs 35A, 500 VAC
90-00056	Fuse link with isolated metal grip lugs 35A, 500 VAC
90-00130	Fuse link with nonisolated metal grip lugs 50A, 500 VAC
90-00055	Fuse link with isolated metal grip lugs 50A, 500 VAC
90-00125	Fuse link with nonisolated metal grip lugs 63A, 500 VAC
90-00054	Fuse link with isolated metal grip lugs 63A, 500 VAC
90-00124	Fuse link with nonisolated metal grip lugs 80A, 500 VAC
90-00053	Fuse link with isolated metal grip lugs 80A, 500 VAC
90-00126	Fuse link with nonisolated metal grip lugs 100A, 500 VAC
90-00052	Fuse link with isolated metal grip lugs 100A, 500 VAC
90-00051	Fuse link with isolated metal grip lugs 125A, 500 VAC
90-00050	Fuse link with isolated metal grip lugs 160A, 500 VAC
90-00230	Fuse link with isolated metal grip lugs 35A, 690 VAC
90-00132	Fuse link with isolated metal grip lugs 40A, 690 VAC
90-00111	Fuse link with isolated metal grip lugs 50A, 690 VAC
90-00133	Fuse link with isolated metal grip lugs 63A, 690 VAC

Modular Construction System

MCS System



Description

FRAKO MCS System, Specimen order 1

Example: assembly of an unchoked power factor correction system with the following specification:

Total power: 350 kvar, 400 V, 50 Hz
 Step rating: 2 × 25 kvar and 6 × 50 kvar

12-step power factor control relay with switching times less than 5 seconds.

1. Step:

The system has 8 switching stages and requires a 12-step power factor control relay. Please select a reactive power control relay package with relay EMR 1100 S, consisting of the relay, temperature switch for the monitoring of the cabinet temperature, terminal strip with control system fuse and connecting cables.

2. Step:

The system requires 2 contactors for 25 kvar, 400 V, 50 Hz and 6 contactors for 50 kvar, 400 V, 50 Hz. Please select contactors with series resistors:

25 kvar steps: contactors type K3-32K00
 Article-No.: 89-00278
 50 kvar steps: contactors type K3-62K00
 Article-No.: 89-00276

3. Step:

Choose the power factor correction capacitors: Please select standard power factor correction capacitors with a rated voltage of 400 V for a mains rated voltage of 400 V. For the 25 kvar step rating, depending on the construction and the available space, one can choose between 2 pcs. of LKT 12.5-400-DP, or 1 pc. of LKT 25.0-400-DP. For the 50 kvar step one can choose between 4 pcs. of LKT 12.5-400-DP or 2 pcs. of LKT 25.0-400-DP.

For the complete system one requires either 28 pcs. of capacitor LKT 12.5-400-DP or 14 pcs. LKT 25.0-400-DP.

4. Step:

The short switching times given, require a discharge of the capacitors by means of discharge reactors. For 25 and 50 kvar the same discharge reactor can be selected. The 8 capacitor steps require 8 discharge reactors.

5. Step:

One 25 kvar step has a rated current of 36.1 A at 400 V, 50 Hz. This requires a protection with a 63 A, gl fuse. One 50 kvar step has a rated current of 72.2 A at 400 V, 50 Hz. This requires a protection with a 100 A, gl fuse. For this system we would need altogether 6 pcs NH-fuses 63 A, 500 V, gl (Article-No. 90-00054) and 18 pcs NH-fuses 100 A, 500 V, gl (Article-No. 90-00052). **FRAKO** recommend to use NH-fuses with isolated grip lugs.

6. Step:

For the fuse links, NH-bus-mounting isolating switches size 00 (article-no. 90-00166) should be selected. For the 8 steps, 8 pcs. of bus-mounting isolating switches will be needed.

7. Step:

For the assembly of the busbar system **FRAKO** recommend a maximum space of 250 mm for the busbar holders. So 8 pieces of busbar holders are needed (article-no. 90-00046) for the busbar system.

Due to the total rated current of the system of 505 A, copper busbars with 30 × 10 mm are required.

8. Step:

ordering chart:

Qty	Article-No.	Description:
1	34-72024	complete power factor control relay package EMR 1100S
2	89-00278	contactor K3-32K00
6	89-00276	contactor K3-62K00
28	31-10502	capacitor LKT 12.5-400-DP
8	88-02013	discharge reactor
6	90-00054	NH-fuse size 00, 63 A, 500 V, gl
18	90-00052	NH-fuse size 00, 100 A, 500 V, gl
8	90-00166	NH-bus-mounting isolating switch size: 00, 160 A
8	90-00046	busbar holder, 60 mm, 30x10 mm

Modular Construction System

MCS System



Description

FRAKO MCS System, Specimen order 2

Example: assembly of a power factor correction system with the following specification:

Total power: 375kvar, 400V, 50Hz, series resonance frequency of 189Hz (7%)

Step rating: 1 × 25kvar and 7 × 50kvar

Power factor control relay with 12 control contacts.

1. Step:

The system has 8 switching stages and requires a 12-step power factor control relay. We select a complete power factor control relay package with a relay EMR 1100 S, consisting of the relay, temperature switch for the monitoring of the cabinet temperature, clamp with control fuse and connecting cables.

2. Step:

The system requires one contactor for 25kvar, 400V, 50 Hz and 7 contactors for 50 kvar, 400V, 50Hz. Please select contactors without series resistors.

25kvar step: contactor type K3-32A00,
Article-No.: 89-00290

50kvar steps: contactors type K3-62A00,
Article-No.: 89-00292

3. Step:

Choose the power factor correction capacitors: Please select standard power factor correction capacitors with a rated voltage of 440V or premium capacitors with a rated voltage of 400V for a mains rated voltage of 400V. For the 25 kvar step rating we need 2 pcs. of LKT 11.7-400-DL. For the 50 kvar step we need 4 pcs. of LKT 11.7-400-DL.

4. Step:

The 25 kvar step requires one 25kvar reactor ¹⁾ and the 7 × 50 kvar steps require 7 × 50kvar reactors ²⁾.

5. Step:

One 25 kvar step has a rated current of 36.1 A at 400 V, 50 Hz. This requires a protection with a 63 A, gl fuse. One 50 kvar step has a rated current of 72.2 A at 400 V, 50 Hz. This requires a protection with a 100 A, gl fuse. For this system we would need altogether 3 pcs NH-fuses 63 A, 500 V, gl (Article-No. 90-00054) and 21 pcs NH-fuses 100 A, 500 V, gl (Article-No. 90-00052). **FRAKO** recommends to use NH-fuses with isolated grip lugs.

6. Step:

For the fuse links, NH-bus-mounting isolating switches size 00 Article-No. 90-00166 should be selected. For the 8 steps, 8 pcs. NH-bus-mounting isolating switches would be needed.

7. Step:

For the assembly of a busbar system **FRAKO** recommend a maximum space of 250 mm for the busbar holders. So 8 pieces of busbar holders are needed (Article-No. 90-00046) for the busbar system.

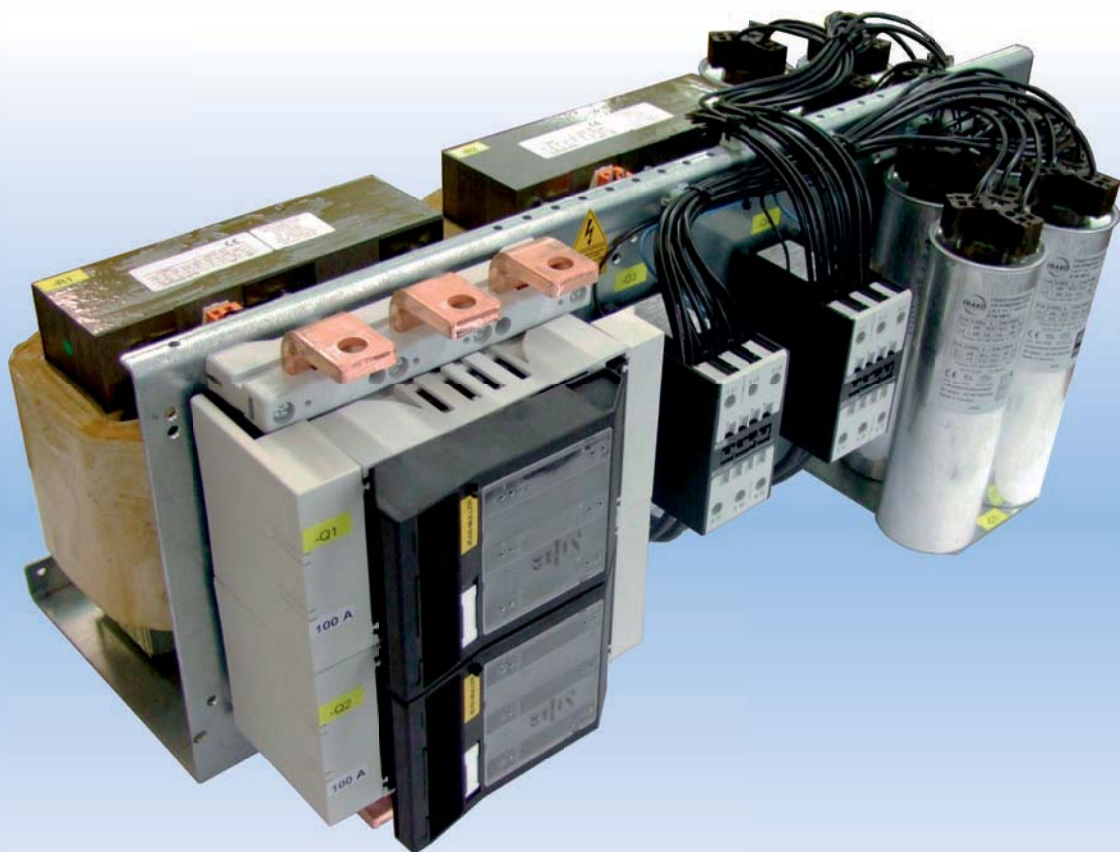
8. Step:

ordering chart:

Qty	Article-No.	Description:
1	34-72024	power factor control relay package EMR 1100S
1	89-00290	contactor K3-32A00
7	89-00292	contactor K3-62A00
30	31-10604	capacitor LKT 11.7-400-DL
1 ¹⁾	88-01768	FDR 25-400-P7
7 ²⁾	88-01769	FDR 50-400-P7
3	90-00054	NH-fuse size 00, 63 A, 500 V, gl
21	90-00052	NH-fuse size 00, 100 A, 500 V, gl
8	90-00166	NH-bus-mounting-isolating switch size 00, 160 A
8	90-00046	busbar holder, 60 mm, 30x10 mm

Modules for Power Factor Correction Systems

Type C...C / C...D / C...D-E



/ The universal solution for all switchgear systems

- Power Factor Correction Systems without reactors
- Power Factor Correction Systems with reactors
- Power Factor Correction Systems with reactors and thyristor switches
- Compact design for mounting in all common low voltage switchgear systems

Modules for Power Factor Correction Systems

Type C



Decisive Advantages

- Compact compensation module
 - Ideal for mounting in all common switchgear systems
- High performance in the smallest possible space
 - Up to 100 kvar for each module, with or without reactors
- Up to 5 modules per cabinet
 - Supplying 500 kvar even with 7 % reactors
- Easy to service with a common bus bar
 - Upright bus bar and NH fuse elements. No special cable required between the individual modules for systems with two or more units

Design

Mounted and fully-wired galvanized sheet steel chassis consisting of:

- Self-healing power capacitors with a low-loss polypropylene foil dielectric and PCB-free filler, type LKT with discharge resistors acc. to DIN VDE 0560 parts 46 and 47, EN 60831-1 and 2 as well as IEC 831-1 and -2.
- Capacitor contactors with leading resistor contacts attenuate current peaks
- Common mounting rail with locking elements
- Fuse elements, 3-pin, NH00
- Low-loss filter reactors with temperature switches for the following series resonance frequencies:

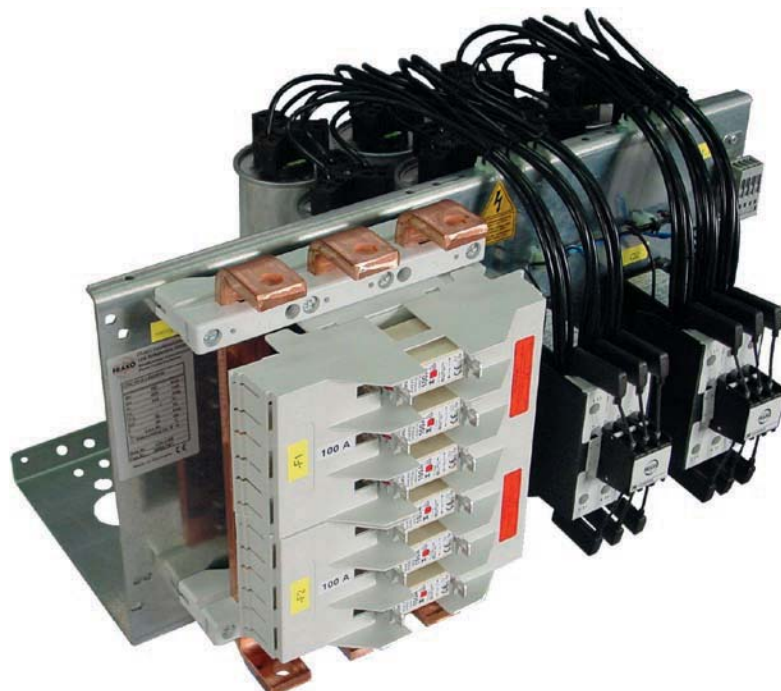
Version	Series resonance frequency	Detuning factor	For mains with utility audiofrequency ¹⁾
-P1	134 Hz	$p = 14 \%$	$\geq 166 \text{ Hz}$
-P7	189 Hz	$p = 7 \%$	$\geq 228 \text{ Hz}$

¹⁾ Please observe any deviation from utility company requirements.

In addition, also note version specifications given in our Manual of Power Factor Correction.

Quick Mounting with Multifunctional Rails

When designing this series, special attention was given to the simplest way of installing modules in all commonly used switchgear systems. The mounting rails used (shown in grey in the dimensional sketch) can be supplied as an optional accessory. These replace the time-consuming work of installation and drilling. Only the control unit cutout and ventilation holes are required. Once the rails are mounted, the modules are simply inserted and firmly attached by two screws – it couldn't be simpler!



Modules for Power Factor Correction Systems

Type C



Connection

The cable is connected directly to the busbar. A connecting bracket CU-AW 1 can be supplied as an accessory for vertical connection.

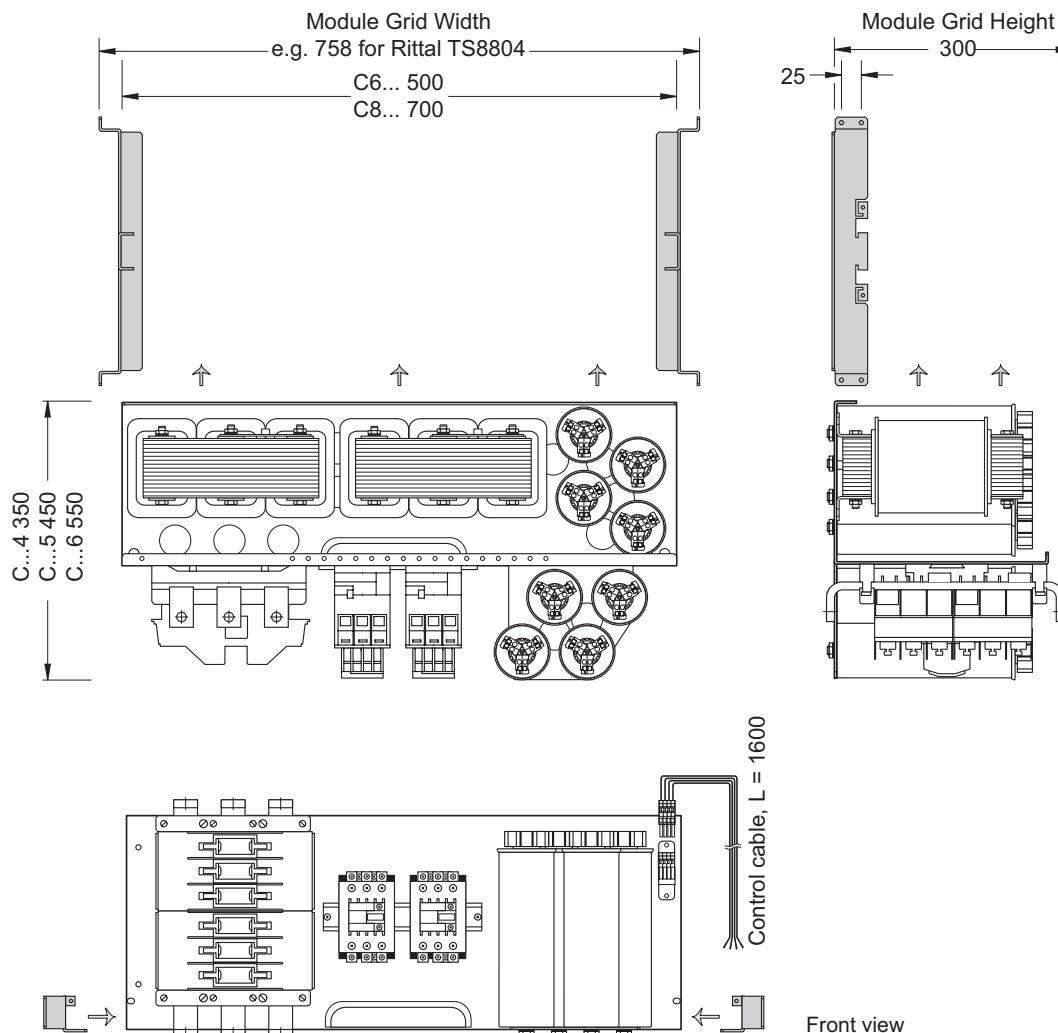
Ideal for all common switchgear systems, e.g.

MT-C8-...	Cabinet type
ABB	MNS
ELEK	Unistar
Hensel	SAS 2008
Moeller	Modan, IVS, ID, GU
Mona	Mona 5000
Rittal	TS, ES, PS
Siemens	SIKUS, Sivacon, 8MF, 8PU
Striebel & John	XA

Accessories / Options

- Complete power factor control relay package **STR-RM 9606, STR-EMR 1100 S or STR-EMR 1100**
- Control cables from the control terminal strip to the module are included with delivery together with pin connections
- Mounting plate **SB-C8**
- Module rails **MT-C8-...-cabinet depth** (see table)
- Bus connection bracket set **CU AW-1**
- Fan package **LP-LSFC**
- NH isolating switch instead of NH fuse elements for group protection type designation: **-SLT**

Dimensional sketch



Modules for Power Factor Correction Systems

Type C...C



Technical Data

Design	Sheet steel chassis with premounted capacitors, fuses and contactors	Discharge	With discharge resistors acc. to VDE 0560, part 46
Rated voltage	Min. 440 V/50 Hz (capacitors)	Power loss	Capacitors: 0.5 W/kvar
Rated power	See table (at 400 V mains voltage)	Standards	Acc. to VDE 0560 Parts 46 and 47, EN 60831-1 and -2 together with IEC 831-1 and -2, VDE 0660 part 500 and EN 60439-1 with type test TSK
Ingress protection	IP 00 acc. to DIN 40 050, for control cabinet mounting	Rated capacity determination	See FRAKO Manual of Power Factor Correction
Ambient temperature	-5° to +60°C acc. to DIN VDE 0660 part 500 Sect. 6.1.1.1 (when assembled)		
Air humidity	Max. 90 %, no condensation		

Minimum rated voltage of capacitors 440 V / 50 Hz · **Rated power at 400 V/50 Hz mains voltage** · other voltages on request

Article-No.	Rated Power in kvar at 400 V	Step Power in kvar at 400 V	Switching sequence	Type and order code
Capacitor Module, type: C64C				
34-64167	25.00	3.13	1:1:2:4	C64C 25-3.13-211-400/440-64
34-64163	25.00	6.25	1:1:2	C64C 25-6.25-21-400/440-64
34-64164	25.00	12.50	1:1	C64C 25-12.5-2-400/440-64
34-64165	25.00	25.00	-	C64C 25-25-1-400/440-64
34-64170	31.25	6.25	1:2:2	C64C 31.25-6.25-12-400/440-64
34-64180	34.38	3.13	1:2:4...	C64C 34.38-3.13-112-400/440-64
34-64172	37.50	6.25	1:1:2...	C64C 37.5-6.25-22-400/440-64
34-64173	37.50	12.50	1:2	C64C 37.5-12.5-11-400/440-64
34-64177	43.75	6.25	1:2:4	C64C 43.75-6.25-111-400/440-64
34-64181	46.88	3.13	1:2:4:8	C64C 46.88-3.13-1111-400/440-64
34-64288	50.00	3.13	1:1:2:4:8	C64C 50-3.13-2111-400/440-64
34-64182	50.00	6.25	1:1:2:4	C64C 50-6.25-211-400/440-64
34-64185	50.00	12.50	1:1:2	C64C 50-12.5-21-400/440-64
34-64186	50.00	25.00	1:1	C64C 50-25-2-400/440-64
34-64187	50.00	50.00	-	C64C 50-50-1-400/440-64
34-64193	62.50	12.50	1:2:2	C64C 62.5-12.5-12-400/440-64
34-64194	68.75	6.25	1:2:4...	C64C 68.75-6.25-112-400/440-64
34-64845	75.00	12.50	1:2:3	C64C 75-12.5-11A-400/440-64
34-64200	75.00	25.00	1:2	C64C 75-25-11-400/440-64
34-64203	87.50	12.50	1:2:4	C64C 87.5-12.5-111-400/440-64
34-64205	93.75	6.25	1:2:4:8	C64C 93.75-6.25-1111-400/440-64
34-64206	100.00	12.50	1:1:2:4	C64C 100-12.5-211-400/440-64
34-64208	100.00	25.00	1:1:2	C64C 100-25-21-400/440-64
34-64188	100.00	50.00	1:1	C64C 100-50-2-400/440-64

Dimensions C64D: WxHxD 500x300x350 mm (for cabinets with a min. W / D: 600 x 400 mm)

Modules for Power Factor Correction Systems

Type C...C



Article-No.	Rated Power in kvar at 400V	Step Power in kvar at 400V	Switching Sequence	Type and order code
Capacitor-Reactor-Module, type: C84C				
34-64289	25.00	3.13	1:1:2:4	C84C 25-3.13-211-400/440-84
34-64290	25.00	6.25	1:1:2	C84C 25-6.25-21-400/440-84
34-64213	25.00	12.50	1:1	C84C 25-12.5-2-400/440-84
34-64214	25.00	25.00	-	C84C 25-25-1-400/440-84
34-64291	31.25	6.25	1:2:2	C84C 31.25-6.25-12-400/440-84
34-64292	34.38	3.13	1:2:4...	C84C 34.38-3.13-112-400/440-84
34-64293	37.50	6.25	1:1:2...	C84C 37.5-6.25-22-400/440-84
34-64215	37.50	12.50	1:2	C84C 37.5-12.5-11-400/440-84
34-64294	43.75	6.25	1:2:4	C84C 43.75-6.25-111-400/440-84
34-64295	46.88	3.13	1:2:4:8	C84C 46.88-3.13-1111-400/440-84
34-64296	50.00	3.13	1:1:2:4:8	C84C 50-3.13-2111-400/440-84
34-64297	50.00	6.25	1:1:2:4	C84C 50-6.25-211-400/440-84
34-64217	50.00	12.50	1:1:2	C84C 50-12.5-21-400/440-84
34-64218	50.00	25.00	1:1	C84C 50-25-2-400/440-84
34-64219	50.00	50.00	-	C84C 50-50-1-400/440-84
34-64222	62.50	12.50	1:2:2	C84C 62.5-12.5-12-400/440-84
34-64298	68.75	6.25	1:2:4...	C84C 68.75-6.25-112-400/440-84
34-64846	75.00	12.50	1:2:3	C84C 75-12.5-11A-400/440-84
34-64224	75.00	25.00	1:2	C84C 75-25-11-400/440-84
34-64227	87.50	12.50	1:2:4	C84C 87.5-12.5-111-400/440-84
34-64229	93.75	6.25	1:2:4:8	C84C 93.75-6.25-1111-400/440-84
34-64126	100.00	12.50	1:1:2:4	C84C 100-12.5-211-400/440-84
34-64232	100.00	25.00	1:1:2	C84C 100-25-21-400/440-84
34-64127	100.00	50.00	1:1	C84C 100-50-2-400/440-84

Dimensions C84C: WxHxD 700x300x350 mm (for cabinets with a min. W / D: 800 x 400 mm)

Modules for Power Factor Correction Systems

Type C...D



Technical Data

Design	Sheet steel chassis with premounted capacitors, filter reactors, fuses and contactors	Discharge	With discharge resistors acc. to VDE 0560, Part 46
Rated voltage	Min. 440 V/50 Hz (Capacitors)	Power loss	Capacitors: 0.5 W/kvar, reactors: 3.5–6W /kvar (depending on version and harmonic distortion)
Rated power	See table (at 400V mains voltage)	Standards	Acc. to VDE 0560 parts 46 and 47, EN 60831-1 and -2 as well as IEC 831-1 and -2, VDE 0660 part 500 and EN 60439-1 with type test TSK
Ingress protection	IP 00 acc. to DIN 40 050, for cabinet mounting	Rated capacity determination	See FRAKO Manual of Power Factor Correction
Ambient temperature	–5° to +60 °C acc. to DIN VDE 0660 part 500 Sect. 6.1.1.1 (when assembled)		
Air humidity	Max. 90 %, no condensation		

Minimum rated voltage of capacitors 440V/50 Hz · **Rated power at 400 V/50 Hz mains voltage** · other voltages on request

Article-No.	Rated Power in kvar at 400 V	Step Power in kvar at 400 V	Switching Sequence	Type and order code
Capacitor-Reactor-Module, type: C64D / C65D				
P1: series resonance frequency 134Hz, p = 14%				
34-64264	25.00	6.25	1:1:2	C64D 25–6.25–21–400/480–64–P1
34-64242	25.00	12.50	1:1	C64D 25–12.5–2–400/480–64–P1
34-64243	25.00	25.00	-	C64D 25–25–1–400/480–64–P1
34-64244	50.00	50.00	-	C64D 50–50–1–400/480–64–P1
P7: series resonance frequency 189Hz, p = 7%				
34-64300	25.00	3.13	1:1:2:4	C64D 25–3.13–211–400/440–64–P7
34-64257	25.00	6.25	1:1:2	C64D 25–6.25–21–400/440–64–P7
34-64262	25.00	12.50	1:1	C64D 25–12.5–2–400/440–64–P7
34-64245	25.00	25.00	-	C64D 25–25–1–400/440–64–P7
34-64301	31.25	6.25	1:2:2	C64D 31.25–6.25–12–400/440–64–P7
34-64389	34.38	3.13	1:2:4	C64D 34.38–3.13–112–400/440–64–P7
34-64246	37.50	12.50	1:2	C64D 37.5–12.5–11–400/440–64–P7
34-64247	43.75	6.25	1:2:4	C64D 43.75–6.25–111–400/440–64–P7
34-64248	50.00	12.50	1:1:2	C64D 50–12.5–21–400/440–64–P7
34-64249	50.00	25.00	1:1	C64D 50–25–2–400/440–64–P7
34-64250	50.00	50.00	-	C64D 50–50–1–400/440–64–P7
34-64261	75.00	25.00	1:2	C65D 75–25–11–400/440–65–P7

Dimensions C64D: WxHxD 500x300x350 mm (for cabinets with a min. W / D: 600 x 400 mm)

Dimensions C65D: WxHxD 500x300x450 mm (for cabinets with a min. W / D: 600 x 500 mm)

Modules for Power Factor Correction Systems

Type C...D



Article-No.	Rated Power in kvar at 400V	Step Power in kvar at 400V	Switching Sequence	Type and order code
Capacitor-Reactor-Module, type: C84D / C85D				
P1: series resonance frequency 134Hz, p = 14%				
34-64069	25.00	6.25	1:1:2	C84D 25-6.25-21-400/480-84-P1
34-64070	25.00	12.50	1:1	C84D 25-12.5-2-400/480-84-P1
34-64039	25.00	25.00	-	C84D 25-25-1-400/480-84-P1
34-64271	31.25	6.25	1:2:2	C84D 31.25-6.25-12-400/480-84-P1
34-64374	37.50	6.25	1:1:2...	C84D 37.5-6.25-22-400/480-84-P1
34-64018	37.50	12.50	1:2	C84D 37.5-12.5-11-400/480-84-P1
34-64002	43.75	6.25	1:2:4	C84D 43.75-6.25-111-400/480-84-P1
34-64003	50.00	12.50	1:1:2	C84D 50-12.5-21-400/480-84-P1
34-64004	50.00	25.00	1:1	C84D 50-25-2-400/480-84-P1
34-64005	50.00	50.00	-	C84D 50-50-1-400/480-84-P1
34-64006	75.00	25.00	1:2	C84D 75-25-11-400/480-84-P1
34-64040	100.00	50.00	1:1	C85D 100-50-2-400/480-85-P1
P7: series resonance frequency 189Hz, p = 7 %				
34-64071	25.00	6.25	1:1:2	C84D 25-6.25-21-400/440-84-P7
34-64072	25.00	12.50	1:1	C84D 25-12.5-2-400/440-84-P7
34-64015	25.00	25.00	-	C84D 25-25-1-400/440-84-P7
34-64339	31.25	6.25	1:2:2	C84D 31.25-6.25-12-400/440-84-P7
34-64073	43.75	6.25	1:2:4	C84D 43.75-6.25-111-400/440-84-P7
34-64305	46.88	3.13	1:2:4:8	C84D 46.88-3.13-1111-400/440-84-P7
34-64007	50.00	6.25	1:1:2:4	C84D 50-6.25-211-400/440-84-P7
34-64008	50.00	12.50	1:1:2	C84D 50-12.5-21-400/440-84-P7
34-64009	50.00	25.00	1:1	C84D 50-25-2-400/440-84-P7
34-64010	50.00	50.00	-	C84D 50-50-1-400/440-84-P7
34-64041	62.50	12.50	1:2:2	C84D 62.5-12.5-12-400/440-84-P7
34-64074	68.75	6.25	1:2:4...	C84D 68.75-6.25-112-400/440-84-P7
34-64848	75.00	12.50	1:2:3	C84D 75-12.5-11A-400/440-84-P7
34-64011	75.00	25.00	1:2	C84D 75-25-11-400/440-84-P7
34-64012	87.50	12.50	1:2:4	C84D 87.5-12.5-111-400/440-84-P7
34-64648	100.00	12.50	1:1:2...	C85D 100-12.5-211-400/440-85-P7
34-64013	100.00	25.00	1:1:2	C84D 100-25-21-400/440-84-P7
34-64014	100.00	50.00	1:1	C84D 100-50-2-400/440-84-P7

Dimensions C84D: WxHxD 700x300x350 mm (for cabinets with a min. W / D: 800 x 400 mm)

Dimensions C85D: WxHxD 700x300x450 mm (for cabinets with a min. W / D: 800 x 500 mm)

Modules for Power Factor Correction Systems

Type C



Description

Application / Installation

The Power Factor Correction Module Type C is the ideal answer for designing power factor correction systems. It can be choked or unchoked and reach a capacity of up to 400 kvar per enclosure. The enclosure can be up to 2.000 mm high and 400 mm deep. When installing several modules, they should be mounted first at the bottom, working upwards. This enables additional modules to be installed at a later date without disconnecting the cable. If the feed-in is at the top of the enclosure the modules should be mounted from top to bottom. Prewired control cabling can be used for connecting the power factor control relay to the control terminal strip and the individual modules. The mounting rails of the module have folding tabs to which a vertical connecting cable can be attached. To ensure that the system can be extended at a later date, the cable and its protective device as well as any audiofrequency rejector circuit required should be designed to meet the final specifications of the system.

Example

Design of a power factor correction system with reactors in an enclosure (Rittal TS8804) with dimensions 800 × 2.000 × 400 mm (H × W × D), with a nominal capacity of 300 kvar, with 6 steps each of 50 kvar, switching sequence 1:1:2...

Components required:

- 1 complete power factor control relay package **STR-EMR 1100**, consisting of EMR 1100, RKL-EMR 1100 and RK EMR 1100-1150
- 1 mounting plate **SB-C8**
- 3 capacitor choke modules **C84D 100-50-2-400-P..**
The control cable from the control terminal strip to the modules together with pin connections are included in delivery.
- 8 mounting rails **MT-C8-Rittal TS8-400**
- 1 connecting bracket set **CU AW-1**
- 1 fan package **LP-LSFC**

Slot 5:

Space for the control unit. The mounting plate SB... has room for the control terminal strip RKL... with control transformer and thermostat if required.

Slot 4:

Space for an additional capacitor/reactor module.

Slot 3:

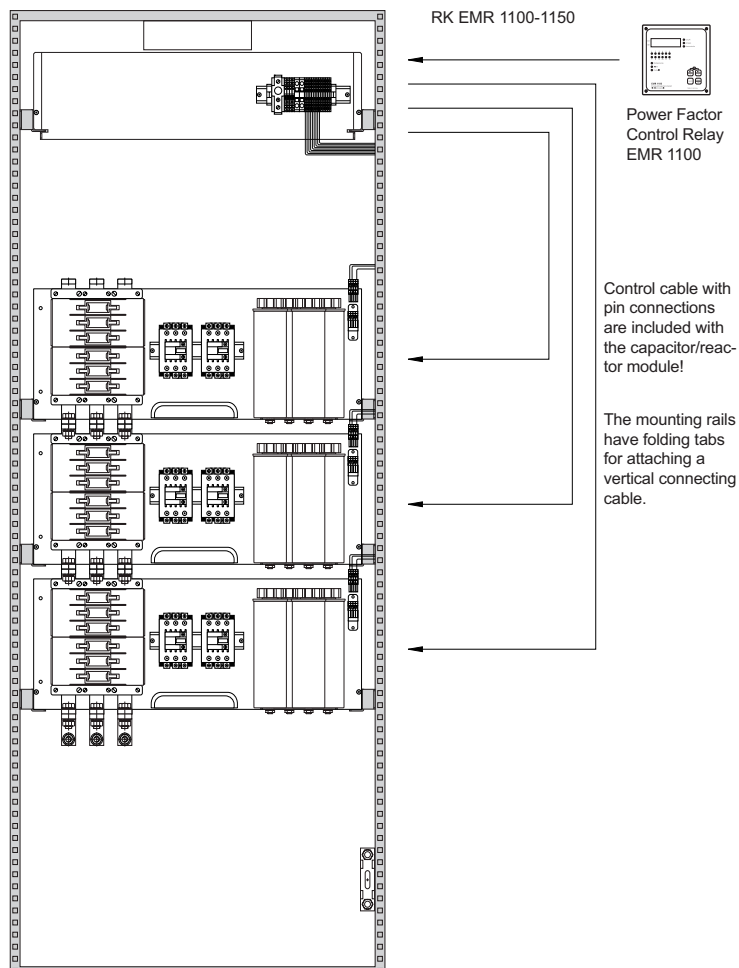
Space for the third capacitor/reactor module.

Slot 2:

Space for the second capacitor/reactor module.

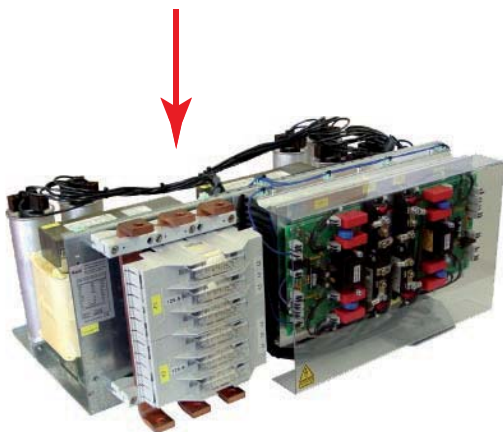
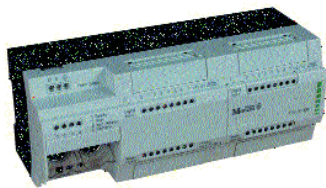
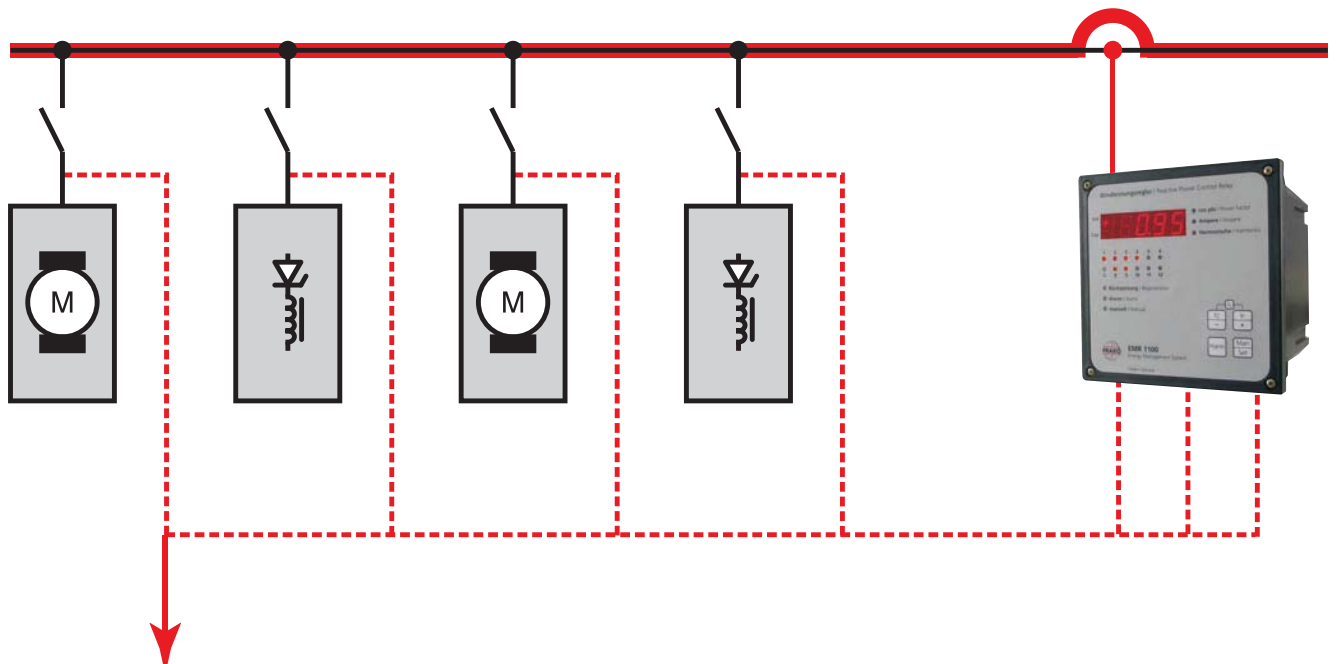
Slot 1:

Space for the first module. The busbar set CU AW-1 enables the first capacitor choke module to be connected vertically if required.



Modules for Dynamic Power Factor Correction Systems

Type C...D-E



The SBS dynamic power factor correction unit from FRAKO features:

- No delay in switching in capacitance thanks to **FRAKO's** fast-acting control system
- Fastest possible direct compensation by SBS unit with superposed power factor control loop
- No additional active power losses through discharge reactors
- Continuous rating, no auxiliary contactors in parallel
- Compact design achieved by new cooling technique
- Solid-state switches mean no limit on number of switching cycles and no wear and tear
- Patented control principle offers excellent price/performance ratio

The benefits:

- Optimum network utilization
- Improved power quality, hence best product quality
- Reduced energy costs
- Modular design, the same construction as **FRAKO C Modules**
- Predictive control with superposed feedback control

Nothing could be faster!

Typical low voltage networks are those supplying:

- Spot welding machines
- Motors with high power ratings
- Rolling mills, kneading machine drives, etc.

Typical Applications

The SBS dynamic power factor correction unit finds application in low voltage networks:

- With low short-circuit capacities where disruptions occur when large consumers are switched on
- Where a fast-acting power factor correction system and a large number of switching cycles are necessary
- Where power factor correction is required for only a few supply cycles at a time

Modules for Dynamic Power Factor Correction Systems

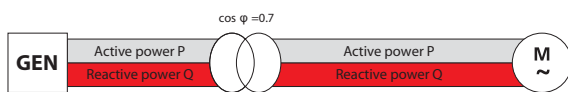
Type C...D-E



Power Factor Correction

All electrical consumers that make use of a magnetic field in order to function, such as induction motors, chokes and transformers, draw not only active current from the supply network but also reactive current. This current is necessary to create and reverse the magnetic field, and it flows back and forth between the generator (at the power station) and the load.

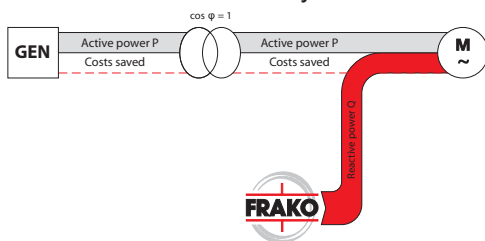
As the electrical supply network must be dimensioned to carry the total current, the goal is always to keep the reactive current as low as possible.



The reactive power flowing between the generator and the load is converted into heat in the supply lines.

This represents an additional load on generators, transformers, cabling and switchgear. Power losses and voltage drops also result. With a high proportion of reactive current, the installed conductor cross sections cannot be fully utilized for power transmission or need to be overdimensioned to cope. From the point of view of the power supply company, poor power factors increase the investment and maintenance costs for the supply network. These additional costs are charged to the consumers causing the problem, i.e. those drawing a high proportion of reactive current.

If suitably sized capacitors are installed in parallel to the loads, the reactive current flows back and forth between the capacitors and the loads. There is then no additional load on the rest of the supply network. If a power factor of 1 is achieved by means of these corrective measures, only active current is carried by the network.



The most cost-effective and easily monitored method for power factor correction is the central system. With this variant the entire capacitor bank is installed at a central location, for example the low voltage main distribution board. The required capacitance is divided into several switchable stages, which are switched in and out by special capacitor contactors controlled by an automatic reactive power control relay to suit load conditions. When motors are switched on, there is a transient reactive current peak, which can result in serious voltage dips, depending on the short-circuit capacity of the network. Modern production lines require machinery of ever-increasing power and therefore necessitate more stable low voltage networks. Typical applications include

rolling mills, in which great load fluctuations occur, and the drives for kneading machines, shredders and large presses.

The starting inrush currents can cause major upsets, particularly in production lines with spot welding machines.

The conventional approach has been to design the supply networks for installations of this type with extremely high short-circuit capacities. Increasing the transformer capacity or interconnecting several transformers at the low voltage side is not always economically viable. The most cost-effective solution is therefore to compensate for the reactive current with response times in the order of milliseconds. Conventional power factor correction systems switch in the capacitor stages by means of contactors with a service life up to a maximum of 80,000 switching cycles. A reactive power control relay switches the stages in when the capacitors are in a discharged condition. This usually results in a delay of some 60 seconds before the capacitors can be switched in again.

Even when using a reactive power control relay that measures reactive power demand within 1 or 2 supply cycles, it may not be possible to reduce the delay in correcting the inductive reactive power below 100 to 200 ms because of the required stability of the control loop. This is too slow for those applications in which voltage dips and flicker must be corrected. In order to suppress the above disruptions to the network effectively, the required corrective capacitance must be switched in within a few milliseconds. Problems of this type can be solved optimally with a **FRAKO** SBS fast-acting power factor control unit.

Act or react?

Feedback control means:

Measure – switch – measure – correct – measure – correct – and so on until the difference between the target and actual power factors is less than the correction provided by one capacitor stage. At a supply frequency of 50 Hz, each measurement takes at least one to two cycles to carry out, i.e. 20 to 40 ms. In order to avoid instability, a classical control relay always switches in only a part (40 to 60%) of the capacitor allocation computed from the first measurement. Several hundred milliseconds or as much as a second can then elapse until the corrective action is complete.

Predictive control means:

Not first measuring, but immediately switching in capacitance. The signal to switch on an inductive load is

Modules for Dynamic Power Factor Correction Systems

Type C...D-E



simultaneously an input signal to the **FRAKO** SBS, causing it to compensate directly for the reactive power demand of that load. The corrective action is effective at the latest 3 to 24 ms after the switching signal.

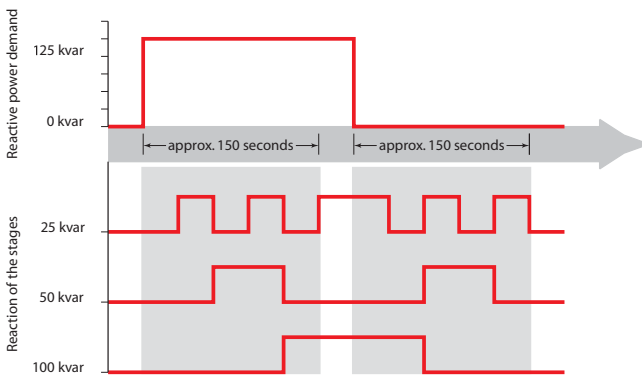
Nothing could be faster!

This is the solution for low voltage networks with fast-switching inductive loads to:

- Suppress flicker and
- Stabilize the supply voltage.

Control Methods

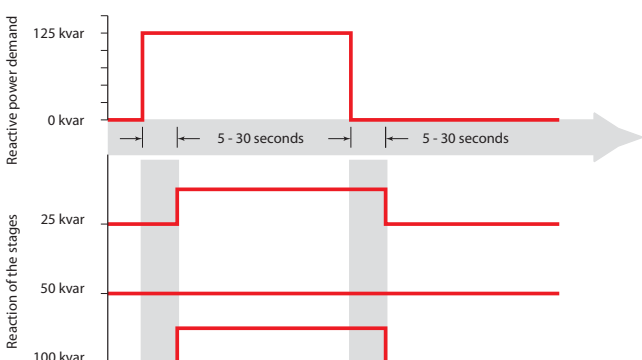
a) The classical reactive power control relay using step-by-step progressive switching



Power factor correction as our grandfathers knew it: the classical reactive power control relay using contactors to switch capacitor stages of different sizes in and out in a progressive sequence. It requires some 30 seconds per switching step until the target power factor is achieved.

The contactor serving the smallest capacitor stage has the shortest working life due to its frequent switching.

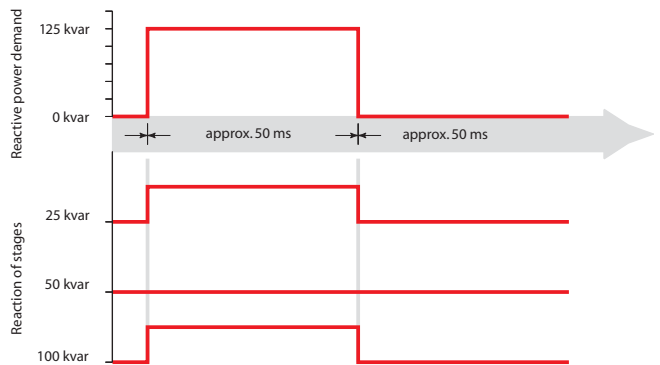
b) **FRAKO** RM 9606 or EMR 1100 reactive power control relays



FRAKO reactive power control relays adjust the switching delay to suit the power demand. Large changes of load are compensated for quickly, minor load variations more slowly. Capacitor stages of different sizes are switched in selectively to match the power demand, the number of switching operations minimized by computation, and all equally sized capacitor stages are used in rotation. These control characteristics combine to give a uniform utilization of the capacitor contactors and the lowest possible number of switching cycles, thus reducing wear and tear in the power factor correction system.

At the same time, critical network constellations are avoided – unlike in the classical step-by-step switching process – by rapidly adjusting the capacitor allocation to match demand precisely when major load changes occur.

c) Dynamic correction with the **FRAKO** RM 2012 reactive power control relay



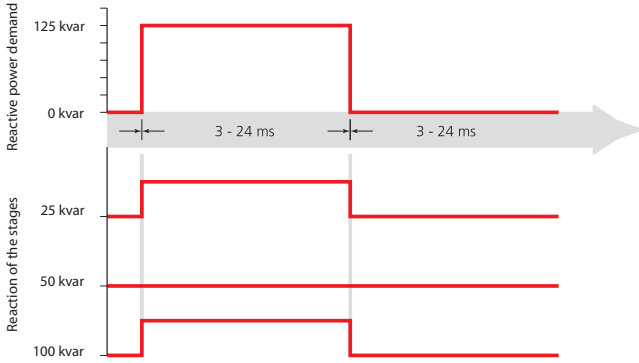
The **FRAKO** RM 2012 reactive power control relay has all the monitoring functions necessary incorporated in it, since stable control characteristics are a prime concern. As soon as the control relay detects reactive power demand, it computes the sequences requiring the least number of switching operations, verifies the selected setting in an additional measurement operation and initiates switching. This makes the control characteristics absolutely stable with no hunting. With classical power factor correction systems this process protects the contactors. With dynamic correction systems it reduces the number of switching operations in the network. It effectively suppresses network fluctuations better than switching too quickly and hence overshooting and undershooting several times. This variant represents the best solution for power factor correction in installations such as rolling mills or kneading machines, where a switching delay of 0.5 – 1.0 seconds is acceptable.

Modules for Dynamic Power Factor Correction Systems

Type C...D-E



d) Dynamic correction with the FRAKO SBS



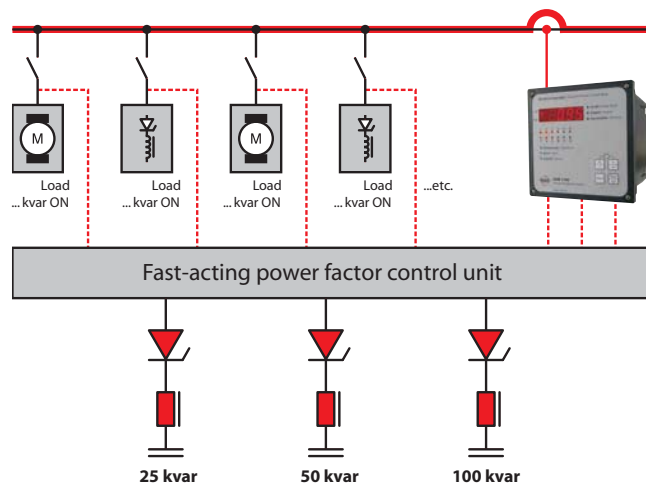
Just as quick as individual power factor correction for each load, but considerably less expensive, due to the intelligent control system, which converts the reactive power demand from all loads into the capacitor stage allocation for the power factor correction system. The fast-acting control system ensures that the required power factor correction is achieved within 3–24 ms, depending on the phase angle of the switching signal. **Just as accurate as feedback control**, since a superposed reactive power control relay compensates for the remaining reactive power demand not covered by the predictive control system.

The Ideal Formula

- The SBS dynamic power factor correction unit from **FRAKO** switches without delay at the next voltage zero at the thyristor switch and thus avoids any peak inrush current.
- Any desired frequency of switching with no contact wear and tear and no additional loss of active power. The solid-state switches function without any problems even when the capacitors are not discharged and without causing peak inrush currents.
- Power circuits are designed for a continuous rating, i.e. no parallel auxiliary contactor is needed to reduce the load on the thyristors. The switching delay of at least 50 ms when using auxiliary contactors is therefore also not necessary.

Power Factor Correction and Network Stabilization

- An innovative cooling technique makes the unit particularly compact.
- The service life of capacitor contactors is normally limited to a maximum of 80,000 switching cycles. In the case of installations with frequent switching, such as welding systems, it is necessary to cater for at least 10^8 switching cycles. The **FRAKO SBS** unit is designed for duties of this type.
- **FRAKO's** patented predictive control principle enables the reactive power to be compensated for as quickly as possible for as much switched load capacity as desired. The reactive power demand from loads of any power rating is converted without delay into the optimum allocation of capacitor stages for that load.
- The greater part of the reactive power is compensated for without delay. This eliminates major voltage dips that could result in flicker. The superposed reactive power control relay then compensates for the remaining reactive power demand. These signals are also processed by the control unit, which determines the required capacitor allocation from their sum total.
- Until now, a comparable response without delay was only possible when correcting the power factor for large reactive loads by assigning a rapidly switched-in capacitor stage to each individual load. In contrast, the SBS is a variant that cuts costs and offers the fastest possible switching response. Numerous inputs with widely differing reactive power demands are converted into the equivalent capacitor allocation for the power factor correction system.



Modules for Dynamic Power Factor Correction Systems

Type C...D-E



Technical Data

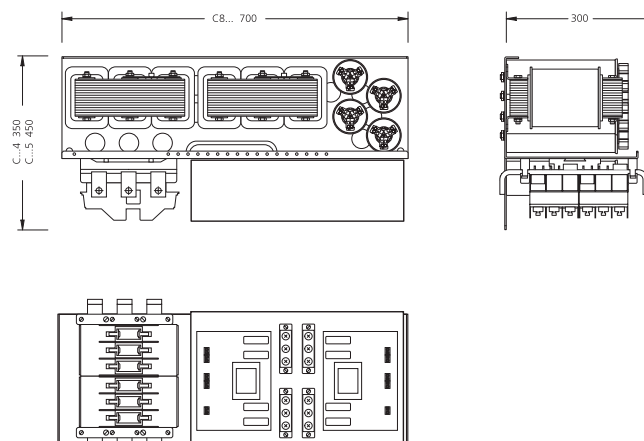
Design	Sheet steel chassis with premounted capacitors, filter reactors, fuses and contactors	Discharge	With discharge resistors acc. to VDE 0560, part 46
Rated voltage	Min. 440V/50 Hz (capacitors)	Power loss	Capacitors: 0.5 W/kvar Reactors: 3.5-6 W/kvar (depending on version and harmonic distortion)
Rated power	See table (at 400V mains voltage)	Standards	Acc. VDE 0560 parts 46 and 47, EN 60831-1 and -2 as well as IEC 831-1 and -2, VDE 0660 part 500 and EN 60439-1 with type test TSK
Protection	IP 00 acc. to DIN 40 050, for cabinet mounting	Rated capacity determination	See FRAKO Manual of Power Factor Correction
Ambient temperature	-5° to +60 °C acc. DIN VDE 0660 part 500 sect. 6.1.1.1 (when assembled)		
Air humidity	Max. 90 %, no condensation		

Minimum rated voltage of capacitors 440V/50 Hz · **Rated power at 400 V/50 Hz mains voltage** · other voltages on request

Article-No.	Rated Power in kvar at 400V	Step Power in kvar at 400V	Switching sequence	Type and order code
Capacitor-Reactor-Module, type: C84D-E / C85D-E, wear-free and fast switching, with thyristors				
P1: series resonance frequency 134Hz, p = 14%				
-	25.00	25.00	-	C84D 25-25-1-400/480-84-P1-E
-	37.50	12.50	1:2	C84D 37.5-12.5-11-400/480-84-P1-E
34-64802	50.00	25.00	1:1	C84D 50-25-2-400/480-84-P1-E
-	50.00	50.00	-	C84D 50-50-1-400/480-84-P1-E
34-64376	75.00	25.00	1:2	C85D 75-25-11-400/480-85-P1-E
34-64036	100.00	50.00	1:1	C85D 100-50-2-400/480-85-P1-E
P7: series resonance frequency 189 Hz, p = 7%				
34-64028	25.00	25.00	-	C84D 25-25-1-400/440-84-P7-E
34-64061	37.50	12.50	1:2	C84D 37.5-12.5-11-400/440-84-P7-E
34-64029	50.00	25.00	1:1	C84D 50-25-2-400/440-84-P7-E
34-64030	50.00	50.00	-	C84D 50-50-1-400/440-84-P7-E
34-64031	75.00	25.00	1:2	C85D 75-25-11-400/440-85-P7-E
34-64032	100.00	50.00	1:1	C85D 100-50-2-400/440-85-P7-E
Accessories				
34-80056	Power supply 24 VDC / 2.5 A - for thyristor switches, built on the mounting plate and wired up to the control terminal			SBS-PS 24VDC-2.5A

Dimensions C84D: WxHxD 700x300x350 mm (for cabinets with a min. W / D: 800 x 400 mm)
Dimensions C85D: WxHxD 700x300x450 mm (for cabinets with a min. W / D: 800 x 500 mm)

Dimensional Sketch



Components for Dynamic Power Factor Correction Systems

Thyristor switches type DCS



Description

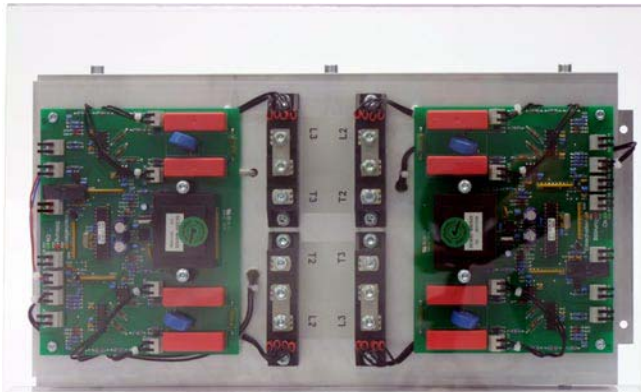
A skilled switchgear manufacturer can easily design and assemble his own Dynamic PFC System by using dynamic PFC components from **FRAKO**.

These dynamic components are also used in **FRAKO**'s own modules for Dynamic Power Factor Correction Systems (see technical data, page 51).

Article No.	Type	Dimensions (WxHxD):
34-80274	DCS 50 x 1-400/415	430x265x170mm
34-80243	DCS 50 x 2-400/415	430x265x170mm
34-80275	DCS 50 x 1-440/525	430x265x170mm
34-80276	DCS 50 x 2-440/525	430x265x170mm

Accessories:		
39-21010	Power Supply-6-thyristor switches 115/230 VAC - 24 VDC	
39-29050	with 12 control contacts, 6 with reaction time between 20/40 ms	RM 2012 6+6D
39-29051	with 12 control contacts, reaction time between 20/40 ms	RM 2012 12D

34-80243 front

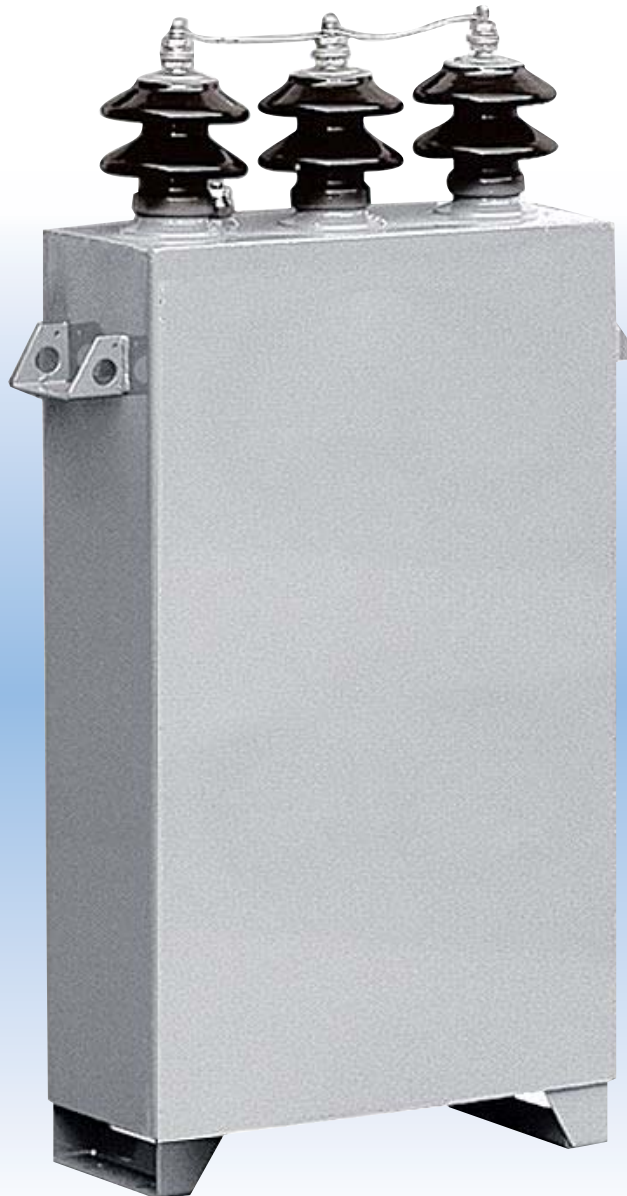


34-80243 back



Medium Voltage Capacitors

Type MSCD / MSCE



// Features that matter:

- Voltage rating from 3 to 24 kV, 50 Hz or 60 Hz
- Power rating from 50 to 700 kvar per capacitor casing
- Single- and three-phase capacitors
- For indoor or outdoor installation
- IEC 60871-1, IEC 60871-2 and IEC 60871-4 compliance

Medium Voltage Capacitors

Type MSCD/MSCE



Technology

FRAKO Medium Voltage (MV) Capacitors have been successfully manufactured for many years using all-film technology.

The dielectric material consists of high quality polypropylene film sandwiched between aluminium foil electrodes. A large number of capacitor elements are assembled to form a capacitor unit (see Fig. 1), also known as a winding pack. If desired by the customer, the elements can be provided with internal fuses. Each capacitor unit is permanently connected to a discharge resistor. The winding packs are housed in a sheet steel casing, which is filled with a high quality, environmentally sound impregnating oil.

Residual moisture and oxygen are removed from the winding pack in a drying and impregnation process taking place under vacuum at an increased temperature and lasting several days. The process is carried out very carefully by experienced personnel. This is crucial to producing a quality capacitor that is highly reliable and offers a long life expectancy.

Following this process, the capacitors are hermetically sealed by welding and are subjected to a routine test according to IEC 60871-1. They are then given a final finish with a high quality paint. The capacitors comply with the requirements of IEC 60871-1, IEC 60871-2 and IEC 60871-4. **FRAKO**'s wide range of manufacturing facilities makes it possible to produce capacitors in numerous dimensions with a variety of voltage and power ratings.

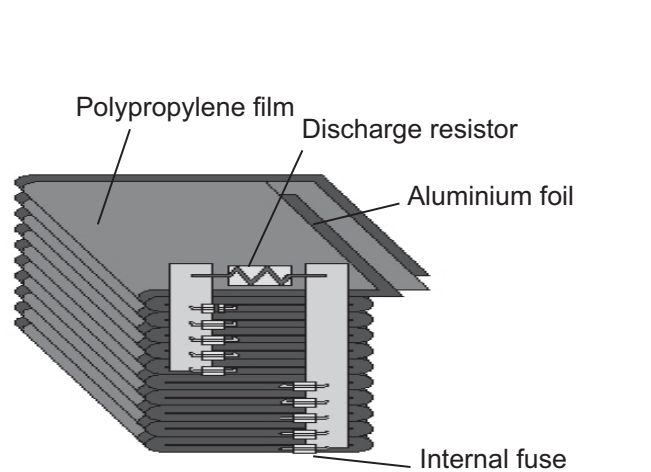


Fig. 1:
Capacitor unit

Safety

FRAKO Medium Voltage Capacitors are manufactured in two different versions: either for use with external fuses or already fitted with internal fuses.

External Fuses

Fig. 2 illustrates the internal arrangement in a capacitor. If it is overloaded, or another fault occurs, it is particularly important to prevent the capacitor casing rupturing. We therefore recommend the use of current-limiting HV HRC fuses to IEC 60549. As heavy transient currents and high voltages can occur when capacitors are switched in and out, the fuse rating should be at least twice the value of the capacitor current rating, and the voltage rating of the HV HRC fuse should be one level higher than the network nominal voltage (e.g. for a 12kV network voltage use a fuse with a 24kV voltage rating). IEC 60549 must be complied with.

Internal Fuses

Fig. 3 illustrates the internal configuration and the operating principle. Each capacitor element has its own internal fuse, which can isolate the element if it breaks down. The overloaded or damaged element is thus disconnected from the network. This means that the capacitor loses some of its capacitance, but is still able to operate safely. Switching out individual elements in this way has the consequence, however, that the voltage across the other elements generally rises. If many individual elements are disconnected, the voltage acting on the remaining elements can become too high. The capacitor must then be taken out of service and repaired. **FRAKO** internal fuses comply with the requirements of IEC 60871-4.

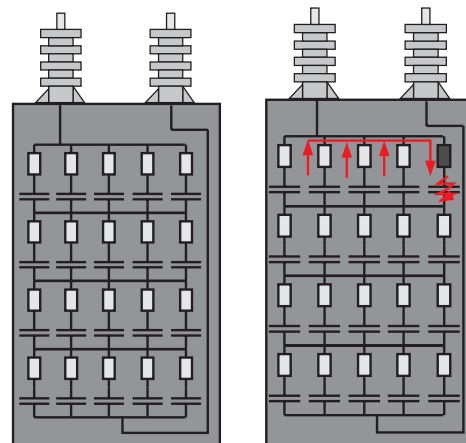


Fig. 2:
Schematic of an
MV capacitor with
internal fuses

Fig. 3:
Operating principle of
the internal fuses

Medium Voltage Capacitors

Type MSCD/MSCE



Technical Data

- Voltage ratings from 3 to 24 kV, 50 or 60 Hz
- Power rating 50 to 700 kvar per capacitor casing
- Single-phase and three-phase capacitors
- Available for indoor or outdoor installation
- Overpressure switch available on request
- Temperature class - 40°C to +50°C
- Power loss < 0.2 W/kvar
- Discharge to less than 75 V in < 10 minutes
- IEC 60871-1, IEC 60871-2 and IEC 60871-4 compliance

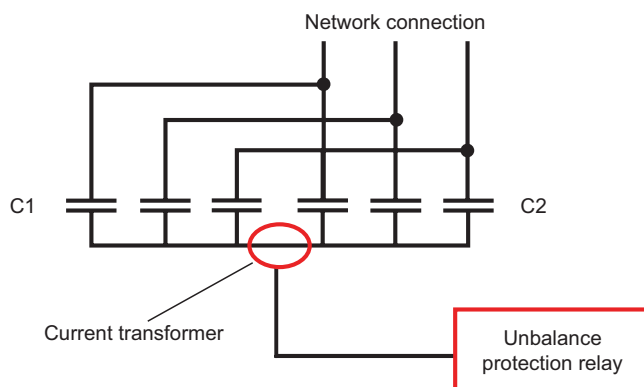
Power kvar	Voltage rating kV (at 50Hz)	H 1 mm	H 2 mm	D mm	Configuration	Type	Weight kg
200	6	580	760	160	Δ	MSCD 200-6	34
300	6	670	850	160	Δ	MSCD 300-6	46
400	6	870	1050	160	Δ	MSCD 400-6	57
500	6	810	990	175	Δ	MSCD 500-6	68
100	12	410	590	160	Δ	MSCD 100-12	22
200	12	580	760	160	Δ	MSCD 200-12	34
300	12	670	850	160	Δ	MSCD 300-12	46
400	12	870	1050	160	Δ	MSCD 400-12	57
500	12	810	990	175	Δ	MSCD 500-12	68
150	12	410	631	160	I	MSCE 150-12	31
250	12	670	891	160	I	MSCE 250-12	43
500	12	780	1001	175	I	MSCE 500-12	70

Other power and voltage ratings on request.
We reserve the right to change the technical data and dimensions.

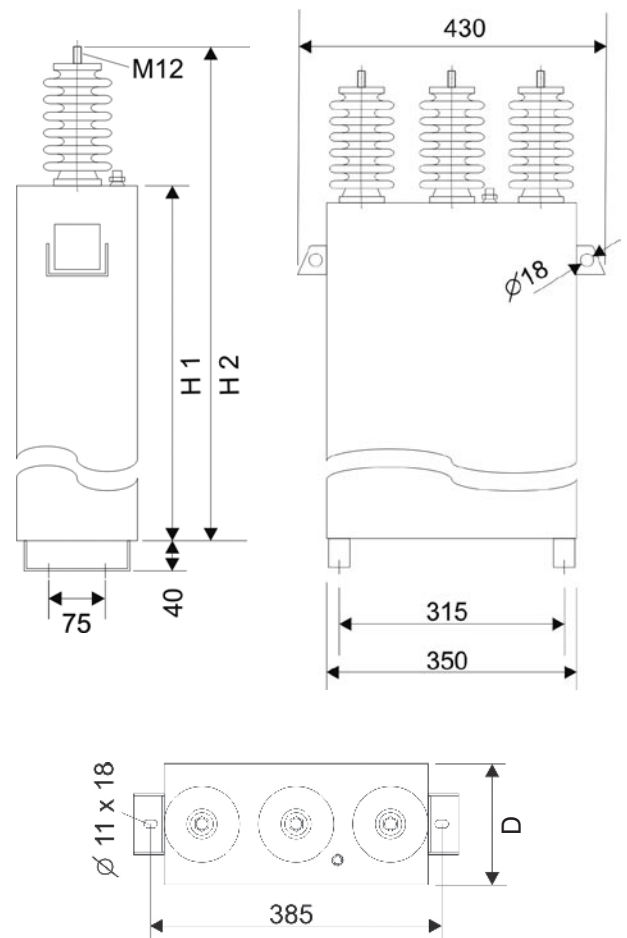
Operating reliability of MV Capacitors

Single-phase Medium Voltage Capacitors are frequently connected in a double star configuration in order to be used at higher network voltages. In these applications the operating reliability of the capacitors can be significantly increased by electronically monitoring the conductor between the star points of two capacitor groups, a current transformer being used to measure the current flowing between them. If a breakdown occurs in an element in one of the capacitors, an unbalanced current will start to flow through the current transformer. An electronic relay monitors this current and sends an alarm signal to the appropriate control system if the current reaches an adjustable set point. The control system then switches this capacitor bank out.

If the capacitor bank is tripped out in this way, it must be isolated and then inspected by appropriately qualified electricians, any necessary repairs being carried out.



Dimensions



High Reliable Components for Power Factor Correction and Power Quality



C E R T I F I C A T E

DQS GmbH
Deutsche Gesellschaft zur Zertifizierung von Managementsystemen
hereby certifies that the company



FRAKO Kondensatoren- und Anlagenbau GmbH

Tscheulinstraße 21a
D-79331 Teningen

for the scope

Development, production and sales of power factor correction equipments and energy management systems which save energy, improve network quality and advance environmental protection.

has implemented and maintains a

Quality and Environmental Management System.

Audits, documented in a report, have verified that this management system fulfills the requirements of the following standards:

DIN EN ISO 9001 : 2000
December 2000 edition

EN ISO 14001 : 2004
November 2004 edition

This certificate is valid until 2009-10-27

Certificate Registration No. 001410 QM UM

Frankfurt am Main 2006-10-28

Ass. iur. M. Drechsel

MANAGING DIRECTORS

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