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PQM -电能质量管理®

低压功率因数校正产品及滤波设备

Low Voltage Reactive Power Correction Products and Filter Equipment

德国莱茵豪森集团与 PQM
Reinhausen Group and PQM

About Reinhausen Group and PQM

Reinhausen Group(MR) was founded in 1868 and its headquater is located in Regensburg, Germany. MR is the technology pioneer and market leader of onload tap-changers for power transformers. In 2006, MR set up its subsidary – MR China Ltd., in Shanghai.

In 1997 and 2003, MR took over the business of Siemens MV reactive power compensation and AEG LV reactive power compensation, which constituted MR PQM Division. In 2007, MR commenced its PQM business in China.

MR PQM is the leading supplier of power compensation and filter circuits equipment in MV and LV network, can offer a large variety of serivces and products, such as harmonic measurement and analysis, conventional and dynamic power compensation, tuned filter circuits equipment, active filter system, and its power capacitors, filter reactors, thyristor power modules and power factor controllers.

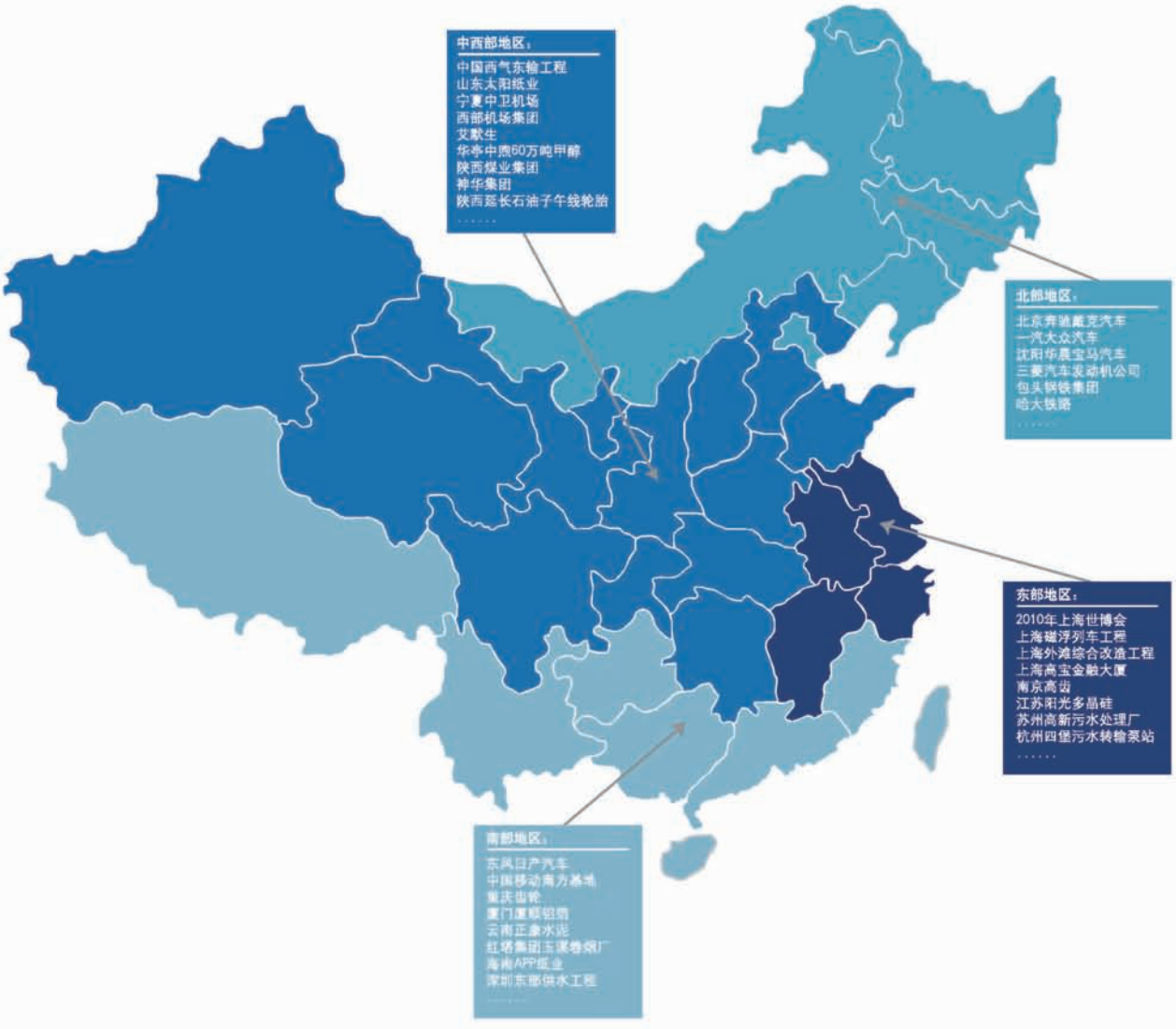
德国莱茵豪森集团与 PQM 简介

德国莱茵豪森集团（即 MR 公司）成立于 1868 年，总部位于德国雷根斯堡市。MR 公司是变压器有载分接开关的技术先锋和市场领导者。2006 年，MR 公司在上海建立全资中国子公司。

1997 年和 2003 年，MR 公司分别收购了德国西门子公司的中压补偿及滤波系统部门和 AEG 公司的低压补偿及滤波系统部门，组成 MR 公司电能质量管理部门（MR PQM）。2007 年，MR PQM 部门开始在中国推广电能质量产品业务。

MR PQM 是中、低压滤波补偿设备的领先供应商，专门从事电网谐波治理的测量服务、谐波分析及方案设计，主要包括常规无功功率补偿、动态补偿、无源滤波和有源滤波等，并销售电力电容器、电抗器、功率晶闸管和功率因数控制器等元器件。

PQM 的业绩和客户遍布全中国



低压滤波补偿设备
Low voltage PFC and filter circuits equipment

常规功率因数补偿设备
Conventional PFC equipment

动态功率因数补偿设备
Dynamic PFC equipment

无源滤波设备
Tuned filter circuits equipment

有源滤波设备
Active filter equipment

元件和模块
Components and assemblies

电容器组预装模块
Capacitor bank assemblies

MKK 电力电容器
MKK power capacitors

滤波电抗器
Filter reactors

Thyro-C 晶体管
Thyro-C power modules

实时控制器
Real-time controllers

放电线圈
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电容专用接触器
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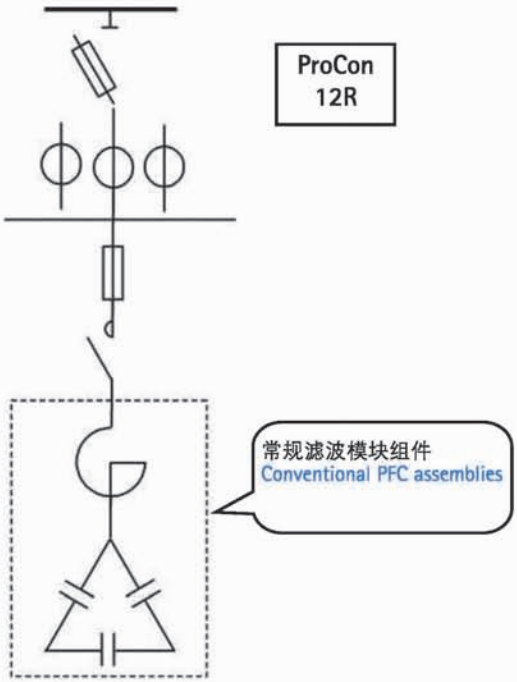
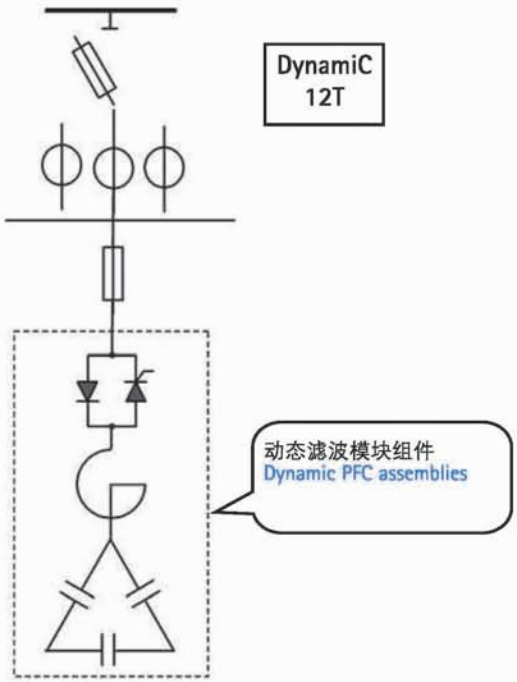
滤波模块组件图例
Singleline of PFC assemblies





常规滤波模块组件
Conventional PFC assemblies

MRFC 25 - DR 7 - 440

- 440 — 电容器额定电压 / Capacitor rated voltage
- 7 — 电抗系数：7 / 14 / Reactor value
- DR — 组件由电容器和电抗器构成 / Configuration: capacitors and reactors
- 25 — 工作电压下的有效容量（kvar）：25 / 50 / Effective power at operated voltage
- MRFC — MR滤波模块组件型号 / MR design code

动态滤波模块组件
Dynamic PFC assemblies

MRFC 25 - DYC 7 - 440

- 440 — 电容器额定电压 / Capacitor rated voltage
- 7 — 电抗系数：7 / 14 / Reactor value
- DYC — 组件由电容器、电抗器和晶闸管构成 / Configuration: capacitors, reactors and thyristors
- 25 — 工作电压下的有效容量（kvar）：25 / 50 / Effective power at operated voltage
- MRFC — MR滤波模块组件型号 / MR design code

注：其他电压等级的电容器与电抗器的滤波模块组件，请垂询。
Note: PFC assemblies for other mains voltages are available upon request.

滤波模块组件简介
Description of PFC assemblies

PFC assemblies

Reactor value of MR PFC assemblies are as follows:

- p = 5.67%
- p = 7%
- p = 12.5%
- p = 14%

The often applied value p = 7% results in a series resonance of 189 Hz. This detuned filter circuit absorbs 20% of the 5th harmonic current and a small part of the 7th harmonic current, whereas the greater part is supplied to the power supply network.

In the network of high harmonics, p = 5.67% can be applied, which results in a series resonance of 210 Hz and can absorb 50% of the 5th harmonic current.

For p = 14%, the detuned frequency is 133Hz, which mainly restrains the 3rd harmonic current.

滤波模块组件

MR滤波模块组件主要有以下电抗系数：

- p = 5.67%
- p = 7%
- p = 12.5%
- p = 14%

经常使用的电抗率是p = 7%，滤波模块组件主要用于谐波很少的电网中，基于它的单调谐频率为189Hz，可吸收20%用电设备产生的5次谐波及少量7次谐波，但对含有谐波的上一级电网具有阻隔左右。

如果用电设备的电网中谐波含量比较多，则采用p = 5.67%的滤波模块组件，它的单调谐频率为210Hz，可吸收50%用电设备产生的5次谐波。

如果p = 14%，则单调谐频率为133Hz，主要用于抑制3次谐波。

推荐的滤波模块组件（400V 50Hz）
Recommended configuration of PFC assemblies(400V 50Hz)

模块参数 Technical data	滤波模块组件 PFC assemblies
7%, 25kvar, 400V	MRFC25-DR7-440
7%, 50kvar, 400V	MRFC50-DR7-440
7%, 25kvar, 400V	MRFC25-DR7-480
7%, 50kvar, 400V	MRFC50-DR7-480
7%, 25kvar, 400V	MRFC25-DR7-525
7%, 50kvar, 400V	MRFC50-DR7-525
14%, 25kvar, 400V	MRFC25-DR14-480
14%, 50kvar, 400V	MRFC50-DR14-480
14%, 25kvar, 400V	MRFC25-DR14-525
14%, 50kvar, 400V	MRFC50-DR14-525
5.67%, 25kvar, 400V	MRFC25-DR5.67-440
5.67%, 50kvar, 400V	MRFC50-DR5.67-440
7%, 20kvar, 400V	MRFC20-DR7-480
7%, 30kvar, 400V	MRFC30-DR7-480
7%, 12.5kvar, 400V	MRFC12.5-DR7-525

注：其他电压及功率等级的滤波模块组件，请垂询。

Note: PFC assembiles of other voltages and reactive power are also available upon request.

功率因数控制器选型表
Selection table of power factor controllers

型号 Order code	主要功能 Main functions
Pro-Con 6R Pro-Con 12R	用于常规功率因数校正 For conventional power factor control 前面板安装，液晶显示 U, I, f, Q, P, S, cosφ及 1-19 次谐波电流和电压，6 或 12 路继电器输出 Front-plate mounting, LCD multifunction display of U, I, f, Q, P, S, cosφ and 1-19 harmonics,6 or 12 relay outputs
Pro-Con 12RS	用于常规功率因数校正 For conventional power factor control 前面板安装，液晶显示 U, I, f, Q, P, S, cosφ及 1-19 次谐波电流和电压，12 路继电器输出，RS485 接口，Modbus RTU 和 Profibus DP 通讯协议 Front-plate mounting, LCD multifunction display of U, I, f, Q, P, S, cosφ and 1-19 harmonics,12 relay outputs, interface RS485, protocol Modbus RTU and Profibus DP
DynamiC 6T DynamiC 12T	用于动态功率因数校正 For dynamic power factor control 前面板安装，液晶显示 U, I, f, Q, P, S, cosφ及 1-19 次谐波电流和电压，6 或 12 路晶体管输出 Front-plate mounting, LCD multifunction display of U, I, f, Q, P, S, cosφ and 1-19 harmonics,6 or 12 transistor outputs
DynamiC 12TS	用于动态功率因数校正 For dynamic power factor control 前面板安装，液晶显示 U, I, f, Q, P, S, cosφ及 1-19 次谐波电流和电压，12 路晶体管输出，RS485 接口，Modbus RTU 和 Profibus DP 通讯协议 Front-plate mounting, LCD multifunction display of U, I, f, Q, P, S, cosφ and 1-19 harmonics,12 transistor outputs, interface RS485, protocol Modbus RTU and Profibus DP

滤波模块组件选型指南
Selection guide of PFC assemblies

对于常规400V, 50Hz系统，针对不同的变压器容量，推荐的滤波模块组件选型如下：
For mains 400V, 50Hz, recommended PFC assemblies for different power transformers are as follows:

电抗率p=7%，单调谐频率189Hz
p=7%, detuned frequency 189Hz

变压器容量（kVA） TR rating	补偿容量（kvar） Reactive power	滤波模块组件 PFC assemblies	模块容量（kvar） Power rating	模块数量 Qty
315	100	MRFC25-DR7-440	25	2
		MRFC50-DR7-440	50	1
400	125	MRFC25-DR7-440	25	1
		MRFC50-DR7-440	50	2
500	150	MRFC25-DR7-440	25	2
		MRFC50-DR7-440	50	2
500	175	MRFC25-DR7-440	25	1
		MRFC50-DR7-440	50	3
630	200	MRFC25-DR7-440	25	2
		MRFC50-DR7-440	50	3
630	225	MRFC25-DR7-440	25	1
		MRFC50-DR7-440	50	4
800	250	MRFC25-DR7-440	25	2
		MRFC50-DR7-440	50	4
800	275	MRFC25-DR7-440	25	1
		MRFC50-DR7-440	50	5
1000	300	MRFC25-DR7-440	25	2
		MRFC50-DR7-440	50	5
1000	350	MRFC50-DR7-440	50	7
1250	400	MRFC50-DR7-440	50	8
1600	500	MRFC50-DR7-440	50	10
2000	600	MRFC50-DR7-440	50	12
2500	750	MRFC50-DR7-440	50	9
		2x (MRFC50-DR7-440)	2x50	3
2500	800	MRFC50-DR7-440	50	8
		2x (MRFC50-DR7-440)	2x50	4
3150	1000	2x (MRFC50-DR7-440)	2x50	10

注：对于电抗率p=14%，电容器额定电压选择为480V
Note: For p=14%, rated voltage of power capacitor is 480V

Installation and operation

For installation and operation of power capacitors, installation and operating instructions such as VDE 0100, VDE 0101, VDE 0105, VDE 0560 part 4 and 46 as well as EN 60831 and IEC 831 must be taken into account. Power capacitors must be installed in a cool and well ventilated area, and should not be installed within the range of heat radiating objects. Normally, the natural heat release of the power capacitors is sufficient for cooling provided that provision is made for free entry and exit of the cooling air and a minimum distance of 50 mm between the power capacitors is observed. In the case of an installation within an insufficiently cooled area, a forced ventilation is necessary. The forced ventilation must take place, however, within the range of allowable cooling air temperatures.

安装与运行

关于电力电容器的安装与运行，必须参照VDE0100，VDE0101，VDE0105，VDE0506第4和45部分以及EN60831和IEC831等安装与运行指导的规定。电力电容器必须安装在凉爽通风场所，不应安装在热辐射源的影响范围内。通常，只要提供冷却空气的自由进出口，且电容器之间的安装距离不小于50mm，电力电容器的自然散热方式足以使其冷却。如果在没有充分冷却的场所，则须采用强制通风。但是，强制通风的空气温度必须在允许的范围内。

Discharge

Each power capacitor must be provided with a device for discharging of the capacitor unit within 3 min to 75 V or less. No switch, fuse, or any other isolating device should be between the power capacitor and the discharge device.
Power capacitors which are directly connected to other electrical equipment providing a discharge path can be considered as properly discharged, provided that the circuit characteristics ensure the discharge of the power capacitors within the time specified above.

放电装置

每台电力电容器都必须带有放电装置，能在3分钟内使电容器电压放电到70V以下。电力电容器和放电装置之间不应有开关、熔断器或其他隔离装置。直接将电容器连接到其他放电回路的电力设备，只要放电回路特性能保证电容器在上述规定的时间之内完成放电，即可视为是充分放电了。

电容器的额定容量指导值–单台电动机功率补偿容量指导值
Guide values of capacitor rating-Power compensation of single motors

电动机额定功率 (kW) Motor rating (kW)	电容器额定容量 (kvar) Capacitor rating (kvar)
4.0-4.9	2.0
50.-7.9	3.0
8.0-10.9	4.0
11.0-13.9	5.0
14.0-17.9	6.0
18.0-21.9	7.5
22.0-22.9	10.0
30 and above / 30以上	approx. 35% of motor rating / 约为电动机功率的35%

变压器功率补偿单步容量指导值 – 连接在变压器的二次侧
Single compensation of power transformers – Connection to the secondary side of power transformers

变频器额定功率 (kW) Power transformer rating (kW)	电容器额定容量 (kvar) Capacitor rating (kvar)
160	5.0
400	12.5
630	20.0
1000	30.0
1600	50.0
higher power ratings / 更高容量	approx.3% of transformer rating / 约为变压器额定容量的 3%

MKK 电力电容器
MKK power capacitors

Construction

MKK capacitors are self-healing capacitors with dry windings built in an aluminium can. The dielectric consists of low loss metallized polypropylene film. Due to a new technology in winding production, a high performance of the capacitor is reached. On a metal pipe three electrically isolated partial capacitances are concentrically grouped. They may be connected in either a star or delta configuration. The construction of the capacitor and the tests to be carried out are according to EN 60831-1/-2 (DIN VDE 0560 part 46/47). Because of the dry construction, the capacitor can be installed in any position. The used protection gas (nitrogen) inside the capacitor is neutral an not flammabel.

Terminal

The terminal is designed as a triple-pole terminal block. It is possible to clamp safely multiple-wires with a cross section up to 16 mm² Cu. The construction of the terminal block avoids a loosening of the screws, even in the case of strong mechanical and electrical stresses. Required torque T = 1,2 Nm.
The terminal corresponds to VDE 106 / BGV A2.

High current loading

Power capacitors in power factor correction equipment are frequently switched. The high current peaks during switching have to be managed without affecting the life time of the capacitor. Through specific technological arragements in the contact zones an inrush current of up to 200 I_N is admissible!

Self-healing

Due to switching operations, inadmissible voltage peaks of up to 3 times that of the rated voltage can occur in low voltage networks. If these stresses effect a dielectric breakdown, the self-healing mechanism will function. After self-healing, the capacitor continues its complete operation. The decrease in capacitance in negligible.

Expansion fuse

MKK capacitors are equipped with overpressure expansion fuses. The expansion fuses operate when the internal pressure rise effected by repeated self-healings on faulty spots has reached a determined value. In this case the lid of the aluminium can will slightly bulge out breaking the fuses at the planned fracture. The expansion fuses disconnect the capacitor safely from the power supply system.

结构

MKK电容器具有自愈性功能，采用干式绕组，装在铝制圆筒内，其电介质为低损耗的金属化聚丙烯薄膜。由于在绕组制造中采用了新技术，电容器性能大大提高。电容器 由三组电容组成，电气上相互绝缘地同心布置在铝管芯上，三组电容可以是星型连接或三角型连接。电容器的结构和试验均按EN60831-1/-2*（DIN VDE0560第46/47部分）进行。由于采用干式结构，电容器可以安装在任何场所，其内部充有保护气体（氮气），具有不可燃性。

端子

接线端子设计成三极型式的端子块，以便可靠地夹紧横截面积16mm²以下的多芯铜线。端子块的结构可以保证即使在很大的电气和机械应力作用下，接线螺丝也不会松动。端子符合VDE106/BGV A2标准。

接线端子力矩要求：T=1.2Nm。

大电流负载

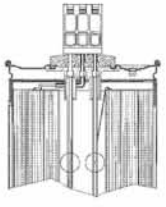
功率因数补偿设备内的电力电容器需要频繁切换，它必须能承受切换过程的大电流峰值，且不影响电容器的寿命。由于在触头区域采用特殊的技术设计，冲击电流允许达到200I_N。

自愈性功能

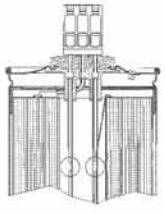
在切换操作过程中，低压电网的电压峰值可能达到额定电压的3倍，这是不允许的。只要该电压强度将电介质击穿，自愈性功能即发生作用。自愈之后，电容器可以继续运行。电容量发生细微降低，可以忽略。

膨胀式熔断器

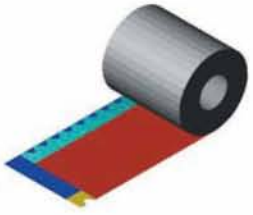
MKK电容器都带有过压力膨胀熔断器。如果故障点反复自愈，导致内部压力上升并达到一定数值，膨胀式熔断器即动作。这时，铝制圆筒顶盖会轻微鼓起，熔断器在设计的断裂处被拉断。膨胀式熔断器可以将电容器安全地从电力系统中断开。



正常运行
Normal operation



拉断状态
Interruption state



MKK电力电容器电解质的波纹切割
Wave cut at the dielectric of MKK AC power capacitors.

MKK 电力电容器
MKK power capacitors

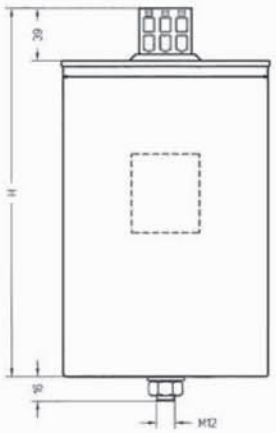
技术参数
Technical specification

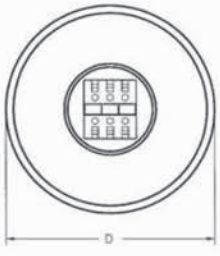
MKK 电力电容器 MKK Power capacitors	
额定电压，额定容量，额定电流 Rated voltage, -power, -current	见选型表 see selection table
最大允许工作电压 Max. allowable operating voltage	长期：1.0 U_N　　每日8小时：1.1 U_N 1.0 U_N permanently　1.1 U_N 8 h daily
最大允许工作电流 Max. allowable operating current	约1.8I_N，最大电压谐波符合IEC 1000-2-4，工业电网（2级） approx. 1.8 I_N, max. voltage harmonics acc. to IEC 1000-2-4 for industrial mains (class 2)
最大允许涌流 Max. allowable inrush current	200 x I_N
绝缘水平 Insulation level	U_N ≤ 660 V: 3/- kV U_N > 660 V: 6/- kV
保护等级 Degree of protection	IP20 (/IP42/IP55)
损耗 Losses	≤ 0.13 W/kvar*　(tested data / 试验数据)
耐热等级，温度限值 Temperature class, temperature limits	-25/D
温度限值（24小时平均，年平均，短时） Temperature limits (24-h-average, annual average, short time)	+45 °C +35 °C +55 °C
湿度 Humidity	≤ 95 %
运行海拔高度 Operating altitude	额定运行的海拔高度≤ 4000 m ≤ 4000 m above sea level at rated operation
安装 Installation, mounting	户内，自由安装　螺杆M24 Indoor, random position　Stud M24
放电时间 Discharge time	≤带放电电阻，3分钟放电到30V以下*　（试验数据） ≤ 3 minutes to 30V or less with discharge resistors (tested data)
寿命 Life time	额定条件下≥150000工作小时 ≥ 150.000 operating hours under rated conditions
标准 Standards	IEC 831-1/2, EN 60831-1/2, VDE 0560-46/47

MKK 电力电容器
MKK power capacitors

选型表
Selection table

额定容量 Rated power (kvar)	额定电容量 Rated capacitance (μF)+10%,-5%	额定电流 Rated current (A)	重量 Weight appr. (kg)	外形尺寸 宽 高 Dimensions DxH (mm)	型号 Order code
额定电压 440V Rated voltage 440V					
15	3x83 Δ	19.7	1.4	122x200	MKK 15/440 D
20	3x111Δ	26.2	1.7	122x240	MKK 20/440 D
28	3x154Δ	36.4	2.5	142x240	MKK 28/440 D
30	3x165Δ	39.4	2.6	142x240	MKK 30/440 D
额定电压 480V Rated voltage 480V					
15	3x69 Δ	18	1.4	122x240	MKK 15/480 D
20	3x92 Δ	24	1.8	122x240	MKK 20/480 D
25	3x115Δ	30	2.2	142x240	MKK 25/480 D
30	3x138Δ	36.1	2.5	142x240	MKK 30/480 D
33	3x152Δ	39.7	2.5	142x240	MKK 33/480 D
额定电压 525V Rated voltage 525V					
8.33	3x32 Δ	9.2	1.1	122x200	MKK 8.33/525 D
10	3x39 Δ	11	1.2	122x200	MKK 10/525D
15	3x58 Δ	16.5	1.5	122x200	MKK 15/525D
16.7	3x64 Δ	18.5	1.6	122x200	MKK 16.7/525 D
20	3x77 Δ	.22	1.8	122x240	MKK 20/525 D
21	3x81 Δ	23	1.8	122x240	MKK 21/525 D
25	3x96 Δ	27.5	2.3	142x240	MKK 25/525 D
额定电压 580V Rated voltage 580V					
15	3x48 Δ	14.9	1.5	122x200	MKK 15/580 D
额定电压 690V Rated voltage 690V					
12.5	3x28 Δ	10.5	1.4	122x200	MKK 12.5/690 D
25	3x56 Δ	20.9	2.2	142x240	MKK 25/690 D
额定电压 800V Rated voltage 800V					
15	3x25 Δ	11	1.5	122x200	MKK 15/800 D
19.3	3x32 Δ	13.9	2.3	142x240	MKK 19.3/800 D
25	3x41.5 Δ	18	2.3	142x240	MKK 25/800 D
28	3x46 Δ	20	2.4	142x240	MKK 28/800 D





MKK 电力电容器
MKK power capacitors

Dimensioning of fuse and cable

Recommendation according to VDE 0100, Part 430 and Part 530 for fusing and cross sections of cables for three-phase power capacitors:

熔断器和电缆尺寸选择

按VDE 0100，第430部分和530部分标准的规定，对三相电力电容器的熔断器和电缆截面作如下推荐：

额定容量 Rated power	额定电压 Rated voltage 400V,50Hz			额定电压 Rated voltage 525V,50Hz			额定电压 Rated voltage 690V,50Hz		
	额定电流 Rated current	熔断器电流 Fuse/phase	电缆截面 Cross section	额定电流 Rated current	熔断器电流 Fuse/phase	电缆截面 Cross section	额定电流 Rated current	熔断器电流 Fuse/phase	电缆截面 Cross section
Q_N (kvar)	I_N (A)	(A)	(mm² Cu)	I_N (A)	(A)	(mm² Cu)	I_N (A)	(A)	(mm² Cu)
5.00	7.4	16	1.5	5.5	10	1.5	4.2	10	1.5
6.25	9.0	20	2.5	6.9	16	1.5	5.2	10	1.5
7.50	10.8	20	2.5	8.3	16	1.5	6.3	10	1.5
8.33	12.0	20	2.5	9.1	20	2.5	7.0	16	1.5
10.00	14.4	25	2.5	11.0	20	2.5	8.4	16	2.5
12.50	18.1	25	2.5	13.8	20	2.5	10.5	20	2.5
15.00	21.6	36	4.0	16.5	25	2.5	12.5	20	2.5
16.70	24.0	36	6.0	18.4	25	2.5	14.0	25	2.5
20.00	29.0	50	6.0	22.0	36	4.0	17.0	25	2.5
25.00	36.0	63	10.0	27.5	50	6.0	21.0	36	4.0
30.00	43.0	80	16.0	33.0	50	6.0	25.0	50	6.0
33.00	48.0	80	16.0	36.3	63	10.0	28.0	50	6.0
37.50	54.0	100	25.0	41.3	63	10.0	31.4	50	6.0
40.00	58.0	100	25.0	44.0	80	16.0	33.0	63	6.0
50.00	72.0	125	35.0	55.0	100	25.0	42.0	80	10.0
60.00	87.0	160	50.0	66.0	100	25.0	50.0	80	16.0
67.00	96.0	160	50.0	74.0	125	35.0	56.0	100	25.0
75.00	108.0	160	50.0	82.0	125	35.0	63.0	100	25.0
80.00	115.0	200	70.0	88.0	160	50.0	67.0	100	25.0
100.00	144.0	250	70.0	110.0	160	50.0	84.0	160	35.0

This table is valid for low voltage power capacitors with and without filter reactor, for four-wire PVC-cables (NYY)Uo/U = 0,6/1 kV for three-phase operation, laid in air, for continuos operation at an ambiant temperature of +30 °C.
If a filter reactor has to be connected with more than one power capacitor, the filter reactor MUST be connected with each power capacitor by individual cable in order to have safe and reliable operation.

表中数值用于低压电力电容器，带或不带滤波电抗器，四芯PVC电缆(NYY)，U0/U=0.6/1kV，三相运行，安装于空气中，在环境温度+30 °C时连续运行。

如果一台电抗器需连接多个电容器，电抗器接线排必须分别引出电缆至每个电容器，以确保电容器运行安全。

滤波电抗器
Filter reactors

Application

Harmonics generated by non-linear loads such as variable speed drives or other static power conversion equipment have grown rapidly in recent years. Harmonic currents and the voltage distortion, created by these currents have devastating effects on power supply and distribution systems and its connected loads.
This can result in failure of power factor correction capacitors due to overloading, system resonance, overheating of cables and transformers as well as misoperation of PLC's, computer and other sensitive appliances.
A present method to treat harmonic problems is the use of filter reactors combined with power capacitors in detuned and tuned filters. As well as the improvement of the power factor and the power quality, harmonics are also absorbed from the networks. Furthermore, a critical amplification of the current harmonics caused by a parallel resonance between the power capacitors and the inductances of the power supply system can be avoided.

Design

MR filter reactors are designed as three-phase reactors with an iron core and air gap.
For small filter reactors the winding material is Cu-wire, whereas for bigger filter reactors, an aluminium band is used as winding material.
The filter reactors are completely impregnated under vacuum and over pressure in an impregnating resin of class H and then hardened in a furnace.

Dimensioning

The dimensioning of the filter reactors is based on the recommendation for allowable limits of voltage harmonics in public and industrial networks according to IEC 1000-2-4.
In the case of higher harmonic loads in networks, special designed filter reactors have to be used. The actual loads can be detected by means of a harmonic analysis. The measured values form the basis for the dimensioning of the filter reactors.

Losses

The 50 Hz losses are comparatively low but when the filter reactors are installed into the cabinets, they are charged with additional currents, predominately those of the 5th, 7th and 11th harmonics. Then the total heat losses dissipated can be of a level whereby they have to be extracted from the cabinets, e.g. by means of fans.

Noise level

Filter reactors are nearly silent when operated at 50 Hz or 60 Hz loads. At rated operation with harmonic currents according to the table, the noise level can reach ≤ 60 dB measured at a distance of 1 m.
The filter reactors should be installed in an upright position and the assembly arranged in such a way that no vibration will be transferred to other parts of the equipment.

Terminals

The terminals for filter reactors are either designed as cable terminals (d = 8,5 mm) or copper bus bar terminals, 20 x 3 mm (d = 9 mm) according to DIN 46206.

应用

近年来，非线性负载如变频调速设备或其他静止型电能转换装置产生的谐波迅速增加。谐波电流和由此而产生的电压畸变破坏性地影响到电力供应和配电系统，以及相连接的负载。

由于过载，系统谐振，电缆和变压器的过热以及程序逻辑控制系统、计算机和其他敏感装置的误动作，可能导致功率因数补偿系统的失灵。

当前，解决谐波问题的方法是存单调谐与多调谐滤波设备中，组合使用滤波电抗器和电力电容器。这种方法，除提高功率因数和电能质量，还吸收了电网中的谐波。其次，还可以避免因电力电容器和供电系统阻抗之间的并联谐振而严重放大谐波电流。

设计

滤波电抗器设计为三相电抗器型式，具有铁心和空气间隙。

小规格的滤波电抗器，绕组材料是铜线，大规格的滤波电抗器则采用铝带作为绕组材料。

滤波电抗器先在真空和压力下彻底浸渍H级浸渍树脂，然后在干燥炉内固化。

参数的确定

滤波电抗器的参数是依据IEC 1000–2–4标准而推荐的公用电网 和工业电网中电压谐波的允许限值来确定的。

对于具有更多谐波负载的电网，则需使用特殊设计的滤波电抗器。实际负载情况可以利用谐波分析仪来检测。实测值是滤波电抗器参数确定的基础。

损耗

滤波电抗器的50Hz损耗相对较低，但是如果安装在配电柜内，可能有其他电流成份流过它，其中主要是5次，7次和11次谐波。因此，总的热损耗可能达到很高水平，这时可使用风扇将热量排除到配电柜外。

噪声水平

滤波电抗器在50Hz或60Hz负载下的运行是很安静的。在表内规定的额定谐波电流运行下，1m范围内测量的噪声水平可能达到≤60dB。

滤波电抗器应该竖直安装。采用这种安装方式，振动不会传递到设备的其他部分。

端子

滤波电抗器的端子按DIN 46206标准设计成为电缆接线端子型式(d=8.5mm)或者20×3mm(d=9mm)的铜排接线端了型式。

滤波电抗器
Filter reactors

Technical specification

Rated voltage
See selection list

Rated output
See selection list

Max. allowable operating current
See selection list

Max. allowable harmonic voltage
See selection list

Linear range
$L(1.85\ I_N) \geq 0.95 L_N$

Adjustment accuracy
-2% ... +3% from L_N

Insulation level
UN ≤ 1100 V; 3/- kV (Line-to-line voltage)

Loss
See selection table

Temperature limits
+35°C annual average
Insulation class T40/H – Filter reactors with Al-winding
Insulation class T40/F – Filter reactors with Cu-winding

Cooling method
Natural cooling (AN)

Installation
Indoor

Protection degree
IP 00

Operating altitude
1000 m above sea level at rated operation

Design specification
According to IEC 1000-2-4 the following recommended values for voltage harmonics in % related to the agreed operating voltage are valid in low voltage power supply systems. If not stated otherwise the design will be suitable for class 2 industrial mains.

技术参数

额定电压
见选型表

额定输出
见选型表

最大允许工作电流
见选型表

最大允许谐波电压
见选型表

线性范围
$L(1.85\ I_N) \geq 0.95 L_N$

调整精度
L_N 的-2% ... +3%

绝缘水平
UN ≤ 1100 V; 3/- kV(线对线电压)

损耗
见选型表

温度限值
+35°C 年平均值
绝缘等级T40 / H-铝带绕组滤波电抗器
绝缘等级T40 / F-铜线绕组滤波电抗器

冷却方式
白然冷却(AN)

安装方式
户内

防护等级
IP00

运行海拔高度
额定运行条件下，至1000米。

设计规范
依据IEC 1000-2-4标准，对低压供电系统中所允许的谐波电压相对于运行电压的比值(%)作如下推荐。

谐波次数 Order No. h	50 Hz时的频率 50 Hz Mains	60 Hz时的频率 60 Hz Mains	1级（%）公用电网 Class 1 (%) Public mains	2级（%）公用电网 Class 2 (%) Public mains
5.	250	300	3	6
7.	350	420	3	5
11.	550	660	3	3.5
13.	650	780	3	3
17.	850	1020	2	2
19.	950	1140	1.5	1.5
23.	1150	1380	1.5	1.5
>25.	1250	1500	0.2	0.2

滤波电抗器
Filter reactors

Selection table
Filter reactors for mains 400 V, 50 Hz

选型表
系统电压 400 V, 50 Hz

容量 Power kVar	型号 Filter reactor	L值 L 3 x ... mH	绕组 Winding Al/Cu	重量 Weight kg	损耗 Losses W		最大运行电流 Max. operating current A		
					50Hz	r.m.s.	50Hz	250Hz	350Hz
Detuned to 210Hz / 单调谐频率 210Hz (p=5.67%)									
5	DD6NM-5,97/8/5/1	5.97	Cu	7	40	70	8.1	5.0	1.4
6.25	DD7NM-4.99/10/6/2	4.99	Cu	10	40	80	9.7	6.0	1.6
8.33	DD7NM-4.05/12/7/2	4.05	Cu	11	50	90	12.0	7.4	2.0
10	DD7NM-2.8/17/11/3	2.80	Cu	11	50	110	17.4	10.7	2.9
12.5	DD8NM-2.49/20/12/3	2.49	Cu	13	80	130	19.5	12.5	3.5
16.7	DD9NM-1.94/25/15/4	1.94	Al	19	70	130	24.0	13.0	4.0
22	DD9NM-1.39/34/18/6	1.55	Al	18	90	170	33.7	18.0	5.9
25	DD9NM-1.26/37/20/7	1.26	Al	18	90	170	37.2	23.9	6.8
30	DD11NM-1.05/46/29/8	1.05	Al	26	120	240	46.5	28.6	7.8
33.3	DD11NM-0.93/52/32/9	0.93	Al	27	110	240	52.0	32.0	9.0
40	DD11NM-0.76/64/39/11	0.76	Al	28	130	270	64.0	39.4	10.8
50	DD12NM-0.63/77/48/13	0.63	Al	35	130	290	77.1	47.5	13.0
60	DD13NM-0.51/95/58/16	0.51	Al	39	170	350	94.6	58.3	16.0
66.7	DD15NM-0.47/104/64/18	0.47	Al	45	170	360	104.3	64.3	17.6
75	DD16MN-0.42/117/72/20	0.42	Al	50	170	380	116.9	72.0	19.7
Detuned to 189Hz / 单调谐频率 189Hz (p=7%)									
5	DD6NM-7.38/8/3/1	7.38	Cu	7	50	60	8.2	2.8	1.0
6.25	DD7NM-6.16/10/3/1	6.16	Cu	10	50	60	9.9	3.3	1.2
8.33	DD7NM-4.99/12/4/1	4.99	Cu	10	70	80	12.2	4.1	1.5
10	DD7NM-3.45/18/6/2	3.45	Cu	11	70	90	17.6	6.0	2.1
12.5	DD8NM-3.07/20/7/2	3.07	Cu	13	80	110	19.8	6.7	2.4
16.7	DD8NM-2.4/25/9/3	2.40	Cu	14	95	130	25.4	8.6	3.1
20	DD9NM-1.71/36/12/4	1.71	Al	18	90	130	35.6	12.0	4.3
25	DD9NM-1.56/39/13/5	1.56	Al	18	110	160	39.0	13.2	4.8
30	DD10NM-1.29/47/16/6	1.29	Al	19	160	200	47.0	16.0	6.0
33.3	DD11NM-1.15/53/18/6	1.15	Al	26	140	200	53.0	18.0	6.0
40	DD11NM-0.95/64/22/8	0.95	Al	27	160	230	64.1	21.7	7.8
50	DD11NM-0.78/75/26/10	0.78	Al	28	180	250	75.2	26.4	9.5
60	DD12NM-0.63/96/32/12	0.63	Al	34	200	280	95.6	32.4	11.7
66.7	DD13NM-0.57/106/36/13	0.57	Al	37	240	330	105.9	35.8	12.9
75	DD13NM-0.52/117/40/14	0.52	Al	39	250	350	117.2	39.6	14.3
Detuned to 133Hz / 单调谐频率 133Hz (p=14%)									
6.25	DD7NM-14.75/9/1/0	14.75	Cu	10	60	65	8.9	0.8	0.4
8.33	DD8NM-10.27/13/1/1	10.27	Cu	13	90	95	12.8	1.2	0.6
12.5	DD8NM-6.9/19/2/1	6.90	Cu	15	130	140	19.1	1.8	0.9
16.7	DD9NM-5.13/26/2/1	5.13	Cu	20	140	150	25.6	2.5	1.3
25	DD11NM-3.46/38/4/2	3.46	Al	27	190	190	38.0	3.6	1.8
33.3	DD12NM-2.57/51/5/2	2.57	Al	33	240	250	51.3	4.8	2.4
50	DD15NM-1.73/76/7/4	1.73	Al	44	250	270	76.1	7.1	3.6
60	DD16NM-1.37/96/9/4	1.37	Al	49	350	370	96.2	9.2	4.5
66.7	DD16NM-1.28/103/10/5	1.28	Al	50	370	380	102.6	9.6	4.8

滤波电抗器
Filter reactors

Selection table
Filter reactors for mains 690 V, 50 Hz

选型表
系统电压 690 V, 50 Hz

容量 Power kVar	型号 Filter reactor	L值 L 3 x ... mH	绕组 Winding Al/Cu	重量 Weight kg	损耗 Losses W		最大运行电流 Max. operating current A		
					50Hz	r.m.s.	50Hz	250Hz	350Hz
Detuned to 210Hz / 单调谐频率 210Hz (p=5.67%)									
12.5	DD8NM-7.70/11/7/2	7.70	Cu	13	70	130	10.9	6.7	1.8
25	DD9NM-3.85/22/13/4	3.85	Cu	22	90	180	21.8	13.4	3.7
40	DD11NM-2.35/34/18/6	2.35	Al	28	120	240	34.4	18.3	6.0
52	DD12NM-1.76/46/24/8	1.76	Al	34	140	280	45.9	24.5	8.0
Detuned to 189Hz / 单调谐频率 189Hz (p=7%)									
12.5	DD7NM-9.51/11/4/1	9.51	Cu	11	80	100	11.0	3.7	1.3
25	DD9NM-4.75/22/7/3	4.75	Cu	20	120	160	22.1	7.5	2.7
40	DD11NM-2.9/36/12/4	2.9	Al	27	160	230	36.2	12.2	4.4
52	DD12NM-2.17/48/16/6	2.17	Al	34	170	250	48.4	16.4	5.9
Detuned to 133Hz / 单调谐频率 133Hz (p=14%)									
13	DD8NM-19.01/12/1/1	19.01	Cu	14	130	140	11.5	1.2	0.6
26	DD11NM-9.51/24/2/1	9.51	Cu	29	200	210	23.9	2.4	1.2
39	DD13NM-6.34/35/3/2	6.34	Al	38	210	220	34.5	3.5	1.8
50	DD15NM-4.75/46/4/2	4.75	Al	44	300	320	46.0	3.9	2.3

Note:

When placing an order, the inductance, the rated voltage, as well as the respective harmonic current values and frequencies have to be specified.

On request the filter circuit reactors can be delivered or retrofit optionally either with a temperature sensor (PTC resistor) or a thermal switch.

Filter reactors for other mains voltages and mains frequencies are available upon request!

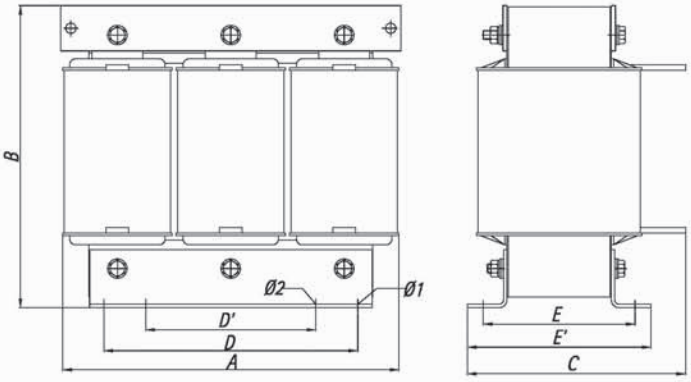
注：

订货时应提供电感值，额定电压以及各次谐波电流值和频率。作为改装选件，滤波电抗器可以附加温度传感器(PTC电阻)或热敏开关。

其他电压等级和频率的滤波电抗器，均可按要求供货。

外形尺寸图
Dimension

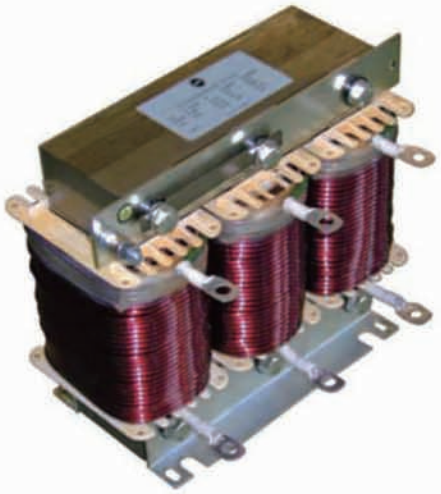
铝带绕组的滤波电抗器
Filter reactor with aluminum windings (Al)

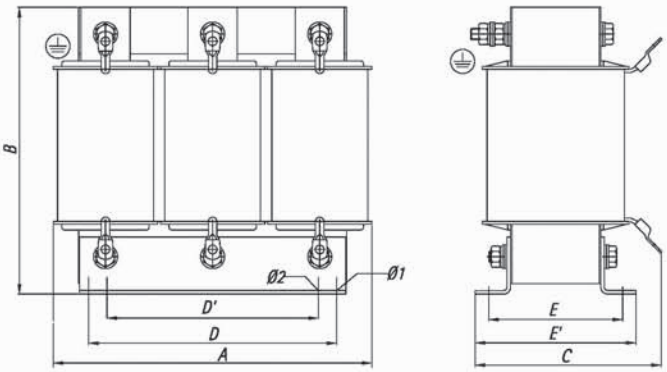


Type / 型号	A	B	C	D	D'	E	E*	Ø1	Ø2
DD9NM...	230	205	135	176	150	95	114	7	11
DD10NM...	260	235	125	200	150	76	106	10	11
DD11NM...	260	235	150	200	150	102	132	10	11
DD12NM...	300	235	165	224	150	119	147	10	11
DD13NM...	300	265	165	224	150	119	147	10	11
DD14NM...	300	235	180	224	150	134	162	10	11
DD15NM...	300	265	180	224	150	134	162	10	11
DD16NM...	300	265	295	224	150	147	175	10	11

尺寸单位：mm
All dimensions in mm!

铜线绕组的滤波电抗器
Filter reactor with copper windings (Cu)





Type / 型号	A	B	C	D	D'	E	E*	Ø1	Ø2
DD6NM...	180	160	105	136	100	57	76	7	9
DD7NM...	180	160	125	136	100	77	96	7	9
DD8NM...	230	205	115	176	150	68	90	7	11
DD9NM...	230	205	140	176	150	95	114	7	11
DD11NM...	260	235	150	200	150	102	132	10	11

尺寸单位：mm
All dimensions in mm!

功率晶闸管
Thyristor power modules

Introduction

The thyristor power module Thyro-C from MR Power Quality Management is a ready-to installation solution for **dynamic power factor correction equipment**.

The following advantages are result of using the Thyro-C instead of classic switches, such as air contactors. For example:

- very high lifetime due to unlimited switching frequency
- smooth switching of the capacitors
- short switching delay
- suitability for realisation of real time power factor compensation equipment
- AC or DC control
- complete and compact assembly, each consisting of two modules with heat sink, power block and control electronics
- no auxiliary supply voltage needed
- no services necessary due to wearlessness
- noiselessness
- simple mounting

Range of operation

The thyristor power module Thyro-C can be used in combination with the following:

- Programmable logic controls (PLC)
- Power-factor controllers
- Computer systems

Especially for:

- fast and
- wearless switching

Typical applications are:

- Cranes
- Elevators
- Welding machines

简介

MR的Thyro-C功率晶闸管是用于**动态功率因数校正**的即装即用的解决方案。

与传统的接触器切换相比较，采用Thyro-C具有以下优点：

- 由于开关频率是无限的，使用寿命长
- 实现电容器的平滑切换
- 极短的切换时间延迟
- 实现功率因数的"实时"补偿
- 可以是交流或直流控制
- 完整而紧凑的结构，每台Thyro-C由两个模块组成，含有散热片、功率元件和控制电路
- 不需要辅助电源
- 由于无磨损，不需要维护
- 运行无噪声
- 安装简便

运行范围

Thyro-C功率晶闸管可与以下装置组合使用

- PLC-可编程序逻辑控制器
- 功率因数控制器
- 计算机系统

特别适用于

- 快速
- 且无磨损的切换场合

典型的应用

- 起重设备
- 电梯
- 电焊机

不同等级电压下，适用的Thyro-C
Range of types Thyro-C

型号 Order Code	Thyro-C 2C 400-45 Ω	Thyro-C 2C 400-100 Ω	Thyro-C 3C 400-100 Ω	Thyro-C 2C 500-75 Ω
额定电压 Rated Voltage (URMS)	400 V, 525 V *	400 V	400 V	525 V
接线方式 Connection Δ / 人	图 19 Fig. 19 (Δ)	图 19 Fig. 19 (Δ)	图20 Fig. 20 (人)	图 19 Fig. 19 (Δ)
系统额定电压 Mains – Rated Voltage (URMS)	220 - 400 V 300 - 525 V *	220 - 400 V	400 - 690 V	300 - 525 V
额定电流 Rated Current (IRMS)	45 A	100 A	100 A	75 A

Note:Thyro-C 2C 400 - 45Ω on request with internal change of setting also available for 525 V.

注：Thyro-C 2C 400-45Ω可根据需要修改内部设置以适用于525V电压等级

功率晶闸管
Thyristor power modules

Mode of operation

The Thyro-C is suitable for switching power capacitors with or without filter reactors.

The simultaneous operation of Thyro-C modules and capacitor contactors in one low voltage distribution is only allowed in power-factor correction equipment with filter reactors. This is necessary because of the high inrush overcurrents of capacitors switched by contactors.

运行模式

Thyro-C用于切换电容器，可带或不带滤波电抗器。

由于接触器在切换电容器的过程中会产生很高的涌流，当Thyro-C模块和电容接触器在一个低压配电系统中同时使用时，功率因数校正设备必须配有滤波电抗器。

Working principle

The device consists of two thyristor modules, switching phase L1 and L3. Phase L2 is not switched. Alternatively, the thyristor modules can be used for single phase applications.

工作原理

装置由两个功率晶闸管组成，切换L1和L3时，L2不切换。相应地，功率晶闸管还可用于单相系统。

连线图
Connection diagram

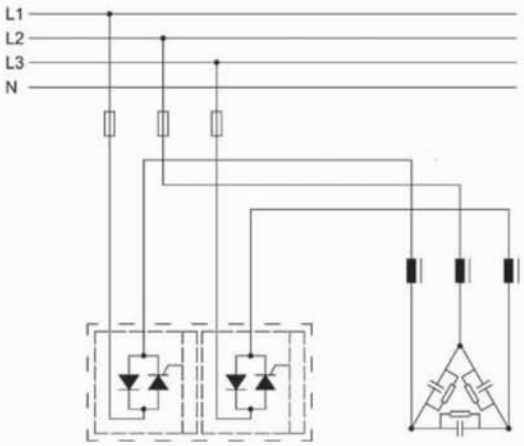


Fig. 19 / 图19 Thyro-C 2C (Δ)

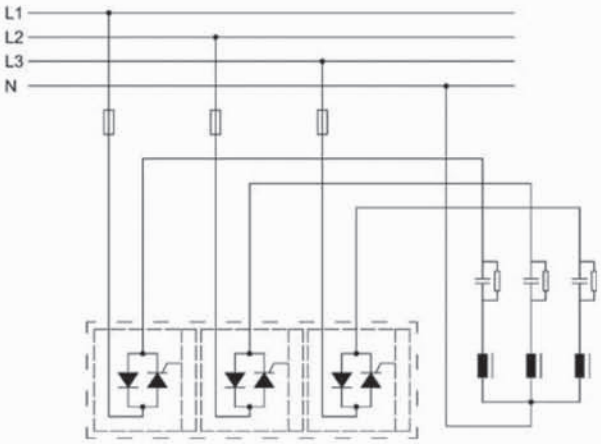
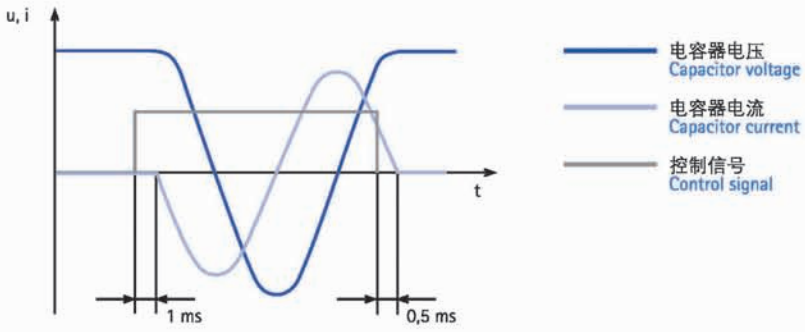


Fig. 20 / 图 20 Thyro-C 3C (人)

After feeding the control input of the Thyro-C with the signal "ON", the integrated electronics fire the thyristors separately for each phase in the next following negative zero current crossing. The switch-off also occurs in the current zero crossing. Transient effects and reflections to the mains are suppressed due to this principle. During the switch-off periods, the capacitors remain loaded with the mains peak voltage and can therefore be switched on again at any time.

通过给Thyro-C的控制输入侧施加"开"信号，其内部集成的控制电路分别触发每相的晶闸管，并在电流到达负零位时分别导通，晶闸管也在电流过零时关断。这样的工作原理可以抑制作用在系统上的暂态效应。在关断期间，电容器的电压保持在系统电压的峰值，因此可以在任何时候再次投入运行。



功率晶闸管
Thyristor power modules

Control signal

The Thyro-C has galvanicly separated control inputs (terminal X1). The LED installed in front side of the housing displays the control signal "ON".

控制信号

Thyro-C具有独立的控制输入(端子X1)，外壳正面的LED灯显示控制信号为"开"。

	Control signal (terminal X1) / 控制信号 （端子X1）	
Thyro-C	DC (X1: 1-3)	AC(X1:1-2)
OFF / 关	0 ... 3 VDC	0 ... 10 VAC
ON / 开	10 ... 30 VDC / Is = 15 mA	50 ... 230 VAC / Ri = 20 kΩ
Switching sequence / 开关频率	16 / sec	10 / sec
Turn-on / -off delay / 开/关时间延迟	1 ms ... 15 ms	10 ms ... 25 ms

Discharge of capacitors

According to EN 60831, power capacitors have to be firmly connected with discharge devices. Because the capacitors are constantly recharged to mains peak voltage during switch-off periods (while the compensation stage is connected to mains), only resistors are allowed as discharge devices for the capacitors.

Important: Even when the thyristor switches are turned off, the capacitors are under tension. The capacitors are not discharged, until they are completely disconnected from mains, e.g. through opening of breaker.

电容器的放电

根据EN60831，电力电容器必须与放电装置可靠连接。因为电容器在关断期间时常被充电至系统电压的峰值(补偿回路仍与电网相连接)，只允许使用电阻对电容器进行放电。

注意：甚至当晶闸管投切装置被关闭时，电容器仍处于充电状态。直到电容器完全从系统中断开，例如断开开关，其放电才能完成。

Putting into operation

- Check the design of the equipment.
- Remove low-voltage fuses from the stages, the whole compensation unit and the control fuses (external).
- Set up the Thyro-C in an upright position. Please ensure a sufficient cooling for the device (pg. 20).
- Remove the plastic housings by pushing the clamp in the front side of the housing.
- Make the electric connections acc. to connection diagram (pg. 23).
- Fit plastic housing again to Thyro-C.
- Insert NH fuses into the stages first, then the fuses for the whole unit. Attention: Capacitors are loaded immediately!
- Insert the control fuses.
- After switching on to mains the Thyro-C is immediately ready for operation. Please observe that the Thyro-C is in the "OFF" position, when connecting to mains.

投入运行

- 检查设备的设计
- 取下补偿回路和控制回路的熔断器
- Thyro-C 模块要垂直摆正，并保证装置足够的散热条件
- 按住正面塑料罩盖的卡簧，取下罩盖
- 根据接线图接线
- 把塑料罩盖安装到Thyro-C
- 把熔断器依次插入回路中，注意此时电容器即被通电
- 插入控制回路熔断器
- 主回路通电后，Thyro-C可立即投入运行，注意在通电前，Thyro-C处于关断状态

功率晶闸管
Thyristor power modules

Technical specification

Voltage range U_{RMS}
400 V: 320 ... 460 V
525 V: 450 ... 550 V

Rated frequency
50 / 60 Hz ± 3 Hz

Losses
app. 1,9 W / A

Power consumption of the electronics
app. 2 x 6 VA

Test voltage
EN 50178 (4/98)

Operation altitude
≤ 1000 m above sea level

Operating temperature
- 10° C ... + 45° C
in case of reduced current up to + 55° C
Reduction of rated current: 2 % / ° C

Storage temperature
- 40° C ... + 85° C

Humidity
EN 50178, Tab. 7, Type B

Operating conditions
Device is designed under consideration of:
EN 50178 (4/98); VDE 0106 Part 100 (3/83)
Pollution category 2 acc. VDE 0110 Part 1 (1/89)
Overvoltage category Ü III acc. EN 50178 (4/98)
Terminal block X1:
designed for safe disconnection up to V / 690 V (size 3)
Connection voltage of device: VDE 0160 5.6 (5/88)

Design
Acc. VDE 0558 Part 1

Mounting
Orthogonal
Underclearance: ≥100 mm
Upperclearance: ≥150 mm

Connection
With ring terminal M6 from top, see figure 22
Torque of connecting screws
3 Nm acc. VDE 0609 Part 1 (6/83)

Fuses
Special low voltage fuses for protection of semiconductors and lines required,
e.g.: SiBA, series URL, see selection table
Recommended: Low voltage fuse breaker for fuses up to
3 x 160 A, Gr00.

技术参数

额定电压U_{RMS}
400 V: 320 ... 460 V
525 V: 450 ... 550 V

额定频率
50 / 60 Hz ± 3 Hz

损耗
约1,9 W / A

集成电路功耗
约2 x 6 VA

测试电压
根据EN50178

运行海拔
高度至1000米

工作温度
-10°C ～±45°C
如果运行电流降低，可达±55°C
额定电流降低的比例为2%/°C 。

储存温度
-40°C ～+85°C

湿度
EN 50178, Tab. 7, Type B

工作条件
装置的设计考虑到以下因素：
EN50178，VDE0106第100部分
污染等级2，根据VDE0110第1部分
过电压类型UIII，据EN50178
端子块X1：
设计用于断开电压至690V(尺寸等级3)
装置连接电压等级根据VDE0160 5.6

设计
根据VDE0558第1部分

安装
垂直方式，
下部爬电距离≥100mm，
上部爬电距离≥150mm

接线
采用上部的M6环型端子
连接螺丝的力矩
3Nm，根据VDE0609第1部分

熔断器
应采用半导体保护的低压专用熔断器，如SiBA的URL系列，见选型表
推荐采用熔断器开关，电流至3x160A，Gr00。

选型表
Selection table

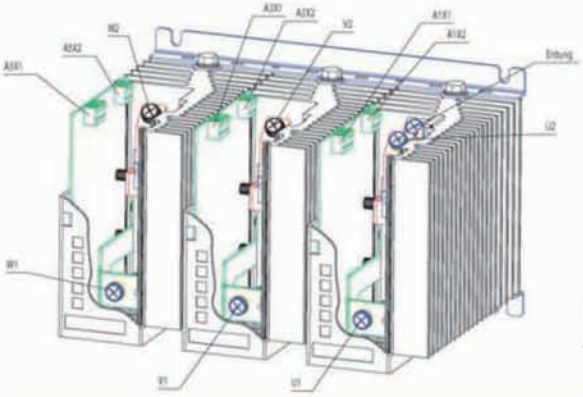


图22 Thyro-C端子图
Fig. 22 Terminals at Thyro-C

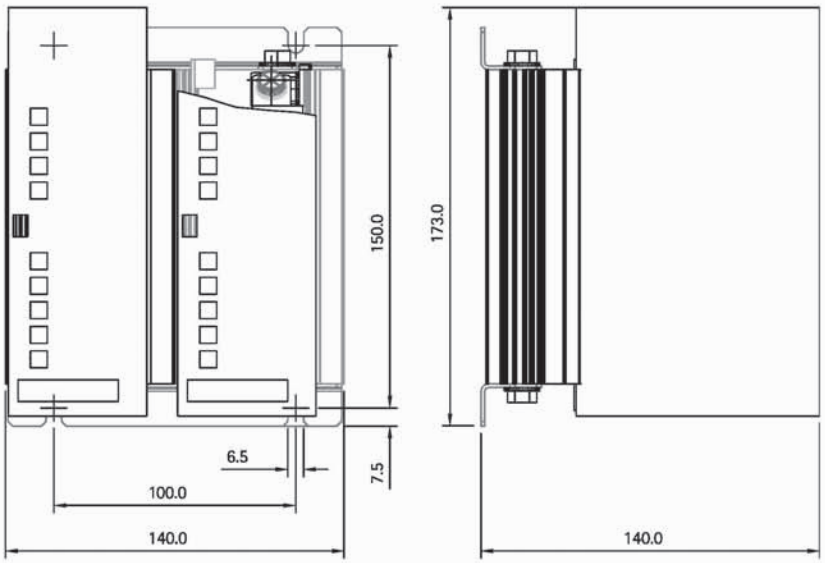
额定容量 Rated power	接线方式 Connection	额定电流 Rated current (A)		熔断器 Required fuses	重量 Weight (kg)	尺寸 Dimensions WxDxH (mm)	尺寸等级 Size	型号 Order code
		I1	I_{RMS} max.					
Rated voltage / 额定电压 400 V								
non-tuned / 不带电抗器								
12.5	Δ	18	25	3 x 50 A URL	2.1	140 x 140 x 173	1	Thyro-C 2C 400-45Ω
25	Δ	36	45	3 x 50 A URL	2.1	140 x 140 x 173	1	Thyro-C 2C 400-45Ω
50	Δ	72	100	3 x 100 A URL	3.7	170 x 172 x 173	2	Thyro-C 2C 400-100Ω
reactor protected, detuned to / 带电抗器保护，单调谐频率 210 Hz (p= 5,67%)								
12.5	Δ	18	25	3 x 50 A URL	2.1	140 x 140 x 173	1	Thyro-C 2C 400-45Ω
25	Δ	36	45	3 x 50 A URL	2.1	140 x 140 x 173	1	Thyro-C 2C 400-45Ω
50	Δ	72	100	3 x 100 A URL	3.7	170 x 172 x 173	2	Thyro-C 2C 400-100Ω
reactor protected, detuned to / 带电抗器保护，单调谐频率 133...189Hz (p= 7%...14%)								
12.5	Δ	18	25	3 x 50 A URL	2.1	140 x 140 x 173	1	Thyro-C 2C 400-45Ω
25	Δ	36	45	3 x 50 A URL	2.1	140 x 140 x 173	1	Thyro-C 2C 400-45Ω
50	Δ	72	100	3 x 100 A URL	3.7	170 x 172 x 173	2	Thyro-C 2C 400-100Ω
60	Δ	87	100	3 x 100 A URL	3.7	170 x 172 x 173	2	Thyro-C 2C 400-100Ω
Rated voltage / 额定电压 525 V								
non-tuned / 不带电抗器								
12.5	Δ	14	21	3 x 50 A URL	2.1	140 x 140 x 173	1	Thyro-C 2C 400-45Ω*
25	Δ	27	35	3 x 50 A URL	2.1	140 x 140 x 173	1	Thyro-C 2C 400-45Ω*
50	Δ	55	75	3 x 80 A URL	3.6	170 x 172 x 173	2	Thyro-C 2C 500-75Ω
reactor protected, detuned to / 带电抗器保护，单调谐频率 210 Hz (p= 5,67%)								
13	Δ	14	19	3 x 50 A URL	2.1	140 x 140 x 173	1	Thyro-C 2C 400-45Ω*
26	Δ	29	37.5	3 x 50 A URL	2.1	140 x 140 x 173	1	Thyro-C 2C 400-45Ω*
52	Δ	57	75	3 x 100 A URL	3.6	170 x 172 x 173	2	Thyro-C 2C 500-75Ω
reactor protected, detuned to / 带电抗器保护，单调谐频率 133...189Hz (p= 7%...14%)								
13.5	Δ	15	17	3 x 50 A URL	2.1	140 x 140 x 173	1	Thyro-C 2C 400-45Ω*
27	Δ	30	34	3 x 50 A URL	2.1	140 x 140 x 173	1	Thyro-C 2C 400-45Ω*
54	Δ	59	68	3 x 100 A URL	3.6	170 x 172 x 173	2	Thyro-C 2C 500-75Ω
Rated voltage / 额定电压 690 V								
non-tuned / 不带电抗器								
50	人	42	55	3 x 100 A URL	5.6	255 x 172 x 173	3	Thyro-C 3C 400-100Ω
87.5	人	73	95	3 x 100 A URL	5.6	255 x 172 x 173	3	Thyro-C 3C 400-100Ω
reactor protected, detuned to / 带电抗器保护，单调谐频率 210 Hz (p= 5,67%)								
44	人	37	50	3 x 100 A URL	5.6	255 x 172 x 173	3	Thyro-C 3C 400-100Ω
88	人	74	100	3 x 100 A URL	5.6	255 x 172 x 173	3	Thyro-C 3C 400-100Ω
reactor protected, detuned to / 带电抗器保护，单调谐频率 133...189Hz (p= 7%...14%)								
50	人	42	50	3 x 100 A URL	5.6	255 x 172 x 173	3	Thyro-C 3C 400-100Ω
100	人	84	100	3 x 100 A URL	5.6	255 x 172 x 173	3	Thyro-C 3C 400-100Ω

Note:Thyro-C 2C 400 - 45Ω on request with internal change of setting also available for 525 V.

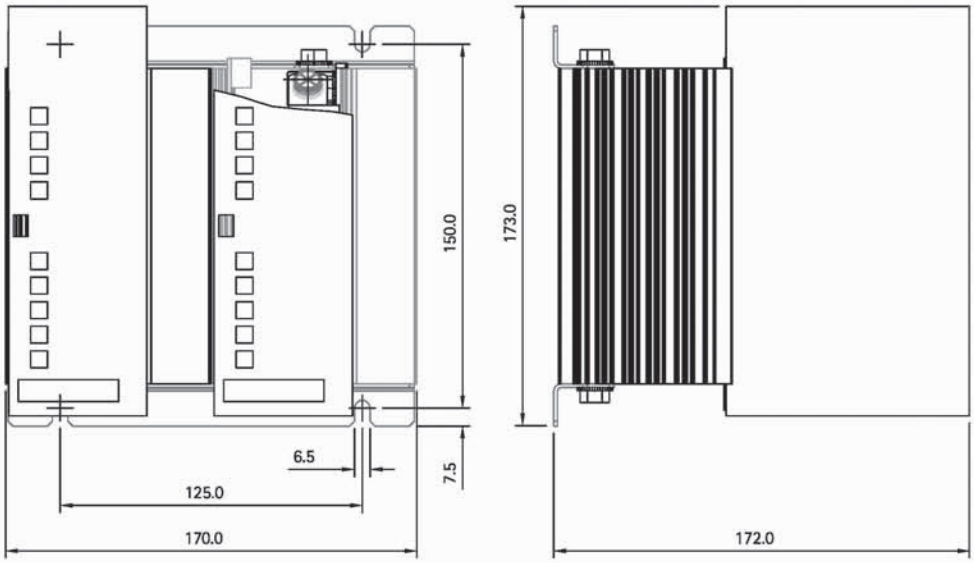
注：Thyro-C 2C 400-45Ω可根据需要修改内部设置以适用于525V电压等级。

外形尺寸图
Dimension

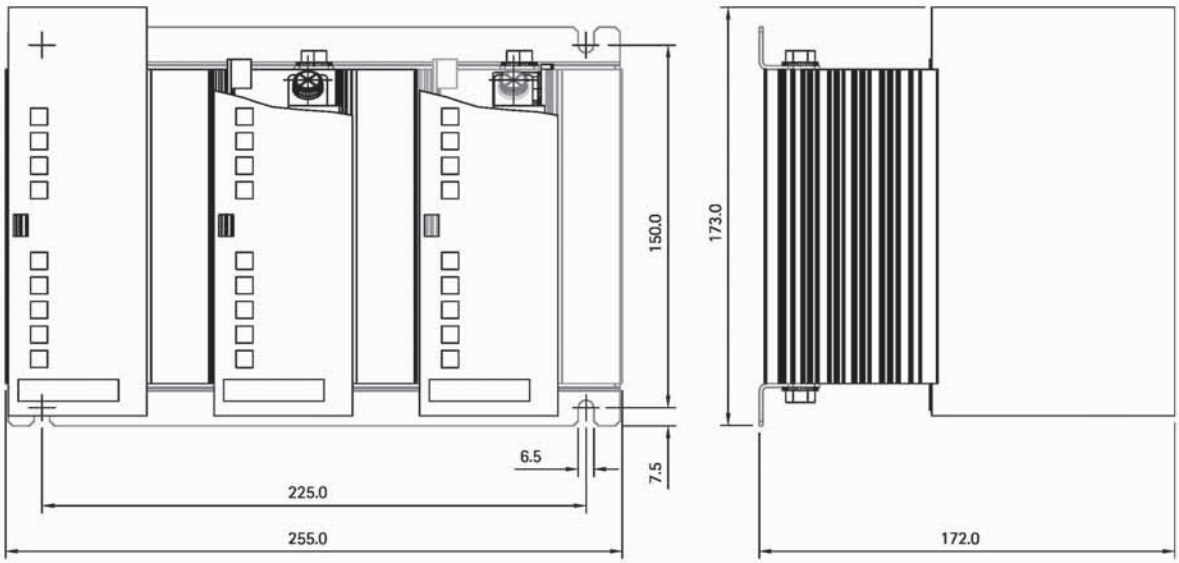
尺寸等级1
Size 1



尺寸等级2
Size 2



尺寸等级3
Size 3

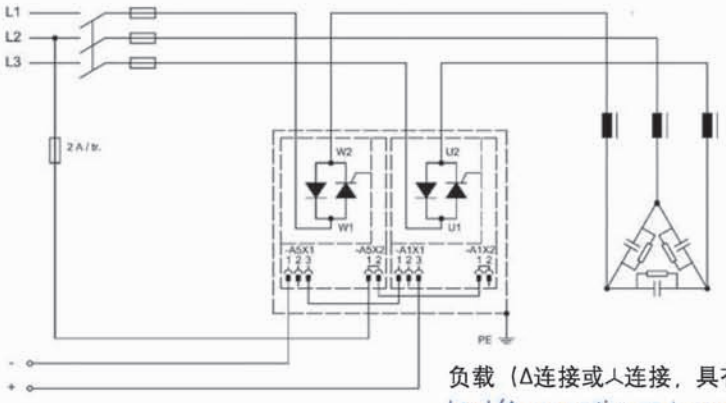


接线图
Connection diagrams

接线图—直流控制
Connection diagram – DC control
Thyro-C 2C

开关
Breaker acc.
EN 50178 (4/98)

直流控制
DC-Control
-X1/1-3 (1: u-/3: u+)
0-3 V OFF / 关
10-30 V ON / 开



滤波电抗器（可选项）
Filter reactor (optional)

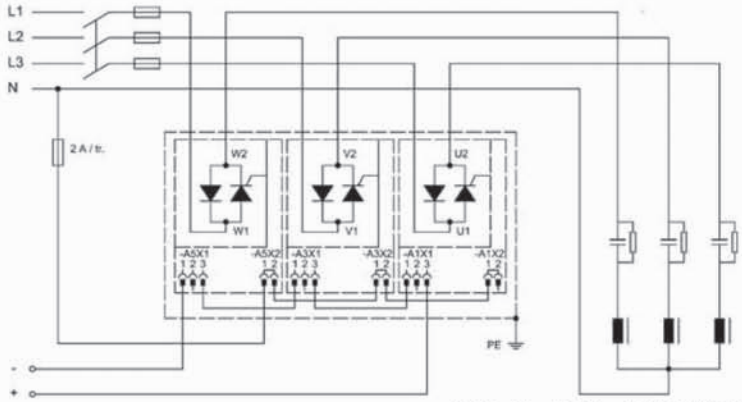
电容器带放电电阻
Capacitors with
discharge resistors

负载（Δ连接或人连接，具有隔离星型点）
Load (Δ-connection or 人-connection with isolated star point)

Thyro-C 3C

开关
Breaker acc.
EN 50178 (4/98)

直流控制
DC-Control
-X1/1-3 (1: u-/3: u+)
0-3 V OFF / 关
10-30 V ON / 开



电容器带放电电阻
Capacitors with
discharge resistors

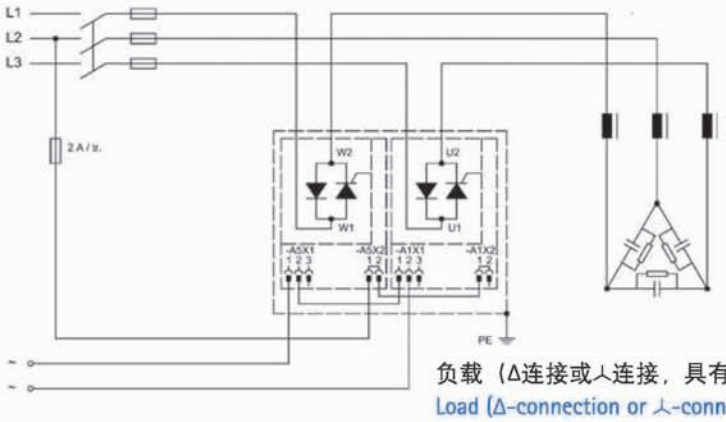
滤波电抗器（可选项）
Filter reactor (optional)

负载（人一连接，具有可连接的星型点）
Load (人-connection with connected star point)

接线图—交流控制
Connection diagram – AC control
Thyro-C 2C

开关
Breaker acc.
EN 50178 (4/98)

交流控制（预设置）
AC-Control (Presetting)
-X1/1-2
0-10 V OFF / 关
50-230 V ON / 开



滤波电抗器（可选项）
Filter reactor (optional)

电容器带放电电阻
Capacitors with
discharge resistors

负载（Δ连接或人连接，具有隔离星型点）
Load (Δ-connection or 人-connection with isolated star point)

注：熔断器2A/tr.用于线路保护。
Note: Fuse 2 A/tr is assigned for line protection

功率因数控制器 Pro-Con/DynamiC
Power factor controller Pro-Con/DynamiC

Characteristics:

- 4-quadrant measurement and constant supervision of inductive / capacitive load
- Measurement of reactive power by DFT, applicable in networks with high harmonic distortion
- Measurement, display and supervision of line voltage and current, active and reactive power, harmonics of U and I, line frequency, inside temperature
- Storage of maximum values
- Adjustment of target cosφ in range 0.80 (lag) - 1 - 0.80 (lead)

- External tariff change via port
- Discharge time and switch-off delay programmable
- Manual switching selectable
- Up to three fixed steps programmable
- No-volt release after network interruption longer than 15 ms.
- Optical indication of steps
- Alarm when target cos φ is not achieved

Supply and measuring voltage
230 V or 400 V, 45 ... 65 Hz
Measuring current
0 ... 5 A, operating threshold 10 mA, power consumption 0.2 VA
ct-ratio 1 ... 4000, overload 180 A for 2 sec
Steps
6 or 12 NO-contacts, common root, switching current:
250 V AC, 1000 W (Pro-Con) / 30 V DC, 50 mA (DynamiC)
Alarm-contact
1 NO-contact, volt-free, normal active
switching current contact 250 V AC, 1000 W
Interface
RS485 optional, backside, Profibus and Modbus protocol
Ambient temperature
Operating 10° C ... + 55° C, storing -20° C ... +60° C
Ambient humidity
0 % ... 95 %, moisture condensation not allowed
Over voltage class
III, pollution degree 2 (DIN VDE 0110, part1/IEC 60664-1)
Terminals: Cage clamps, max. 2.5 qmm
Dimensions / weight: 144 x 144 x 58 mm H x B x T, approx. 1000 g
Cutout:136 x 136mm

特性：

- 进行4象限测量，并连续监控感性/容性负荷。

- 通过DFT测量无功功率，应用在谐波失真较大的电网

- 测量，显示及监视线路电压和电流，有功和无功功率，谐波电压和电流，线路频率，内部温度等

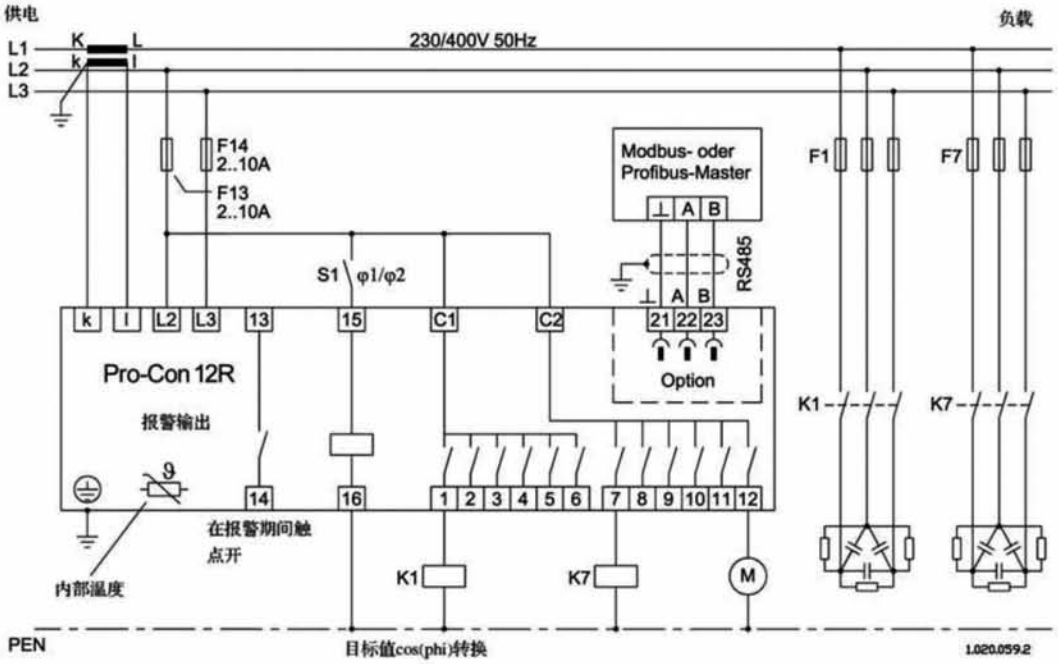
- 最大值储存
- 在范围0.80(滞后) - 1 - 0.80(超前)内，调整目标功率因数cosφ
- 通过通讯口从外部输入费率变化值
- 可对放电时间和切除延时编程
- 可对手动投切进行选择
- 最多可对三个固定调节级编程
- 电网中断供电超过15 ms后，失压释放
- 调节级指示
- 未达到目标功率因数cosφ时，发出警报

电源及测量电压
230 V 或 400 V，45 ... 65 Hz
测量电流
0 ... 5 A，运行极限电流 10 mA，功耗 0.2 VA ct-比率 1 ... 4000，过载 180 A，2 秒
调节步数
6 或 12 无触点，公共接点
单触点开关电流 250 V AC，1000 W
报警触点
1 无触点，常闭，正常有功
开关电流触点250 V AC，1000 W
接口
RS485 可选，后侧，Profibus和Modbus通讯协议
环境温度
运行 10° C ... + 55° C，储存 -20° C ... +60° C
环境湿度
0% ... 95 %，无潮湿及凝露
过压等级
III，污染等级 2 (DIN VDE 0110，第1部分/IEC 60664-1)
端子：自卡钢夹，最大 2.5 qmm
尺寸 / 重量：144 x 144 x 58 mm H x B x T，大约1000 g

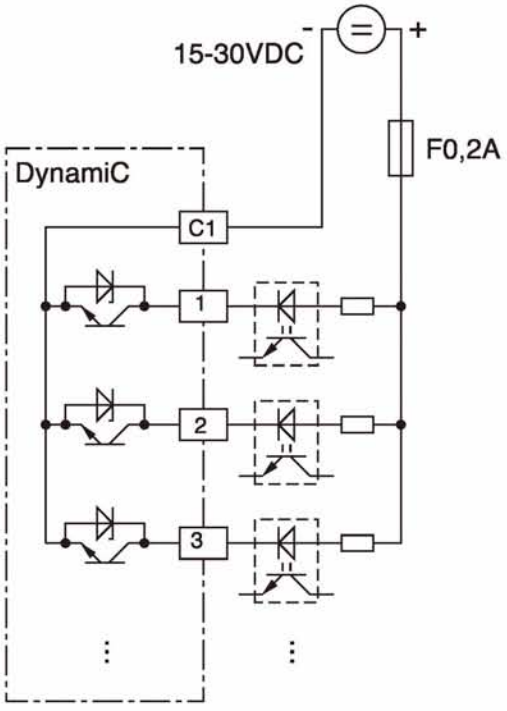
开孔：136 x 136mm

接线图
Connection diagrams

功率因数控制器接线图
Wiring of power factor controller



动态功率因数控制器与功率晶闸管的接线图
Wiring of DynamiC and Thyro-C module



注：端子 13-14 和 15-16 一般不必接线。
Note: No wiring connection is needed for terminal 13-14 and 15-16.

常规功率因数校正设备
Conventional power compensation equipment

Theoretical fundamentals

It is found that power factor compensation capacitors and the inductances of transformers and the power supply network form a parallel resonant circuit whose impedance at the resonant frequency of the oscillating circuit can be extremly high (theoretically infinite). If the resonant frequency approximates any harmonic frequency generated by the rectifier, then the harmonic current concerned will be forced over this high oscillatory impedance and the resultant voltage drop will lead to very high harmonic current that could damage the plant (Fig. 8).

In order to prevent resonances, a reactor will be connected in series with the compensation capacitor (Fig. 9). The resultant series resonant circuit is tuned to a resonant frequency that is beneath the lowest harmonic frequency. The power of the reactor concerned is specified as a percentage of the capacitor impedance referred to the fundamental current. Such reactor protected capacitors are also referred to as detuned filter circuits. How great the "absorption effect" (degree of filter) is, depends on the short-circuit impedance of the power supply network and the residual resistance of the detuned filter which is determined by the filter quality. The harmonic current generated by the current converter has to be suitably dimensioned.

Guide values

5th harmonic $I_5 = 0.23 \times I_1$
7th harmonic $I_7 = 0.12 \times I_1$
11th harmonic $I_{11} = 0.085 \times I_1$

These values are valid for ideal smoothing. If no smoothing or only slight smoothing is provided, then higher amplitudes must be anticipated, particulary in the case of the 5th harmonic (30 ... 35 % of the fundamental current). The advantages of detuned filter circuits are obvious:

- Compensation of the reactive power fundamental to a specified cosφ
- Avoidance of resonance in the power supply network

理论基础

研究表明，功率因数补偿电容器以及变压器和电网的电感构成了一个并联谐振电路，在谐振频率下，该电路的谐振阻抗可能会非常大（理论上无限大）。如该谐振频率接近整流器产生的任何谐波频率，则相关的谐波电流就会加到此高谐振阻抗上，所产生的电压降将导致非常大的谐波电流，这将损坏电厂设备（图 8）。

为避免谐振，可将一台电抗器与补偿电容器串联连接（图 9）。所构成的串联谐振电路可调谐到最低谐波频率以下。电抗器的功率可根据基波电流定义为电容器阻抗的一个百分比数值。这样的电抗器保护电容器组也称为去谐（可调）滤波器电路。吸收效果的大小（滤波器等级）取决于电网的短路阻抗和去谐滤波器的剩余阻抗（由滤波器质量决定）。电流变换器（变频器）产生的谐波电流会被适当调整。

参考数据

5次谐波 $I_5 = 0.23 \times I_1$
7次谐波 $I_7 = 0.12 \times I_1$
11次谐波 $I_{11} = 0.085 \times I_1$

这些数值是根据理想的平滑波形计算得到的。如波形不平滑或不够平滑，则应考虑更高幅值，特别是对于5次谐波的情形（30 ... 35%的基波电流）。可调滤波器电路的优势非常明显：

- 根据特定的功率因数cosφ，补偿无功功率。
- 避免电网谐振

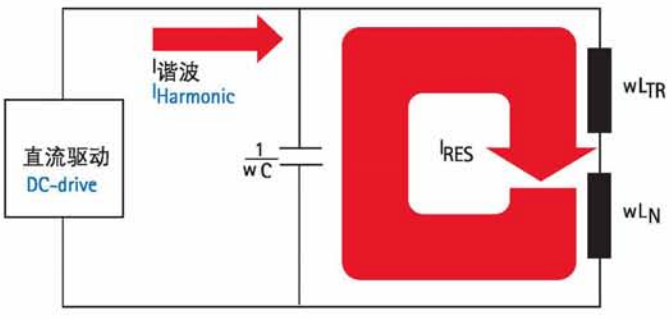


图 8: 并联谐振时的电流放大作用
Fig. 8: Current amplification in case of parallel resonance

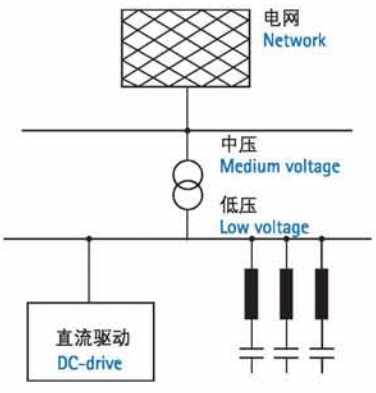


图 9: 用电抗器保护的电容器实现补偿
Fig. 9: Compensation with reactor-protected capacitors

动态功率因数校正设备
Dynamic power compensation equipment

General

Many industrial plants today use highly dynamic drive technology. In addition to the undisputed advantages of this modern technology, however, there is the disadvantage that the power networks are stressed by frequent changes in load as well as harmonics. This causes unstable voltage conditions, flickering, excessive currents and greater losses in power distribution. This in turn not only decreases the amount of useable network power but also affects the functions of sensitive electronic controllers.

Conventional reactive power compensation systems are designed for the pure optimization of the power factor and also to reduce the harmonics level but are not able to keep up with fast load changes and do not provide a satisfactory solution to the problem described above. The application area of these systems is the compensation of static, or slowly changing loads with switching cycles in the minutes range.

DynamiC

- At each moment optimized cosφ
- Soft switching without transients
- Flicker eliminated

Application

The real-time power factor compensation equipment in the DynamiC series offers a solution. In these assemblies the classic components controller and air contactor are substituted by a combination of corresponding high speed controller and thyristor power modules Thyro-C. This system reacts immediately to load fluctuation and reactive power surges will be neutralised in the supply network. The power factor is optimised at each moment, the negative effects described above are reduced to a minimum. This gives the consumer not only the advantage of a stable supply ratio, but the ability to minimise energy distribution and reduce costs. To increase the switching performance to an optimum, the control signal for the control of the capacitor banks can alternatively be given directly by the logic control of bigger loads.

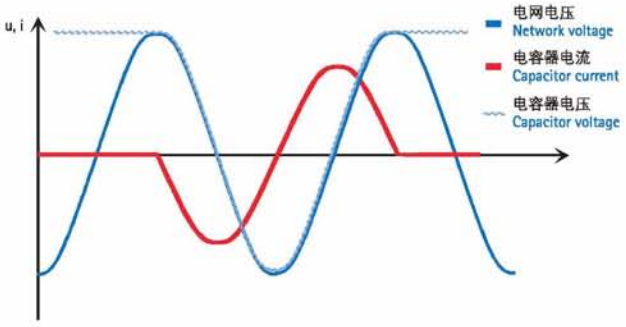


图 8：电压和电流曲线
Fig. 8: Voltage and current curves

基本原理

今天，很多工厂都采用高动态变频驱动技术。虽然这种现代科技会具有无可争辩的优势，但是负荷频繁的变化也会给电网带来很大压力，譬如谐波。这将导致电压不稳定运行状态、瞬变、大电流冲击以及功率传输中较大的功率损耗等。其结果不仅减少了电网的可用功率，同时也干扰了敏感的电子控制器设备的运行。

传统无功功率补偿系统用来全面优化功率因数和降低谐波水平，但是无法适应负荷的快速变化，因此无法为上述问题提供满意答案。这些系统的应用领域是静态，或者变化缓慢的负荷的补偿（开关周期为分钟级）。

DynamiC

- 随时优化功率因数cosφ
- 无瞬变电流平滑切换
- 消除瞬变

应用

DynamiC系列产品中的实时功率因数补偿装置为此提供了解决方案。在这些配件中，传统控制器及空气接触器被相应的高速控制器及半导体晶闸管功率模块Thyro-C替代。该系统可快速响应负荷波动，抑制电网无功功率浪涌，对功率因数随时进行优化，将上述负面影响减至最小。这不仅为用户提供了稳定电源，还极大的减少了电能传输的损耗，从而降低了费用。为了优化补偿装置的开关性能，可选择由大负荷逻辑控制电路直接提供电容器组控制器的控制信号。

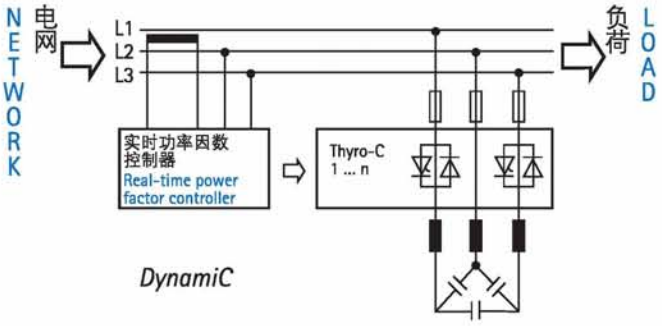


图 9：电路原理图
Fig. 9: Schematic circuit diagram

无源调谐滤波设备
Tuned filter circuits equipment

General

Filter circuit systems are used in very harmonics-stressed networks. They compensate existing inductive reactive power and, at the same time, improve the quality of the system voltage. Adherence to the limit values for the harmonic load in accordance with EN 61000-2-2 can only be accomplished in many industrial power networks by using these especially tuned filter circuits (also called passive filter circuits). Figures 14 and 15 illustrate how the filter circuits work.

概述

滤波器电路系统可用于谐波污染严重的电网。它们可以补偿已有的感性无功功率，同时改善系统电压的质量。在许多工业电网中，只有使用这些按特定频率调谐的滤波器电路（又称为被动滤波器电路），才能确保满足标准EN 61000-2-2中针对谐波负荷的限制条件。图14和15说明了滤波器电路的工作原理。

Application

Filter systems are (similar to reactor-protected compensation systems) made up of modules. The number and capacity of the individual modules depends on both the amount of compensation capacity needed and, much more importantly, on the amount of discrete harmonic currents.

应用

滤波器系统由各种模块组成（类似于电抗器保护的补偿系统）。个体模块的数量及容量取决于所需的补偿容量，更取决于离散谐波电流的大小。

Regarding the compensation capacity, the selection of the tuning frequencies only plays a minor role but not with regard to the effect of the filter circuit system for improvement of the quality of the network voltage. This is the special significance of the systems with tuned filter circuits in comparison to the systems with reactor-protected capacitors. To obtain optimum efficiency at the same time as inexpensive design, the filter circuits must be precisely tuned to the existing network conditions. They are made up of modules whose resonance frequencies correspond to the frequencies of the power converter perturbations. With the 6 and 12-pulse power converters which usually exist in the low voltage network, these are modules for the 5th, 7th, 11th and 13th harmonics.

如果不考虑滤波器电路系统在改善电网电压质量方面的作用，那么比起补偿容量，调谐频率的选择只扮演了次要角色。这就是调谐滤波器电路和电抗器保护电容器组相比所具有的特殊意义。为取得最佳效果，同时减少设计成本，滤波器电路必须精确调谐，以适应现有的电网条件。滤波器电路组成模块的谐振频率与功率变换器的扰动频率相对应。
6相及12相功率变换器通常存在于低压电网，这里可采用适用于5次，7次，11次和13次谐波的模块。

Calculation of the harmonic currents to be expected must always be performed for the greatest load (worst case). The following values derived from experience can be used to estimate the harmonic currents.

必须根据最大负荷（最差情况）来计算谐波电流。以下的经验值可用于估算谐波电流：

- 5th harmonics $I_5 = 0.30 \ldots 0.35\ I_1$
- 7th harmonics $I_7 = 0.10 \ldots 0.12\ I_1$
- 11th harmonics $I_{11} = 0.08 \ldots 0.10\ I_1$
- 13th harmonics $I_{13} = 0.06 \ldots 0.08\ I_1$

- 5次谐波 $I_5 = 0.30 \ldots 0.35\ I_1$
- 7次谐波 $I_7 = 0.10 \ldots 0.12\ I_1$
- 11次谐波 $I_{11} = 0.08 \ldots 0.10\ I_1$
- 13次谐波 $I_{13} = 0.06 \ldots 0.08\ I_1$

These standard values apply to 6-pulse power converters and frequency converters with network-side diode bridge. Otherwise the specifications of the power converter suppliers apply. An optimal tuning of the filter circuits to the existing power and load conditions can be achieved with a harmonics analysis (network measurement).

这些标准计算数值可用于6相功率变换器和带电网侧整流桥的频率变换器。否则应该由功率变换器的供应商提供以上数值。通过谐波分析（电网测量），可获得符合当前功率和负荷条件的滤波器电路优化调谐。

有源滤波系统
Active filter system

General

Active power capacity filters differ fundamentally from passive compensation and filter circuit systems. They function like a controlled current source. This permits current in any phase, amplitude and frequency to be supplied to the network. Reactive power, changes in load and harmonics are actively compensated by the principle of suppression.

概述

有源滤波器与被动式无功补偿和滤波器电路系统有着本质的区别。其功能相当于一个可控电流源，可向电网提供任意相位、幅值和频率的电流。随负荷和谐波改变的有功功率，可根据抑制原理得到主动补偿。

Technology

Active filter systems basically consist of an (IGBT) voltage source DC link converter. To eliminate the clock pulse frequency, this is connected via a power filter to the power to be compensated. The DC link is equipped with a direct current capacitor as the source of power. The control electronics continuously compare the actual value on the network with the specified ideal value and simultaneously update the current flow for each phase separately (phase current control).

技术

有源滤波系统主要部件是一个（IGBT）电压源直流环节变换器。为消除时钟振荡频率，它通过功率滤波器连接到需要补偿的功率电路中。该直流环节装有一个直接电流电容器作为功率源。控制电子元件会连续比较网络实际参数值和给定的理想参数值，同时单独调整每相的电流（相电流控制）。

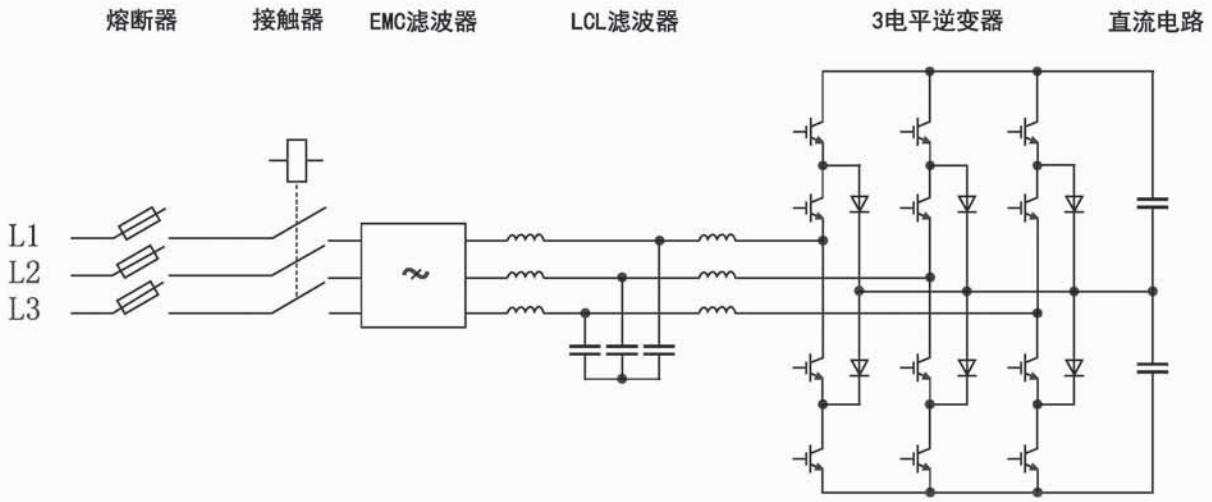


Fig. 17 Principle circuit diagram of active filters(four-conductor model shown with broken lines).

图 17:有源滤波器电路原理图（虚线表示4线制类型）。

Reactive power compensation

The device can supply any basic harmonic reactive power inductively and capacitively at the connection point to the network. This is done separately for each phase which also contributes to the symmetry of current consumption.

无功功率补偿

该装置可从电网接入点向电网提供任何基本谐波的感性无功和容性无功功率。它为每个相位单独提供功率，这样也可以起到平衡三相电流的作用。

Harmonics compensation

The load current to be compensated is acquired via a current converter. The active filter isolates the harmonics portion from this signal and feeds this during phase opposition back to the network. This causes a suppression and the network current now only consists of the pure basic harmonics portion. The controller can both suppress all harmonics in real time or, as an alternative, compensate individually selected harmonics as well as reactive power.

谐波补偿

通过变频器获得需要补偿的负荷电流。有源滤波器将谐波部分从该信号中分离出来，通过反相叠加，将其返回至电网中。这就起到了抑制谐波的作用，从而使电网电流只包含纯粹的基波部分。该控制器不仅可以实时抑制所有的谐波，也可单独补偿用户所选择的谐波及无功功率。

Neutral conductor compensation

In the special model for four-conductor networks, the device consists of four power circuits. This is necessary for the compensation of harmonics of the 3rd harmonic and their multiples on the neutral conductor. The design of the neutral conductor circuit can be selected up to three times the load of the outer conductor.

中性线补偿

在四线制电网的特定模型中，装置由四个功率电路组成。这对于3次谐波及其在中性线上叠加的谐波的补偿都是十分必要的。中性线负载能力最大可为外部导体负荷的三倍。

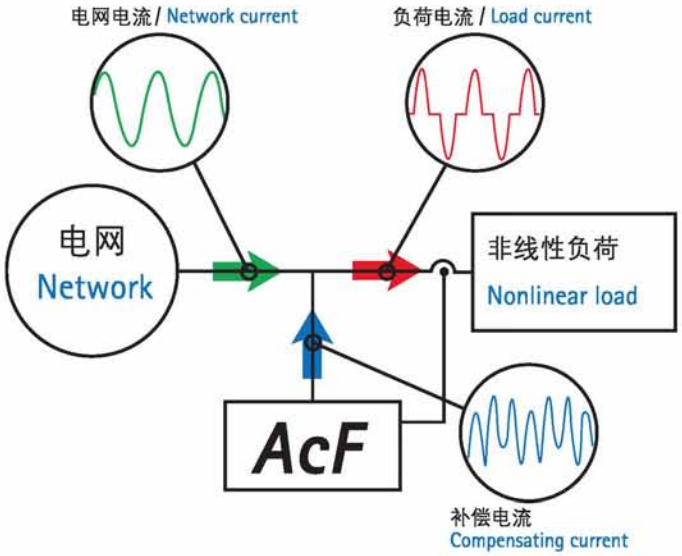


Fig. 18: Function principle of active filter

图 18:有源滤波器功能原理

Flicker compensation

With a fast increase in the load to be compensated, the active filter briefly feeds the power stored in the DC link capacitor to the power network. When the load drops, the active filter pulls power in reverse from the network into the DC link. Using this principle, the network-side change in load is smoothed and the flicker effect (perceptible light fluctuations) is reduced to below perception (Pst = 1). The devices must be equipped for flicker compensation with an enlarged DC link capacity.

瞬变补偿

补偿负荷快速增加时，有源滤波器暂时将在直流环节电容器中储存的功率反馈到电网中。负荷下降时，有源滤波器将功率从电网拉回到直流环节中。借助该原理，电网侧的负荷变化被平滑处理，瞬变效应（可感觉到的光波动）降低到无法感知的程度（Pst = 1）。为实现瞬变补偿功能，该设备必须和大容量的直流环节配合使用。

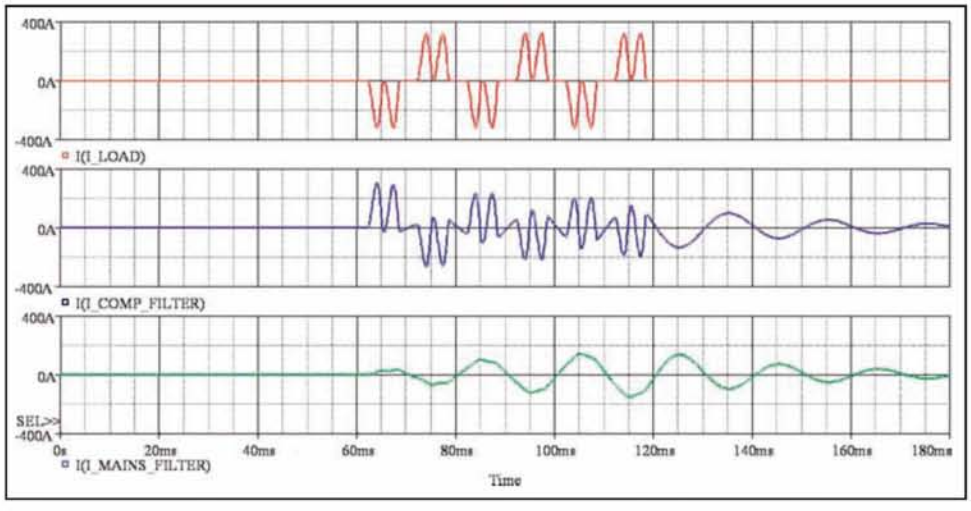


图 19:负荷中的脉动电流（红色），有源滤波器中电流（兰色）以及平滑输出的电网电流（绿色）

Fig. 19: Pulsed current consumption of a load (red), of the active filter (blue) and smoothed out of the network (green).

有源滤波系统
Active filter system

Typical application areas are networks with:

- High harmonic load
- Harmonic currents on the neutral conductor
- Asymmetrical load
- Quickly changing loads
- Flicker load

典型应用领域：

- 高谐波负载
- 中性线导体上的谐波电流
- 不对称负载
- 快速变化的负载
- 瞬变负载

适用于三相三线系统
ACF for three wire system

功率 Power (kvar)	订货号 Order code	电流每相 Current per phase (A)	尺寸 Dimensions W x D x H (mm)	重量 Weight (kg)	推荐 CT Recommended CT	熔断器 Fuse (A)	电缆尺寸 Cable size (mm2)
Rated Voltage / 额定电压400 V							
87	GRIDCON ACF-400/125-P3	125	800x600x2000	340	xx/5,kl.1	250	95
174	GRIDCON ACF-400/250-P3	250	800x600x2000	460	xx/5,kl.1	315	120
261	GRIDCON ACF-400/375-P3	375	800x600x2000	580	xx/5,kl.1	450	2x70
348	GRIDCON ACF-400/500-P3	500	800x600x2000	700	xx/5,kl.1	630	2x120
Rated Voltage / 额定电压 690 V							
150	GRIDCON ACF-690/125-P3	125	800x600x2000	340	xx/5,kl.1	250	95
300	GRIDCON ACF-690/250-P3	250	800x600x2000	460	xx/5,kl.1	315	120
450	GRIDCON ACF-690/375-P3	375	800x600x2000	580	xx/5,kl.1	450	2x70
600	GRIDCON ACF-690/500-P3	500	800x600x2000	700	xx/5,kl.1	630	2x120

注：适用于三线四线的有源滤波设备请垂询。

Note: ACF for four wire system are available upon request.

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