LTE 雷特电机
Power · Quality · Resource

Dry Type Phase-shifting Rectifier Transformers

高压变频器用移相整流变压器

专业制造

About LTEC

Founded in 2004,LTEC has become the long-term partners of many global enterprises. We are located in Kunshan, China, covering an area of about 20,000 square meters with annual sales of nearly 100 million yuan.

We are dedicated to provide the power quality and converter solutions up to 35kV, including LV and MV detuned or filter reactors, passive filters, sine filters, and MV rectifier transformer. Our products are widely used in power grid, industry, transportation, IT, education, and municipal projects.

LTEC is continually striving to improve our process and technology,approved by ISO9001 quality system. We have the leading certifications of reactors and MV transformers, in consist of UL, TUV, CE, EAC,GOST. In addition to that, we cooperate closely with domestic universities for technical innovation. We build up our name with superior quality. By 2020, our products have sold out to more than 30 countries and regions, including Europe, America, Asia, Oceania and so on.

关于雷特

雷特电机位于江苏省昆山开发区，成立于2004年，注册资本5000万元，占地面积约20000平方米，年销售额近亿元，已成为众多知名企业电能质量领域的长期合作伙伴。

公司致力于提供35kV以下的电能质量及变压器等相关产品，包括中低压补偿及滤波电抗器，无源和正弦波滤波器，高压移相整流变压器等，主要覆盖输配电网，工业制造，轨道交通，信息通信,医疗教育,市政工程等项目,为国网江苏、上海虹桥机场、博世汽车、金鹰广场、武汉硅谷等许多现场提供过产品。

作为行业内的知名企业，我们一直追求工艺和技术领先，率先进行电抗器和变压器的国际认证，并通过ISO9001质量管理体系认证。变压器和电抗器产品已通过北美UL认证，德国莱茵的欧盟CE和TUV标识双重认证，并具有俄哈地区的EAC和GOST认证。同时与国内高校紧密合作，不断追求技术创新，以品质可靠享誉业界。至2020年，产品已销售到世界30多个国家及地区，包括欧洲、美洲、亚洲、大洋洲等。

E487892 ISO9001 ISO14001

MV Workshop / 中压车间

c UL us
E487892

FTA thermal Class 220(R)
Electrical insulation system

www.ltec.com.cn

Certificates & Patents/证书及专利


CERTIFICATE OF COMPLIANCE


CERTIFICATE
of Conformity
Low Voltage Directive 2006/95/EC


Zertifikat Certificate


Zertifikat Certificate


QUALITY MANAGEMENT SYSTEM CERTIFICATE


安全生产标准化
Work Safety Standardization
证书
CERTIFICATE


ЕВРАЗИЙСКИЙ ЭКОНОМИЧЕСКИЙ СОЮЗ
ДЕКЛАРАЦИЯ О СООТВЕТСТВИИ
EAC


ДЕКЛАРАЦИЯ О СООТВЕТСТВИИ


高新技术企业
证书


昆山市
企业技术中心
昆山市"三自"创新办公室
2014年12月


苏州市
高性能电力电抗器工程技术研究中心
苏州市科学技术局
二〇一六年


昆山市科技研发机构
昆山市科学技术局
二〇一四年


江苏省
企业研究生工作站
江苏省教育厅
江苏省科学技术厅
二〇一五年十月


昆山市科技成长型"小巨人"
重点培育企业
昆山市推进转型升级发展领导小组办公室
昆山市经济和信息化委员会
二〇一五年六月

R&D Capability

Our R&D group have more than 30 years experiences of designing and manufacturing the transformers. The advanced Solidworks software stimulates the transformers in view of 360 degree.Up to now, our dry type transformers can be up to 14MVA, with BIL170kV at 35kV system. We could offer you the high performance transformers, superior to the defined standard.The customized solutions are also available upon requested,to satisfy your requirements in any applications.

UL 1446 EN 50588
IEC 60076 EN 50216
IEEE 519

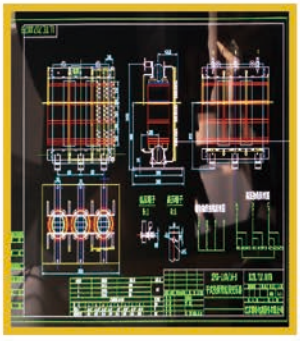
Up to July 2020, we have achieved 3 invention patents, 29 utility model patents, and 10 software copyrights.

研发实力

我们的技术团队拥有30多年的设计和实践经验，采用先进的SOLIDWORKS三维设计软件，可对产品360度模拟、仿真。目前干式变压器设计制造能力达到14MVA，满足35kV产品雷电冲击170kV标准，且实际性能明显优于国内外相关标准。可提供各种定制化方案，以最大程度地满足客户的实际使用要求。

GB/T 10228 GB/T 14549
GB/T 18494
GB/T 1094

至2020年7月，我司已取得3个发明专利，29个实用新型，10个软件著作权。



西安交通大学
XI'AN JIAOTONG UNIVERSITY

Production Management

We are specialized in manufacturing the high efficiency and excellent performance MV transformers, with optimization of our quality management system time to time.All our products are manufactured based on the ISO9001:2015 certified by CQC in China. In addition, we have been approved by the safety production standardization. By 2021, the environmental system of ISO14001:2015 will be carried out in our factory.

We delicately select the UL approved insulation materials with VPI(vacuum pressure impregnated) process to every transformer.Typically we have the 220 degree insulation system approved by UL, so the life expectations and insulation strength of transformers can be longer than before.

From the beginning, we follow the strict sampling inspection regulations to the incoming materials, and confirm all the key characteristics each lot before in-house, including appearances, dimensions, specifications, insulation performances, electrical conductivities, and then implement the product traceability in the whole process.

生产管理

我们致力于生产能效高且性能优越的干式变压器，并通过不断优化生产管理流程来实现 。 生产制造过程已通过CQC认证中心ISO9001:2015版质量体系最新认证，并取得安全生产标准化的证书，于2021年获得ISO14001:2015版的环境体系认证。

产品选用UL标准绝缘材料，采用VPI真空压力无溶剂浸漆工艺，并已取得美国UL220度绝缘系统认证报告。产品寿命和绝缘性能显著增强。

根据公司体系管理的要求，对所有原材料进行严格的来样检查制度，对外观构造、尺寸规格、电气绝缘性能、导电率等关键特性进行复核确认，保证每批原材料的合格率，并对整个生产流程实行严格的可追溯性管理。

Process Control

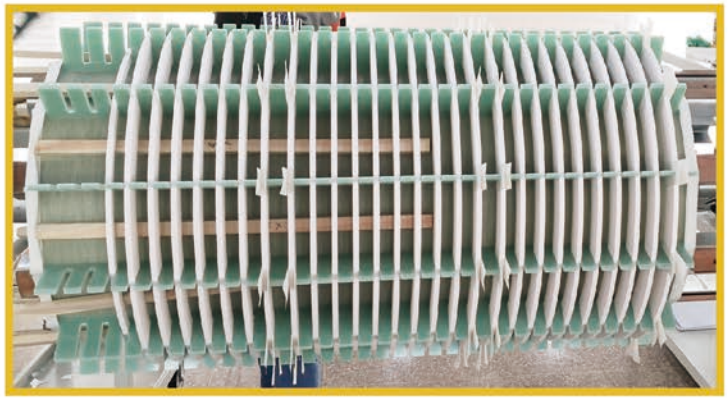
Magnetic cores are manufactured with cold rolled magnetic sheet with high permeability. The individual 45 degree cut sheets use the step lap technique. The special coating to the core surface helps the anti-rust and moisture, with very lower losses and noise under no load conditions.

The windings are made by H or C Class paper covered wires, with NOMEX insulation paper between the winding groups. The dis wound coils guarantees mechanical strength. The connection between the wires and Copper busbar are TIG welded.

Temperature sensor of PT100 is also embedded inside the coils. Customers could have the options to connect with the external monitoring devices to detect the three phase winding temperature rise in one circle, and convert it to the digital signal through RS232/485 MODBUS.

The C class silicon rubber at the bottom of the mounting brackets can reduce the vibration of the transformers in real operations.

Our dry type rectifier transformer is forced air cooling. In normal operations, the capacity can be increased by 30% to 40%,compared with natural air transformers.



过程控制

铁芯采用优质冷轧高导磁性取向或无取向硅钢片，45度斜角三步进结构，铁芯表面进行特殊的防锈防潮涂层处理，确保产品空载损耗低，噪音小。

线圈可选用H级(180度)或C级（220度）优质NOMEX纸包线，出线绝缘采用NOMEX纸包裹，连续式线圈结构确保机械性能强。导线和铜排采用电弧焊连接。

变压器线圈内侧预埋PT100温度传感器，可外接控制器自动检测三相的绕组温度值，并通过RS232/485通讯接口实现数字信号的输出。

变压器还内装C级硅橡胶减振垫块，降低产品运行中的噪音。

目前，我司生产的移相整流变压器为强制风冷型，正常使用时，比自冷变压器增容30%～40%。

Testing Capacity

The testing facility area covers about 1000 square meters, for comprehensive testing of dry type transformers. We can perform the routine, type and special tests, such as temperature rise, partial discharge, lightning impulse. All the transformers will be 100% tested before delivery, along with the full testing reports and technical drawings for file.

The testing center is also equipped with the frequency conversion power, frequency ranging from 45Hz to 240Hz, output current to 1300A, to meet any frequency testing request. The AC withstand voltage level is up to 250kV,and the lightning impulse testing capability is up to 1200kV,with chop wave output voltage to 900kV.

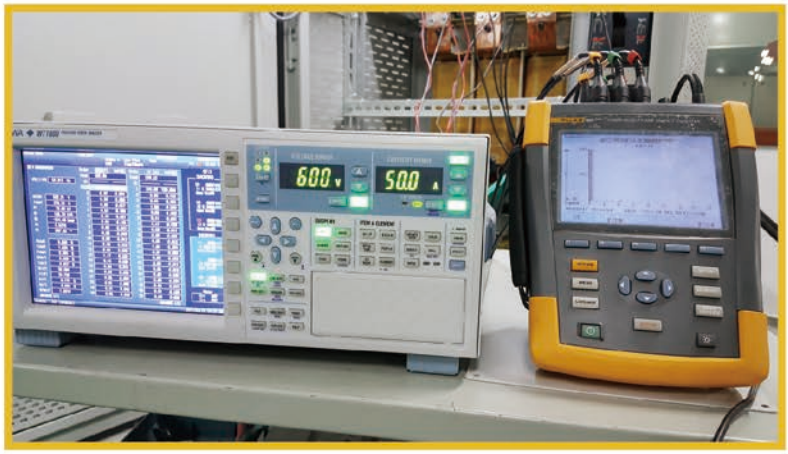
测试能力

我们拥有1000平米的测试中心，现场可满足干式配变和移相整流变压器的全套测试要求，包括例行试验、型式实验和特殊试验，如温升试验，局放试验，雷电冲击试验等。所有变压器产品100%测试合格后才可交付，并可提供完整的测试报告。

测试中心配备的变频电源，频率范围从45Hz到240Hz，输出电流达到1300A，满足客户任一频率的测试要求。工频耐压设备可达250kV，雷电冲击设备能力高达1200kV，截波输出电压到900kV。

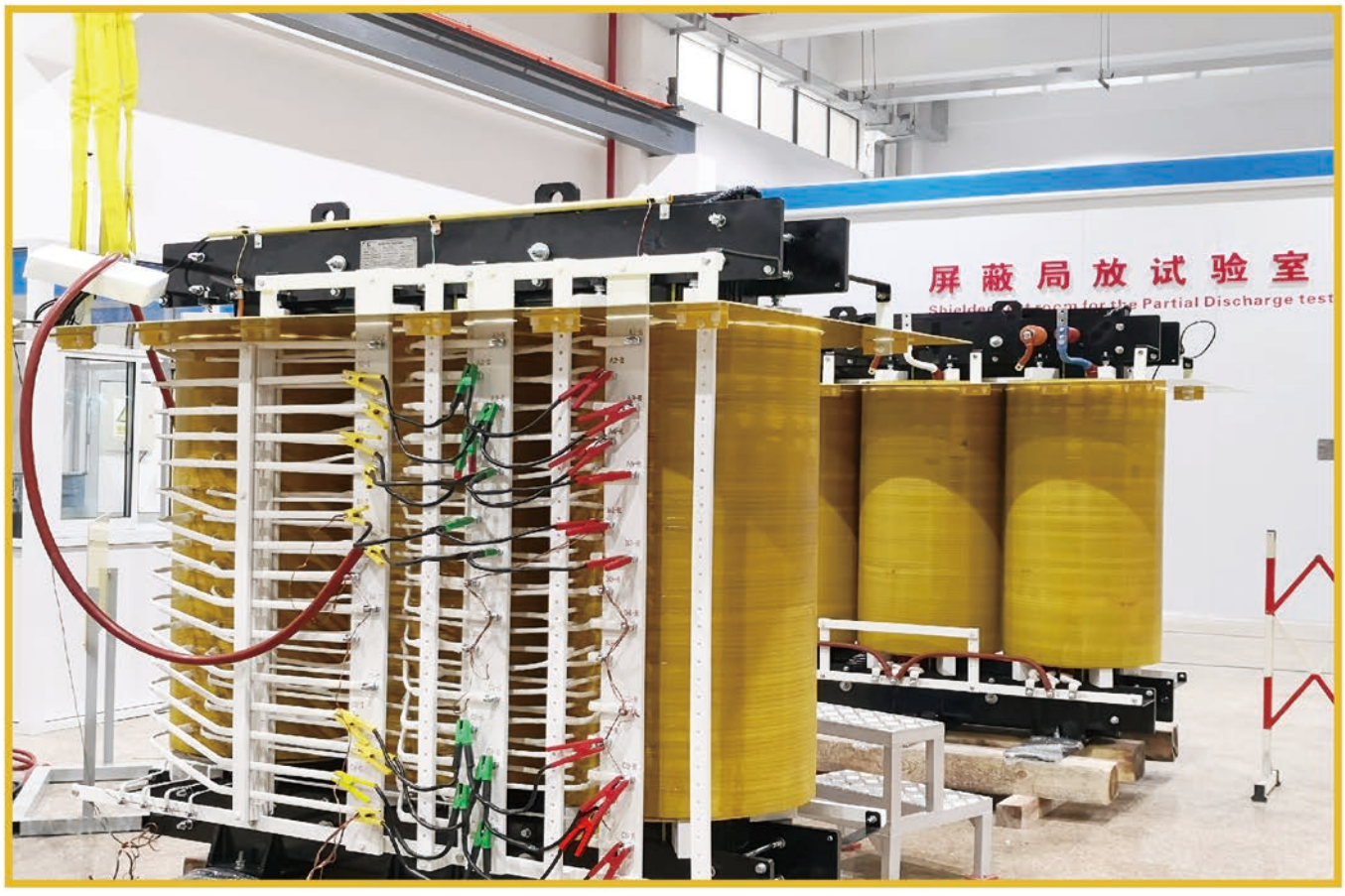
Quality Assurance

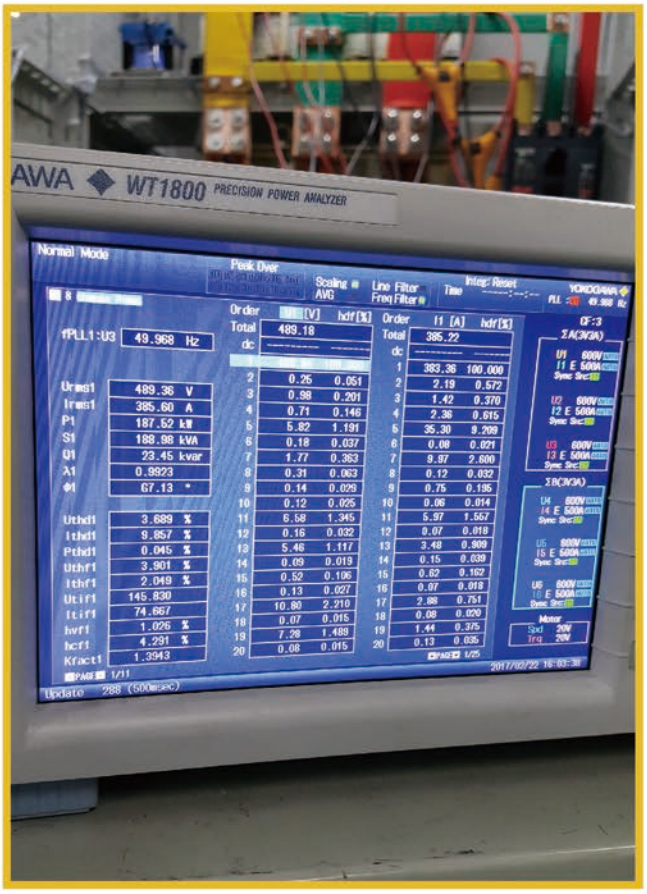
In addition, the 250kVA PD testing equipment is installed in an independent room with 1pC background PD, to test the single transformers within 10pC at 1.3 Un. We are also equipped with the YOGOKAWA power analyzer to precisely measure the losses and other parameters with a high level of 0.2%. Above all, 200Hz frequency doubling generator without partial discharge can magnify 3 times of frequency (50Hz/60Hz) for further inductive or PD testing to the transformers.



品质保证

另有250kVA容量的独立屏蔽局放试验室（背景局放<1pC），可在1.3Un条件下测试单台变压器的局放水平在10pC以下。采用日本横河的功率分析仪，精度可达0.2%，确保损耗等参数测量值的精准度。另外，我们还配有200Hz倍频无局放发电机组，可对50Hz/60Hz产品做3倍频感应或局放试验。




WT1800 PRECISION POWER ANALYZER


ICM-3000 冲击控制系统
MCGS


FLUKE
47.8°C
F1
F2
F3


综合性能测试台
功率分析仪
江苏雷特电机股份有限公司
Jiangsu LTEC Electric Co., Ltd.

Temperature Rise

The temperature rise of phase-shifting rectifier transformer is same as general purposed transformers. Please pay more attentions to below points:

1) The high frequency harmonics in transformer operations will increase to some extent the stray losses, which must be considered in calculating the temperature rise.

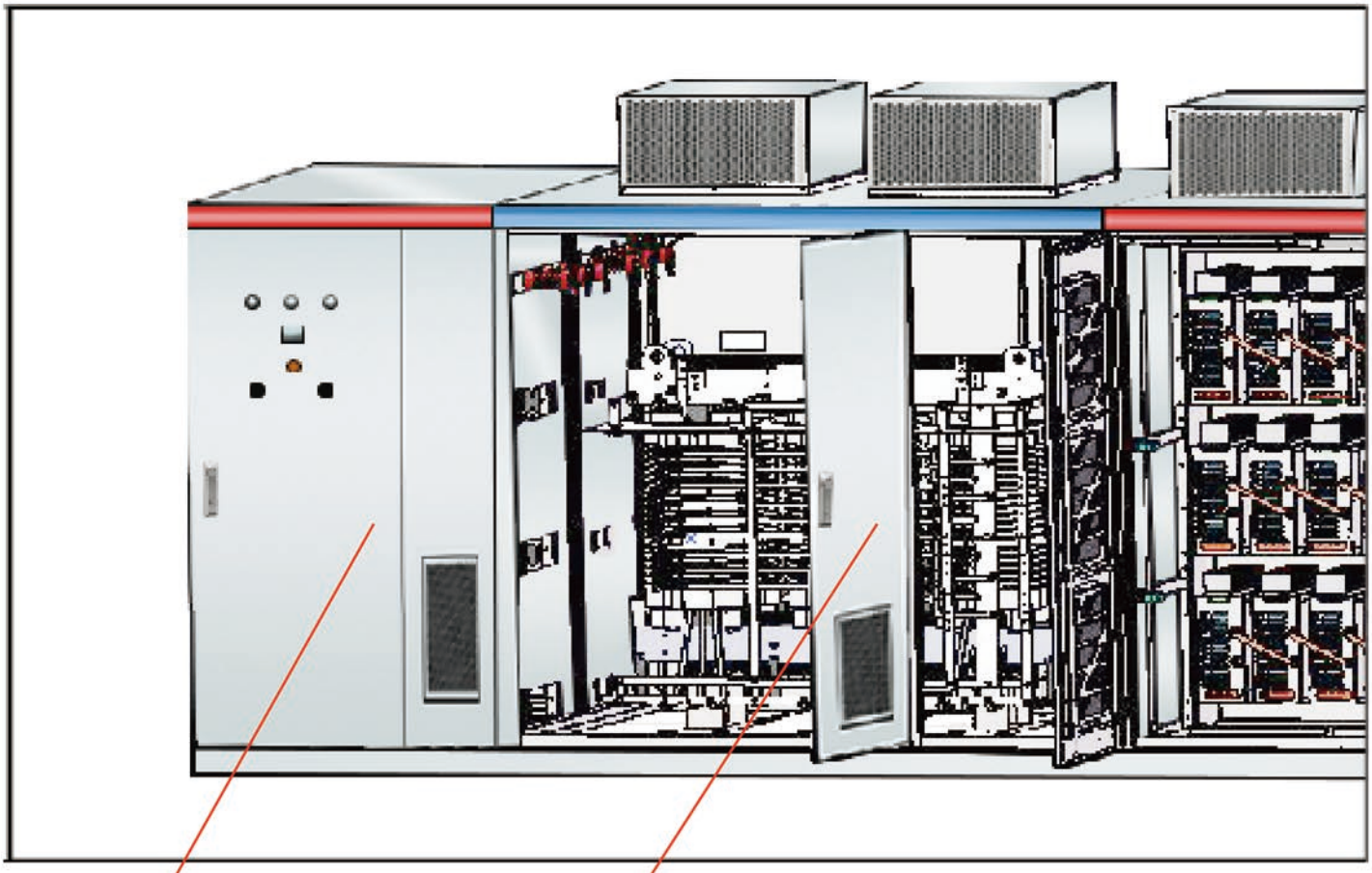
2) When the transformer is energized, a large impulse current will be generated as the DC capacitors are charged. This inrush current is equivalent to a simultaneous short-circuit current of all the secondaries, and it will last for one and half cycle, which should not be ignored.

温升

移相整流变压器的温升同常规变压器相同，但要注意以下几点：

1）移相整流变压器在运行时有高频谐波，由谐波电流引起的杂散损耗会增加，必须在计算温升时考虑在内。

2）当移相整流变压器运行时，因高压变频器的直流电容充电会产生一个相当大的冲击电流，这个冲击电流相当于所有副边同时短路，并持续一个半周期，这个因素不应忽略。



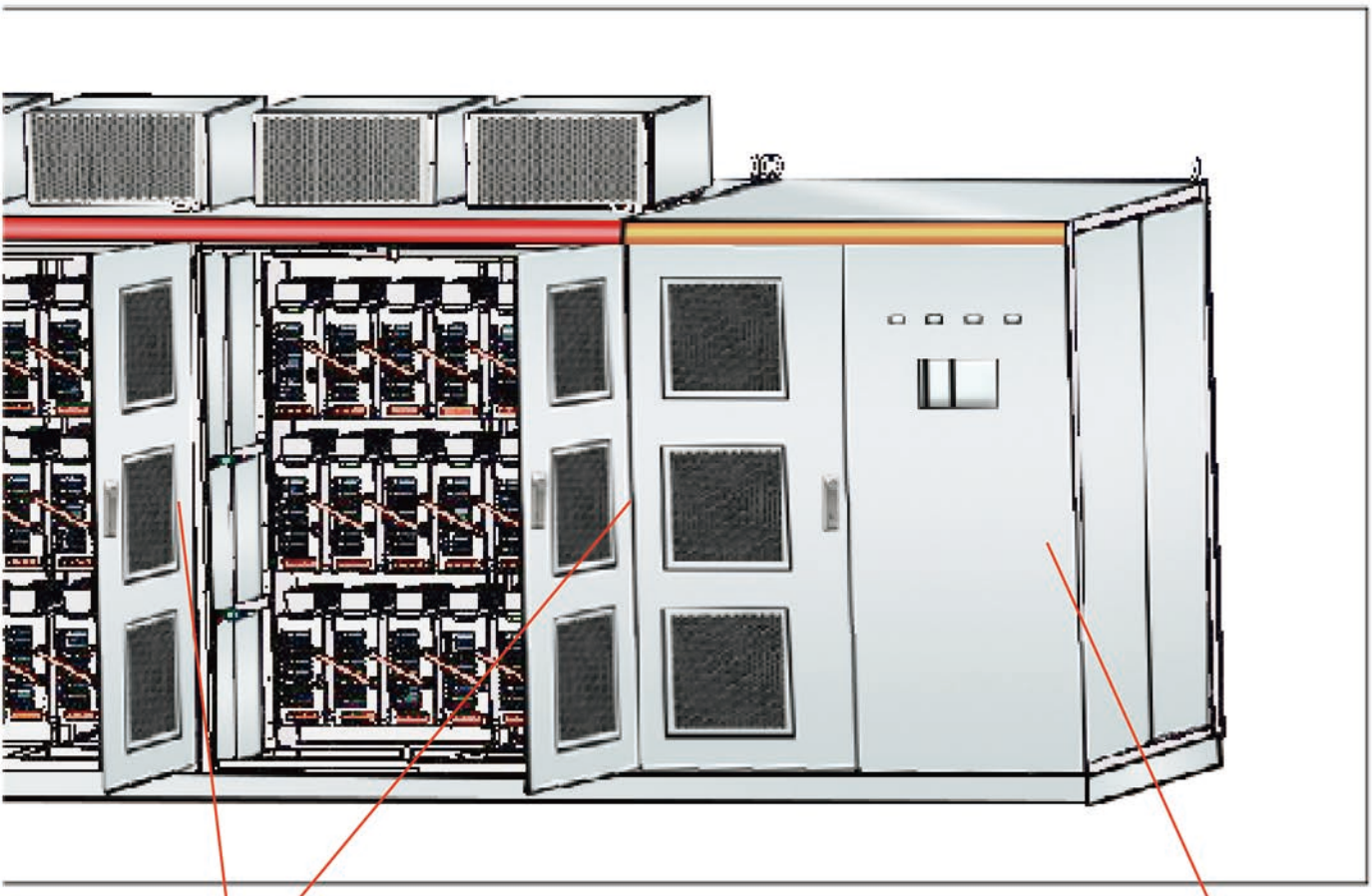
旁路柜
Bypass cabinet

变压器柜
Transformer cabinet

Structure of MV Inverters

As a trend of green power, VFD technology is dramatically used in all industry applications. According to the statistics, it can reach 30% to 40% energy saving. The basic principle is n = 60 f(1 - s) /p, the speed n and frequency f becomes linear, and does not exist the power loss of regulating excitation slip and throttling effect in the process of speed regulation. With the development of modern power electronic, the technology of high voltage, big power frequency conversion speed regulation is getting more matured, many motor speed control mode has been changed,in this direction. It adopts the phase shifting rectifier transformer, with nearly perfect sinusoidal wave, so there is no more the harmonic pollutions from LV inverter. Moreover, you don't need to install the distribution transformers in the system.

Since motors, water pumps, compressors, rolling mills have been widely used in the large mining industry, cement factory, petrochemical, municipal water supply, metallurgy steel and other electrical industries, phase-shifting rectifier transformers will have a great potential market as the core part of MV inverter,which requires safety and reliability.



功率单元柜
Power unit cabinet

控制柜
PLC

高压变频器的架构

在环境保护日益重视的今天，变频调速技术日益广泛应用。据统计通过变频调速技术其节能效果能达到30%-40%，其原理是n=60f(1-s)/p,其中转速n与频率f成线性，且在调速过程中不存在励磁滑差和节流作用带来的功率损失。随着现代电力电子技术的发展,高压大功率变频调速装置技术日趋成熟，很多中高压电机的调速方式已改为高压变频调速，通过采用移相整流变压器，实现了变频器近似完美无谐波，因此不需要考虑及处理低压变频器带来的谐波污染问题，同时又节省了中间配电变压器的使用。

在大型矿业生产、水泥、石油化工、市政供水、冶金钢铁及电力能源等行业中，各种风机、水泵、压缩机、轧钢机等已被广泛应用，因此有较大的市场需求，而作为其重要部件-移相整流变压器在高压变频器中扮演重要角色，要求其安全可靠。雷特电机的变压器团队在此领域已有近30年的生产制造经验。

Core Part of MV Inverter

The phase-shifting rectifier transformer, featured by dis wound coils, can effectively eliminate the harmonic pollution of the inverters to the grid, so the designs of MV inverters could be more flexible.

In the three phase power grid, multi-phase rectifier circuit is adopted, so the output of low-voltage DC side after rectification shows better waveform and less harmonic content.

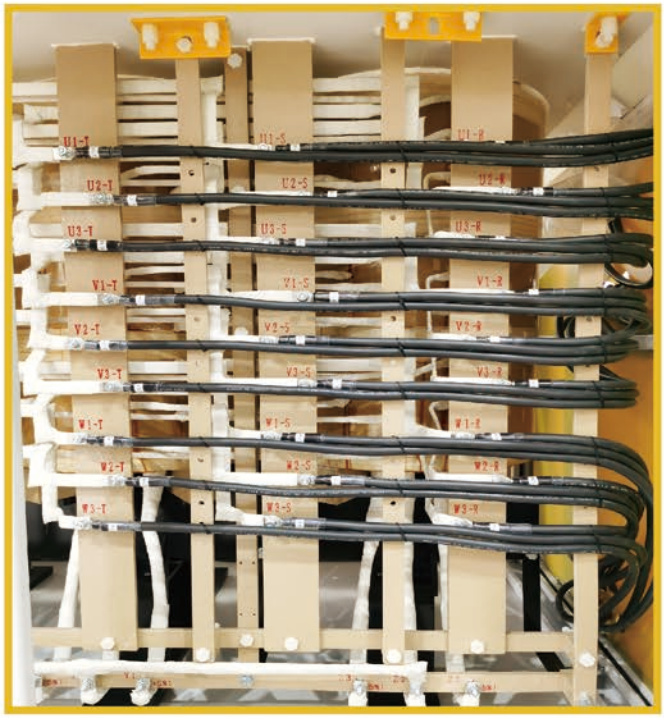
The phase-shifting rectifier transformer adopts 60 pulse wave rectifier. Theoretically it would eliminate 59 harmonics and below (while 48 pulse wave, 47 harmonics and below...) Therefore, the output waveform of the frequency conversion device will not cause resonance of the motor. It meets the requirements of IEEE 519-1992, which is the most authoritative American standard (ANSI) formulated by IEEE. This standard is higher than the requirement of National standard GB14549-93 in the terms of the total voltage harmonic distortion rate no more than 4% (odd harmonics no more than 3.2%, even harmonics no more than 1.6%) for 10kV system.

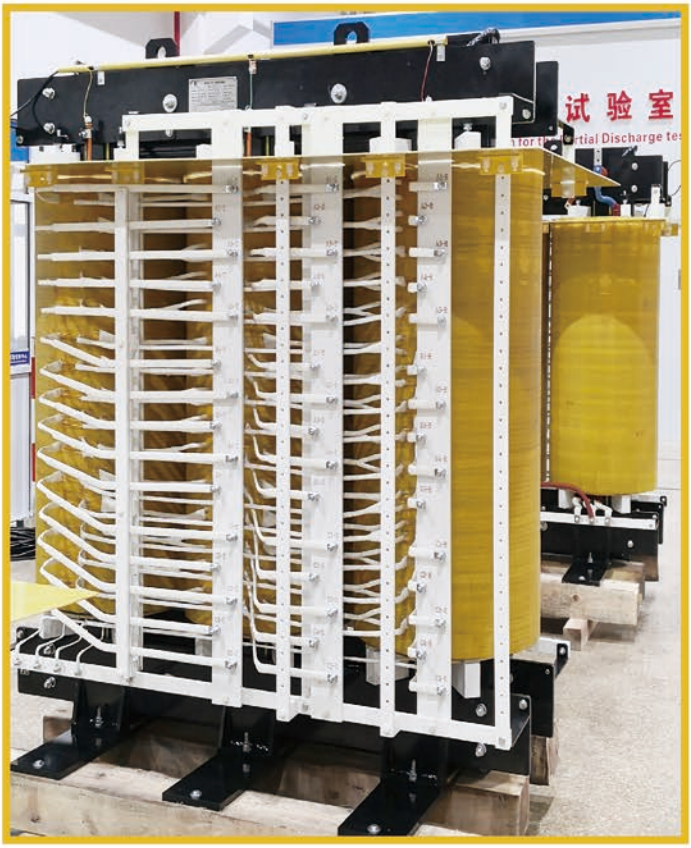
高压变频器的重要部件

该移相整流变压器属于多绕组结构，可有效消除变频器对电网的谐波污染，使高压变频器的设计变得更加灵活。

在三相电网中，采用多相的整流线路，整流后的低压直流输出侧的波形更好，谐波含量更少。

移相整流变压器若采用60脉波整流，理论上可以抵消59次及以下谐波等(而48脉波，理论上47次谐波及以下都可以抵消……)，因此变频装置输出波形不会引起电机的谐振。由最具权威性的美国电器电子工程协会(IEEE)制定，符合美国国家标准(ANSI)的IEEE519-1992的要求，并高于国标GB14549-93对10kV系统电压总谐波畸变率不大于4%的要求(奇次不大于3.2%，偶次不大于1.6%)。




试 验 室

Phase-shifting Method

In order to improve the power factor and reduce the harmonic current in the power grid, the pulse number of rectifier equipment must be increased, especially for big facilities. The purpose of phase-shifting is to make a shift angle between the terminal voltages at the same end of the secondary windings of rectifier transformer. The most common methods are star winding, phase shifting winding and phase shifting autotransformer.

In the figure, 18 pulse rectifier is used for phase -shifting rectifier transformer, and the input harmonic current meets the IEEE519 standard. In the real manufacturing, the number of pulse rectifiers can be a little more.

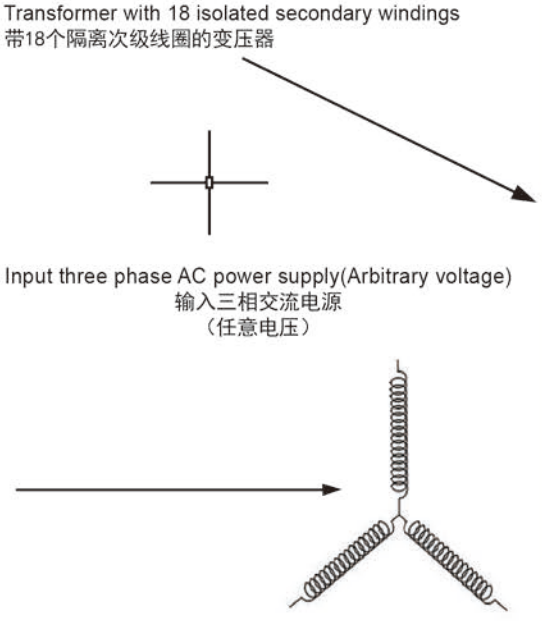
The secondary windings of transformers have a certain phase-shifting angle between the windings ,which not only dramatically reduces the input harmonic current, but also improves the power factor to 95% or above at partial or full load.

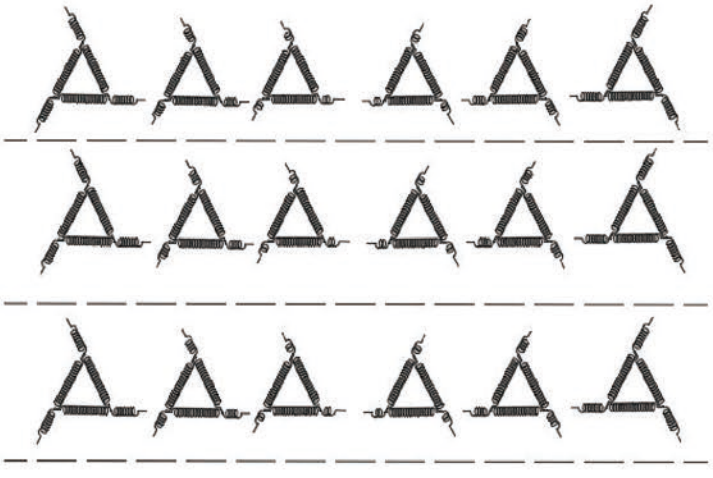
移相方法

对于大功率整流设备，为了提高功率因素，减小网侧谐波电流，必须提高整流设备的脉波数，为此采用移相的方法来实现。移相的目的是使整流变压器二次绕组的同名端线电压之间有一个相位移，从而提高整流设备的脉波数。常用的移相方式分为星角绕组移相、移相绕组移相、自耦移相变压器移相。

图中移相整流变压器采用了18脉冲整流，输入谐波电流满足IEEE519标准。在实际制造时，脉冲整流数目还可以更多一些。

移相整流变压器的二次测绕组相互之间有一定的移相角度间隔，这样既大大降低了输入谐波电流，也使功率因数能在较高或满载负荷时达到95%及以上。






B
C
A1-R
A2-R
A3-R
A4-R
A5-R
A6-R
B1-R
B2-R
B4-R
B6-R
C1-R
C2-R
C4-R
C6-R
A1-S
A2-S
A3-S
A4-S
A5-S
A6-S
B1-S
B2-S
B3-S
B4-S
B6-S
C1-S
C2-S
C4-S
C6-S
A1-T
A2-T
A3-T
A4-T
A5-T
A6-T
B1-T
B2-T
B4-T
B5-T
B6-T
C1-T
C2-T
C4-T
C6-T
Z1
(+10%)

Phase-shifting Angle

While the phase-shifting method is adopted, it shall be designed on the secondary side of the rectifier transformer.

There are three ways to connect the phase winding to the primary winding:
1. zigzag line
2. hexagon
3. extended triangle preferred

According to different pulse waves, the number of rectifier transformers required in parallel operation and the phase-shifting angle of each transformer are also different.

The combined relationship between the pulses P of the unit and the phase-shifting angle α of each transformer is shown in below figure.

移相角

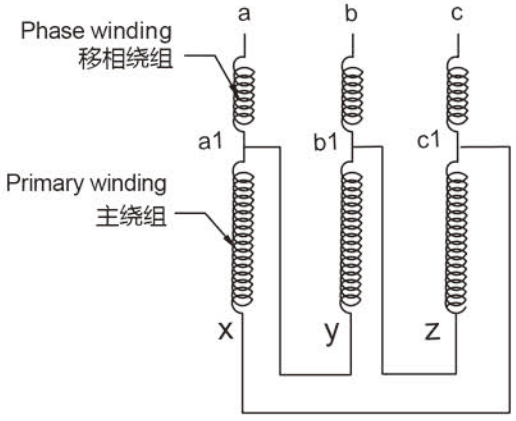
采用移相绕组进行移相，移相绕组设置在移相整流变压器的二次侧。

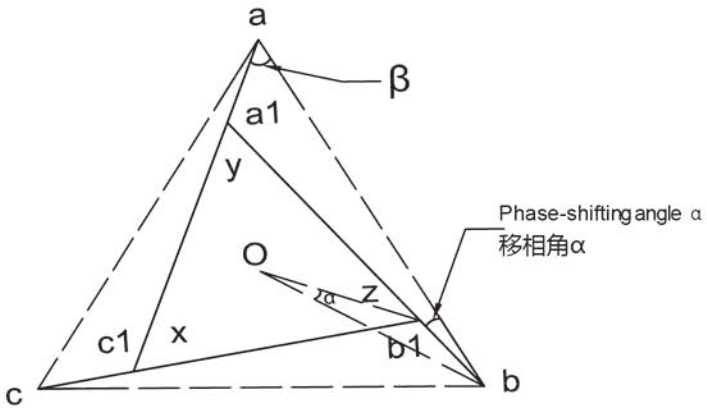
移相绕组与主绕组连接方式有三种:
1、曲折形
2、六边形
3、延边三角形优先

根据所需脉波数的不同，所需并联工作的移相整流变压器的台数及各台变压器的移相角也不同。

机组脉波数P与各台变压器的移相角度α的组合关系见下表。

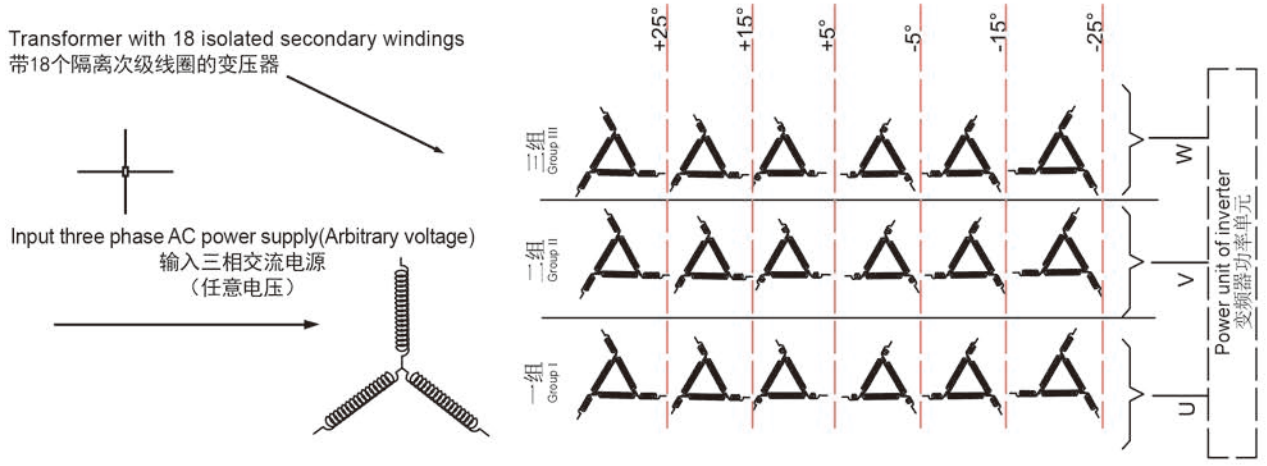
Pulses 脉冲数	Groups 组数	Motor voltage 电机电压	Phase-shifting angle 移相角	Angle distribution 角度分布
18	3	3kV system/系统用	20°	0°、±20°
24	4		15°	±7.5°、±22.5°
30	5	6kV system/系统用	12°	0°、±12°、±24°
36	6		10°	±5°、±15°、±25°
48	8	10kV system/系统用	7.5°	±3.75°、±11.25°、±18.75°、±26.25°
54	9		6.67°	0°、±6.67°、±13.33°、±20°、±26.67°
60	10	10~13.8kV system/系统用	6°	±3°、±9°、±15°、±21°、±27°





The phase difference of the secondary windings is determined by the pulse waves of the rectifier, that is, by the number of power units in series with the high-voltage inverter. Taking the above example, 6 power units are designed for each phase, so the output of pulse waves of a phase-shifting rectifier transformer is 6×6=36. The phase difference of the secondary winding is 360/36 =10°, and the phase shift angle is: +25°, +15°, +5°, -5°, -15° and -25°.

移相整流变压器的二次绕组的相位差是由整流的脉波数决定的，也就是由高压变频器的功率单元的串联数量决定，以上述为例，每相设计6个功率单元，那么单台移相整流变压器输出的脉波数为6×6=36脉波。则二次绕组的相位差为360／36=10°，那么移相角为：+25°、+15°、+5°、-5°、-15°、-25°。



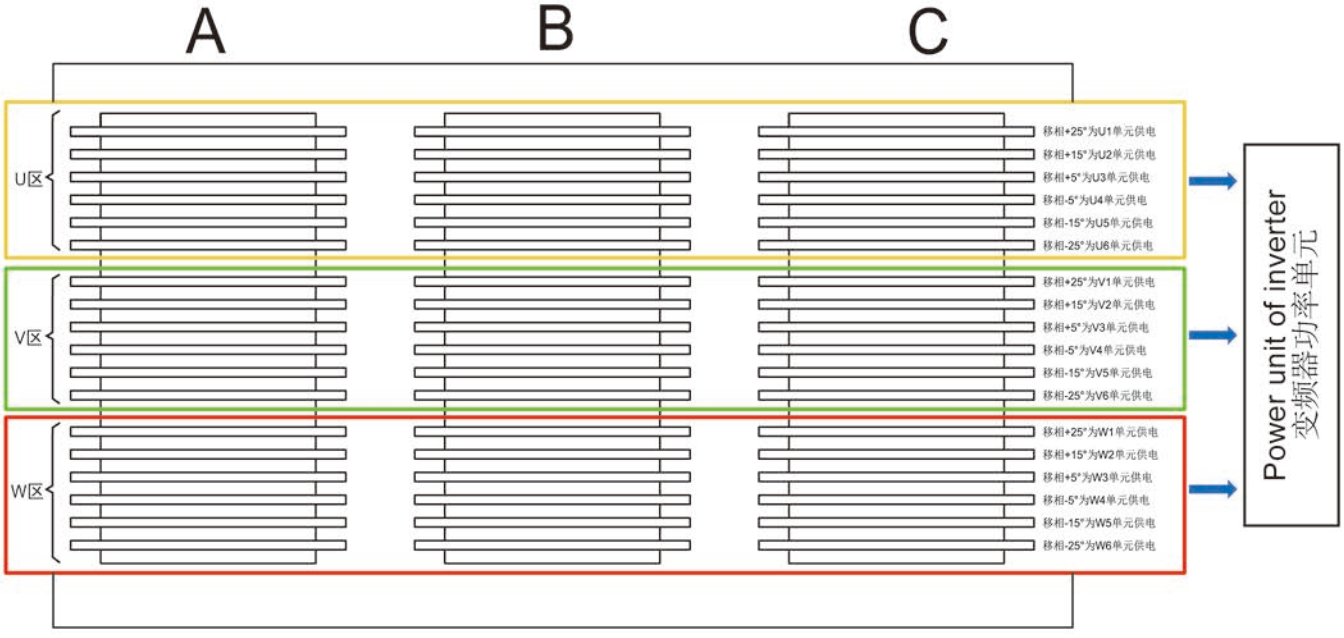
Phase-shifting Angle

It can be seen from the figure that three functional areas, U,V and W, are distributed on each core column, and there are 6 groups of windings in each functional area. They achieve phase-shifting angles of +25°、+15° 、 +5°、-5°、 -15° and -25° respectively. Of course, the phase-shifting angle depends on the A, B and C phases of the transformer.

移相角

由图可见，在每一个铁芯柱上分布着U、V、W三个功能区域，在每一个功能区域内部有6组绕组。它们分别实现+25° 、+15° 、+5° 、-5° 、-15° 、-25° 移相角。当然这个移相角需要依靠与变压器的A、B、C相对应绕组连接成延边三角形来实现。

The corresponding windings are connected into an extended triangle to realize the phase shifting.
对应绕组连接成延边三角形来实现。



Transformer Accessories/变压器组成件

① Lifting eyebolts/起重吊环

② Insulator/绝缘子

③ Temperature control line/温控线

④ LV output terminals/低压引线

⑤ Auxiliary power/辅助电源

⑥ MV input bars/高压引线

⑦ Magnetic core/铁芯

⑧ Nameplate/铭牌

⑨ MV windings/高压绕组

⑩ LV windings/低压绕组

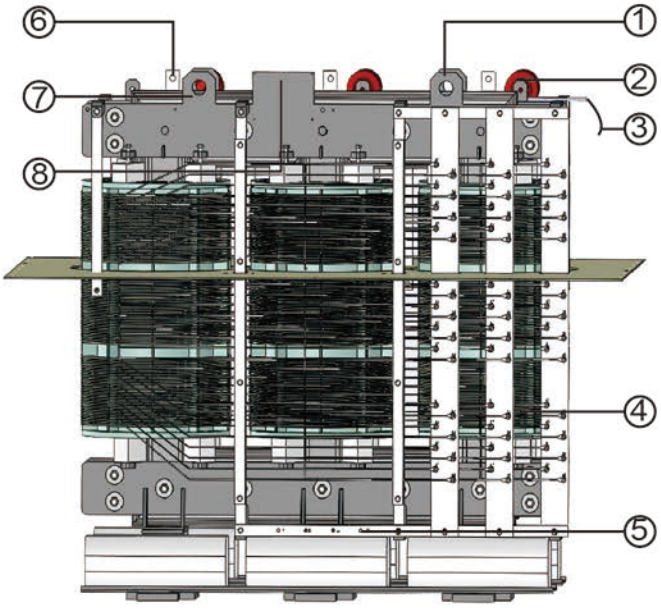
⑪ MV regulating tapping/高压分接

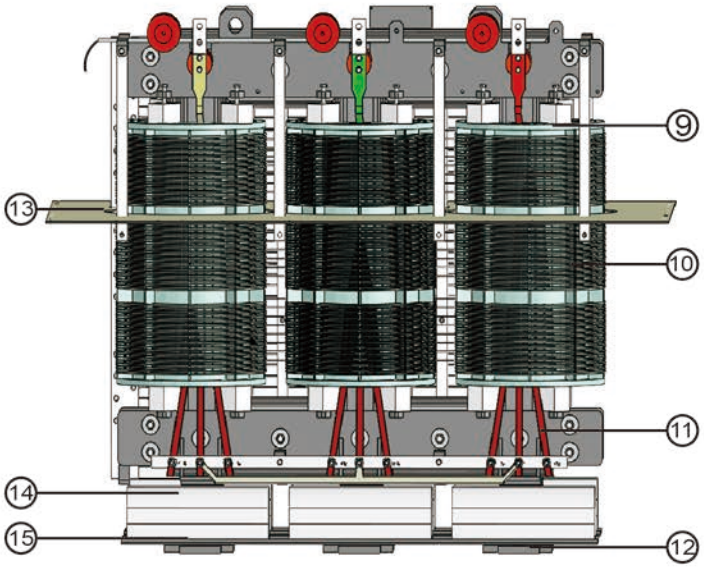
⑫ Mounting bracket/底脚

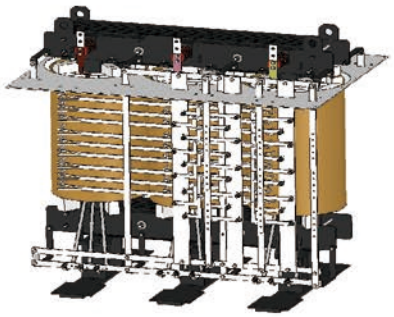
⑬ Air duct damper/风道挡板

⑭ Fan/风机

⑮ Fan frame/风机架







Our Capability/测试范围

Please send us the detailed specifications for quotations or fill in below form upon request. Thanks a lot!

1) Measurement of insulation resistance
2) Measurement of winding resistance
3) Measurement of voltage ratio and check of phase displacement
4) Measurement of short-circuit impedance and load loss
5) Measurement of no-load loss and current
6) Separate-source AC withstand voltage test
7) Induced AC withstand voltage test
8) Lightning impulse test
9) Partial discharge measurement (200Hz frequency doubling generator without partial discharge)
10) Noise test
11) Temperature rise test

1) 绝缘电阻测量
2) 绕组电阻测量
3) 电压比和联结组标号(移相角)检定
4) 短路阻抗和负载损耗测量
5) 空载损耗和空载电流测量
6) 外施耐压试验
7) 感应耐压试验
8) 雷电冲击试验
9) 局部放电测量(200Hz无局放倍频发电机组)
10) 噪音测定
11) 温升试验

Ordering Instructions

Please send us the detailed specifications for quotations or fill in below form upon request. Thanks a lot!

Item	Description	Value	
1.	Applicable standards	☐ IEC60076	☐ UL1446
2.	MV Dry type transformer	☐ Rectifier transformer	☐ Distribution transformer
3.	Cooling method	☐ Cross cooling fan ☐ Enclosed type	☐ Natural air
4.	Number of phases	☐ 1 phase	☐ 3 phases
5.	Rated frequency	☐ 50Hz	☐ 60Hz
6.	Temperature class	☐ 180 °C (H class)	☐ 220 °C(C class)
7.	Winding wires	☐ Copper	☐ Aluminum
8.	Iron core	☐ Oriented silicon steel	☐ Non-oriented silicon steel
9.	Rated power	_____kVA	
10.	Rated primary voltage	_____kV	
11.	Primary Taps	_____%	
12.	Rated primary current	_____A	
13.	Rated secondary voltage	_____kV	
14.	Number of secondary windings	_____	
15.	Rated secondary current	_____A	
16.	Auxiliary power	_____kVA _____kV	
17.	Efficiency at full load	_____%	
18.	Total impedance	_____%	
19.	Insulation level	BIL_____AC_____/AC_____kV	
21.	Max altitude	_____m	
22.	Further requirements		

订货须知

如需询价，请提供详细的技术参数或填写以下技术信息表至我司，谢谢合作！

项目	描述	
1.	适用标准	□ IEC60076 □ UL1446 □ GB1094.11
2.	干式变压器种类	□ 移相整流变压器 □ 配电变压器
3.	冷却方式	□ 横流风机型 □ 风桶型 □ 自冷型
4.	相数	□ 单相 □ 3相
5.	额定频率	□ 50Hz □ 60Hz
6.	耐热等级	□ 180 °C (H class) □ 220 °C(C class)
7.	线圈材质	□ 铜 □ 铝
8.	铁芯材质	□ 有取向矽钢片 □ 无取向矽钢片
9.	额定容量	_____kVA
10.	一次侧额定电压	_____kV
11.	一次侧分接头	_____%
12.	一次侧额定电流	_____A
13.	二次侧额定电压	_____kV
14.	二次侧绕组数量	_____
15.	二次侧额定电流	_____A
16.	辅助电源	_____kVA _____kV
17.	满载能效	_____%
18.	阻抗电压	_____%
19.	绝缘水平	LI_____ AC_____ /AC_____ kV
20.	最高海拔	_____m
21.	其它要求	

Notes

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LOFUTEC®

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