

JETTER

Digital Power Controllers

数字功率控制器

JS3000 Series

JS3000系列

Three-phase load control

三相负载控制

User Manual

用户手册

JS3000 JS3000

USER MANUAL 用户手册

CONTENTS	PAGE
目录	
PRECAUTIONS	4
警告	
Chapter 1 IDENTIFYING THE CONTROLLERS	5
第一章 控制器信息	
GENERAL INTRODUCTION TO THE JS3000 SERIES	5
JS3000系列概述	
TECHNICAL SPECIFICATION	8
技术说明	
PRODUCT CODE	11
产品代码	
EXAMPLE OF PRODUCT CODE	12
选型样例	
Chapter 2 INSTALLATION	13
第二章 安装	
INSTALLATION - SAFETY	13
安装安全规范	
DIMENSIONAL DETAILS	14
详细产品尺寸说明	
MOUNTING DETAILS	14
详细安装尺寸说明	
Chapter 3 WIRING	16
第三章 接线	
WIRING - SAFETY	16
接线规范	
POWER WIRING	18
主回路动力线	
USER TERMINAL BLOCKS	21
用户接线端子图	
Chapter 4 CONFIGURATION	23
第四章 配置	
CONFIGURATION - SAFETY	23
配置安全规范	
DRIVER BOARD CONFIGURATION	24
触发板配置说明	

Chapter5 OPERATION	<u>26</u>
第五章 操作	
CONTROL OPERATION	<u>26</u>
控制操作	
THYRISTOR FIRING MODES	<u>28</u>
晶闸管触发模式	
 Chapter 6 COMMISSIONING PROCEDURE	 <u>31</u>
试运行操作步骤	
COMMISSIONING PROCEDURE - SAFETY	<u>31</u>
试运行安全规范	
CHECKING THE CHARACTERISTICS	<u>32</u>
检查特征	
POWERING UP THE CONTROLLER	<u>33</u>
使控制器上电	
 Chapter 7 DISPLAY MESSAGES	 <u>34</u>
第七章 显示信息	
General	<u>34</u>
概述	
Steady messages	<u>35</u>
直亮信息	
Flashing messages	<u>35</u>
数码管信息	
Error	<u>35</u>
错误	
Failures	<u>35</u>
故障	
Microprocessor failure	<u>35</u>
微处理器故障	
 Chapter 8 ALARMS	 <u>38</u>
第八章 报警	
Alarm strategy	<u>38</u>
报警策略	
Alarm relays	<u>39</u>
报警继电器	
Alarm acknowledgement	<u>39</u>
报警常识	
 Chapter 9 MAINTENANCE	 <u>41</u>
第九章 维护	
FUSES	<u>41</u>
快熔保险	
SERVICING	<u>42</u>
维修	

PRECAUTIONS

警告

Safety symbols

安全标志

Important safety precautions and special information are indicated in the text of the manual by two symbols:

重要安全警告和特殊信息在本手册中用以下两个标志阐明：

DANGER

危险



This symbol means that failure to take note of the information given in this manual may have serious consequences for the safety of personnel and may even result in electrocution.

这个标志说明如果操作失误可能会引起严重的人员安全问题，可能会造成人员触电的后果。

ATTENTION

注意



This symbol means that failure to take note of the information may

- have serious consequences for the installation or

- lead to the incorrect operation of the power unit

这个标志说明如果没有按手册中的规范可能导致安装不正确或调功器不能正常工作。

These symbols must be observed for particular points.

这些标志必须特别遵守。

However the whole of the manual remains applicable.

然而手册中的其他部分可采取适用性原则。

Personnel

人员

The installation, configuration, commissioning and maintenance of the power unit should only be carried out by personnel **qualified and trained** to work with low voltage electrical equipment in an industrial environment.

安装，配置，试车和维护必须由受过专业训练的人员完成，而且其要有在工业现场环境中的低压电器设备的操作经验。

Independent alarm

独立报警

Given the value of the equipment controlled by **JS3000** products it is the responsibility of the user, and it is highly recommended, that an independent safety device (alarm) should be installed. This alarm must be tested regularly.

用户应该对JS3000产品控制的设备提高重视，我们强烈建议用户安装一个独立的安全（报警）设备。而且这个报警一定要经过检测合格。

Jetter can supply suitable equipment.

杰顿可以提供合适的设备。

Chapter 1

第一章

IDENTIFYING THE CONTROLLERS

控制器信息

Contents

目录

GENERAL INTRODUCTION TO THE JS3000 SERIES6

JS3000系列概述

TECHNICAL SPECIFICATION9

技术说明

PRODUCT CODE13

产品选型代码

EXAMPLE OF PRODUCT CODE14

产品选型范例

Chapter 1 IDENTIFYING THE CONTROLLERS

第一章 控制器信息

GENERAL INTRODUCTION TO THE JS3000 SERIES

JS3000 系列产品概述

The **JS3000** series of controllers are thyristor units designed to **control** the electrical **power** of industrial three-phase loads.

JS3000系列是晶闸管控制单元，是用来控制工业三相负载的功率。

A **JS3000** series controller is made up of three channels, each comprising a pair of thyristors connected in anti-parallel.

JS3000系列控制器由三个通道组成，每一个通道包括一对反并联的晶闸管。

The **JS3000** series is designed to control the following loads:

JS3000系列可以用来控制以下负载：

- inductive (inductors or primary transformer coils),
感性负载（变压器的主、次级线圈）
- resistive (with low or high temperature coefficient),
阻性负载（带高低温系数）
- composed of short wave infrared elements.
远红外发热元件

Three-phase loads can be connected:

三相负载连接方式：

- in star with neutral
中性点接零的星形接法

- in star without neutral
中性点不接地的星形接法
- in closed delta
封闭内三角接法
- in open delta.
展开外三角接法

The wiring of the controller is **indifferent** to the order of the supply phase rotation. Automatically identify the phase sequence. No need to check the phase sequence.

接线和相序无关紧要。自动判相，无需核对相序

The nominal currents of the **JS3000** series controllers are between **20A** and **1200A**, per phase, defined at an ambient temperature of 45°C.

JS3000系列的控制器的电流范围可以从20A到1200A，每相的工作温度在45°C以下。

Attention!

注意



In order to allow for variations in load resistance, the calculated current should not exceed 0.8 times the maximum rated current of the unit.

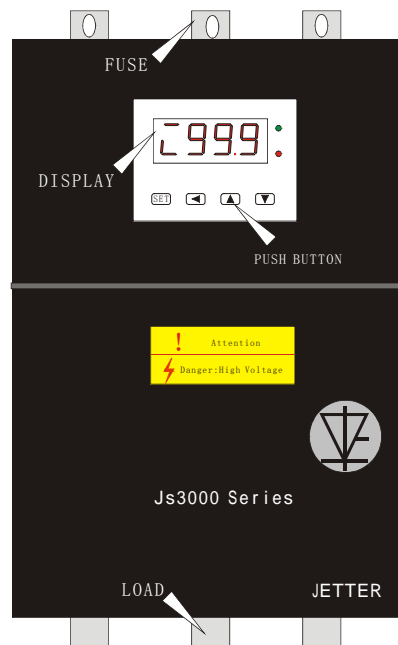
为了变阻负载，计算电流不应超过控制单元最大额定电流的0.8倍。

The load current is calculated from the supply voltage and the load power (or resistance).

负载电流的计算应该根据工作电压和负载的功率（或阻抗）计算。

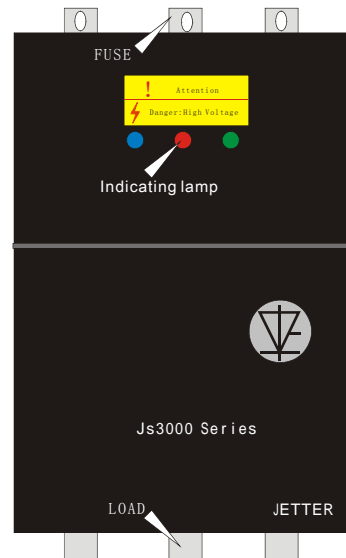
With Diode display & Communication

带数码管显示和通讯



Without Diode display & Communication

不带数码管显示和通讯



The unit is controlled by **analogue** signals.
调功器单元的控制信号为模拟信号。

For the input analogue signals, there are four possible voltage levels:

输入的模拟信号包括四种电压等级信号：

0-5 V ; 1-5 V ; 0-10 V ; 2-10 V

and two current levels:

和两种电流信号：

0-20 mA and 4-20 mA.

The instantaneous state of the thyristor unit, its operating mode, a load failure or the enabled alarms are indicated by message on a 7 segment **display** located on the front panel.

调功器单元的即时状态，工作方式和负载故障均通过前面板上的4位数码管显示出来。

The front panel also includes:

前面板还包括：

- **4 push button** for the main operating parameters

4个设定操作参数用的按键

An **alarm** system detects failures in the loads and abnormal variations in the voltage and current.

报警系统检测负载的故障和电流、电压的错误变化。

Failure detection **is signalled** by the switches of one alarm relays and by the display.

故障通过一个报警继电器表现出来。

If the current threshold pre-adjusted by the user or in the factory is exceeded, **the current monitoring system**

如果用户或厂家预设电流超标，电流监控系统将：

- stops the thyristor unit in Burst firing or Logic operation
停止晶闸管工作
- limits the current by thyristor angle variation in Phase angle.
限制晶闸管的通过电流。

The electronics of the **JS3000** controllers are self-supplied from the power voltage and do not require external connections.

JS3000的电源由自身的动力电压提供，不需要额外的外接电源线。

The control method of the **JS3000** series includes **line voltage squared (V²) compensation** for line variations in the range **+10% to -10%** of the nominal voltage of the controller.

JS3000系列具有电压补偿特性，其电压范围可在控制器标称的+10%到-10%。

A **JS3000** series controller is equipped with:

JS3000系列控制器配备以下 部件：

· A **'driver board'** which generates thyristor firing pulses, implements control and provides power for the electronics. This board is also used for the signal and operating mode configurations (Please specify before ordering)

触发板，提供晶闸管的触发脉冲，执行控制，提供动力。此板经常用作信号和操作模式的配置。（需订货说明）

The user terminal block beside the controller is used for the control signal connection without having to open the front door of the unit.

用户控制线接线端子在控制器边上，无需打开产品前盖。

TECHNICAL SPECIFICATION

技术规范

The JS3000 series of controllers is intended for thyristor regulation and control of an industrial three-phase load. JS3000系列控制器是由晶闸管调节控制工业三相负载。

Danger !

危险！



An isolating device must be installed between the equipment and the mains supply in order to perform the maintenance in complete safety.

为了安全必须要在设备和主供电之间加装隔离断路器。

Thyristors are not isolating devices.

晶闸管不是绝缘设备。

Touching load terminals, even if there is no loads current (unit in the off-state), is as dangerous as touching power supply terminals.

即使没有负载电流，触摸负载接线端子和触摸供电端子一样危险。

Attention !

注意！



It is the user's responsibility to ensure that the nominal values of the thyristor unit are compatible with the conditions of installation and operation before commissioning the thyristor unit.

在试车之前，用户有责任确定晶闸管单元的额定值与安装操作条件相匹配。

Power

电源

Nominal current (per phase)	20A, 30A, 50A, 100A, 150A, 200A, 250A, 300A,
（每相）额定电流	350A, 500A, or 1000A 。

Line-to-line voltage	380V (+10%, -15%)
相间电压	380V(+10%, -15%)

Supply frequency	50Hz
频率	50Hz

power and control

电源和控制

Cooling

Natural convection for 20A, 30A ratings Permanent

冷却	20A, 30A自然冷却
fan-cooling 风冷	for 50A , 100A, 150A。。。1000A rating 50A以上, 风冷
Load 负载	All types of industrial three-phase load: 所有类型的工业三相负载: resistive, short wave infrared, inductive, tungsten, 阻性, 远红外发热元件, 感性, 钨, primary transformer coil, etc. 变压器一次侧, 等。
Load connection 负载连接	Independent of the phase rotation order 自动判相, 无需核对相序
Load configuration 负载配置	Closed (3 wires) and open (6 wires) delta 封闭三角 (3线) 和 开放三角 (6线) Star without Neutral (3 wires) and with Neutral (4 wires) 中性点不接地星形 (3线) 和中性点接零 (4线) Load type and assembly configuration using jumpers 负载配置变化用跳线
Control 控制	
External control signal : 扩展控制信号:	Analogue voltage 0 to 5V or 0 to 10V; current 4 to 20mA 模拟电压0-5V或0-10V; 电流4-20 mA
Input impedance: 输入阻抗:	Voltage input: >100k Ω , current input: 120 Ω 电压输入大于100K Ω , 电流输入: 120 Ω
Thyristor firing mode 晶闸管出发方式	<ul style="list-style-type: none"> • Phase angle 移相调压型 Be applicable to resistance load and inductive load 适用于阻性负载和感性负载 Current-limiting function and over-current protection function are Provided 具备电流限制和过流保护功能 Output resolution: Approx. 10 A/D 输出分辨率: 10位A/D • Cycle base zero voltage trigger mode: 周期调功型 Cycle based, zero voltage trigger, and ON-OFF control mode: 变周期, 过零触发, 通断控制方式 Be applicable to resistance load 适合于阻性负载 Reduce noise to power supply, with obvious effect of Energy-saving. 对电网干扰小, 节能效果明显
Manual power control: 手动控制	Adjustment output can be adjusted continuously by wexternal manual power adjuster. (The effect is the same as automatic control mode) 调整功率输出可以通过一个连续的外部手动功率调整器。(这个作用和自动模式一样)
Time of soft start and soft stop: 缓启动缓关断时间:	Both are 15 sec. 均为15sec.

Control performance

控制性能

Linearity

线性

Better than $\pm 2\%$ of the full scale

优于满度的 $\pm 2\%$

Stability With variations:

波动的稳定性

- Of the supply voltage $+10\%$, -15%
电压在额定电压的 $+10\%$, -15% 的范围内
- Of the temperature from 0 to 70°C
温度在 0 to 70°C 的范围内
stability is better than $\pm 2\%$ of full scale
稳定性优于满度的 $\pm 2\%$

Output range:

输出范围:

Phase angle control mode :0-98% of input voltage

调压型: 电源电压的0-98%。

Cycle base zero voltage trigger mode:Ecentricity ratio is 0-100%.

调功型: 占空比为0-100%。

Current-limiting:

电流限制:

- Only be applicable to the phase angle control mode.
- 仅适用于移相调压方式
Over-current value can be set in the range of $20\sim 100\%$ of rating current.
- 电流限制值可在额定电流的 $20\sim 100\%$ 间设定
- After the current of load is up to the preset value,it will not increase following the input signal
- 负载电流达到设定值后不再随输入值增加
- This function can prevent the heater from becoming too hot to break.
- 可防止温度增长过快和烧坏加热器

Alarms and protection

报警 和保护

Voltage

电压

Absence of supply voltage on each phase

(inhibition of the thyristor unit)

电源供电缺相 (晶闸管关断)

Under-voltage (thyristor firing stopped below 70% of the nominal thyristor unit voltage)

欠压 (低于正常电压的 70%)

Over-voltage (alarm for a voltage greater than the nominal thyristor unit voltage by 20%)

过压 (高于正常标称电压的 20%)

Over-current protection:

过电流保护:

- Be applicable to the phase angle control mode and cycle base zero voltage trigger mode
- 调功型在导通的时间内“过流保护”功能起作用
- Over-current protection function works in the time of the thyristor opening in the mode of cycle base zero voltage trigger.
- 负载电流达到过流保护设定值后即: 停止输出、报警继电器动作、红色 LED 灯直亮

Environment

环境

Operating temperature

工作温度

0°C to $+45^{\circ}\text{C}$ at maximum altitude of 2000m

0°C to $+45^{\circ}\text{C}$, 最高海拔2000m以内

Storage temperature

存储温度

-10°C to $+70^{\circ}\text{C}$

-10°C to $+70^{\circ}\text{C}$

Thyristor protection

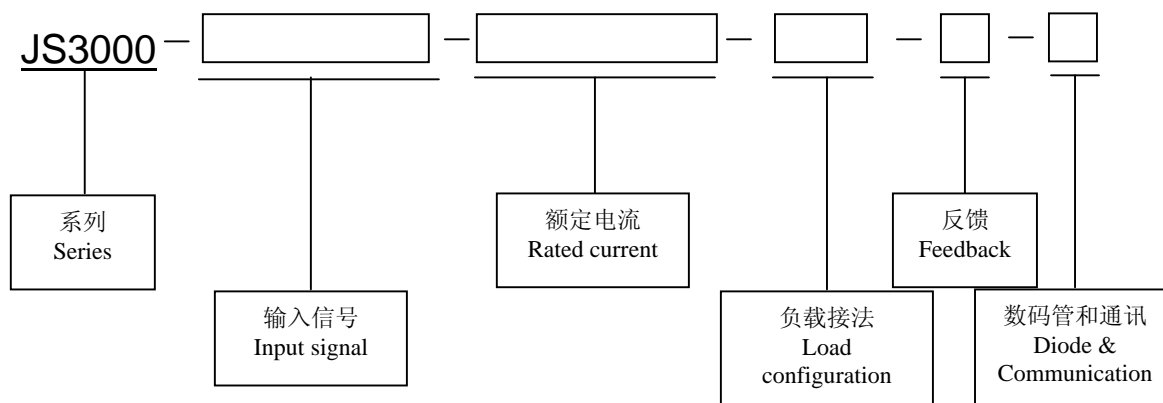
晶闸管保护

High-speed external and RC snubbers

快速熔断和阻熔吸收、电子互感器保护

Protection
保护IP20 on the front fascia
前面板符合IP20**External wiring**
扩展接线

To be carried out in compliance with standard

Operating atmosphere
操作气氛Non-explosive, non-corrosive, non-conductive
无暴露，无腐蚀，无传导**Humidity RH:**
湿度5% to 95%, non-condensing
5% to 95%,无冷凝**Material/Finish**
壳体材料及涂层Ordinary steel plate/paint coating
钢板/喷塑**PRODUCT CODE**
定货代码

输入信号 Input signal	代码 Code
0 – 5V 0 to 5 volts	0V5
1 – 5V 1 to 5 volts	1V5
0 – 10V 0 to 10 volts	0V10
2 – 10V 2 to 10 volts	2V10
0-20 mA 0 to 20 milliamps	0mA20
4-20 mA 4 to 20 milliamps	4mA20

Nominal current 额定电流	Code 代码
20 amps	20A
30 amps	30A
50 amps *	50A
80 amps *	80A
100 amps *	100A

150 amps *	150A
200 amps *	200A
250 amps *	250A
300 amps *	300A
400 amps *	400A
500 amps *	500A
600 amps *	600A
800 amps **	800A
1000 amps **	1000A

* Fan cooled 风冷

Load configuration 负载接法	Code 代码
Delta (3-wire) 三角形 (3线)	3D
Star without neutral (3-wire) 中性点不接地的星形 (3线)	3S
Star with neutral (4-wire) 中性点接零的星形 (4线)	4S

Feedback 反馈	Code 代码
With feedback 带反馈	F
Without feedback 不带反馈	N

Diode & Communication 数码管和通讯	Code 代码
With Diode & Communication 带数码管显示和通讯	S
Without Diode & Communication 不带数码管显示和通讯	N

EXAMPLE OF PRODUCT CODE

选型举例

Controller and installation parameters

控制和安装参数

Input signal 4 to 20 milliamps

输入信号4-20 mA

Nominal load current 150 amps

额定电流150A

Load configuration Star without neutral

负载是中性点不接地的星形接法

With feedback

带反馈

With Diode & Communication

带数码管显示和通讯

Controller code:

控制器代码:

JS3000 – 4 mA 20 – 150A – 3S – F – S

Chapter 2

第二章

INSTALLATION

安装

Contents

目录

INSTALLATION - SAFETY	16
安装安全规范	
DIMENSIONAL DETAILS	16
详细尺寸说明	
MOUNTING DETAILS	17
开孔尺寸	

Chapter 2 INSTALLATION

第二章 安装

INSTALLATION - SAFETY

安装安全规范

DANGER!

危险!



JS3000 units must be installed by personnel qualified and trained to work with low voltage electrical equipment in an industrial environment.

JS3000调功器单元安装维护必须由受过专业训练的人员完成，而且其要有在工业现场环境中的低压电器设备的操作经验。

Units must be installed in electrical cabinets correctly fan-cooled to ensure that condensation and pollution are excluded.

调功器单元要安装在电气控制柜中，风扇可以排除污染和灰尘。

The cabinet must be closed and bonded to the safety earth in accordance with Standards NFC 15-100, IEC 364 or current national Standards.

控制柜必须保证安全接地。

The units must be mounted with the heatsink positioned vertically, with no obstructions above or below which could inhibit or impede airflow.

调功器单元必须在有强度的安装板上垂直安装，上下不能放置影响空气流通的物品。

If several units are mounted in the same cabinet, they should be arranged in such a way that air expelled from one cannot be drawn into the unit located above it.

如果一个控制柜中安装多个调功器单元，它们的安装排列方式应以不影响空气循环流通的原则。

Attention!

注意!



The units are designed to be used at an ambient temperature less than or equal to 45°C.
调功器单元的使用温度设计为控制柜内的温度要低于45°C。
Leave a minimum gap of 5cm between two units placed side by side.
如果两个单元并排放置，应保证两个之间最小留有5cm的距离。
Excessive overheating of the controller may lead to incorrect operation of the unit.
控制器过热可能导致调功器单元停止工作。
This may in turn cause damage to the components.
这是为了防止元器件的损坏。

DIMENSIONAL DETAILS(mm)

详细尺寸(mm)

NO. 编号	Current 电流	A (Length)	B (Width)	C(Height)	Cooling
1	10-30A	266	170	175	Self-cooling
2	50-100A	323	255	232	Fan-cooling
3	120-160A	373	252	236	Fan-cooling
4	200-330A	425	373	280	Fan-cooling
5	400-500A	573	373	280	Fan-cooling
6	600-1200A	Mounted in electrical cabinets,1600(Height)*800(Width)*450(Deepth), Or in accordance with user's dimension.			

The overall dimensions of JS3000 controllers are given in Figure 2-1.
JS3000尺寸图见2-1。

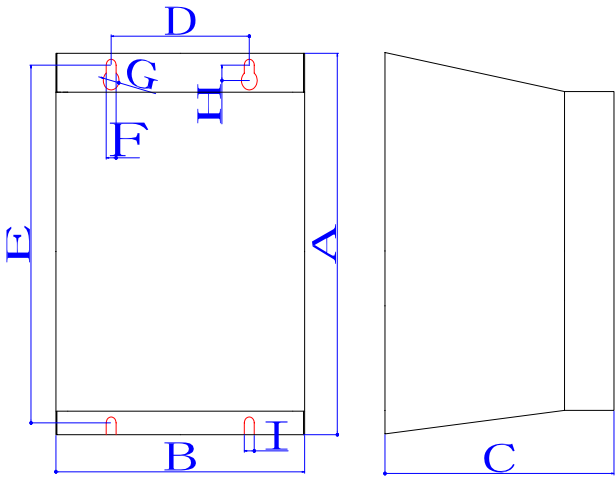


Figure 2-1 The overall dimensions of JS3000 controllers

MOUNTING DETAILS (mm)

开孔尺寸(mm)

NO.	Current	D	E	F	G	H	I
-----	---------	---	---	---	---	---	---

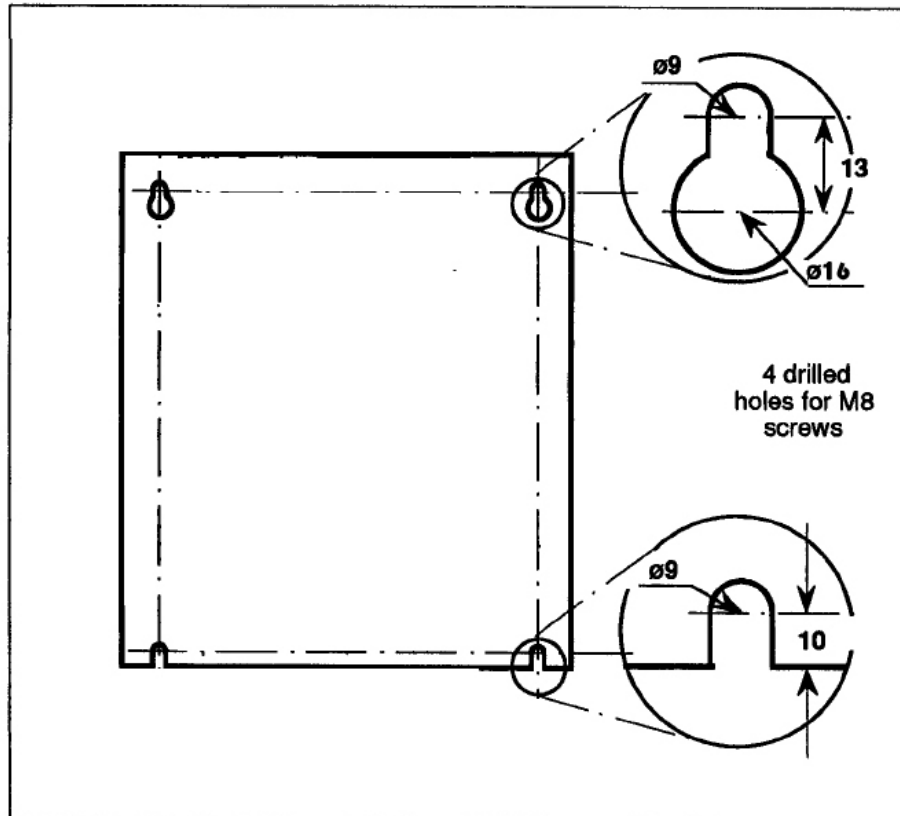
编号	电流						
1	10-30A	138	252	6	10	8	6
2	50-100A	140	303	10	16	13	10
3	120-160A	140	353	10	16	13	10
4	200-330A	328	402	10	16	13	10
5	400-500A	328	547	10	16	13	10

INSTALLTION DETAILS

安装详图

JS3000 series units are designed to be mounted directly on panels at the fixing points located on the rear of the units.

JS3000系列单元设计为直接安装背面的固定孔在平面上。



Fasten the 4 screws correctly.

正确固定4个螺栓。

Chapter 3

第三章

WIRING

接线

Contents

目录

WIRING - SAFETY	20
接线安全规范	
POWER WIRING	21
动力线接法	
CONNECTION	21
连接	
POWER WIRING DIAGRAMS	21
动力线接法图表	
STAR WITHOUT NEUTRAL AND CLOSED DELTA CONFIGURATION ...	22
中性点不接地的星形和内三角配置	
STAR WITH NEUTRAL CONFIGURATION	23
中性点接零的配置	
OPEN DELTA CONFIGURATION	24
外三角配置	
USER TERMINAL BLOCKS	25
用户接线端子块	
GENERAL INTRODUCTION	25
概述	
EXTERNAL INPUT WIRING	26
扩展输入线	
CONTROL WIRING IN LOCAL MODE	26
控制线	

CHAPTER 3 WIRING

第三章 接线

WIRING - SAFETY

接线安全规范

DANGER!

危险!



Wiring must only be carried out by personnel who are qualified to work in a low voltage industrial environment.

调功器单元安装维护必须由受过专业训练的人员完成，而且其要有在工业现场环境中的低压电器设备的操作经验。

It is the user's responsibility to wire and protect the installation in accordance with current professional Standards.

安装接线应符合电工专业标准。

A suitable device ensuring electrical isolation between the equipment and the supply must be installed upstream of the unit in order to permit safe operation.
为了保证安全操作，应在设备和电源供电之间增加适合的设备。

JS3000 series units have a protective cover.
JS3000系列有保护外壳。

DANGER!


危险！

Before any connection or disconnection, ensure that power and control cables or leads are isolated from voltage sources.
在接断线之前，一定要保证电源和控制器切断电源。



For safety reasons, the safety earthing cable must be connected before any other connection is made during wiring and it should be the last cable to be disconnected.

在接线之前首先要保证接地线已良好接地，而在拆线时一定要最后在拆接地线。

The safety earth is connected to the screw located on the slot at the side of the controller and is denoted by the symbol: 

安全地一定要接在指定的螺丝上，而且要有明确指示。

Attention!

注意！

To ensure correct grounding of the JS3000 unit, make sure that it is mounted on the **reference ground surface** (panel or bulkhead).

为了保证JS3000单元的正确接地，一定要确定开孔在参考地表。

Failing this, it is necessary to add a ground connection **at most 10cms** long between the earth connection and the reference ground surface.

如果没有的话，应该在在接地端和参考地表有根长度不超过10cm的连接。



DANGER!

危险！



This connection, which is intended to ensure good ground continuity, can never be used to replace the safety earth connection.

这个连接是为了接地的连贯性，而不能代替安全地的连接。

POWER WIRING

电源连接

The control terminal block has a plug-in connector.

控制接线端由接插件连接。

The safety earth is connected to an **M6** screw and bolt.

接地端由M6螺栓连接。

Power wiring diagrams

动力线接线图

The **JS3000** power wiring diagram depends on the load configuration.

JS3000的动力线接线说明要根据负载的配置。

The following three **power** and **safety earth** wiring diagrams are given below to illustrate different types of load configuration.

下面给出各种负载配置的三相动力线和安全地线的接法。

Star without neutral and closed delta configuration

Three-phase loads connected in star without neutral or in closed delta are configured as 3-wire.

中性点不接地的星形和内三角形的三线制的三相负载接法。

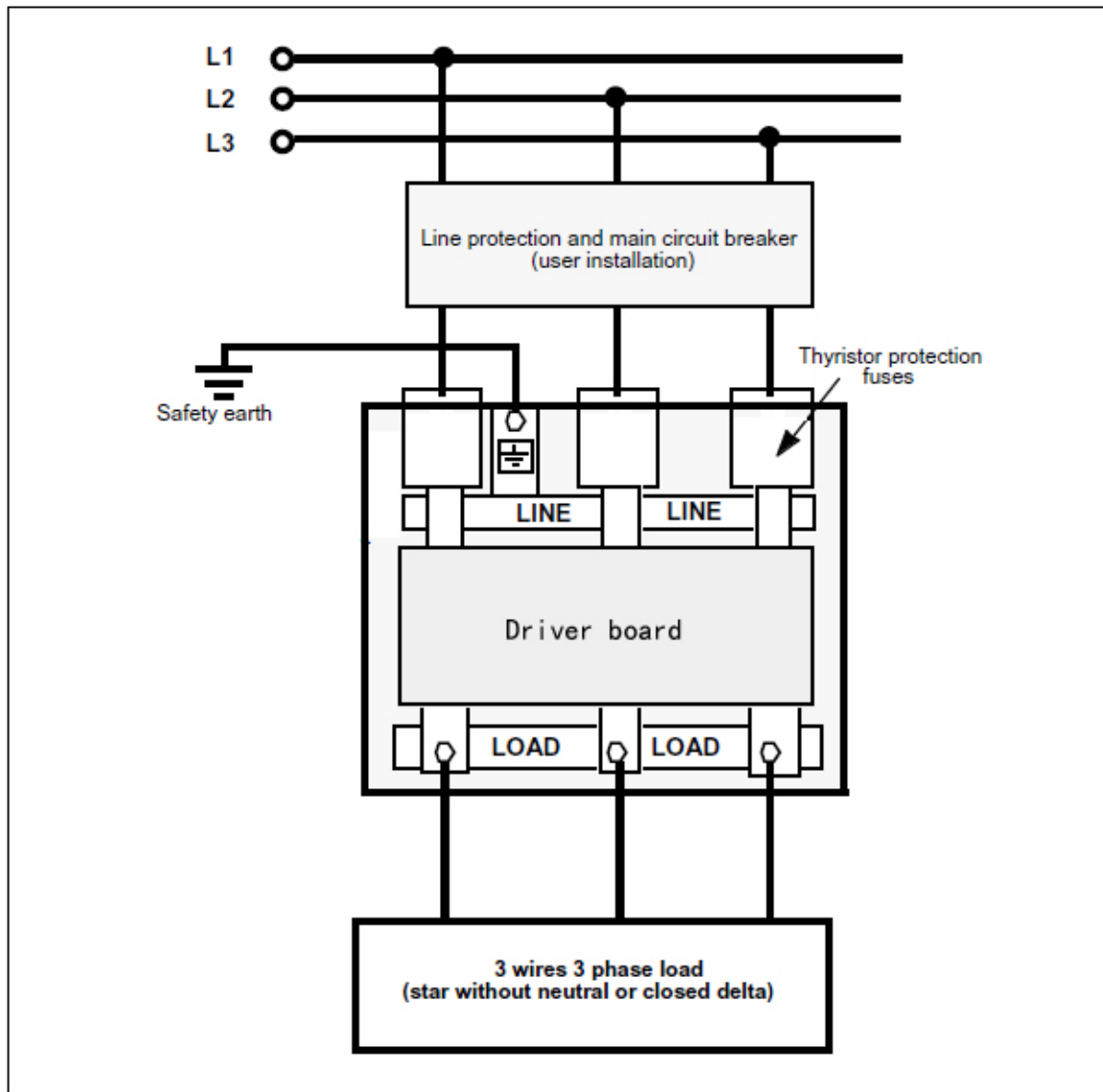


Figure 3-1 Power and safety earth wiring diagram for a 3 wires load

Star with neutral configuration

中性点接零的星形接法

A three-phase load connected in star with neutral is configured as 4-wire.

中性点接零的星形的4线制三相负载接法。

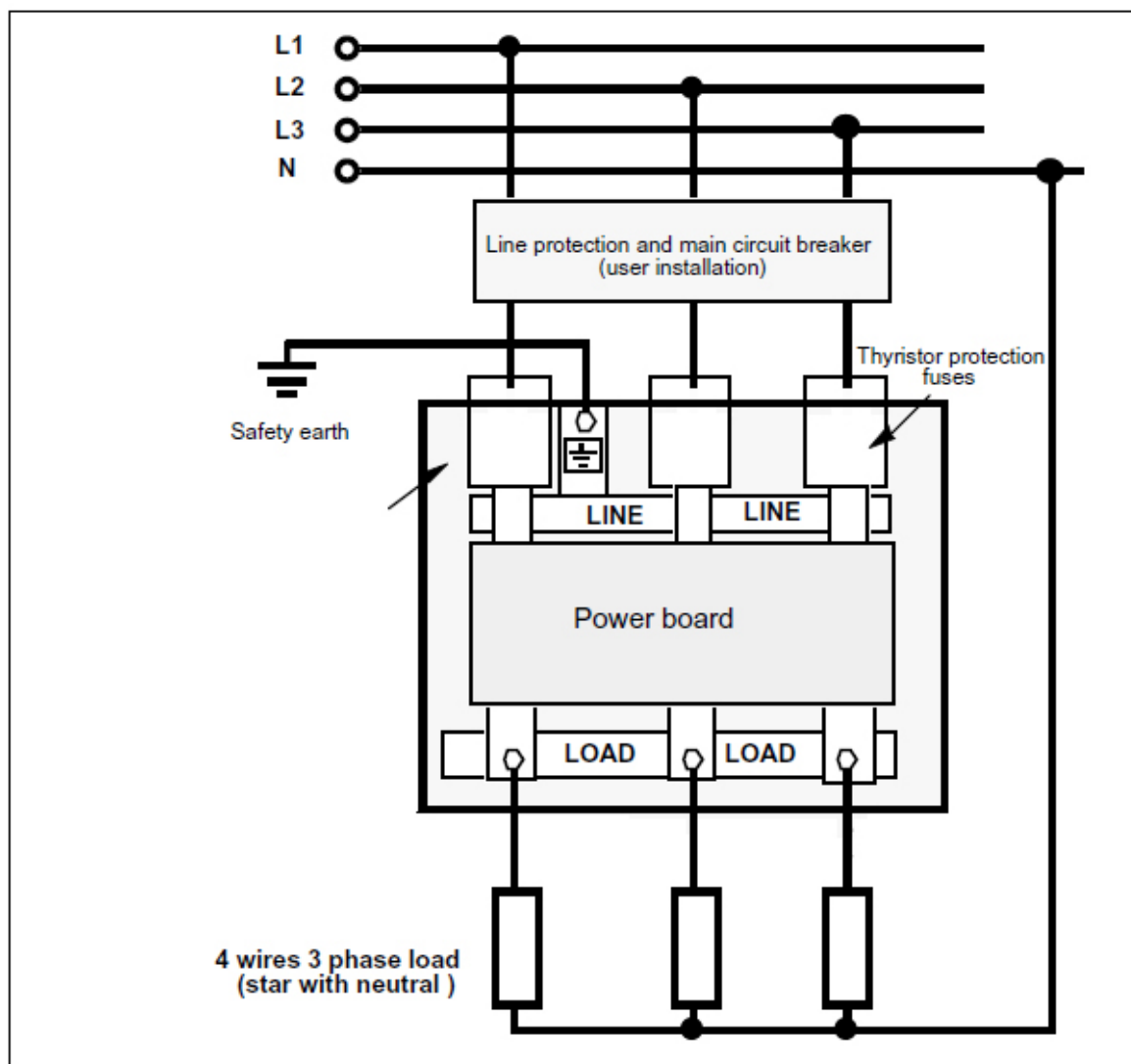
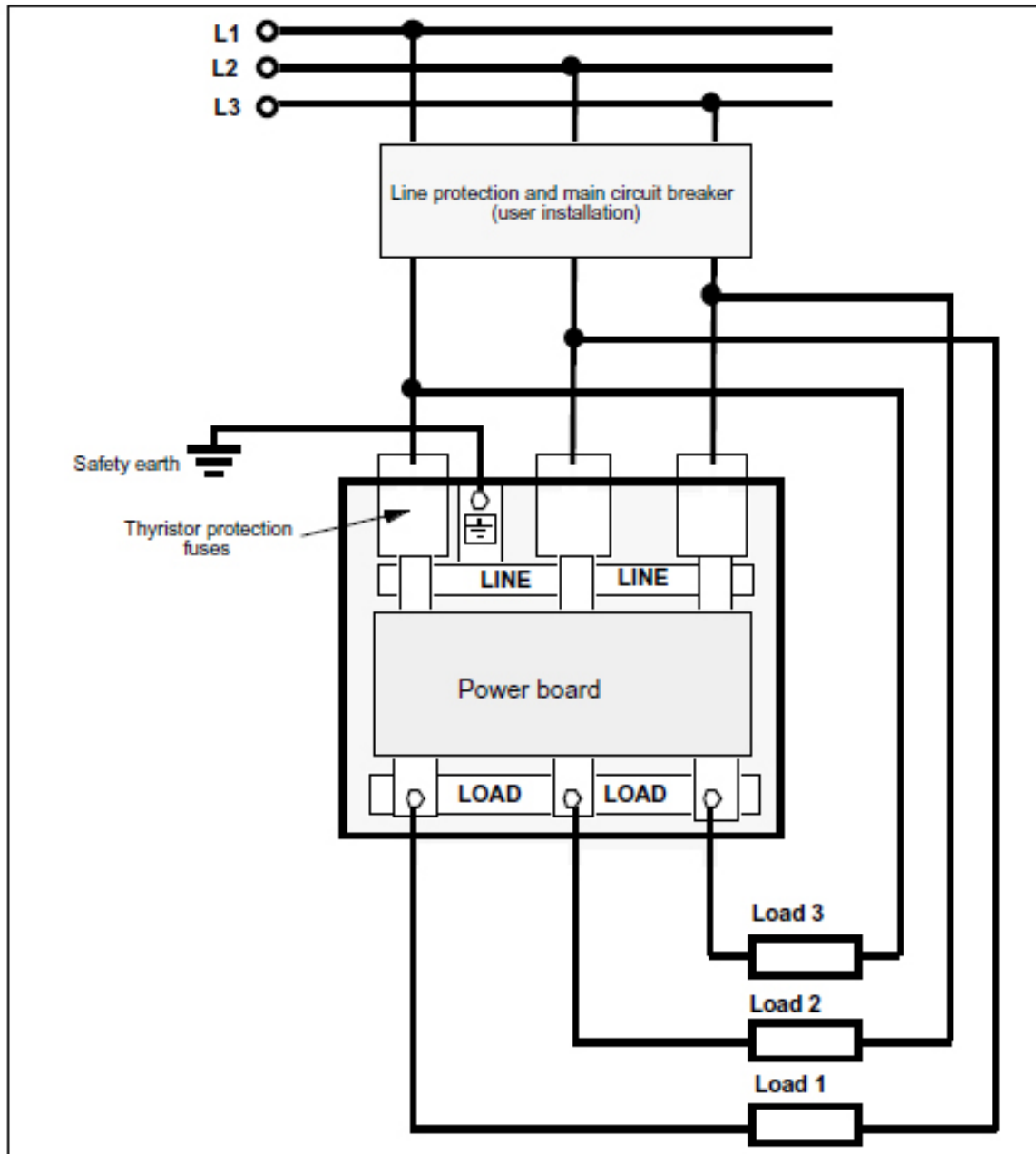


Figure 3-2 Power, safety earth and neutral wiring diagram for a load connected in 'Star with neutral' (4 wires)

Open delta configuration

外三角配置



Important!

重要!

The load wiring given below must be observed.
负载接线一定要按图势说明。

USER TERMINAL BLOCKS

用户接线端子排

General introduction

总体介绍

The user terminal blocks comprise:

用户端子排包括以下内容:

· A control terminal block

控制端子

· A fan terminal block

风机端子（出厂已接好）

The control terminal block is located **beside** the controller on the **left** side.

控制端子在控制器的左边。

The fan terminal block is located **over** the controller on the **top** side.

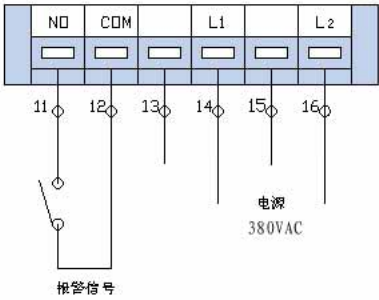
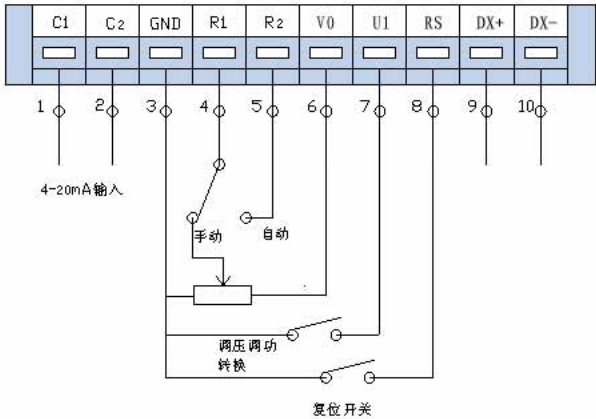
风扇端子在控制器的上面。

These connectors for the wires **plug in**.

这些连接都是接插件连接。

Terminal numbers 端子号	Designation on label 标签名称	Function 功能
1	C1	Input signal “+”
2	C2	Input signal “-”
3	GND	Signal GND
4	R1	Auto/Manual switch
5	R2	Auto/Manual switch
6	V0	Reference voltage
7	U1	Working mode
8	RS	Reset
9	DX+	Modbus communication “+”
10	DX-	Modbus communication “-”
11	NO	Alarm nomal open
12	COM	Alarm
13	NC	NC
14	L1	Power
15	NC	NC
16	L2	Power

自动/手动切换



Control wiring in local mode

手动控制接线

The controller can be driven in **local mode** by a potentiometer.
控制器在手动模式下可以由电位器控制。

For operation with manual control, a **10k** external potentiometer must be used, connected between terminals **3** ('0V') and **6** ('+5V', **0.5mA**).
在手动模式下，需使用一个10K Ω 的电位器，在3,6之间。

The potentiometer wiper is connected to the control terminal block input (terminal **4**).
电位器引出端接在4号端子。

Danger !
危险!



With the door open, dangerous live parts may be accessible if the JS3000 thyristor unit is switched on.
如果JS3000调功器单元正在工作，打开盖门会有危险。

Chapter 4

第四章

CONFIGURATION

配置

Contents

目录

CONFIGURATION - SAFETY28
配置安全规范

DRIVER BOARD CONFIGURATION28
触发板配置

GENERAL INTRODUCTION29
总体介绍

Chapter 4 CONFIGURATION

第四章 配置

CONFIGURATION - SAFETY

配置安全规范

The controller is configured , located on the driver board.
触发板上有控制器的配置部分。

Important!

重要！



The controller is supplied fully configured in accordance with the product code on the identification label and is ready for operation after wiring.
控制器必须完全根据产品代码配置完毕后，才能接线准备使用。

This chapter is included with a view to:

这章包括以下内容：

- Checking that the configuration is suitable for the application
检查配置是否符合要求
- Modifying, if necessary, certain characteristics of the controller on site.
修改必需的控制参数。

DANGER!

危险！

For safety reasons, re-configuration of the controller must be carried out with



the unit switched off and by personnel qualified and trained to work with electrical equipment in a low voltage industrial environment.
为了安全，调功器单元的再配置必须在切断电源的情况下由受过专业训练的人员完成，而且其要有在工业现场环境中的低压电器设备的操作经验。

Before starting the re-configuration procedure, ensure that the controller is isolated and that any accidental power-up is not possible.
在再配置之前，请确保控制器已经隔离电源，并且不会意外上电。

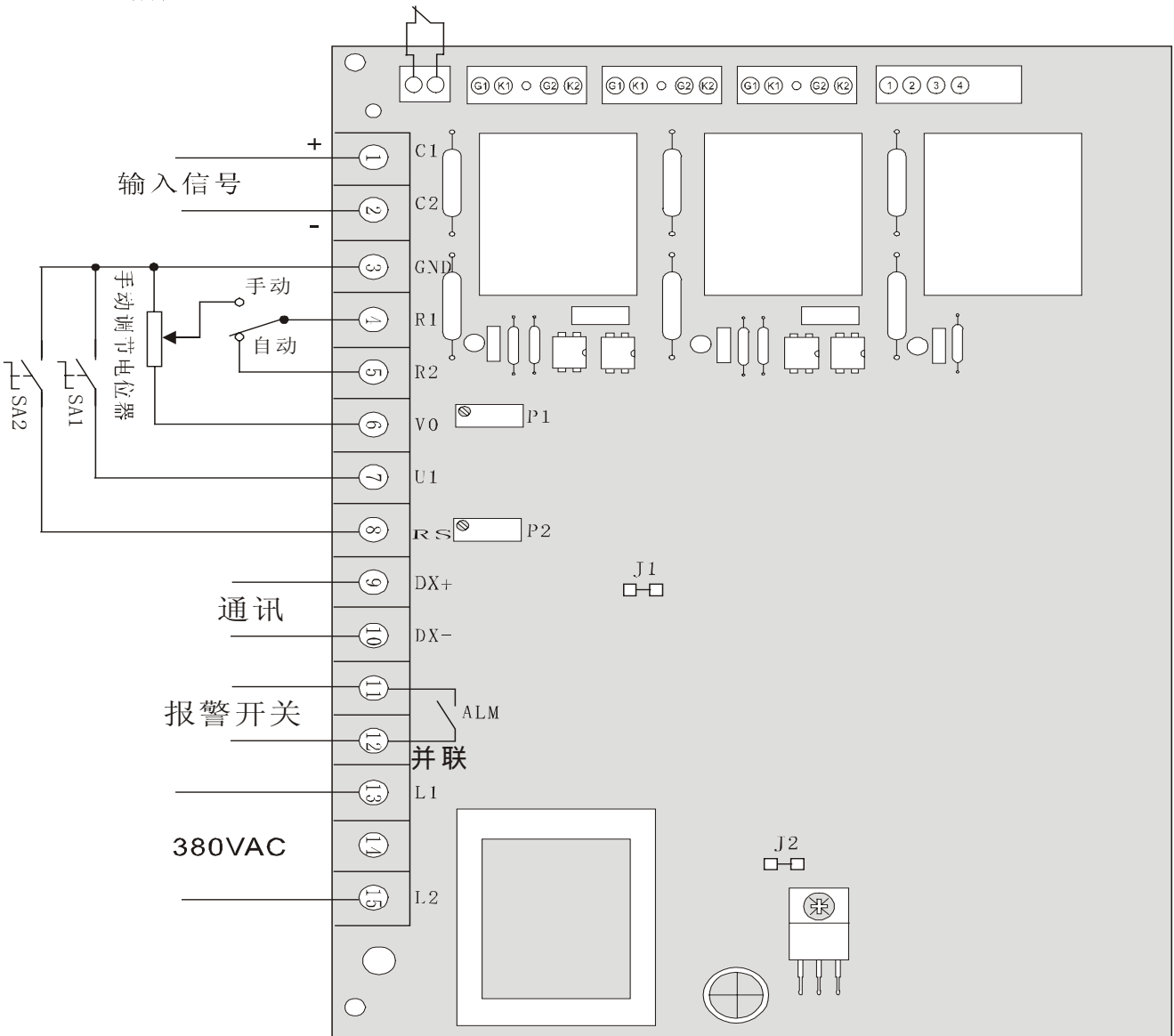
After re-configuring the controller, amend the codes on the identification label to prevent any later maintenance problems.
重新配置以后，修改标签说明，以便日后维护。

DRIVER BOARD CONFIGURATION

触发板配置

General introduction

总体介绍



Js3000触发板

- potentiometer
电位器

P1: Scale range adjuster

P1:量程调整电位器

P3:Current-limiting adjuster

P3:电流限制电位器

P2:Setting over-current adjuster

P2:过流设定电位器

- 端子代码及定义
Terminal code and definition

1, 2: C1, C2: Control signal input

1, 2: C1, C2:控制信号输入

3, 8: GND, RS: Active and reset switch

3, 8: GND, RS: 运行及复位状态转换

4, 5: R1, R2: External power adjustment

4, 5: R1, R2: 外部电压调节

3, 7: GND, U1: Work mode switch

3, 7: GND, U1: 工作方式选择

9, 10: DX+, DX-: Communication

9, 10: DX+, DX-: 通讯

11, 12: NO, COM: Alarm

11, 12: NO, COM: 报警输出端

14, 16: L1, L2: Power

14, 16: L1, L2: 电源输入端

Chapter 5

第五章

OPERATION

操作

Contents

目录

CONTROL OPERATION	32
控制操作	

THYRISTOR FIRING MODES	33
晶闸管触发模式	

GENERAL INTRODUCTION	33
总体介绍	

'PHASE ANGLE' MODE	33
移相角调压模式	

'BURST-FIRING' MODE	35
调功模式	

Chapter 5 OPERATION

第五章 操作

CONTROL OPERATION

控制操作

JS3000 controllers include an internal control loop.

JS3000数字功率控制器采用先进的微处理器数字锁相环控制技术。

Thyristors

晶闸管

The 3 pairs of thyristors modulate the supply voltage which is applied to the three-phase load.

三相晶闸管功率控制器调压后给负载。

Display board

显示板

Four operation push button located on the **display board** (which is mounted parallel to the driver board) can be accessed on the front panel. They are used to adjust the main thyristor unit operating parameters without having to open the front door.

四个操作按键固定在调节板上（与触发板平行放置）在前面板上。这些按钮可以调整调功器的主要参数而无须打开前盖。

Five calibration potentiometers can be accessed when the front door is open.

打开前盖可以调整五个电位器。

The functions of the operation potentiometers are indicated on the front panel of the thyristor unit and are explained in the relevant paragraph .

前面板的操作板功能在相应章节有说明。（本章）

If the thyristor unit is replaced, the potentiometer board can be transferred to the new thyristor unit and thus retain all the adjustments specific to the application concerned.

如果晶闸管更换以后，调整板可以继续使用并保留原来的调参数。

Display

显示

Four 7 segment display is used for steady and flashing messages indicating the current operating mode of the thyristor unit, the alarm state and the error or fault type.

四个7段数码管显示直亮、闪烁显示晶闸管工作的电流、电压等参数和报警及错误故障的类型。

Diagnostic connector

通讯诊断连接

The values from the feedback and the operation of the thyristor unit are available on the diagnostic connector located on the side panel.

通过前面板的诊断接口，可以看到晶闸管的工作参数和反馈参数。

Driver board

触发板

The analogue control signals and parameter retransmissions are applied to the driver board **user terminal blocks**.

模拟控制信号可以通过现场总线MODBUS 485用户接线端块实现的。

The **synchronisation** circuit supplies the microprocessor with three signals corresponding to the sign of the line voltages measured and a signal corresponding to the zero voltage crossing.

同步环提供给微处理器相应的三相相电压和零电压点。

A square raising circuit supplies four signals corresponding to the squares of the measured signals: I_1^2 , I_2^2 , I_3^2 and V^2 .

平方放大电路提供四个相应信号： I_1^2 , I_2^2 , I_3^2 and V^2 。

An 'OR' circuit selects the highest value from the squares of the three currents which is compared to an adjustable threshold of the current limit setpoint.

通过一个‘或’电路选择三个电流平方的最大值和电流限定的设定值做比较。

The **multiplexer** selects the signal applied to the analogue/digital converter inside the microprocessor from the measurements, front panel potentiometer voltages and the control signals, according to the program procedure.

多路选择信号器将采集到的模拟信号通过10位A/D转换器送给微处理器，这些模拟信号是通过程序过程采集到的电压、控制等信号。

The driver board **microprocessor** controls the entire operation of the thyristor unit and the message display.

微处理器控制着整个晶闸管的动作和显示的信息。

The amplification of the input signals converts the low level signals and amplifies the retransmissions.

输入放大电路将弱信号放大传输。

One **relays** are used for the external detection of the active alarm state.

一个报警继电器指示报警状态。

A **diagnostic connector** located on the front panel of the thyristor unit is used to control or measure the main thyristor unit operating parameters.

位于调功器前盖的MODBUS 485通讯接口可以用来控制调功器的动作参数。

The **watchdog** monitors the correct functioning of the software; in the event of a fault, it sends a 'Reset' signal to the microprocessor.

看门狗监视软件是否正常工作，如果发生错误，微处理器会得到一个复位信号。

THYRISTOR FIRING MODES

晶闸管触发方式

'Phase angle' mode

移相角调压模式

In '**Phase angle**' mode, the power transmitted to the load is controlled by firing the thyristors on a part of the supply voltage alternation.

在移相触发模式中，负载的功率控制是靠晶闸管的提供的交流电压的部分电压完成的。

For the three-phase load configuration in star **with neutral**, the load voltage is composed of portions of supply '**phase-neutral**' voltage alternations.

如果三相负载是中性点接零的星形接法，负载电压有一部分是靠供电电压的零线交替提供的。

For the three-phase load configuration in **open delta**, the load voltage is composed of portions of **line-to-line** voltage alternations.

如果负载是外三角形接法，负载电压有一部分是靠供电的线电压交替提供的。

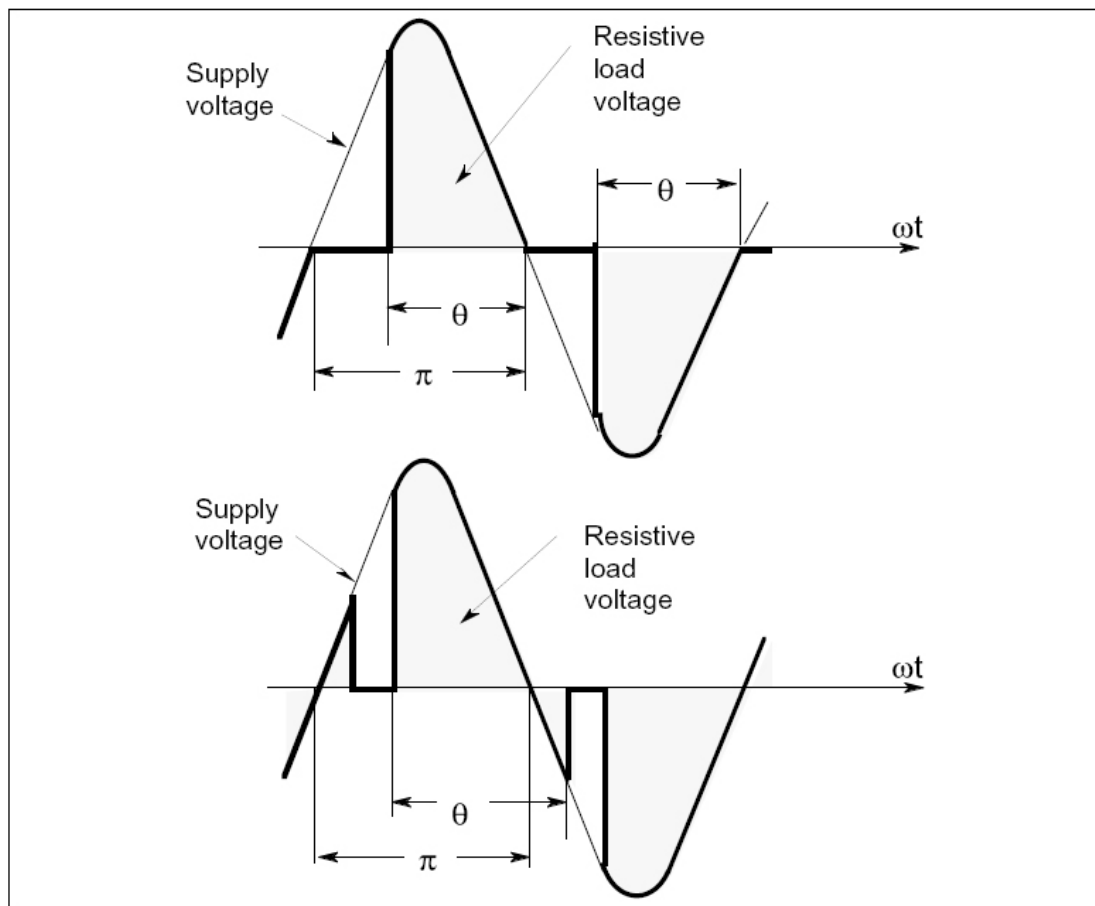


Figure 5-1 Load voltage in 'Phase angle' (star with neutral or open delta)
负载电压，（中性点接零或开放三角形）

The firing angle (α) varies in the same way as the control system signal.

触发角 (α) 的变化同样的作为控制信号。

The output power is not a linear function of the firing angle.

输出功率和触发角不是线性的。

The three-phase load voltage, configured in star **without neutral** or in **closed delta** (3 wire configuration), is composed

of portions of **two-** or **three-phase** waves according to the thyristor firing angle value.

如果负载接法是星形中性点不接零或内三角形（3线制），三相负载电压根据晶闸管的触发角的两个或三个波形组成。

In **two-phase** operation, the thyristor output voltage (between 'LOAD' terminals) is the voltage between two **firing** phases.

在两相操作中，晶闸管输出电压在两个触发相中。

In **three-phase** operation, the voltage of each load arm is the **phase** voltage for the star without neutral configuration or the **line-to-line** voltage for the closed delta configuration.

在三相负载中，如果是中性点不接零的星形每相负载电压就是相电压，在内三角形中每相负载电压就是线电压。

The figure below shows two examples of **three-phase resistive** voltages configured in star without neutral.

下面是两个中性点不接零的星形接法的三相负载电压的例子。

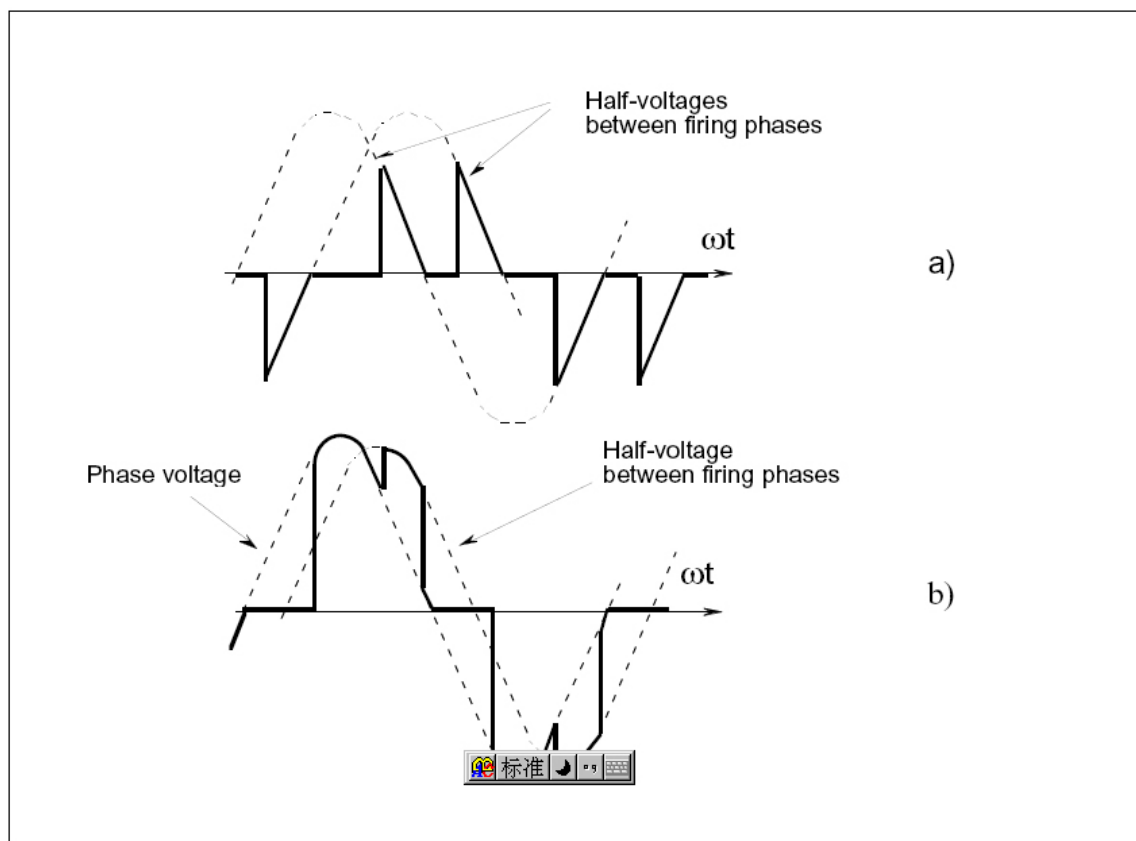


Figure 5-2 Resistive load voltage (star without neutral) in 'Phase angle'
移相阻性负载电压（中性点不接零的星接）

For a small firing angle ($\alpha < 60^\circ$), the load voltage is composed of portions of half-voltages between phases (figure 5-2,a).
如果触发角小于60度 ($\alpha < 60^\circ$)，负载电压由相间的半电压组成。（图5-2,a）

For a large firing angle ($\alpha > 60^\circ$), the load voltage is composed of portions of voltage of one phase and portions of half-voltages between phases (figure 5-2,b).

如果触发角大于60度 ($\alpha > 60^\circ$)，负载电压由一相和相间的半电压组成。（图5-2, b）

'Burst firing' mode

调功模式

The 'Burst firing' mode is a **proportional cycle** which consists of supplying a series of **complete** supply voltage **periods to the load**. (see figure 5-3).

调功模式是一个比例圈，是由一系列的完整供电组成给负载的。

Thyristor firing and non-firing are synchronised with the supply and are performed **at zero voltage** for a resistive load. 对于阻性负载，于供电同步的触发电压和非触发电压是在零电压点执行的。

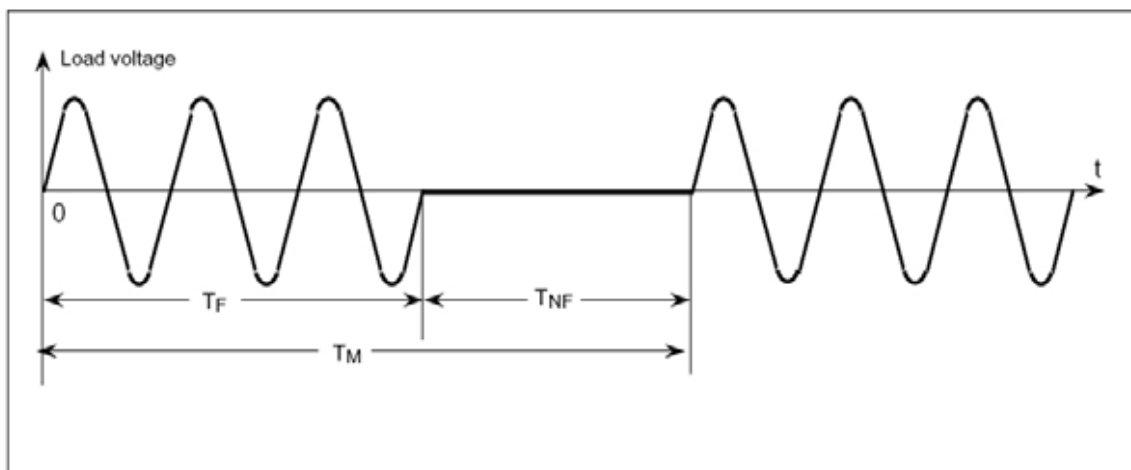


Figure 5-3 'Burst firing' mode (T_F - firing time; T_M - modulation period)

调功模式 (T_F -触发电时间; T_M -调节时间)

The control algorithm of the **JS3000** series takes into account the value of the r.m.s. load voltage **squared**.

JS3000系列的运算法则采用的是负载电压的平方值。

The square of the r.m.s. load voltage represents the power dissipated in a purely resistive load whose resistance remains constant with temperature.

负载电压的平方值表明了功率消耗为阻性负载的持续温度。

The output power of the controller is linear between **0%** and **100%** of maximum power for an analogue input signal variation between **4%** and **96%** of full scale.

控制器的输出功率的0%到最大功率的100%与输入信号的4%到额定范围的96%成线性变化。

Control precision is guaranteed to $\pm 2\%$ of the power dissipated in the load (for constant resistance).

控制精度保证在负载消耗功率的 $\pm 2\%$ 。

The output power of the controller is calibrated according to the nominal voltage specified when ordering.

控制器输出功率的计算根据定货时的标称电压。

Chapter 6

第六章

COMMISSIONING PROCEDURE

试车程序

Contents

目录

COMMISSIONING PROCEDURE - SAFETY37
试车程序安全规范

CHECKING THE CHARACTERISTICS38
检查特征

LOAD CURRENT39
负载电流

SUPPLY VOLTAGE39
提供电压

CONTROL SIGNALS40
控制信号

POWERING UP THE CONTROLLER40
控制器上电

Chapter 6 COMMISSIONING PROCEDURE

第六章 试车程序

Read this chapter carefully before commissioning the controller

试车之前请仔细阅读本章

COMMISSIONING PROCEDURE - SAFETY

试车程序安全规范

Important!

重要！



JETTER cannot be held responsible for any damage to persons or property or any financial loss or costs arising from incorrect use of the product or failure to observe the instructions contained in this manual.

杰顿不负责由于对产品不正确的使用或不遵守本手册的指导而导致的人员或财产或金钱的损失。

It is therefore the user's responsibility to ensure, before commissioning the unit, that all the nominal ratings of the power unit are compatible with the conditions of use and the installation.

因此，用户在试车之前有责任确保标称的额定功率与安装和使用的是相符的。

DANGER!**危险!**

A thyristor is not an isolating device.

晶闸管不是孤立的设备。

Touching a load terminal even with a zero load current is as dangerous as touching mains live.

在无负载的情况下，触摸负载端子与触摸主回路同样危险。

Only personnel qualified and trained to work with low voltage electrical equipment in an industrial environment should have access to the interior of the unit.

只有受过专业培训，而且有在工业现场环境中的低压电器设备的操作经验的人员才能接触调功器单元内部。



Access to internal components of the controller is prohibited to users who are not authorised to work in an industrial low voltage electrical environment.

The temperature of the heatsink may exceed 100°C.

不允许非在工业现场环境中的低压电器设备的操作经验和授权人员接触调功器内部组件。受热面温度可能超过100°C。

Avoid all contact, even occasional, with the heatsink when the controller is operational. The heatsink remains hot for around 15mins after the unit has been switched off.

在控制器工作时，避免接触受热面，甚至是偶然接触。在调功器单元断电以后的15分钟内，受热面的周围仍会保持很热。

CHECKING THE CHARACTERISTICS**检查特性****Load current****负载电流**

The maximum load current must be less than or equal to the value of the nominal current of the controller, taking into account the load and power supply variations.

最大的负载电流一定要小于或等于控制器的额定标称电流，估计负载功率提供的变化。

If three identical loads are configured in **closed delta**, the current of each phase of the controller is **√3 times greater** than the current in each **branch** of the load.

如果同样的负载是内三角形接法，控制器的每相电流要比负载分立的分支电流大 **√3倍**。

For a given power (**P**) of a three-phase load and with line-to-line voltage **VL**, the current to be compared with the nominal current of the controller is:

给定一个三相负载的功率和相与相之间的电压，则额定标称电流如下：

$$I = \frac{P}{\sqrt{3} \times V_L}$$

For open delta, the current to be compared with the nominal current of the controller is:

如果是开放三角形接法，则控制器的额定标称电流如下：

$$I = \frac{P}{3 \times V_L}$$

Supply voltage 供电电压

For starts configurations without neutral or closed delta,the nominal value of the thyristor unit voltage must be greater than or equal to the line to line voltage of the supply used.

对于中性点不接零的星接或封闭三角形接法，晶闸管单元的标称电压一定要高于或等于供电电压。



Danger!

危险！

Never use a thyristor unit with a supply voltage greater than the nominal unit voltage speaciald in the coding .

晶闸管单元一定不能用在比定货电压高的供电系统中。

If the line voltage is less than 80% of the nominal voltage,the thyristor unit is inhibited.

如果电压低于标称电压的80%，晶闸管单元将停止工作。



Attention!

注意！

In order for the control algorithm to function correctly, the nominal unit voltage rating must be as close as possible to the supply voltage.

为了保证控制器运算功能正确完成，额定标称电压应该最可能接近电源提供的电压。

Control signals控制信号

Configuration on the driver board must be compatible with the type and level of the control signals.

触发板的配置应该与输入信号的类型和级别相一致。

POWERING UP THE CONTROLLER

控制器上电

JS3000 series controllers are ready to operate correctly **immediately** after installation and wiring in accordance with this user manual.

按用户手册安装接线结束后，JS3000系列可以准备正常工作。

After checking that the nominal parameters of the controller (voltages, currents, input signal and load configuration) are compatible with those of the installation, apply volts to the controller.

检查完控制器的标称参数（电压，电流，输入信号和负载配置）和安装参数一致后，控制器可以正式上电。

Check that the current in each phase of the controller is equal to 0 in the **absence** of the control signal.

检查无输入信号时，控制器的各相电流是否为零。

Make sure that the r.m.s. current in each phase **does not exceed** the nominal controller rating when the setpoint is at **maximum**.

当设定值为最大时，确保每相电流不超过控制器的额定标称电流。

Chapter 7

第七章

DISPLAY MESSAGES

显示信息

Contents 目录	page 页
General	42
总述	
Steady messages	42
直亮信息	
Flashing messages	42
闪烁信息	
Error	42
错误	
Failures	42
故障	
Microprocessor failure	42
微处理器故障	

Chapter 7 DISPLAY MESSAGES

第七章

显示信息

GENERAL

总述

During the thyristor unit commissioning procedure and during its operation, messages are displayed on the front panel display. These messages inform the user on:

在调功器试车和工作时，前面数码管会显示相关信息。这些信息包括：

- the type of thyristor unit operation
调功器工作方式
- the enabled alarms
使能的报警
- the errors and the faults.
错误和故障

Two types of message are shown on the display.

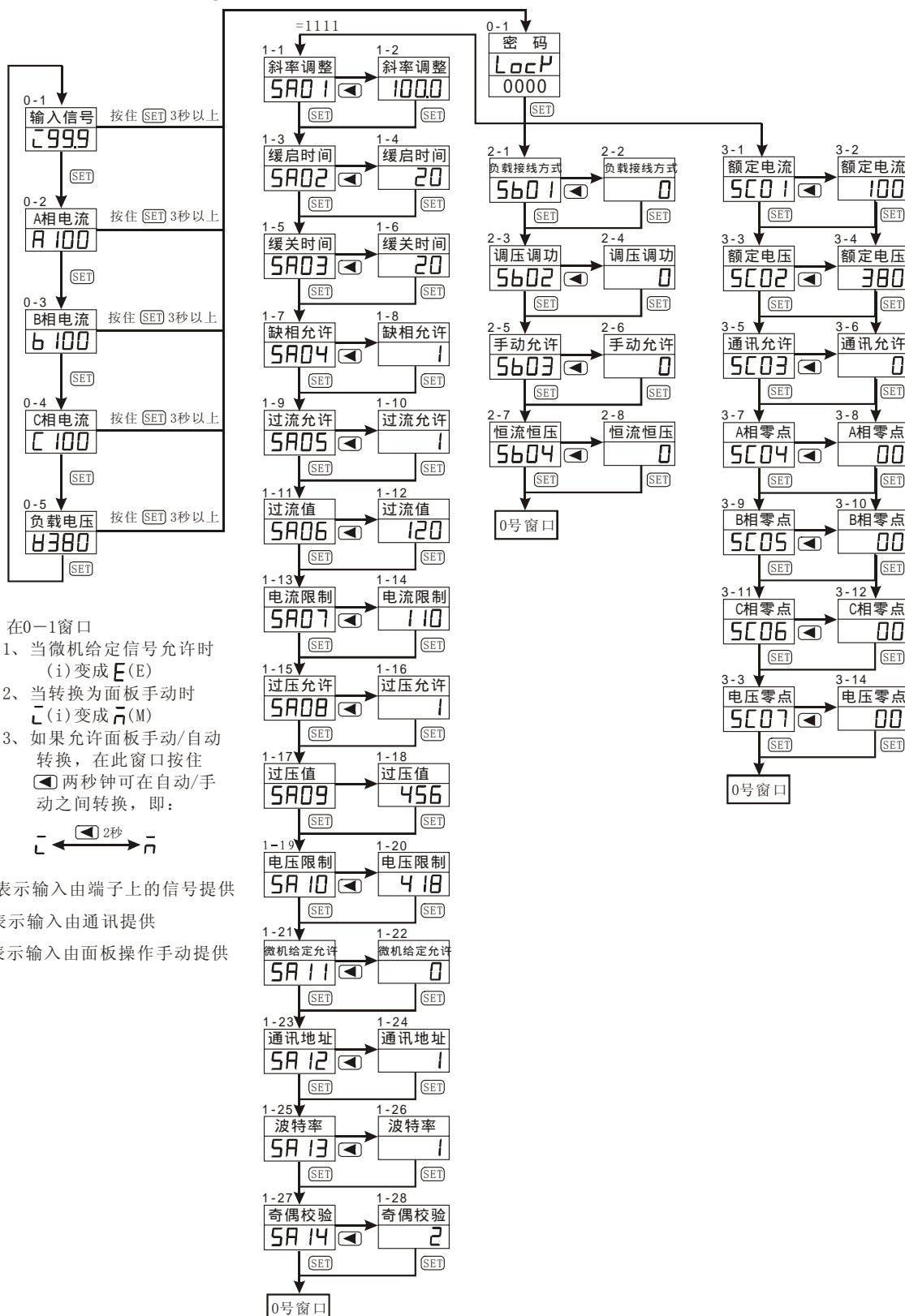
信息显示有两种：

- **Steady** messages indicating the current thyristor unit operating mode.
直亮指示电流和工作模式
- **Flashing** messages indicating **abnormal** operation (an error or a failure).
闪烁信息显示错误和故障。

STEADY MESSAGES

直亮信息

Js3000触发板参数流程图



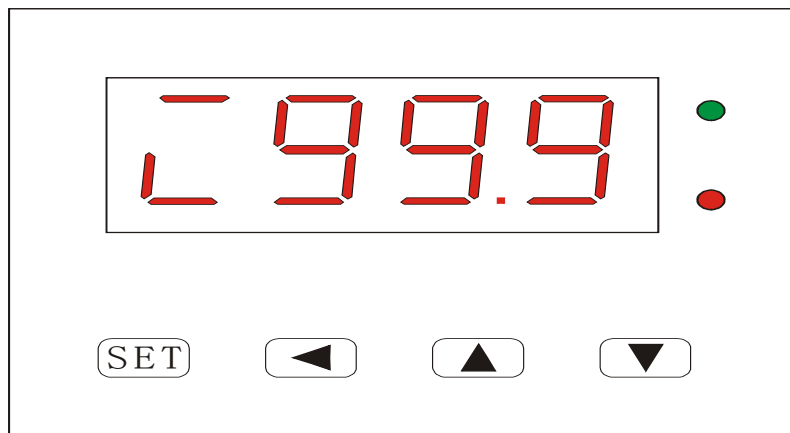
SA series parameter for user operation
SA系列参数为客户操作使用

code 显示代码	Function 功能	Range or value 范围或数值	Remark 备注
SA01	External power adjustment 斜率调整参数	0-100%	
Sa02	Soft start 缓启动时间	0- 60sec 0-60秒	
Sa03	缓关断时间	0 - 60秒	
Sa04	Running with absence of supply 电源缺相运行允许	0: Running with bsence of supply 0:电源缺相继续运行, 1:stop with absence of supply 1:电源缺相停止运行	
SA05	Over-current function 过流限流功能允许	0:Without over-current function 0:不允许过流限流功能, 1:With over-current function 1:允许过流限流功能	
SA06	Value of over-current 过流报警值	0.1 - 1.2Ie	Ie:current rating Ie:额定电流
SA07	Value of limited current 电流限制值	0.1 - 1.1Ie	Ie:current rating Ie:额定电流
Sa08	Over and limit voltage 过压限压功能允许	0:Without over and limit voltage 0:不允许过压限压功能, 1:with over and limit voltage 1:允许过压限压功能	
SA09	Value of over voltage 过压报警值	0.1 - 1.2Ve	Ve:rating voltage Ve为额定电压
SA10	Value of limited voltage 电压限制值	0.1 - 1.1Ve	Ve:rating voltage Ve为额定电压
SA11	Modbus communication MODBUS通讯方式选择	0:RTU , 1:ASCII	
Sa12	Address of communication 通讯地址	1 - 247	
SA13	Bps of communication 通讯波特率	4800,9600,19200	19200 display 1920 19200显示1920
Sa14	parity check 奇偶校验位	0:no check,1:odd,2:even 0:无校验,1:奇校验,2:偶校验	
Sa15	Signle of computer 计算机给定信号允许	0: local 0:给定信号为本地给定, 1:computer 1:计算机给定	

Attention 注意



The SA15 parameter is set 1 only by computer,only 0 is set by panel.
SA15参数只能由计算机改成1，面板操作只能改成0，不能改成1。



SET 设置键

◀ 移位键

▲ 增加键

▼ 减小键

Chapter 8 ALARMS

第八章 报警

Contents	page
目录	
Alarm strategy 47	47
报警原理	
Serious alarms 47	47
严重报警	
Low level alarms 47	47
低级报警	
Alarm relays 48	48
报警继电器	
Alarm acknowledgement 48	48
报警常识	

Chapter 8 ALARMS

第八章 报警

The alarms used by the JS3000 thyristor unit protect the thyristors and the installation against **abnormal operation** and give the user **information** on the type of failures that have occurred.

JS3000晶闸管单元使用的报警可以保护晶闸管的错误动作，并且提供发生的故障信息。



Danger !

危险！

Alarms cannot be used to replace personnel protection.

报警不能用来代替人员防护。

ALARM STRATEGY

报警原理

The **JS3000** thyristor unit alarms are entirely **managed by the microprocessor** of the driver board which retransmits its data (alarms enabled or not) **using the display** on the thyristor unit front panel and **alarm relays**.

JS3000晶闸管单元的报警完全由触发板的微处理器管理，而报警数据和信息由前面板的数码管显示和报警继电器指示。

The enabled state of all the alarms is indicated by the front panel **display** and **alarm relays**.

所有使能的报警状态全部由前面板显示和报警继电器指示。

The highest level alarms detect the following failures:

高级报警检测故障如下：

- absence of one or more supply phases
电源缺一相或几相
- over-current in Burst firing modes
调功模式过流
- under-voltage

欠压

- thyristor short-circuit
晶闸管短路
- external measurement signal failure.
外部输入信号错误
- neutral failure (fuse blow-out on the driver board).
不确定故障（触发板保险烧掉）

The detection of one of these failures causes the thyristor unit operation to be inhibited
这些故障可以引起晶闸管单元停止工作。

The low level alarms monitor:

低级报警检测:

- the over-voltage
过压
- the current unbalance
电流不平衡
- the first over-current in Burst firing mode.
调功模式过流

ALARM RELAYS

报警继电器

The alarm relays are located on the driver board:
报警继电器安装在触发板上:

the relay for all the other alarms (**general alarm relays**).
任意报警发生，继电器都会动作

The switch cut-off capacity is 2 A (250 Vac or 30 Vdc).
报警继电器的开关容量为2A . (250 Vac or 30 Vdc).

The switch operating voltage must never be greater than 250 Vac.
报警继电器的开关的电压不能超过250 Vac。

Alarm acknowledgement

报警常识

With Diode display & Communication

带数码管显示和通讯

reference chapter 7.(参考第七章)。

Without Diode display & Communication

带数码管显示和通讯

three function indicator:

三个功能指示灯:

Green lights:

绿色平光:

Active

运行状态

Red and Green blinks:

红灯和绿灯闪烁:

Reset

复位状态

Red and Green lights:

红灯和绿灯平光:

Setting over-current value

过电流标定指示

Red and green blink alternately:
红绿交替:

Radiator is over-temperature
散热器超温

Red lights:
红色平光:

Over-current protection
过电流保护

Red blinks:

Lack-phase in main loop while control board is provided with power supply.

红色闪烁:

主板正常供电时，主回路缺相

Chapter 9

第九章

MAINTENANCE

维护

Contents

目录

FUSES	50
保险	
THYRISTOR PROTECTION	50
晶闸管保护	
SERVICING	51
维修	

Chapter 9 MAINTENANCE

第九章 维护

DANGER!

危险！



The controller must be maintained by personnel qualified and trained to work with low voltage electrical equipment in an industrial environment.

调功器的维护必须由受过专业培训的人员完成，而且其要有在工业现场环境中的低压电器设备的操作经验。

The user's installation must be protected upstream (non high-speed fuses, thermal or electromagnetic circuit breaker, suitable fuse-isolator) and must comply with current standards.

用户的安装必须有隔离断路器的保护，而且要符合电流标准。

FUSES

保险

Thyristor protection

晶闸管保护

The thyristors in the **JS3000** series controllers are protected in the following way:

JS3000系列控制器的晶闸管保护方式如下：

- external high speed fuses against overcurrents (except for short-wave infrared applications)
额外的快速熔断保护过流
- RC snubbers and MOVs (varistors) protect against over-fast voltage variations and transient overvoltages when the thyristors are not conducting.
阻熔吸收保护晶闸管未导通时的瞬间过压。

**DANGER!****危险！**

High-speed fuses are used only for the protection of thyristors against large amplitude overloads.

快速熔断只能保护晶闸管的过流。

Under no circumstances should these high-speed fuses be used to protect the installation.

不能将快速熔断用作隔离断路器的保护装置。

To protect the thyristors in the **JS3000** series, 3 fuses and a **tri-polar** fuse-holder must be used.
为了保护JS3000系列的晶闸管，每相均有快速熔断。

**SERVICING****维修**

JS3000 controllers must be mounted with the heatsink positioned vertically, with no obstructions above or below which could inhibit or impede airflow.

JS3000控制器必须垂直安装，在其上下都没有阻碍物阻碍空气流通。

Attention!**注意！**

If several units are mounted in the same cabinet, they should be arranged in such a way that air expelled from one cannot be drawn into the unit located above it.

如果一个控制柜中安装多个调功器单元，它们的安装排列方式应以不影响空气循环流通的原则。

In order to ensure correct cooling of the unit, users are advised, depending on the degree of environmental pollution, to regularly **clean the heatsink** and the **protective fan guard**.

为了保证调功器单元的正常冷却，建议用户，根据环境污染情况，定期的清洁受热面，保护风机正常。

**DANGER!****危险！**

Cleaning should only be carried out when the controller supply is disconnected and at least 15 minutes after it has ceased operating.

清洁工作必须在控制器切断电源停止工作15分钟以后进行。

Every six months check that the screws of the power and safety earth cables are correctly tightened.

每6个月检查动力线和接地线的螺栓是否紧密。