一、竞赛设备描述

I. Description of competition device

竞赛设备以"KNT-WP01 型风光互补发电实训系统"为载体，该设备由光伏供电装置、光伏供电系统、风力供电装置、风力供电系统、逆变与负载系统和监控系统组成，如图 1 所示。

The competition device uses "KNT-WP01 wind-solar hybrid generating training system" as its carrier. It consists of the photovoltaic power supply device, photovoltaic power supply system, wind power supply device, wind power supply system and inverter and load system as well as the monitoring system, as shown in Fig. 1.

（a）（b）（c）（d）（e）（f）

(a) (b) (c) (d) (e) (f)
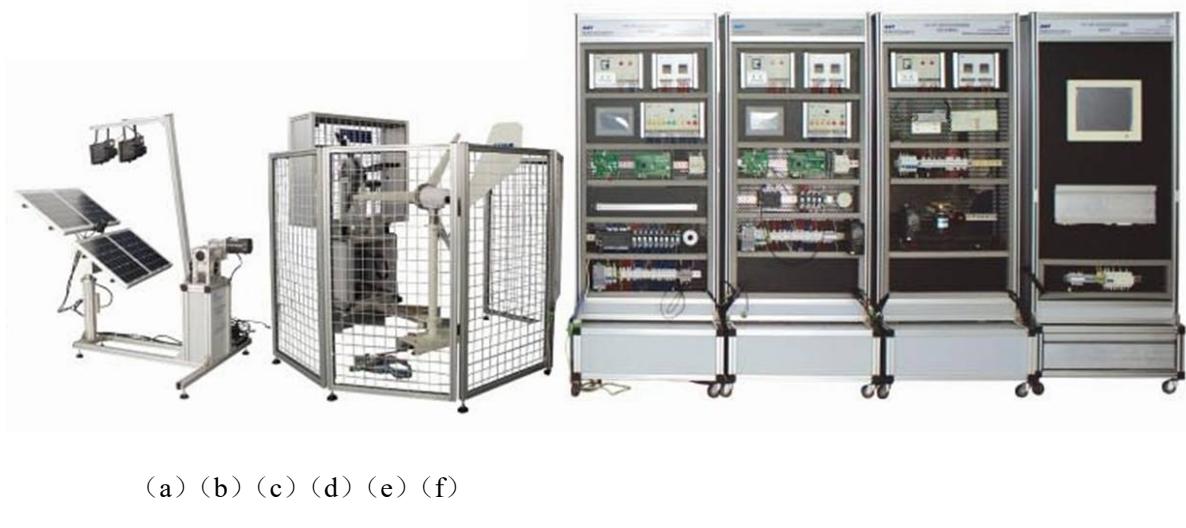
图 1　KNT-WP01 型风光互补发电实训系统外形图

Fig. 1 Exterior View of KNT-WP01 Wind-Solar Hybrid Generating Training System

（a）光伏供电装置（b）风力供电装置（c）光伏供电系统

(a) PV power supply device (b) Wind power supply device (c) PV power supply system

（d）风力供电系统（e）逆变与负载系统（f）监控系统

(d) Wind power supply system (e) Inverter and load system (f) Monitoring system

1．光伏供电装置

1. PV power supply device

光伏供电装置主要由光伏电池组件、投射灯、光线传感器、光线传感器控制盒、水平方向和俯仰方向运动机构、摆杆、摆杆减速箱、摆杆支架、单相交流电动机、电容器、直流电动机、接近开关、微动开关、底座支架等设备与器件组成。

The PV power supply device primarily consists of PV solar module, projection LED lamp, light sensor, light sensor control box, horizontal and pitching direction movement mechanism, rod of pendulum, reduction box of rod of pendulum, rod of pendulum support, single phase alternating motor, capacitor, direct current motor, proximity switch, micro switch, base support and other devices and components.

光伏供电装置的光伏电池组件偏移方向的定义和摆杆移动方向的定义如图2所示，靠近摆杆的投射灯定义为投射灯1（简称灯1），另1盏投射灯定义为投射灯2（简称灯2）。

The definitions of PV solar module's offset direction and the rod of pendulum's movement direction of the PV power supply device are shown in Fig. 2. One of the projection LED lamps next to the rod of pendulum is defined as projection LED lamp 1 (LED 1 for short). The other projection LED lamp is defined as projection LED lamp 2 (LED 2 for short).

型号、参数相同的4块光伏电池组件和光线传感器均已安装在光伏供电装置上。

4 PV solar modules and the light sensor in the same model and with the same parameters have been mounted on the PV power supply device.

2．光伏供电系统

2. PV power supply system

光伏供电系统主要由光伏电源控制单元、光伏输出显示单元、触摸屏、光伏供电控制单元、DSP 核心单元、信号处理单元、接口单元、西门子 S7-200 CPU226PLC、继电器组、蓄电池组、可调电阻、断路器、开关电源、应用软件、接线排、网孔架等组成。

The PV power supply system primarily consists of PV supply control unit, PV output display unit, touch screen, PV power supply control unit, DSP core unit, signal processing unit, interface unit, Siemens S7-200 CPU226PLC, relay unit, battery pack,

adjustable resistor, switch supply, applications, terminal strip, mesh frame.

仅拆除光伏控制 PLC 输入、输出接线，其它部分接线已完成。

The PV control PLC input and output wires are removed only. Wiring of other parts has been completed.
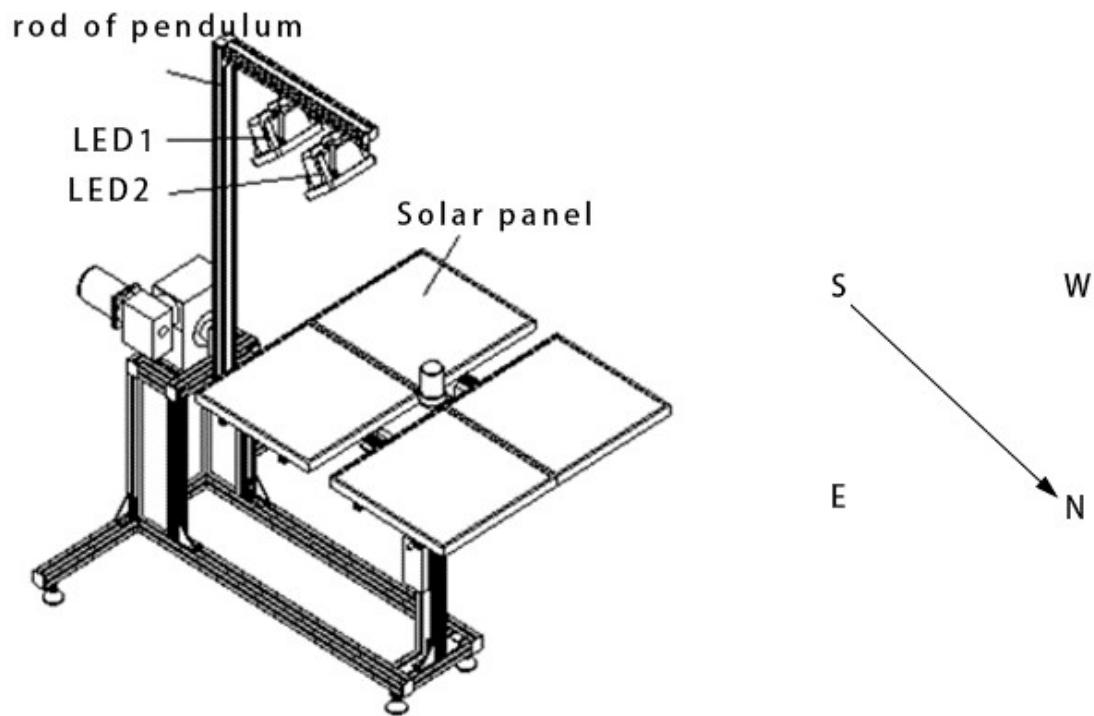

图 2　光伏供电装置外形图及方向定义

Fig. 2 Exterior View and Definition of Directions of the PV Power Supply Device

3．风力供电装置

3. Wind power supply device

风力供电装置主要由水平轴永磁同步风力发电机、塔架和基础、测速仪、测速仪支架、轴流风机、轴流风机支架、轴流风机框罩、单相交流电动机、电容器、风场运动机构箱、护栏、连杆、滚轮、万向轮、微动开关和接近开关等设备与器件组成。如图 3 所示是风力供电装置示意图，风场运动机构箱运动方向的定义已在图中标明。

The wind power device primarily consists of the horizontal axis permanent magnet synchronous generator, tower and base, anemometer, anemometer support, axial flow fan, fan support, fan mask, single phase alternating motor, capacitor, wind farm kinematics casing, guardrail, connecting rod, roller, universal wheel, micro switch, proximity switch. Fig. 3 is the schematic diagram of the wind power supply

device. The definition of the movement direction of wind farm kinetics casing has been indicated on the drawing.

水平轴永磁同步风力发电机由叶片、轮毂、发电机、机舱、尾舵、侧风偏航机械传动机构组成，均已安装完成。

The horizontal axis permanent magnet synchronous generator consists of blade, hub, generator, machinery space, rear control, crosswind yawing mechanical transmission mechanism, all of which have been installed.


顺时	Clockwise
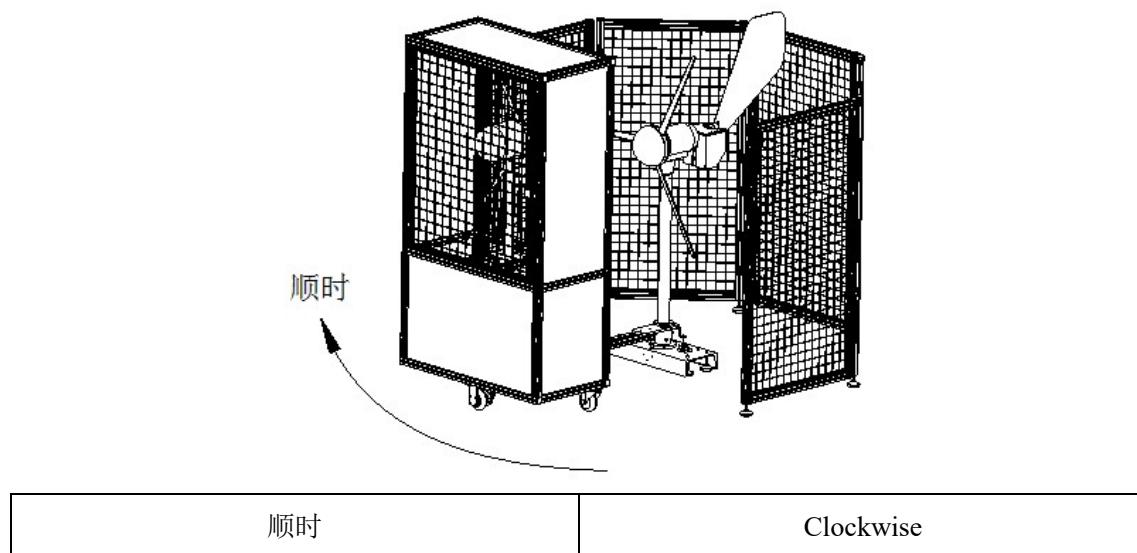
图 3　风力供电装置示意图

Fig. 3 Wind Power Supply Device Schematic

4．风力供电系统

4．Wind power supply system

风力供电系统主要由风电电源控制单元、风电输出显示单元、触摸屏、风力供电控制单元、DSP 控制单元、接口单元、西门子 S7-200 CPU224PLC、变频器、继电器组、可调电阻、断路器、应用软件、开关电源、接线排、网孔架等组成。

The wind power supply system primarily consists of the wind power supply control unit, wind power output display unit, touch screen, wind power supply control unit, DSP control unit, interface unit, Siemens S7-200 CPU224PLC, frequency converter, relay unit, adjustable resistor, circuit breaker, applications, switch supply, terminal strip, mesh frame.

风力供电装置叶片、轮毂、尾舵、侧风偏航机械传动机构、测速仪已安装完

成，除 PLC 输入、输出接线拆除外，风力供电系统的接线均完成。

The blade, hub, rear control, crosswind yawing mechanical transmission mechanism and anemometer of the wind power supply device have been installed. The wiring of the wind power supply system has been completed except for PLC input/output wiring to be removed.

5．逆变与负载系统

5. Inverter and load system

逆变与负载系统主要由逆变电源控制单元、逆变输出显示单元、DSP 核心单元、DC-DC 升压单元、单相桥逆变单元、变频器、三相交流电机、发光管舞台灯光模块、警示灯、接线排、断路器、网孔架等组成。

The inverter and load system primarily consists of the inverter supply control unit, inverter output display unit, DSP core unit, DC-DC booster unit, frequency converter, three-phase AC motor, LED stage lamp module, warning light, terminal strip, circuit breaker, mesh frame.

逆变与负载系统的接线均完成。

6．监控系统

6. Monitoring system

监控系统主要由计算机、组态软件、接线排、网孔架等组成。

The monitoring system primarily consists of the computer, configuration software, terminal strip and mesh frame.

二、竞赛任务

II. Training tasks in competition

任务一：设备硬件安装与接线

Task I: Installation and Wiring of Equipment Hardware

1．安装与接线工艺要求

1. Requirements of installation and wiring technology

（1)号码管在套入时，所有接线方向垂直于地面的套管，号码及字母组合读

序从远离接线端至接线口，所有接线方向平行于地面的套管，号码及字母组合读序从左至右，如图 4 所示。

(1) On insertion of the cable marker, if all wiring directions are vertical to the casing on the ground, the reading sequence of a number and alphabet combination will go from the far terminal to the wiring port. If all wiring directions are parallel to the casing on the ground, the reading sequence of a number and alphabet combination will go from left to right, as shown in Fig. 4.
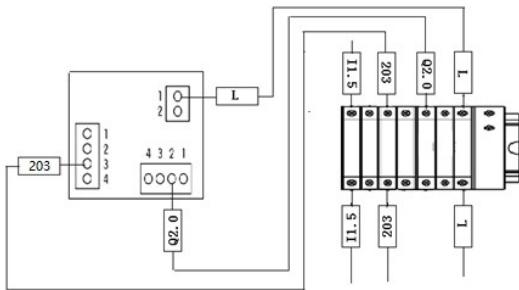
图 4　接线套管方向示意图

Fig. 4 Wiring Casing Direction Schematic

（2)在压接接线端子时，剥开的线芯插入接线端子套时，将所有的线芯全部插入端子中；采用压线钳压接接线端子时，应使压痕在接线端子套的底部（反面），压接后，压接部位不允许有导线外露。如图 5 所示。在本任务书范围内涉及的号码套入、冷压头均压痕参照图 4、图 5、图 6 所示。

(2) On pressing of the terminals, all cores will be inserted into the terminal when the exposed core in inserted into the terminal casing. When the wire crimper is used to press the terminals, the indention shall be at the bottom of the terminal casing (back). Upon completion of pressing, exposed conductors shall not be permitted at the pressed parts, as shown in Fig. 5. Marker insertion and even indention of cold pressing head as referred to within this task are shown in Figures 4, 5 and 6.

反面压痕示意　　　　正面示意　　　U型端正面　U型端底部
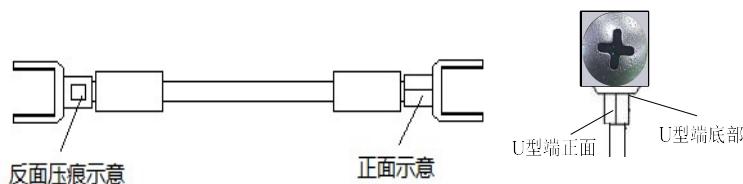
反面压痕示意	Back indention view
正面示意	Front view
U 型端正面	Front of U-shaped end
U 型端底部	Bottom of U-shaped end

图 5　冷压头压痕位置示意图图 6　U 型冷压头与端子排连接示意图

Fig. 5 Schematic of Cold Pressing Head Indention Position　Fig. 6 Schematic Diagram of Connection between U-shaped Cold Pressing Head and Terminal Strip

(3)U 型冷压端子在插入端子排时，U 型部分应充分插入，并保证正面朝外，如图 7 所示。

(3) When the U-shaped cold pressing terminal is inserted into the terminal strip, the U-shaped part will be fully inserted with the front view facing outward, as shown in Fig. 7.

任务二：光伏供电系统

Task II: PV Power Supply System

1．西门子 S7-200 CPU226PLC 的配置

1. Configuration of Siemens S7-200 CPU226PLC

要求：按照输入输出配置表以及继电器顺序要求完成接线。

Requirements: Wiring shall be completed according to the input and output configuration table and the sequence of relays.

2．S7-200 CPU226 输入输出配置

2. Input and output configuration of S7-200 CPU226

S7-200 CPU226 输入输出配置请见表 1。

The input and output configuration of S7-200 CPU226 is included in Table 1.

表 1　S7-200 CPU226 输入输出配置

Table 1 S7-200 CPU226 Input and Output Configuration

序号 S.N.	输入输出 Input/Out put	配置 Configuration	序号 S.N.	输入输出 Input/Out put	配置 Configuration
1	I0.0	旋转开关自动挡 Rotary switch auto	23	I2.6	摆杆东西向限位开关 East-west limit switch of

					rod of pendulum
2	I0.1	启动按钮 Start button	24	I2.7	摆杆西东向限位开关 West-east limit switch of rod of pendulum
3	I0.2	急停按钮 Emergency stop button	25	Q0.0	启动按钮指示灯 Start button indicator
4	I0.3	向东按钮 East button	26	Q0.1	向东按钮指示灯 East button indicator
5	I0.4	向西按钮 West button	27	Q0.2	向西按钮指示灯 West button indicator
6	I0.5	向北按钮 North button	28	Q0.3	向北按钮指示灯 North button indicator
7	I0.6	向南按钮 South button	29	Q0.4	向南按钮指示灯 South button indicator
8	I0.7	灯 1 按钮 LED1 button	30	Q0.5	灯 1 按钮指示灯、KA7 线圈 LED1 button indicator, KA7 coil
9	I1.0	灯 2 按钮 LED2 button	31	Q0.6	灯 2 按钮指示灯、KA8 线圈 LED2 button indicator, KA8 coil
10	I1.1	东西按钮 East-west button	32	Q0.7	东西按钮指示灯 East-west button indicator
11	I1.2	西东按钮 West-east button	33	Q1.0	西东按钮指示灯 West-east button indicator
12	I1.3	停止按钮 Stop button	34	Q1.1	停止按钮指示灯 Stop button indicator
13	I1.4	摆杆接近开关垂直限位 Vertical limit of rod of pendulum proximity switch	35	Q1.2	继电器 KA1 线圈组件东 Relay KA1 coil component east
14	I1.5	无 None	36	Q1.3	继电器 KA2 线圈组件西 Relay KA2 coil component west
15	I1.6	光伏组件向东、向西限位开关 East/West limit switches of PV module	37	Q1.4	继电器 KA3 线圈组件北 Relay KA3 coil component north
16	I1.7	无	38	Q1.5	继电器 KA4 线圈组件南

		None			Relay KA4 coil component south
17	I2.0	光伏组件向北限位开关 North limit switch of PV module	39	Q1.6	继电器 KA5 线圈摆杆东西 Relay KA5 coil rod of pendulum east-west
18	I2.1	光伏组件向南限位开关 South limit switch of PV module	40	Q1.7	继电器 KA6 线圈摆杆西东 Relay KA6 coil rod of pendulum west-east
19	I2.2	光线传感器（光伏组件）向东信号 East signal of light sensor (PV module)	41	1M	0V
20	I2.3	光线传感器（光伏组件）向西信号 West signal of light sensor (PV module)	42	2M	0V
21	I2.4	光线传感器（光伏组件）向北信号 North signal of light sensor (PV module)	43	1L	DC24V
22	I2.5	光线传感器（光伏组件）向南信号 South signal of light sensor (PV module)	44	2L	DC24V

表 2 光伏控制系统工控 M 点分配表

Table 2 Industrial Control Point M Distribution of PV Control System

序号 S.N.	输入输出 Input/Output	配置 Configuration	序号 S.N.	输入输出 Input/Output	配置 Configuration
1	M0.0	旋转开关自动挡 Rotary switch auto	23	M2.6	摆杆东西向限位开关 East-west limit switch of rod of pendulum
2	M0.1	启动按钮 Start button	24	M2.7	摆杆西东向限位开关 West-east limit switch of rod of pendulum
3	M0.2	急停按钮 Emergency stop button	25	Q0.0	启动按钮指示灯 Start button indicator
4	M0.3	向东按钮 East button	26	Q0.1	向东按钮指示灯 East button indicator
5	M0.4	向西按钮	27	Q0.2	向西按钮指示灯

		West button			West button indicator
6	M0.5	向北按钮 North button	28	Q0.3	向北按钮指示灯 North button indicator
7	M0.6	向南按钮 South button	29	Q0.4	向南按钮指示灯 South button indicator
8	M0.7	灯 1 按钮 LED1 button	30	Q0.5	灯 1 按钮指示灯、KA7 线圈 LED1 button indicator, KA7 coil
9	M1.0	灯 2 按钮 LED2 button	31	Q0.6	灯 2 按钮指示灯、KA8 线圈 LED2 button indicator, KA8 coil
10	M1.1	东西按钮 East-west button	32	Q0.7	东西按钮指示灯 East-west button indicator
11	M1.2	西东按钮 West-east button	33	Q1.0	西东按钮指示灯 West-east button indicator
12	M1.3	停止按钮 Stop button	34	Q1.1	停止按钮指示灯 Stop button indicator
13	M1.4	摆杆接近开关垂直限位 Vertical limit of rod of pendulum proximity switch	35	Q1.2	继电器 KA1 线圈组件东 Relay KA1 coil component east
14	M1.5	无 None	36	Q1.3	继电器 KA2 线圈组件西 Relay KA2 coil component west
15	M1.6	光伏组件向东、向西限位开关 East/West limit switches of PV module	37	Q1.4	继电器 KA3 线圈组件北 Relay KA3 coil component north
16	M1.7	无 None	38	Q1.5	继电器 KA4 线圈组件南 Relay KA4 coil component south
17	M2.0	光伏组件向北限位开关 North limit switch of PV module	39	Q1.6	继电器 KA5 线圈摆杆东西 Relay KA5 coil rod of pendulum east-west
18	M2.1	光伏组件向南限位开关 South limit switch of PV module	40	Q1.7	继电器 KA6 线圈摆杆西东 Relay KA6 coil rod of pendulum west-east

19	M2.2	光线传感器（光伏组件）向东信号 East signal of light sensor (PV module)	41	1M	0V
20	M2.3	光线传感器（光伏组件）向西信号 West signal of light sensor (PV module)	42	2M	0V
21	M2.4	光线传感器（光伏组件）向北信号 North signal of light sensor (PV module)	43	1L	DC24V
22	M2.5	光线传感器（光伏组件）向南信号 South signal of light sensor (PV module)	44	2L	DC24V

3．西门子 S7-200 CPU226PLC 的布线与接线

3. Cabling and wiring of Siemens S7-200 CPU226PLC

要求：

Requirements

根据表1西门子S7-200 CPU226PLC 的配置，完成西门子S7-200 CPU226PLC 的布线与接线，接线的线径和颜色要求见表3。赛场提供了设备出厂时的线标套管，接线的线标套管号码与表1要求一致。在进行西门子 S7-200 CPU226PLC 的布线与接线时，不改变光伏供电控制单元的按钮、旋钮、急停按钮的功能。

Cabling and wiring of Siemens S7-200 CPU226PLC shall be completed according to the configuration of Siemens S7-200 CPU226PLC in Table 1. The wire diameter and the color requirements of wiring are included in Table 3. The course provides the cable marker casing delivered by the device manufacturer. The number of cable marker casing of wiring shall be the same as the one in Table 1. On cabling and wiring of Siemens S7-200 CPU226PLC, buttons of the push button, knob button and emergency stop button of the PV power supply control unit shall not be changed.

表 3S7-200 CPU226PLC 接线的线径和颜色要求

Table 3 Wire Diameter and Color Requirements of CPU226PLC Wiring

序号 S.N.	起始端 Start	结束端 End	线型 Wire type	序号 S.N.	起始端 Start	结束端 End	线型 Wire type

	terminal	terminal			terminal	terminal	
1	L	接线排 L Terminal strip L	0.75mm² 红色 0.75mm² red	25	I2.0	略 Omitted	0.3mm² 蓝色 0.3mm² blue
2	N	接线排 N Terminal strip N	0.75mm² 黑色 0.75mm² black	26	I2.1	略 Omitted	0.3mm² 蓝色 0.3mm² blue
3	GND	接线排 PE Terminal strip PE	0.75mm² 黄绿色 0.75mm² yellow/green	27	I2.2	略 Omitted	0.3mm² 蓝色 0.3mm² blue
4	1M	略 Omitted	0.3mm² 白色 0.3mm² white	28	I2.3	略 Omitted	0.3mm² 蓝色 0.3mm² blue
5	2M	略 Omitted	0.3mm² 白色 0.3mm² white	29	I2.4	略 Omitted	0.3mm² 蓝色 0.3mm² blue
6	1L	略 Omitted	0.3mm² 红色 0.3mm² red	30	I2.5	略 Omitted	0.3mm² 蓝色 0.3mm² blue
7	2L	略 Omitted	0.3mm² 红色 0.3mm² red	31	I2.6	略 Omitted	0.3mm² 蓝色 0.3mm² blue
8	3L	略 Omitted	0.3mm² 红色 0.3mm² red	32	I2.7	略 Omitted	0.3mm² 蓝色 0.3mm² blue
9	I0.0	略 Omitted	0.3mm² 蓝色 0.3mm² blue	33	Q0.0	略 Omitted	0.3mm² 蓝色 0.3mm² blue
10	I0.1	略 Omitted	0.3mm² 蓝色 0.3mm² blue	34	Q0.1	略 Omitted	0.3mm² 蓝色 0.3mm² blue
11	I0.2	略 Omitted	0.3mm² 蓝色 0.3mm² blue	35	Q0.2	略 Omitted	0.3mm² 蓝色 0.3mm² blue
12	I0.3	略 Omitted	0.3mm² 蓝色 0.3mm² blue	36	Q0.3	略 Omitted	0.3mm² 蓝色 0.3mm² blue
13	I0.4	略 Omitted	0.3mm² 蓝色 0.3mm² blue	37	Q0.4	略 Omitted	0.3mm² 蓝色 0.3mm² blue
14	I0.5	略 Omitted	0.3mm² 蓝色 0.3mm² blue	38	Q0.5	略 Omitted	0.3mm² 蓝色 0.3mm² blue
15	I0.6	略 Omitted	0.3mm² 蓝色 0.3mm² blue	39	Q0.6	略 Omitted	0.3mm² 蓝色 0.3mm² blue
16	I0.7	略 Omitted	0.3mm² 蓝色 0.3mm² blue	40	Q0.7	略 Omitted	0.3mm² 蓝色 0.3mm² blue
17	I1.0	略 Omitted	0.3mm² 蓝色 0.3mm² blue	41	Q1.0	略 Omitted	0.3mm² 蓝色 0.3mm² blue
18	I1.1	略 Omitted	0.3mm² 蓝色 0.3mm² blue	42	Q1.1	略 Omitted	0.3mm² 蓝色 0.3mm² blue
19	I1.2	略 Omitted	0.3mm² 蓝色 0.3mm² blue	43	Q1.2	略 Omitted	0.3mm² 蓝色 0.3mm² blue

20	I1.3	略 Omitted	0.3mm² 蓝色 0.3mm² blue	44	Q1.3	略 Omitted	0.3mm² 蓝色 0.3mm² blue
21	I1.4	略 Omitted	0.3mm² 蓝色 0.3mm² blue	45	Q1.4	略 Omitted	0.3mm² 蓝色 0.3mm² blue
22	I1.5	略 Omitted	0.3mm² 蓝色 0.3mm² blue	46	Q1.5	略 Omitted	0.3mm² 蓝色 0.3mm² blue
23	I1.6	略 Omitted	0.3mm² 蓝色 0.3mm² blue	47	Q1.6	略 Omitted	0.3mm² 蓝色 0.3mm² blue
24	I1.7	略 Omitted	0.3mm² 蓝色 0.3mm² blue	48	Q1.7	略 Omitted	0.3mm² 蓝色 0.3mm² blue

4．继电器组的配置、布线与接线

4. Configuration, cabling and wiring of relay unit

要求：

Requirements

继电器 KA1、KA2 用于光伏组件东、西方向偏转电机的控制，继电器 KA3、KA4 用于光伏组件北、南方向偏转电机的控制，继电器 KA5、KA6 用于摆杆偏转电机由东向西、由西向东偏转的控制，继电器 KA7 用于灯 1 的控制，继电器 KA8 用于灯 2 的控制。

Relays KA1 and KA2 are used to control the east and the west deflection motors of the photovoltaic module. Relays KA3 and KA4 are used to control the north and the south deflection motors of the photovoltaic module. Relays KA5 and KA6 are used to control the east-west and the west-east deflection of the rod of pendulum deflection motor. Relay KA7 is used to control LED 1. Relay KA8 is used to control LED 2.

5．光伏电池组件跟踪光源的 PLC 程序设计与测试

5. PLC program design and testing of PV solar module light source tracking

将光伏控制单元手自动旋钮旋转至手动状态后：

After rotating the manual/automatic knob of PV control unit to the manual position:

（1）按住向东按钮，光伏电池组件向东偏转，向东按钮的指示灯亮。松开向东按钮或按下停止按钮或按下急停按钮或光伏组件触碰到向东限位，向东按钮的指示灯熄灭，光伏电池组件停止偏转运动。

(1) On pressing down the east button, the PV solar module deflects eastwards, and the east button indicator lights up. On releasing the east button or pushing down the stop button or pressing down the emergency stop button or if the photovoltaic module touches east limit, the east button indicator will light off, and the PV solar module stops deflection movement.

按住向西按钮，光伏电池组件向西偏转，向西按钮的指示灯亮。松开向西按钮或按下停止按钮或按下急停按钮或光伏组件触碰到向西限位，向西按钮的指示灯熄灭，光伏电池组件停止偏转运动。

On pressing down the west button, the PV solar module deflects westwards, and the west button indicator lights up. On releasing the west button or pushing down the stop button or pressing down the emergency stop button or if the photovoltaic module touches west limit, the west button indicator will light off, and the PV solar module stops deflection movement.

（2）光伏电池组件向东偏转和向西偏转在程序上采取互锁关系。向北按钮和向南按钮的作用与向东按钮和向西按钮的功能相同，光伏电池组件向北偏转和向南偏转在程序上采取互锁关系。

(2) The east deflection and the west deflection of PV solar module are interlocked procedurally. The roles of the north and the south buttons are the same as functions of the east and the west buttons. The north deflection and the south deflection of PV solar module are interlocked procedurally.

（3）按下灯1按钮，灯1和灯1按钮指示灯亮，再次按下灯1按钮时，灯1和灯1按钮指示灯熄灭。按下灯2按钮，灯2和灯2按钮指示灯亮，再次按下灯2按钮时，灯2和灯2按钮指示灯熄灭。

(3) On pressing down LED1 button, LED 1 and LED1 button indicator light up. On pressing down LED1 button again, LED 1 and LED1 button indicator light off. On pressing down LED2 button, LED 2 and LED2 button light up. On pressing down LED2 button again, LED 2 and LED2 button indicator light off.

（4）按住东西按钮，东西按钮的指示灯亮，摆杆由东向西方向移动。松开东西按钮时，东西按钮的指示灯熄灭，摆杆停止运动。摆杆由东向西方向移动到达摆

杆西限位位置时，东西按钮的指示灯熄灭，摆杆停止移动。

(4) On pressing down the east-west button, the east-west button indicator lights off, and the rod of pendulum moves from east to west. On releasing the east-west button, the east-west button indicator lights off, and the rod of pendulum stops movement. When the rod of pendulum moves from east to west to its west limit position, the east-west button indicator will light off, and the rod of pendulum stops movement.

如果住下西东按钮，西东按钮的指示灯亮，摆杆由西向东方向移动。松开西东按钮时，西东按钮的指示灯熄灭，摆杆停止运动。摆杆由西向东方向移动到达摆杆东限位位置时，西东按钮的指示灯熄灭，摆杆停止移动。

On pressing down the west-east button, the west-east button indicator lights off, and the rod of pendulum moves from west to east. On releasing the west-east button, the west-east button indicator lights off, and the rod of pendulum stops movement. When the rod of pendulum moves from west to east to its east limit position, the west-east button indicator will light off, and the rod of pendulum stops movement.

摆杆西东和东西方向运动在程序上采取互锁关系。

The west-east and the east-west movement of the rod of pendulum are interlocked procedurally.

任务三：风力供电系统

Task III: Wind Power Supply System

1. 西门子 S7-200 CPU224PLC 的配置

要求：按照输入输出配置表以及继电器顺序要求完成接线。

Requirements: Wiring shall be completed according to the input and output configuration table and relay sequence.

2. 西门子 S7-200 CPU224PLC 的输入输出配置如表 4 所示。

2. The input and output configuration of Siemens S7-200 224PLC are included in Table 4.

S7-200 CPU224 输入输出配置请见表 4。

The input and output configuration of Siemens S7-200 224PLC are included in Table 4.

表 4　S7-200 CPU224 输入输出配置

Table 4 S7-200 CPU224 Input and Output Configuration

序号 S.N.	输入输出 Input/Output	配置 Configuration		序号 S.N.	输入输出 Input/Output	配置 Configuration	
1	I0.0	旋转开关自动挡 Rotary switch auto		23	Q0.0	启动按钮指示灯 Start button indicator	
2	I0.1	启动按钮 Start button		24	Q0.1	顺时按钮指示灯 Clockwise button indicator	
3	I0.2	急停按钮 Emergency stop button		25	Q0.2	逆时按钮指示灯 Counterclockwise button indicator	
4	I0.3	顺时按钮 Clockwise button		26	Q0.3	侧风偏航按钮指示灯 Crosswind yawing button indicator	
5	I0.4	逆时按钮 Counterclockwise button		27	Q0.4	恢复按钮指示灯 Resume button indicator	
6	I0.5	侧风偏航按钮 Crosswind yawing switch		28	Q0.5	停止按钮指示灯 Stop button indicator	
7	I0.6	恢复按钮 Resume switch		29	Q0.6	继电器 KA9 线圈风箱顺时针运动 Clockwise movement of relay KA9 coil bellow	
8	I0.7	停止按钮 Stop switch		30	Q0.7	继电器 KA10 线圈风箱逆时针运动 Counterclockwise movement of relay KA10 coil bellow	
9	I1.0	无 None		31	Q1.0	继电器 KA11 线圈侧风偏航 Crosswind yawing of relay KA11 coil	
10	I1.1	侧风偏航初始位开关 Crosswind yawing initial position switch		32	Q1.1	继电器 KA12 线圈撤销侧风偏航 Withdraw crosswind yawing of relay KA12 coil	

序号 S.N.	输入输出 Input/Output	配置 Configuration	序号	输入输出	配置
11	I1.2	侧风偏航 45°到位开关 Crosswind yawing 45° position switch	33	1M	0V
12	I1.3	侧风偏航 90°到位开关 Crosswind yawing 90° position switch	34	2M	0V
13	I1.4	风场机构顺时到位开关 Wind farm mechanism clockwise position switch	35	1L	+24V
14	I1.5	风场机构逆时到位开关 Wind farm mechanism counterclockwise position switch	36	2L	+24V

表 5 风力控制工控程序 M 点分配表

Table 5 Industrial Control Program Point M Distribution of Wind Control

序号 S.N.	输入输出 Input/Output	配置 Configuration	序号 S.N.	输入输出 Input/Output	配置 Configuration
1	M0.0	旋转开关自动挡 Rotary switch auto	23	Q0.0	启动按钮指示灯 Start button indicator
2	M0.1	启动按钮 Start button	24	Q0.1	顺时按钮指示灯 Clockwise button indicator
3	M0.2	急停按钮 Emergency stop button	25	Q0.2	逆时按钮指示灯 Counterclockwise button indicator
4	M0.3	顺时按钮 Clockwise button	26	Q0.3	侧风偏航按钮指示灯 Crosswind yawing button indicator
5	M0.4	逆时按钮 Counterclockwise button	27	Q0.4	恢复按钮指示灯 Resume button indicator
6	M0.5	侧风偏航按钮 Crosswind yawing switch	28	Q0.5	停止按钮指示灯 Stop button indicator
7	M0.6	恢复按钮 Resume switch	29	Q0.6	继电器 KA9 线圈风箱顺时针运动 Clockwise movement of relay KA9 coil bellow
8	M0.7	停止按钮	30	Q0.7	继电器 KA10 线圈

		Stop switch			风箱逆时针运动 Counterclockwise movement of relay KA10 coil bellow
9	M1.0	无 None	31	Q1.0	继电器 KA11 线圈侧风偏航 Crosswind yawing of relay KA11 coil
10	M1.1	侧风偏航初始位开关 Crosswind yawing initial position switch	32	Q1.1	继电器 KA12 线圈撤销侧风偏航 Withdraw crosswind yawing of relay KA12 coil
11	M1.2	侧风偏航 45°到位开关 Crosswind yawing 45° position switch	33	1M	0V
12	M1.3	侧风偏航 90°到位开关 Crosswind yawing 90° position switch	34	2M	0V
13	M1.4	风场机构顺时到位开关 Wind farm mechanism clockwise position switch	35	1L	+24V
14	M1.5	风场机构逆时到位开关 Wind farm mechanism counterclockwise position switch	36	2L	+24V

3. 西门子 S7-200 CPU224PLC 的布线与接线

3. Cabling and wiring of Siemens S7-200 CPU224PLC

要求：

Requirements:

根据表3西门子 S7-200 CPU224PLC 的配置，完成西门子 S7-200 CPU224PLC 的布线与接线，接线的线径和颜色要求见表4。赛场工位提供了设备出厂时的线标套管，接线的线标套管号码与表4要求一致。在进行西门子 S7-200 CPU224PLC 的布线与接线时，不改变风力供电控制单元的按钮、旋钮、急停按钮的功能。

Cabling and wiring of Siemens S7-200 CPU224PLC shall be completed according to the configuration of Siemens S7-200 CPU224PLC in Table 3. The wire diameter and the color requirements of wiring are included in Table 4. The course

provides the cable marker casing delivered by the device manufacturer. The number of cable marker casing of wiring shall be the same as the one in Table 4. On cabling and wiring of Siemens S7-200 CPU224PLC, buttons of the push button, knob button and emergency stop button of the PV power supply control unit shall not be changed.

表 6S7-200 CPU224PLC 接线的线径和颜色要求

Table 6 Wire Diameter and Color Requirements of CPU224PLC Wiring

序号 S.N.	起始端 Start terminal	结束端 End terminal	线型 Wire type	序号 S.N.	起始端 Start terminal	结束端 End terminal	线型 Wire type
1	L1	接线排 L Terminal strip L	0.75mm^2 红色 0.75mm^2 red	17	I1.0	略 Omitted	无 None
2	N	接线排 N Terminal strip N	0.75mm^2 黑色 0.75mm^2 yellow	18	I1.1	略 Omitted	0.3mm^2 蓝色 0.3mm^2 blue
3	GND	接线排 PE Terminal strip PE	0.75mm^2 黄绿色 0.75mm^2 yellow green	19	I1.2	略 Omitted	0.3mm^2 蓝色 0.3mm^2 blue
4	1M	略 Omitted	0.3mm^2 白色 0.3mm^2 white	20	I1.3	略 Omitted	0.3mm^2 蓝色 0.3mm^2 blue
5	2M	略 Omitted	0.3mm^2 白色 0.3mm^2 white	21	I1.4	略 Omitted	0.3mm^2 蓝色 0.3mm^2 blue
6	1L	略 Omitted	0.3mm^2 红色 0.3mm^2 red	22	I1.5	略 Omitted	0.3mm^2 蓝色 0.3mm^2 blue
7	2L	略 Omitted	0.3mm^2 红色 0.3mm^2 red	23	Q0.0	略 Omitted	0.3mm^2 蓝色 0.3mm^2 blue
8	3L	略 Omitted	0.3mm^2 红色 0.3mm^2 red	24	Q0.1	略 Omitted	0.3mm^2 蓝色 0.3mm^2 blue
9	I0.0	略 Omitted	0.3mm^2 红色 0.3mm^2 red	25	Q0.2	略 Omitted	0.3mm^2 蓝色 0.3mm^2 blue
10	I0.1	略 Omitted	0.3mm^2 蓝色 0.3mm^2 blue	26	Q0.3	略 Omitted	0.3mm^2 蓝色 0.3mm^2 blue
11	I0.2	略 Omitted	0.3mm^2 蓝色 0.3mm^2 blue	27	Q0.4	略 Omitted	0.3mm^2 蓝色 0.3mm^2 blue
12	I0.3	略 Omitted	0.3mm^2 蓝色 0.3mm^2 blue	28	Q0.5	略 Omitted	0.3mm^2 蓝色 0.3mm^2 blue
13	I0.4	略 Omitted	0.3mm^2 蓝色 0.3mm^2 blue	29	Q0.6	略 Omitted	0.3mm^2 蓝色 0.3mm^2 blue
14	I0.5	略 Omitted	0.3mm^2 蓝色 0.3mm^2 blue	30	Q0.7	略 Omitted	0.3mm^2 蓝色 0.3mm^2 blue

15	I0.6	略 Omitted	0.3mm² 蓝色 0.3mm² blue	31	Q1.0	略 Omitted	0.3mm² 蓝色 0.3mm² blue
16	I0.7	略 Omitted	0.3mm² 蓝色 0.3mm² blue	32	Q1.1	略 Omitted	0.3mm² 蓝色 0.3mm² blue

4. 继电器组的配置、布线与接线

4. Configuration, cabling and wiring of relay unit

（1）继电器 KA9 用于风箱顺时针方向控制，继电器 KA10 用于风箱逆时针方向控制，继电器 KA11 用于偏航控制，继电器 KA12 用于恢复偏航控制。

(1) Relay KA9 is used to clockwise control the bellow. Relay KA10 is used to counterclockwise control the bellow. Relay KA11 is used to control yawing. Relay KA12 is used to resume yawing.

5. 风电系统的 PLC 程序设计与测试

5. PLC program design and testing of the wind power system

将风力供电控制面板手自动旋钮旋转至手动状态后：

After rotating the manual/automatic knob of the wind power supply control panel to the manual position:

（1）按住顺时按钮，风场运动机构箱按顺时针方向移动，顺时按钮指示灯亮，松开顺时按钮时，顺时按钮的指示灯熄灭，风场运动机构箱停止移动。当风场运动机构箱按顺时针方向移动到限位开关时，顺时按钮指示灯熄灭，风场运动机构箱停止移动。

(1) On pressing down the clockwise button, the wind farm kinetics casing moves clockwise, and the clockwise button indicator lights up. On releasing the clockwise button, the clockwise button indicator will light off, and the wind farm kinetics casing stops movement. When the wind farm kinetics casing moves clockwise to the limit switch, the clockwise button indicator will light off, and the wind farm kinetics casing stops movement.

按住逆时按钮，风场运动机构箱按逆时针方向移动，逆时按钮指示灯亮，松开逆时按钮时，逆时按钮的指示灯熄灭，风场运动机构箱停止移动。当风场运动机构箱作逆时针方向移动到限位开关时，逆时按钮指示灯熄灭，风场运动机构箱停止移动。

On pressing down the counterclockwise button, the wind farm kinetics casing moves counterclockwise, and the counterclockwise button indicator lights up. On releasing the counterclockwise button, the counterclockwise button indicator will light off, and the wind farm kinetics casing stops movement. When the wind farm kinetics casing moves counterclockwise to the limit switch, the counterclockwise button indicator will light off, and the wind farm kinetics casing stops movement.

风场运动机构箱按顺时针方向运动和按逆时针方向运动在程序上采取互锁关系。

The clockwise and the counterclockwise movement of the wind farm kinetics casing are interlocked procedurally.

（3）按住偏航按钮，偏航按钮指示灯亮，风力发电机作侧风偏航动作，尾翼偏转到45°左右的位置，侧风偏航结束，偏航按钮指示灯熄灭。风力发电机作侧风偏航的过程中，松开偏航按钮，侧风偏航结束，偏航按钮指示灯熄灭。侧风偏航结束时，点击恢复按钮，恢复按钮指示灯亮，风力发电机撤销侧风偏航，在此过程中，松开恢复按钮，撤销侧风偏航动作停止，恢复按钮指示灯熄灭。在撤销侧风偏航的过程中，当尾翼回到初始状态时，撤销侧风偏航的动作结束，恢复按钮指示灯熄灭。

(3) On pressing down the yawing button, the yawing button indicator lights up, and the wind power generator enables crosswind yawing. The tail fin deflects to the 45° position. Crosswind yawing stops, and the yawing button indicator lights off. During the crosswind yawing of the wind power generator, crosswind yawing stops and the yawing button indicator lights off on releasing the yawing button. At the end of crosswind yawing, clock the resume button, and the resume button indicator lights up, the wind power generator withdraws crosswind yawing. During the course, the crosswind yawing withdrawal action stops and the resume button indicator lights off on releasing the resume button. During the withdrawal of crosswind yawing, the crosswind yawing withdrawal action ends and the resume button indicator lights off when the tail fin returns to the initial state.

任务四：监控系统

Task IV: Monitoring System

监控系统已按照上述 M 点分配表设计完成，选手进行 PLC 相关程序设计，要求监控系统与控制面板功能一致。

The monitoring system has been designed according to the point M distribution table above. The players may start PLC program design. The monitoring system is required to be functional as the control panel.

任务五：波形测试

Task V: Waveform Test

（1）使用示波器双踪同时测量逆变器的 H 桥左上桥功率管的驱动信号波形 1 和右下桥功率管的驱动信号波形 2，要求测得波形 1 置于示波器显示屏上方，测得波形 2 置于示波器显示屏下方，两个波形不出现波形重叠，分别显示 2 个信号的波形并在右上角显示出两种波形的频率，并截图保存在 U 盘和手提计算机的桌面，文件名为：SPWM 波形。

(1) The dual-trace oscilloscope is used to measure waveform 1 of the drive signal of the left upper bridge power tube and waveform 2 of the right lower bridge power tube of bridge H. It is required that the measured waveform 1 should be placed at the

upper part of the oscilloscope display and that the measured waveform 2 should be placed at the lower part of the oscilloscope display. Both waveforms shall not overlap. Waveforms of two signals shall be displayed. Frequencies of both waveforms shall be displayed in the right upper corner. Screenshot shall be taken and saved in USB flash disk and the laptop desktop. The file name is: SPWM waveform.

（2）设置逆变器输出频率为 52.5Hz，合理设置调制比，使得逆变器输出电压幅度为 200V，使用示波器测量逆变器的输出波形，要求在波形右上角显示测得波形的频率及最大值，截图保存在 U 盘和手提计算机的桌面，文件名为：52.5Hz 波形。

(2) The inverter output frequency is set at 52.5Hz. The modulation ratio shall be properly set so that the inverter output voltage amplitude is 200V. The oscilloscope will be used to measure the output waveform of the inverter. It is required that the frequency and the maximum value of the measured waveform should be displayed at the right upper corner of waveform. Screenshot shall be taken and saved in USB flash disk and the laptop desktop. The file name is: 52.5Hz waveform.

（3）合理设置调制比，使逆变器输出电压有效值 220V，频率 50Hz 的正弦波，设置水平扫描时基设置为 5.00ms/div，垂直偏转灵敏度设置为 200mV/div，利用示波器的 FFT 频谱分析功能，测量 2700ns 死区的逆变器输出波形和 800ns 死区的逆变器输出波形，分别截图保存在 U 盘和手提计算机的桌面，文件名分别为：2700ns 死区逆变器输出 FFT 波形、800ns 死区逆变器输出 FFT 波形。

(3) The modulation ratio shall be properly set so that the inverter outputs sine wave with the valid voltage of 220V and frequency of 50Hz. On setting horizontal scanning, time base shall be set at 5.00ms/div. The vertical deflection sensitivity is set at 200mV/div. The inverter output waveforms of 2700ns dead zone and that of 800ns are measured by using the analyzing function of FFT spectrum of the oscilloscope. Screenshots will be taken and saved in USB flash disk and laptop desktop. The file names are: 2700ns dead zone inverter output FFT waveform, 800ns dead zone inverter output FFT waveform.

任务六：理论任务
Task VI: Tasks in Theory

在答题纸上完成 CPU226PLC 的 I/O 接线图绘制

Draw an I/O wiring diagram of CPU226PLC on the answer sheet.