1 Control Unit

1.1 The Principle of the Control Unit

The control unit is an indispensable part of the overall SSA system. Its function mainly includes data collection, data state monitoring, and system control. This unit is composed of the following parts: control & interface board, machine control board, network & control board, power distribution panel, indication lamps (LED), display screen (LCD), key and other interfaces. As is shown in Figure 1:
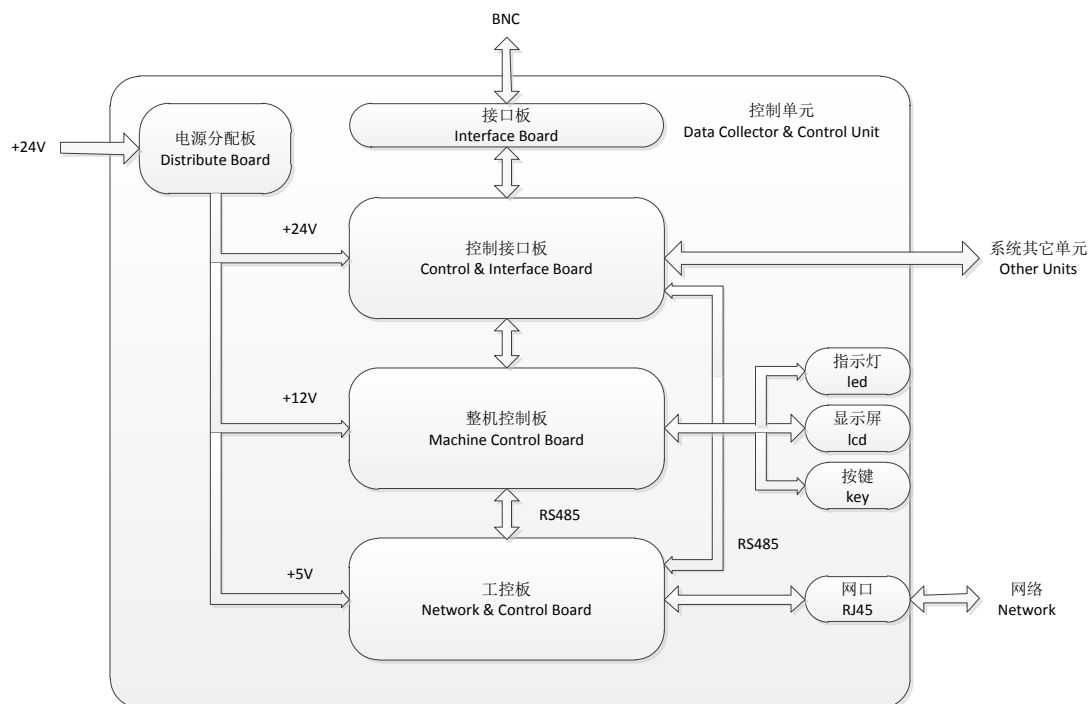

Figure 1. Control Unit Structure Diagram

1.1.1 Control & Interface Board

Control & interface board has the function of data collection and interface conversion. It gains power from the power distribution board with DC 24V. The data collected from other units includes: temperature & moisture signal, flowrate signal, output power signal, reflection power signal, state signals from Preamplifier and PS modules, the external fault signal from BNC interface, and the PA modules state signal from RS485. The control & interface board combines all collected signal and communicate with machine control board and network & control board through relevant interfaces. At the same time, the control & interface board acquires some set up signals and enable signals from machine control board and network & control board.

1.1.2 Machine Control Board

Machine control board is a control circuit that takes the SCM as its core. It gains power from the power distribution board with DC 12V. The machine control board is mainly used for the

collection of data from control and interface board. It also communicates with Network & Control Board through RS485 interface. At the same time, it is connected with LED, LCD and keys. The serial communication is based on the Modbus/RTU communication protocols. The network & control board is the master while the machine control board is the slave. The network & control board sents enquiry and setting command for bidirectional communication.

1.1.3 Network & Control Board

Network & control board is a kind of control circuit that takes ARM processor as the core. It gains power from power distribution board with DC 5V. The control circuit adopts the Linux kernel 3.2.0 system. Network & control board realize communication with control & interface board and machine control board through two RS485 interfaces. It also can realize remote monitoring & control through Ethernet interface. Remote monitoring & control is based on the Modbus/TCP communication protocol. The upper machine is the master, and the network & control board is the slave. Please refer to the communication protocol.

1.1.4 Other circuits and interfaces

Besides the above three modules mentioned, the control unit also includes the power distribution panel, LCD, LED, key and other interfaces. Power distribution board is input with 24V DC voltage and then output 24V, 12V, 5V DC voltage to the control & interface board, machine control board, network & control board respectively. The LEDs mainly indicates the SSA's working state while the LCD displays some important state value. The keys are used for interactive operation. Among the 8 BNC interfaces, four are the external fault input, and the other four are the fault output. Other interfaces are signal collection used which connect to other units of the system.

1.2 Communication protocol

The control unit provides remote monitoring and control interface to realize the monitoring and control function on overall SSA system. The communication protocol for remote monitoring and control is made based on the Modbus/TCP protocol. In the following are some points to be noted:

(1). The protocol follows the Modbus/TCP protocol. The upper computer is the master and the SSA control unit is the slave;

(2). The upper computer is the client, which can be connected to the SSA's control module service through Ethernet. The connecting interface of TCP is 502;

(3). The data of this protocol can be divided into analog values, digital values and Preset values. Among them, the analog value and digital value are stored in the input register as the Query data; while preset values are stored in the holding register. Please refer to relevant sheet for the address of each register;

(4). Unless otherwise specified, the precision of the analog value is 0.1(The precision of PS output power is 0.01) i.e. during practical transmission process, the value will be amplified for 10 times. For example, when the actual analog value is 10.5, during transmission process, it will be 105. And when analyzing data, the value in register should plus 0.1 to get the actual data. Digital value of 1 indicates on or fault, 0 indicates off or normal;

(5). For concrete Modbus request and response rule, please refer to the Modbus protocol.

In the following are the general descriptions of analog values, digital values, and preset values.

Table 1 is for analog values and one should pay attention to the following points:

a. Analog values include the working parameters of SSA and the preset values of PA power supply.

b. The data for internal rack temperature 1(middle part) and internal rack temperature 2(bottom part) are integer, and other analog values are nonnegative integer.

c. Precision represents a conversion coefficient between the register value and the actual value. The actual value= the register value*the precision. All analog value precision is 0.1 except the precision value of PA output power.

d. The definition of register value 0xFFFF represents fault value. When there is an internal communication fault, the register value will be 0xFFFF.

Table 1 Analog Values

No	Analog values	Input register address	Unit	Description	Precision	Data source
1	Input power	0x0000	mW	The original input power value that has not been amplified by SSA	0.1	Machine Control panel
2	Total output power	0x0001	W	The final output power value after amplified by SSA	0.1	
3	Driving stage output power	0x0002	W	The output power value after amplified by preamplifier.	0.1	
4	Driving stage current	0x0003	A	The operating current value (DC 24V) for preamplifier	0.1	
5	Reflection power	0x0004	W	The final reflected power value after SSA	0.1	
6	Inlet water temp.	0x0005	℃	The inlet water temp. of the SSA cooling system	0.1	
7	Outlet water temp.	0x0006	℃	The output water temp. of the SSA cooling system	0.1	
8	Flowrate	0x0007	L/min	The flow rate inside the water pipe of SSA cooling system	0.1	
9	Internal rack temp.1 (middle)	0x0008	℃	The internal temperature value of the SSA rack (middle part)	0.1	

10	Internal rack temp.2 (bottom)	0x0009	℃	The internal temperature value of the SSA rack (bottom part)	0.1	
11	Internal rack humidity.1 (middle)	0x000A	%RH	The humidity value inside the SSA rack (middle part)	0.1	
12	Internal rack humidity.2 (bottom)	0x000B	%RH	The humidity value inside the SSA rack (bottom part)	0.1	
13	Penultimate stage PA_current	0x000C	A	The working DC current after AC/DC converter of penultimate stage PA module	0.1	Penultimate stage PA unit
14	Penultimate stage PA_voltage	0x000D	V	The working DC voltage value after AC/DC converter of the penultimate stage PA module	0.1	
15	Penultimate stage PA_PS temp.	0x000E	℃	The PS temperature of penultimate stage PA module	0.1	
16	Penultimate stage PA_temp 1.	0x000F	℃	The transistor temperature of penultimate stage PA module	0.1	
17	Penultimate stage PA_temp 2.	0x0010	℃	The load temperature of penultimate stage PA module	0.1	
18	Penultimate stage PA_ output power	0x0011	W	The output power value of penultimate stage PA module	0.01	
19	Final stage PA 1_Current	0x0012	A	The working DC current after AC/DC converter of final stage PA module 1	0.1	Final stage PA unit 1
20	Final stage PA 1_voltage	0x0013	V	The working DC voltage after AC/DC converter of final stage PA module 1	0.1	
21	Final stage PA 1_PS temp.	0x0014	℃	The PS temperature of final stage PA module 1	0.1	
22	Final stage PA 1_temp 1.	0x0015	℃	The temperature of transistor inside the final stage PA module 1	0.1	
23	Final stage PA 1_temp 2.	0x0016	℃	The temperature of load inside the final stage PA module 1	0.1	
24	Final stage PA 1_ output power	0x0017	W	The output power value of final stage PA module 1	0.01	
25	Final stage PA 2_Current	0x0018	A	The working DC current after AC/DC converter of final stage PA module 2	0.1	Final stage PA unit 2
26	Final stage PA 2_voltage	0x0019	V	The working DC voltage after AC/DC converter of final stage PA module 2	0.1	
27	Final stage PA 2_PS temp.	0x001A	℃	The PS temperature of final stage PA module 2	0.1	

28	Final stage PA 2_temp 1.	0x001B	℃	The temperature of transistor inside the final stage PA module 2	0.1	
29	Final stage PA 2_temp 2.	0x001C	℃	The temperature of load inside the final stage PA module 2	0.1	
30	Final stage PA 2_ output power	0x001D	W	The output power value of final stage PA module 2	0.01	
31	Final stage PA 3_Current	0x001E	A	The working DC current after AC/DC converter of final stage PA module 3	0.1	Final stage PA unit 3
32	Final stage PA 3_voltage	0x001F	V	The working DC voltage after AC/DC converter of final stage PA module 3	0.1	
33	Final stage PA 3_PS temp.	0x0020	℃	The PS temperature of Final stage PA module 3	0.1	
34	Final stage PA 3_temp 1.	0x0021	℃	The temperature of transistor inside the final stage PA module 3	0.1	
35	Final stage PA 3_temp 2.	0x0022	℃	The temperature of load inside the final stage PA module 3	0.1	
36	Final stage PA 3_ output power	0x0023	W	The output power value of final stage PA module 3	0.01	
37	Final stage PA 4_Current	0x0024	A	The working DC current after AC/DC converter of final stage PA module 4	0.1	Final stage PA unit 4
38	Final stage PA 4_voltage	0x0025	V	The working DC voltage after AC/DC converter of final stage PA module 4	0.1	
39	Final stage PA 4_PS temp.	0x0026	℃	The PS temperature of final stage PA module 4	0.1	
40	Final stage PA 4_temp 1.	0x0027	℃	The temperature of transistor inside the final stage PA module 4	0.1	
41	Final stage PA 4_temp 2.	0x0028	℃	The temperature of load inside the final stage PA module 4	0.1	
42	Final stage PA 4_ output power	0x0029	W	The output power value of final stage PA module 4	0.01	
43	Final stage PA 5_Current	0x002A	A	The working DC current after AC/DC converter of final stage PA module 5	0.1	Final stage PA unit 5
44	Final stage PA 5_voltage	0x002B	V	The working DC voltage after AC/DC converter of final stage PA module 5	0.1	
45	Final stage PA 5_PS temp.	0x002C	℃	The PS temperature of final stage PA module 5	0.1	
46	Final stage PA 5_temp 1.	0x002D	℃	The temperature of transistor inside the final stage PA module 5	0.1	

47	Final stage PA 5_temp 2.	0x002E	℃	The temperature of load inside the final stage PA module 5	0.1	
48	Final stage PA 5_ output power	0x002F	W	The output power value of final stage PA module 5	0.01	
49	Final stage PA 6_Current	0x0030	A	The working DC current after AC/DC converter of final stage PA module 6	0.1	Final stage PA unit 6
50	Final stage PA 6_voltage	0x0031	V	The working DC voltage after AC/DC converter of final stage PA module 6	0.1	
51	Final stage PA 6_PS temp.	0x0032	℃	The PS temperature of final stage PA module 6	0.1	
52	Final stage PA 6_temp 1.	0x0033	℃	The temperature of transistor inside the final stage PA module 6	0.1	
53	Final stage PA 6_temp 2.	0x0034	℃	The temperature of load inside the final stage PA module 6	0.1	
54	Final stage PA 6_ output power	0x0035	W	The output power value of final stage PA module 6	0.01	
55	Final stage PA 7_Current	0x0036	A	The working DC current after AC/DC converter of final stage PA module 7	0.1	Final stage PA unit 7
56	Final stage PA 7_voltage	0x0037	V	The working DC	0.1	
57	Final stage PA 7_PS temp.	0x0038	℃	The PS temperature of final stage PA module 7	0.1	
58	Final stage PA 7_temp 1.	0x0039	℃	The temperature of transistor inside the final stage PA module 7	0.1	
59	Final stage PA 7_temp 2.	0x003A	℃	The temperature of load inside the final stage PA module 7	0.1	
60	Final stage PA 7_ output power	0x003B	W	The output power value of final stage PA module 7		
61	Final stage PA 8_Current	0x003C	A	The working DC current after AC/DC converter of final stage PA module 3	0.1	Final stage PA unit 8
62	Final stage PA 8_voltage	0x003D	V	The working DC voltage after AC/DC converter of final stage PA module 8	0.1	
63	Final stage PA 8_PS temp.	0x003E	℃	The PS temperature of final stage PA module 8	0.1	
64	Final stage PA 8_temp 1.	0x003F	℃	The temperature of transistor inside the final stage PA module 8	0.1	
65	Final stage PA 8_temp 2.	0x0040	℃	The temperature of load inside the final stage PA module 8	0.1	

66	Final stage PA 8_ output power	0x0041	W	The output power value of final stage PA module 8	0.01	
67	Final stage PA 9_Current	0x0042	A	The working DC current after AC/DC converter of final stage PA module 9	0.1	Final stage PA unit 9
68	Final stage PA 9_voltage	0x0043	V	The working DC voltage after AC/DC converter of final stage PA module 9	0.1	
69	Final stage PA 9_PS temp.	0x0044	℃	The PS temperature of final stage PA module 9	0.1	
70	Final stage PA 9_temp 1.	0x0045	℃	The temperature of transistor inside the final stage PA module 9	0.1	
71	Final stage PA 9_temp 2.	0x0046	℃	The temperature of load inside the final stage PA module 9	0.1	
72	Final stage PA 9_ output power	0x0047	W	The output power value of final stage PA module 9	0.01	
73	Final stage PA 10_Current	0x0048	A	The working DC current after AC/DC converter of final stage PA module 10	0.1	Final stage PA unit 10
74	Final stage PA 10_voltage	0x0049	V	The working DC voltage after AC/DC converter of final stage PA module 10	0.1	
75	Final stage PA 10_PS temp.	0x004A	℃	The PS temperature of final stage PA module 10	0.1	
76	Final stage PA 10_temp 1.	0x004B	℃	The temperature of transistor inside the final stage PA module 10	0.1	
77	Final stage PA 10_temp 2.	0x004C	℃	The temperature of load inside the final stage PA module 10	0.1	
78	Final stage PA 10_output power	0x004D	W	The output power value of final stage PA module 10	0.01	
79	Final stage PA 11_Current	0x004E	A	The working DC current after AC/DC converter of final stage PA module 11	0.1	Final stage PA unit 11
80	Final stage PA 11_voltage	0x004F	V	The working DC voltage after AC/DC converter of final stage PA module 11	0.1	
81	Final stage PA 11_PS temp.	0x0050	℃	The PS temperature of final stage PA module 11	0.1	
82	Final stage PA 11_temp 1.	0x0051	℃	The temperature of transistor inside the final stage PA module 11	0.1	
83	Final stage PA 11_temp 2.	0x0052	℃	The temperature of load inside the final stage PA module 11	0.1	
84	Final stage PA 11_ output power	0x0053	W	The output power value of final stage PA module 11	0.01	

85	Final stage PA 12_Current	0x0054	A	The working DC current after AC/DC converter of final stage PA module 12	0.1	Final stage PA unit 12
86	Final stage PA 12_voltage	0x0055	V	The working DC voltage after AC/DC converter of final stage PA module 12	0.1	
87	Final stage PA 12_PS temp.	0x0056	℃	The PS temperature of final stage PA module 12	0.1	
88	Final stage PA 12_temp 1.	0x0057	℃	The temperature of transistor inside the final stage PA module 12	0.1	
89	Final stage PA 12_temp 2.	0x0058	℃	The temperature of load inside the final stage PA module 12	0.1	
90	Final stage PA 12_ output power	0x0059	W	The output power value of final stage PA module 12	0.01	

No.	Analog values	Input register address	Unit	Precision	Description	Data source
1	Penultimate stage PA_Output voltage preset value	0x0060	V	0.1	The preset value of Penultimate stage PA unit's output voltage	Penultimate stage PA_ unit
2	Penultimate stage PA_Preset value for over voltage threshold	0x0061	V	0.1	The preset value of Penultimate stage PA unit's over voltage threshold	
3	Penultimate stage PA_ Preset value for over current threshold	0x0062	A	0.1	The preset value of Penultimate stage PA unit's over current threshold	
4	Penultimate stage PA_ Preset value for over temperature 1 threshold	0x0063	℃	0.1	The preset value of Penultimate stage PA unit's over temperature 1 threshold	
5	Penultimate stage PA_ Preset value for over temperature 2 threshold	0x0064	℃	0.1	The preset value of Penultimate stage PA unit's over temperature 2 threshold	
6	Final stage PA1_ Output voltage preset value	0x0065	V	0.1	The preset value of Final stage PA unit 1's output voltage	Final stage PA

7	Final stage PA1_Preset value for over voltage threshold	0x0066	V	0.1	The preset value of Final stage PA unit 1's over voltage threshold	unit1
8	Final stage PA1_Preset value for over current threshold	0x0067	A	0.1	The preset value of Final stage PA unit 1's over current threshold	
9	Final stage PA1_Preset value for over temperature 1 threshold	0x0068	℃	0.1	The preset value of Final stage PA unit 1's over temperature 1 threshold	
10	Final stage PA1_Preset value for over temperature 2 threshold	0x0069	℃	0.1	The preset value of Final stage PA unit 1's over temperature 2 threshold	
11	Final stage PA2_Output voltage preset value	0x006A	V	0.1	The preset value of Final stage PA unit 2's output voltage	Final stage PA unit2
12	Final stage PA2_Preset value for over voltage threshold	0x006B	V	0.1	The preset value of Final stage PA unit 2's over voltage threshold	
13	Final stage PA2_Preset value for over current threshold	0x006C	A	0.1	The preset value of Final stage PA unit 2's over current threshold	
14	Final stage PA2_Preset value for over temperature 1 threshold	0x006D	℃	0.1	The preset value of Final stage PA unit 2's over temperature 1 threshold	
15	Final stage PA2_Preset value for over temperature 2 threshold	0x006E	℃	0.1	The preset value of Final stage PA unit 2's over temperature 2 threshold	
16	Final stage PA3_Output voltage preset value	0x006F	V	0.1	The preset value of Final stage PA unit 3's output voltage	Final stage PA unit3
17	Final stage PA3_Preset value for over voltage threshold	0x0070	V	0.1	The preset value of Final stage PA unit 3's over voltage threshold	
18	Final stage PA3_Preset value for over current threshold	0x0071	A	0.1	The preset value of Final stage PA unit 3's over current threshold	

19	Final stage PA3_Preset value for over temperature 1 threshold	0x0072	℃	0.1	The preset value of Final stage PA unit 3's over temperature 1 threshold	
20	Final stage PA3_Preset value for over temperature 2 threshold	0x0073	℃	0.1	The preset value of Final stage PA unit 3's over temperature 2 threshold	
21	Final stage PA4_Output voltage preset value	0x0074	V	0.1	The preset value of Final stage PA unit 4's output voltage	Final stage PA unit4
22	Final stage PA4_Preset value for over voltage threshold	0x0075	V	0.1	The preset value of Final stage PA unit 4's over voltage threshold	
23	Final stage PA4_Preset value for over current threshold	0x0076	A	0.1	The preset value of Final stage PA unit 4's over current threshold	
24	Final stage PA4_Preset value for over temperature 1 threshold	0x0077	℃	0.1	The preset value of Final stage PA unit 4's over temperature 1 threshold	
25	Final stage PA4_Preset value for over temperature 2 threshold	0x0078	℃	0.1	The preset value of Final stage PA unit 4's over temperature 2 threshold	
26	Final stage PA5_Output voltage preset value	0x0079	V	0.1	The preset value of Final stage PA unit 5's output voltage	Final stage PA unit5
27	Final stage PA5_Preset value for over voltage threshold	0x007A	V	0.1	The preset value of Final stage PA unit 5's over voltage threshold	
28	Final stage PA5_Preset value for over current threshold	0x007B	A	0.1	The preset value of Final stage PA unit 5's over current threshold	
29	Final stage PA5_Preset value for over temperature 1 threshold	0x007C	℃	0.1	The preset value of Final stage PA unit 5's over temperature 1 threshold	
30	Final stage PA5_Preset value for over temperature 2 threshold	0x007D	℃	0.1	The preset value of Final stage PA unit 5's over temperature 2 threshold	

31	Final stage PA6_Output voltage preset value	0x007E	V	0.1	The preset value of Final stage PA unit 6's output voltage	Final stage PA unit6
32	Final stage PA6_Preset value for over voltage threshold	0x007F	V	0.1	The preset value of Final stage PA unit 6's over voltage threshold	
33	Final stage PA6_Preset value for over current threshold	0x0080	A	0.1	The preset value of Final stage PA unit 6's over current threshold	
34	Final stage PA6_Preset value for over temperature 1 threshold	0x0081	℃	0.1	The preset value of Final stage PA unit 6's over temperature 1 threshold	
35	Final stage PA6_Preset value for over temperature 2 threshold	0x0082	℃	0.1	The preset value of Final stage PA unit 6's over temperature 2 threshold	
36	Final stage PA7_Output voltage preset value	0x0083	V	0.1	The preset value of Final stage PA unit 7's output voltage	Final stage PA unit7
37	Final stage PA7_Preset value for over voltage threshold	0x0084	V	0.1	The preset value of Final stage PA unit 7's over voltage threshold	
38	Final stage PA7_Preset value for over current threshold	0x0085	A	0.1	The preset value of Final stage PA unit 7's over current threshold	
39	Final stage PA7_Preset value for over temperature 1 threshold	0x0086	℃	0.1	The preset value of Final stage PA unit 7's over temperature 1 threshold	
40	Final stage PA7_Preset value for over temperature 2 threshold	0x0087	℃	0.1	The preset value of Final stage PA unit 7's over temperature 2 threshold	
41	Final stage PA8_Output voltage preset value	0x0088	V	0.1	The preset value of Final stage PA unit 8's output voltage	Final stage PA unit8
42	Final stage PA8_Preset value for over voltage threshold	0x0089	V	0.1	The preset value of Final stage PA unit 8's over voltage threshold	
43	Final stage PA8_Preset value for over current	0x008A	A	0.1	The preset value of Final stage PA unit 8's over current	

	threshold				threshold	
44	Final stage PA8_Preset value for over temperature 1 threshold	0x008B	℃	0.1	The preset value of Final stage PA unit 8's over temperature 1 threshold	
45	Final stage PA8_Preset value for over temperature 2 threshold	0x008C	℃	0.1	The preset value of Final stage PA unit 8's over temperature 2 threshold	
46	Final stage PA9_Output voltage preset value	0x008D	V	0.1	The preset value of Final stage PA unit 9's output voltage	Final stage PA unit9
47	Final stage PA9_Preset value for over voltage threshold	0x008E	V	0.1	The preset value of Final stage PA unit 9's over voltage threshold	
48	Final stage PA9_Preset value for over current threshold	0x008F	A	0.1	The preset value of Final stage PA unit 9's over current threshold	
49	Final stage PA9_Preset value for over temperature 1 threshold	0x0090	℃	0.1	The preset value of Final stage PA unit 9's over temperature 1 threshold	
50	Final stage PA9_Preset value for over temperature 2 threshold	0x0091	℃	0.1	The preset value of Final stage PA unit 9's over temperature 2 threshold	
51	Final stage PA10_Output voltage preset value	0x0092	V	0.1	The preset value of Final stage PA unit 10's output voltage	Final stage PA unit10
52	Final stage PA10_Preset value for over voltage threshold	0x0093	V	0.1	The preset value of Final stage PA unit 10's over voltage threshold	
53	Final stage PA10_Preset value for over current threshold	0x0094	A	0.1	The preset value of Final stage PA unit 10's over current threshold	
54	Final stage PA10_Preset value for over temperature 1 threshold	0x0095	℃	0.1	The preset value of Final stage PA unit 10's over temperature 1 threshold	
55	Final stage PA10_Preset value for over	0x0096	℃	0.1	The preset value of Final stage PA unit 10's over	

	temperature 2 threshold				temperature 2 threshold	
56	Final stage PA11_Output voltage preset value	0x0097	V	0.1	The preset value of Final stage PA unit 11's output voltage	Final stage PA unit11
57	Final stage PA11_Preset value for over voltage threshold	0x0098	V	0.1	The preset value of Final stage PA unit 11's over voltage threshold	
58	Final stage PA11_Preset value for over current threshold	0x0099	A	0.1	The preset value of Final stage PA unit 11's over current threshold	
59	Final stage PA11_Preset value for over temperature 1 threshold	0x009A	℃	0.1	The preset value of Final stage PA unit 11's over temperature 1 threshold	
60	Final stage PA11_Preset value for over temperature 2 threshold	0x009B	℃	0.1	The preset value of Final stage PA unit 11's over temperature 2 threshold	
61	Final stage PA12_Output voltage preset value	0x009C	V	0.1	The preset value of Final stage PA unit 12's output voltage	Final stage PA unit12
62	Final stage PA12_Preset value for over voltage threshold	0x009D	V	0.1	The preset value of Final stage PA unit 12's over voltage threshold	
63	Final stage PA12_Preset value for over current threshold	0x009E	A	0.1	The preset value of Final stage PA unit 12's over current threshold	
64	Final stage PA12_Preset value for over temperature 1 threshold	0x009F	℃	0.1	The preset value of Final stage PA unit 12's over temperature 1 threshold	
65	Final stage PA12_Preset value for over temperature 2 threshold	0x00A0	℃	0.1	The preset value of Final stage PA unit 12's over temperature 2 threshold	

Table 2 is for digital values and one should pay attention to the following points:

1. All data in the register are nonnegative integer.

2. 0xFFFF is defined as fault value. When there is an internal communication fault, the register value will be 0xFFFF.

Table2 Digital Values

No.	Digital Values	Input register address	Description	Data source
1	480v circuit breaker closed	0x0100	AC enable switch state. 1 represents AC enable, 0 represents AC disable.	Machine Control panel
2	Emergency switch off	0x0101	Unused	
3	Power supply signal on	0x0102	DC enable switch state. 1 represents DC enable, 0 represents DC disable.	
4	RF enable on	0x0103	RF enable switch state. 1 represents RF enable, 0 represents RF disable.	
5	AC 480V input fault	0x0104	AC 480V input state. 1 represents fault, 0 represents normal.	
6	AC 480V output fault	0x0105	AC 480V output state. 1 represents fault, 0 represents normal.	
7	External fault 1	0x0106	External fault interface 1 state.	

			1 represents fault, 0 represents normal.	
8	External fault 2	0x0107	External fault interface 2 state. 1 represents fault, 0 represents normal.	
9	External fault 3	0x0108	External fault interface 3 state. 1 represents fault, 0 represents normal.	
10	External fault 4	0x0109	External fault interface 4 state. 1 represents fault, 0 represents normal.	
11	SSA output power over high	0x010A	SSA output power state. 1 represents over output power fault, 0 represents normal.	
12	Over-reflective power for SSA	0x010B	SSA reflection power state. 1 represents over reflection power fault, 0 represents normal.	
13	Flowrate over low	0x010C	The cooling system flowrate state. 1 represents flowrate over low fault, 0 represents normal.	Network & Control Board
14	Internal rack temp.1 (middle) over high	0x010D	Internal rack temperature (middle) state. 1 represents temperature over high fault. 0 represents normal.	
15	Internal rack temp.2 (bottom) over high	0x010E	Internal rack temperature (bottom) state. 1 represents temperature over high fault. 0 represents normal.	
16	Internal rack humidity.1 (middle) over high	0x010F	Internal rack humidity (middle) state. 1 represents humidity over high fault. 0 represents normal.	
17	Internal rack humidity.2 (bottom) over high	0x0110	Internal rack humidity (bottom) state.	

			1 represents humidity over high fault. 0 represents normal.	
18	Inlet water temp. over high	0x0111	Cooling system's inlet water temperature state. 1 represents temperature over high fault. 0 represents normal.	
19	Input power over high	0x0112	Pre-Amplifier's input power state. 1 represents input power over high fault. 0 represents normal	
20	Driving stage output power fault	0x0113	Pre-Amplifier's output power state. 1 represents output power fault. 0 represents normal.	
21	Driving stage current fault	0x0114	Pre-Amplifier's current state. 1 represents current fault. 0 represents normal.	
22	Penultimate stage PA_ over current	0x0115	Penultimate stage PA current state 1 represents over current fault, 0 represents normal.	Penultimate stage PA unit
23	Penultimate stage PA_overvoltage	0x0116	Penultimate stage PA voltage state. 1 represents an overvoltage fault, 0 represents normal.	
24	Penultimate stage PA_undervoltage	0x0117	Penultimate stage PA voltage stage. 1 represents an under voltage fault, 0 represents normal.	
25	Penultimate stage PA_PS over temperature	0x0118	PS module (in the penultimate stage PA) temperature state. 1 represents PS over temperature fault, 0 represents normal.	
26	Penultimate stage PA_power on/off	0x0119	Switching power supply (in the penultimate stage PA) state. 1 represents power on (has output power). 0 represents power off (has no output power).	

27	Penultimate stage PA_over temperature 1	0x011A	Load (in the penultimate stage PA) temperature state. 1 represents load over temperature fault, 0 represents normal.	
28	Penultimate stage PA_over temperature 2	0x011B	Transistor (in the penultimate stage PA) temperature state. 1 represents transistor over temperature fault, 0 represents normal.	
29	Final stage PA 1_overcurrent	0x011C	Final stage PA 1 current state. 1 represents over current fault, 0 represents normal.	
30	Final stage PA 1_overvoltage	0x011D	Final stage PA 1 voltage state. 1 represents an overvoltage fault, 0 represents normal.	
31	Final stage PA 1_undervoltage	0x011E	Final stage PA 1 voltage state. 1 represents an under voltage fault, 0 represents normal.	
32	Final stage PA 1_PS over temperature	0x011F	PS module (in the final stage PA 1) temperature state. 1 represents PS over temperature fault, 0 represents normal.	Final stage PA unit 1
33	Final stage PA 1_power on/off	0x0120	The state of switching power supply in final stage PA 1. 1 represents power on (has output power). 0 represents power off (has no output power).	
34	Final stage PA 1_ over temperature 1	0x0121	Transistor (in the final stage PA 1) temperature state. 1 represents transistor over temperature fault, 0 represents normal.	
35	Final stage PA 1_ over temperature 2	0x0122	Load (in the final stage PA 1) temperature state. 1 represents load over temperature fault, 0 represents normal.	
36	Final stage PA 2_overcurrent	0x0123	Final stage PA 2 current state.	Final stage PA unit 2

			1 represents over current fault, 0 represents normal.	
37	Final stage PA 2_overvoltage	0x0124	Final stage PA 2 voltage state. 1 represents an overvoltage fault, 0 represents normal.	
38	Final stage PA 2_undervoltage	0x0125	Final stage PA 2 voltage state. 1 represents an under voltage fault, 0 represents normal.	
39	Final stage PA 2_PS over temperature	0x0126	PS module (in the final stage PA 2) temperature state. 1 represents PS over temperature fault, 0 represents normal.	
40	Final stage PA 2_power on/off	0x0127	The state of switching power supply in final stage PA 2. 1 represents power on (has output power). 0 represents power off (has no output power).	
41	Final stage PA 2_ over temperature 1	0x0128	Transistor (in the final stage PA 2) temperature state. 1 represents transistor over temperature fault, 0 represents normal.	
42	Final stage PA 2_ over temperature 2	0x0129	Load (in the final stage PA 2) temperature state. 1 represents load over temperature fault, 0 represents normal.	
43	Final stage PA 3_overcurrent	0x012A	Final stage PA 3 current state. 1 represents over current fault, 0 represents normal.	
44	Final stage PA 3_overvoltage	0x012B	Final stage PA 3 voltage state. 1 represents an overvoltage fault, 0 represents normal.	Final stage PA unit 3
45	Final stage PA 3_undervoltage	0x012C	Final stage PA 3 voltage state. 1 represents an under voltage fault, 0 represents normal.	

46	Final stage PA 3_PS over temperature	0x012D	PS module (in the final stage PA 3) temperature state. 1 represents PS over temperature fault, 0 represents normal.	
47	Final stage PA 3_power on/off	0x012E	The state of switching power supply in final stage PA 3. 1 represents power on (has output power). 0 represents power off (has no output power).	
48	Final stage PA 3_ over temperature 1	0x012F	Transistor (in the final stage PA 3) temperature state. 1 represents transistor over temperature fault, 0 represents normal.	
49	Final stage PA 3_ over temperature 2	0x0130	Load (in the final stage PA 3) temperature state. 1 represents load over temperature fault, 0 represents normal.	
50	Final stage PA 4_overcurrent	0x0131	Final stage PA 4 current state. 1 represents over current fault, 0 represents normal.	Final stage PA unit 4
51	Final stage PA 4_overvoltage	0x0132	Final stage PA 4 voltage state. 1 represents an overvoltage fault, 0 represents normal.	
52	Final stage PA 4_undervoltage	0x0133	Final stage PA 4 voltage state. 1 represents an under voltage fault, 0 represents normal.	
53	Final stage PA 4_PS over temperature	0x0134	PS module (in the final stage PA 4) temperature state. 1 represents PS over temperature fault, 0 represents normal.	
54	Final stage PA 4_power on/off	0x0135	The state of switching power supply in final stage PA 4. 1 represents power on (has output power). 0 represents power off (has no output power).	

55	Final stage PA 4_ over temperature 1	0x0136	Transistor (in the final stage PA 4) temperature state. 1 represents transistor over temperature fault, 0 represents normal.	
56	Final stage PA 4_ over temperature 2	0x0137	Load (in the final stage PA 4) temperature state. 1 represents load over temperature fault, 0 represents normal.	
57	Final stage PA 5_overcurrent	0x0138	Final stage PA 5 current state. 1 represents over current fault, 0 represents normal.	
58	Final stage PA 5_overvoltage	0x0139	Final stage PA 5 voltage state. 1 represents over voltage fault, 0 represents normal.	
59	Final stage PA 5_undervoltage	0x013A	Final stage PA 5 voltage state. 1 represents an under voltage fault, 0 represents normal.	
60	Final stage PA 5_PS over temperature	0x013B	PS module (in the final stage PA 5) temperature state. 1 represents PS over temperature fault, 0 represents normal.	Final stage PA unit 5
61	Final stage PA 5_power on/off	0x013C	The state of switching power supply in final stage PA 5. 1 represents power on (has output power). 0 represents power off (has no output power).	
62	Final stage PA 5_ over temperature 1	0x013D	Transistor (in the final stage PA 5) temperature state. 1 represents transistor over temperature fault, 0 represents normal.	
63	Final stage PA 5_ over temperature 2	0x013E	Load (in the final stage PA 5) temperature state. 1 represents load over temperature fault, 0 represents normal.	
64	Final stage PA 6_overcurrent	0x013F	Final stage PA 6 current state.	Final stage PA unit 6

			1 represents over current fault, 0 represents normal.	
65	Final stage PA 6_overvoltage	0x0140	Final stage PA 6 voltage state. 1 represents an overvoltage fault, 0 represents normal.	
66	Final stage PA 6_undervoltage	0x0141	Final stage PA 6 voltage state. 1 represents a under voltage fault, 0 represents normal.	
67	Final stage PA 6_PS over temperature	0x0142	PS module (in the final stage PA 6) temperature state. 1 represents PS over temperature fault, 0 represents normal.	
68	Final stage PA 6_Power on/off	0x0143	The state of switching power supply in final stage PA 6. 1 represents power on (has output power). 0 represents power off (has no output power).	
69	Final stage PA 6_over temperature 1	0x0144	Transistor (in the final stage PA 6) temperature state. 1 represents transistor over temperature fault, 0 represents normal.	
70	Final stage PA 6_over temperature 2	0x0145	Load (in the final stage PA 6) temperature state. 1 represents load over temperature fault, 0 represents normal.	
71	Final stage PA 7_overcurrent	0x0146	Final stage PA 7 current state. 1 represents over current fault, 0 represents normal.	
72	Final stage PA 7_overvoltage	0x0147	Final stage PA 7 voltage state. 1 represents an overvoltage fault, 0 represents normal.	Final stage PA unit 7
73	Final stage PA 7_undervoltage	0x0148	Final stage PA 7 voltage state. 1 represents a under voltage fault, 0 represents normal.	

74	Final stage PA 7_PS over temperature	0x0149	PS module (in the final stage PA 7) temperature state. 1 represents PS over temperature fault, 0 represents normal.	
75	Final stage PA 7_power on/off	0x014A	The state of switching power supply in final stage PA 7. 1 represents power on (has output power). 0 represents power off (has no output power).	
76	Final stage PA 7_ over temperature 1	0x014B	Transistor (in the final stage PA 7) temperature state. 1 represents transistor over temperature fault, 0 represents normal.	
77	Final stage PA 7_ over temperature 2	0x014C	Load (in the final stage PA 7) temperature state. 1 represents load over temperature fault, 0 represents normal.	
78	Final stage PA 8_overcurrent	0x014D	Final stage PA 8 current state. 1 represents over current fault, 0 represents normal.	Final stage PA unit 8
79	Final stage PA 8_overvoltage	0x014E	Final stage PA 8 voltage state. 1 represents a under voltage fault, 0 represents normal.	
80	Final stage PA 8_undervoltage	0x014F	Final stage PA 8 voltage state. 1 represents a under voltage fault, 0 represents normal.	
81	Final stage PA 8_PS over temperature	0x0150	PS module (in the final stage PA 8) temperature state. 1 represents PS over temperature fault, 0 represents normal.	
82	Final stage PA 8_power on/off	0x0151	The state of switching power supply in final stage PA 8. 1 represents power on (has output power). 0 represents power off (has no output power).	

83	Final stage PA 8_ over temperature 1	0x0152	Transistor (in the final stage PA 8) temperature state. 1 represents transistor over temperature fault, 0 represents normal.	
84	Final stage PA 8_ over temperature 2	0x0153	Load (in the final stage PA 8) temperature state. 1 represents load over temperature fault, 0 represents normal.	
85	Final stage PA 9_overcurrent	0x0154	Final stage PA 9 current state. 1 represents over current fault, 0 represents normal.	
86	Final stage PA 9_overvoltage	0x0155	Final stage PA 9 voltage state. 1 represents an overvoltage fault, 0 represents normal.	
87	Final stage PA 9_undervoltage	0x0156	Final stage PA 9 voltage state. 1 represents a under voltage fault, 0 represents normal.	
88	Final stage PA 9_PS over temperature	0x0157	PS module (in the final stage PA 9) temperature state. 1 represents PS over temperature fault, 0 represents normal.	Final stage PA unit 9
89	Final stage PA 9_power on/off	0x0158	The state of switching power supply in final stage PA 9. 1 represents power on (has output power). 0 represents power off (has no output power).	
90	Final stage PA 9_ over temperature 1	0x0159	Transistor (in the final stage PA 9) temperature state. 1 represents transistor over temperature fault, 0 represents normal.	
91	Final stage PA 9_ over temperature 2	0x015A	Load (in the final stage PA 9) temperature state. 1 represents load over temperature fault, 0 represents normal.	
92	Final stage PA 10_overcurrent	0x015B	Final stage PA 10 current state.	Final stage PA unit 10

			1 represents over current fault, 0 represents normal.	
93	Final stage PA 10_overvoltage	0x015C	Final stage PA 10 voltage state. 1 represents a overvoltage fault, 0 represents normal.	
94	Final stage PA 10_undervoltage	0x015D	Final stage PA 10 voltage state. 1 represents a under voltage fault, 0 represents normal.	
95	Final stage PA 10_PS over temperature	0x015E	PS module (in the final stage PA 10) temperature state. 1 represents PS over temperature fault, 0 represents normal.	
96	Final stage PA 10_power on/off	0x015F	The state of switching power supply in final stage PA 10. 1 represents power on (has output power). 0 represents power off (has no output power).	
97	Final stage PA 10_ over temperature 1	0x0160	Transistor (in the final stage PA 10) temperature state. 1 represents transistor over temperature fault, 0 represents normal.	
98	Final stage PA 10_ over temperature 2	0x0161	Load (in the final stage PA 10) temperature state. 1 represents load over temperature fault, 0 represents normal.	
99	Final stage PA 11_overcurrent	0x0162	Final stage PA 11 current state. 1 represents over current fault, 0 represents normal.	
100	Final stage PA 11_overvoltage	0x0163	Final stage PA 11 voltage state. 1 represents an overvoltage fault, 0 represents normal.	Final stage PA 11
101	Final stage PA 11_undervoltage	0x0164	Final stage PA 11 voltage state. 1 represents a under voltage fault, 0 represents normal.	

102	Final stage PA 11_PS over temperature	0x0165	PS module (in the final stage PA 11) temperature state. 1 represents PS over temperature fault, 0 represents normal.	
103	Final stage PA 11_power on/off	0x0166	The state of switching power supply in final stage PA 11. 1 represents power on (has output power). 0 represents power off (has no output power).	
104	Final stage PA 11_ over temperature 1	0x0167	Transistor (in the final stage PA 11) temperature state. 1 represents transistor over temperature fault, 0 represents normal.	
105	Final stage PA 11_ over temperature 2	0x0168	Load (in the final stage PA 11) temperature state. 1 represents load over temperature fault, 0 represents normal.	
106	Final stage PA 12_overcurrent	0x0169	Final stage PA 12 current state. 1 represents over current fault, 0 represents normal.	Final stage PA 12
107	Final stage PA 12_overvoltage	0x016A	Final stage PA 12 voltage state. 1 represents a overvoltage fault, 0 represents normal.	
108	Final stage PA 12_undervoltage	0x016B	Final stage PA 12 voltage state. 1 represents an under voltage fault, 0 represents normal.	
109	Final stage PA 12_PS over temperature	0x016C	PS module (in the final stage PA 12) temperature state. 1 represents PS over temperature fault, 0 represents normal.	
110	Final stage PA 12_power on/off	0x016D	The state of switching power supply in final stage PA 12. 1 represents power on (has output power). 0 represents power off (has no output power).	

111	Final stage PA 12_ over temperature 1	0x016E	Transistor (in the final stage PA 12) temperature state. 1 represents transistor over temperature fault, 0 represents normal.	
112	Final stage PA 12_ over temperature 2	0x016F	Load (in the final stage PA 12) temperature state. 1 represents load over temperature fault, 0 represents normal.	
113	Fault state1	0x0170	The fault state that can be defined by customer, 1 represents fault, 0 represents normal	
114	Fault state2	0x0171	The fault state that can be defined by customer, 1 represents fault, 0 represents normal	One or two, or more faults listed in line 5-21 of the sheet can be chosen to define the fault state.
115	Fault state3	0x0172	The fault state that can be defined by customer, 1 represents fault, 0 represents normal	
116	Fault state4	0x0173	The fault state that can be defined by customer, 1 represents fault, 0 represents normal	

Table 3 is for preset values, and one should pay attention to the following points:

1. The data for internal rack temperature 1(middle part) threshold and internal rack temperature 2 (bottom part) threshold are integer; other preset values are nonnegative integer.

2. Precision represents a conversion coefficient between the register value and the actual value. The actual value= the register value*the precision. The precision for all thresholds are 0.1

Table3 Preset values

No.	Preset values	Holding register address	Description	Precision	Range
1	PS enable/ disable	0x0200	Enable/disable the switching power supply setting command. 1 represents enable, 0 represents disable	-	-
2	RF enable/ disable	0x0201	Enable/disable the RF setting command. 1 represents enable, 0 represents disable	-	-
3	Fault state1	0x0202	Fault reset setting command. 1 represents reset	-	-
4	SSA output power threshold	0x0203	The preset value for SSA output power threshold	0.1	0~4500W
5	SSA over-reflective power threshold	0x0204	The preset value for SSA reflection power threshold.	0.1	0~4500W
6	Flowrate threshold	0x0205	The preset value for SSA flowrate threshold.	0.1.	0~50L/ min
7	Internal rack temp.1 (middle) threshold	0x0206	The preset value for SSA internal rack temp1 (middle) threshold.	0.1	-40~ +120 ℃
8	Internal rack temp. 2 (bottom) threshold	0x0207	The preset value for SSA internal rack temp2 (bottom) threshold.	0.1	- 40~ +120 ℃
9	Internal rack humidity.1 (middle)	0x0208	The preset value for SSA internal rack humidity1 (middle part)	0.1	20~80 % RH

	threshold		threshold.		
10	Internal rack humidity. 2 (bottom) threshold	0x0209	The preset value for SSA internal rack humidity2 (bottom) threshold.	0.1	20~80% RH
11	Inlet water temp. threshold	0x020A	The preset value for SSA inlet water temp. threshold.	0.1	0~ 150 ℃
12	PA module address.	0x020B	Used with the PS preset value to represent the address of PA module.		0~13 0 represents the final stage PA broadcasting; 1~13 represent relevant PA's address.
13	PS voltage	0x020C	The preset value for PS voltage.	0.1	9.6~32V
14	Over voltage protection point	0x020D	The preset value for PS overvoltage protection threshold.	0.1	12~ 34V
15	Overcurrent protection point	0x020E	The preset value for PS overcurrent protection threshold.	0.1	15~ 28A
16	PS over temperature point 1	0x020F	The preset value for PS over temperature threshold 1.	0.1	50~ 120 ℃
17	PS over temperature point 2	0x0210	The preset value for PS over temperature threshold 2.	0.1	50~ 120 ℃
18	Self-defined fault state1H	0x0211	Used to define the fault state 1(high bit). Two registers includes 4 bytes, 32bits.Here only 17 bits (starts from lower bit) have been used, which represent the digital values in Table 2 from No. 5 to No.21 respectively. 1 represents the digital value is chosen to conduct OR-operation and 0 represents the digital value is not chosen. For example: The register value 0x00000013 represents a union set of 3 digital values: AC 480V input fault, AC 480V output fault,		

			external fault		
19	Self-defined fault state 1L	0x0212	Used to define the fault state 1(Low bit). Two registers includes 4 bytes, 32bits.Here only 17 bits (starts from lower bit) have been used, which represent the digital values in Table 2 from No. 5 to No.21 respectively. 1 represents the digital value is chosen to conduct OR-operation and 0 represents the digital value is not chosen. For example: The register value 0x00000013 represents a union set of 3 digital values: AC 480V input fault, AC 480V output fault, external fault		
20	Self-defined fault state 2H	0x0213	Used to define the fault state 2(high bit). Two registers includes 4 bytes, 32bits.Here only 17 bits (starts from lower bit) have been used, which represent the digital values in Table 2 from No. 5 to No.21 respectively. 1 represents the digital value is chosen to conduct OR-operation and 0 represents the digital value is not chosen. For example: The register value 0x00000013 represents a union set of 3 digital values: AC 480V input fault, AC 480V output fault, external fault		
21	Self-defined fault state 2L	0x0214	Used to define the fault state 2(low bit). Two registers includes 4 bytes, 32bits.Here only 17 bits (starts from lower bit) have been used, which represent the digital values in Table 2 from No. 5 to No.21 respectively. 1 represents the digital value is chosen to conduct OR-operation		

			and 0 represents the digital value is not chosen.		
			For example: The register value 0x00000013 represents a union set of 3 digital values: AC 480V input fault, AC 480V output fault, external fault		
22	Self-defined fault state 3H	0x0215	Used to define the fault state 3(high bit). Two registers includes 4 bytes, 32bits.Here only 17 bits (starts from lower bit) have been used, which represent the digital values in Table 2 from No. 5 to No.21 respectively.		
			1 represents the digital value is chosen to conduct OR-operation and 0 represents the digital value is not chosen.		
			For example: The register value 0x00000013 represents a union set of 3 digital values: AC 480V input fault, AC 480V output fault, external fault		
23	Self-defined fault state 3L	0x0216	Used to define the fault state 3(low bit). Two registers includes 4 bytes, 32bits.Here only 17 bits (starts from lower bit) have been used, which represent the digital values in Table 2 from No. 5 to No.21 respectively.		
			1 represents the digital value is chosen to conduct OR-operation and 0 represents the digital value is not chosen.		
			For example: The register value 0x00000013 represents a union set of 3 digital values: AC 480V input fault, AC 480V output fault, external fault		
24	Self-defined fault state 4H	0x0217	Used to define the fault state 4(high bit). Two registers includes 4 bytes, 32bits.Here only 17 bits (starts from lower bit) have been		

			used, which represent the digital values of Machine Control Panel 5~21 respectively. 1 represents the digital value is chosen to conduct OR-operation and 0 represents the digital value is not chosen. For example: The register value 0x00000013 represents a union set of 3 digital values: AC 480V input fault, AC 480V output fault, external fault		
25	Self-defined fault state 4L	0x0218	Used to define the fault state 4(low bit). Two registers includes 4 bytes, 32bits.Here only 17 bits (starts from lower bit) have been used, which represent the digital values of Machine Control Panel 5~21 respectively. 1 represents the digital value is chosen to conduct OR-operation and 0 represents the digital value is not chosen. For example: The register value 0x00000013 represents a union set of 3 digital values: AC 480V input fault, AC 480V output fault, external fault		
26	Fault state enable	0x0219	Fault state enable switch. 1 represent the fault state is enabled;0 represents the fault state is disabled.		

1.3 Operation instruction

During SSA's normal operating, one can realize its monitoring and control through Ethernet interface. First, make sure the upper computer and the SSA are in the same LAN. Then, operate the software in the upper computer or Modbus testing tool, making the upper computer the master which is connected with SSA via TCP. When TCP connection is established, one can make query or set up on the SSA through the above mentioned protocol.

1.3.1 Query

Query includes the query of analog values and digital values. Since analog values and digital values are read-only data, they are all stored in input registers and allocated with different register addresses. But, the query of analog values and query of digital value will be conducted separately.

For example, to query all analog dates, except transmitting the MBAP, the structure of PDU is as follows:

Function code	0x04
Starting address Hi	0x00
Starting address Lo	0x00
No of Input register Hi	0x00
No of Input register Lo	0x5A

Function code 04 reads the continuous input register data. According to the protocol, the starting address for analog values is 0x0000, and there are 90 readable analog values. Of course, the analog values can be queried by demand.

It is the same for the digital values. Please refer to the above mentioned protocols the concrete register address.

1.3.2 Setting

Setting includes command setting and data setting. The setting values are read-write, so they can be stored in holding registers. During the setting process, one or more registers can be written. Taking single register as example: to set the PS enable state, except transmitting the MBAP message, the structure of PDU is as follows:

Function code	0x06
Register address Hi	0x02
Register address Lo	0x00
Register value Hi	0x00
Register value Lo	0x01

Function code 06 writes single register. According to the protocol, the register address for PS enable/disable is 0x0200. Preset value 0x0001 represents sending enable command.

In the above mentioned protocol, the setting command includes: PS enable/disable, RF enable/disable, fault reset; the setting data includes: SSA overall reflection power threshold,

flowrate threshold, internal rack temp.1(middle part) threshold; internal rack temp.2(bottom part) threshold, internal rack humidity 1(middle part) threshold, internal rack humidity 2 (bottom) threshold, inlet water temp. threshold, PA module address, PS voltage, PS over voltage protection point, PS overcurrent protection point, PS over temperature protection point 1, and PS over temperature protection point 2. Self-defined fault state 1H, Self-defined fault state 1L, Self-defined fault state 2H, Self-defined fault state 2L, Self-defined fault state 3H, Self-defined fault state 3L, Self-defined fault state 4H, Self-defined fault state 4L, fault enable state.

1.3.3 Fault

Fault includes internal fault and external fault. The internal faults come from the inside of SSA, which include power distribution system fault, power fault, internal environment fault, PA power supply fault, etc. The external faults come from outside through the 4 BNC interface. When internal fault exists, the internal fault indicate light will be on. And relevant register will be at faulty state. The fault state will be blocked and SSA will give fault state signal outside. If the fault is relevantly serious, DC and RF will be disabled, and could not be recovered until the reset operation is conducted. When external fault exists, the external fault indicate light will be on, and relevant register will be at fault state. The fault state will be blocked, and SSA will give fault state signal outside. DC, RF will be disabled and they could not be enabled until the reset operation is conducted.

The SSA faults will be shown in the following table.

Fault type	Indication light state	Fault state given by the control & interface board	Register state	DC disable	RF disable
AC 480V input fault	Internal fault indicate light on	Low level, fault	1, fault	Disable	Disable
AC 480V output fault	Internal fault indicate light on	Low level, fault	1, fault	Disable	Disable
External fault 1	External fault indicate light on	Low level, fault	1, fault	Disable	Disable
External fault 2	External fault indicate light on	Low level, fault	1, fault	Disable	Disable
External fault 3	External fault indicate light on	Low level, fault	1, fault	Disable	Disable
External fault 4	External fault indicate light on	Low level, fault	1, fault	Disable	Disable
SSA output power over high	Internal fault indicate light on	Low level, fault	1, fault	Disable	Disable
Over-reflective power for SSA	Internal fault indicate light on	Low level, fault	1, fault	Disable	Disable

Flowrate over low	Internal fault indicate light on	Low level, fault	1, fault	Disable	Disable
Internal rack temp.1 (middle) over high	Internal fault indicate light on	Low level, fault	1, fault	Disable	Disable
Internal rack temp.2 (bottom) over high	Internal fault indicate light on	Low level, fault	1, fault	Disable	Disable
Internal rack humidity.1 (middle) over high	Internal fault indicate light on	Low level, fault	1, fault	**Enable**	**Enable**
Internal rack humidity.2 (bottom) over high	Internal fault indicate light on	Low level, fault	1, fault	**Enable**	**Enable**
Inlet water temp. over high	Internal fault indicate light on	Low level, fault	1, fault	Disable	Disable
Input power over high	Internal fault indicate light on	Low level, fault	1, fault	Disable	Disable
Driving stage output power fault	Internal fault indicate light on	Low level, fault	1, fault	Disable	Disable
Driving stage current fault	Internal fault indicate light on	Low level, fault	1, fault	Disable	Disable

For single PA unit, the faults are shown in the following table.

And when there is just one PA module fails, only fault state will be reported and the DC, RF will not be disabled. But when more than 1 PA modules fail, the DC and RF will be disabled. More faults exist in one same PA module will taken as only 1 PA module fails. The penultimate PA unit will be calculated separately.

Fault type	Indicate light state	Fault state given by the control & interface board	Register state	DC disable	RF disable
Final stage PA _overcurrent	Internal fault indicate light on	Low level, fault	1, fault	Based on how many PA modules fail	Based on how many PA modules fail
Final stage PA _overvoltage	Internal fault indicate light on	Low level, fault	1, fault	Based on how many PA modules fail	Based on how many PA modules fail
Final stage PA _undervoltage	Internal fault	Low level, fault	1, fault	Based on how many	Based on how many

	indicate light on			PA modules fail	PA modules fail
Final stage PA_PS over temperature	Internal fault indicate light on	Low level, fault	1, fault	Based on how many PA modules fail	Based on how many PA modules fail
Final stage PA _ over temperature 1	Internal fault indicate light on	Low level, fault	1, fault	Based on how many PA modules fail	Based on how many PA modules fail
Final stage PA _ over temperature 2	Internal fault indicate light on	Low level, fault	1, fault	Based on how many PA modules fail	Based on how many PA modules fail

1.3.4 Reset

When fault exists, the fault state will be blocked until the reset operation is conducted. And if the fault still exists during reset operation, the reset will be invalid. Only when all faults are excluded, the reset command will be conducted. Reset operation will turn off the fault indicate light, recover the fault state given by control and interface board to normal state, recover the register state to normal state, and allows user to conduct DC, RF enabling operation. If fault disabled DC,RF, after fault reset, the DC, RF will still be in disabled state. And if the fault did not disable the DC, RF, the reset will not influence the original state. As for all faults, their reset states are shown in the following table.

Fault type	Fault indicate light	Fault state from control & interface board	Register state	DC enable	RF enable
All	Off	High level, normal	0, normal	Allowed	Allowed

Q & A:

1) What do you read back and how is the data acquired - is their data time stamped - do you record data internally

All values in Table 1, 2 could be read back through TCP Modbus.

Data time is not stamped.

NO. We don't record the data internally.

2) How do you check for faults and what prevents false faults - do you issue warnings - how are the faults reported (e.g. last one only, last several, all) - which faults are hard-wired

Before conduct the fault reset command, all faults will be reported.

External faults are hard-wired.

3) How is your software loaded and maintained – We need to have the source code - will we be able to update it via ModBus?

There is no need to install the software. Just copy the content in SD card.

We have designed the function of updating via Modbus, but this function is still under test.

4) How do we reboot the system - does it have a 'dead-man' switch?

By turn off the 120V power supply. We do not have a dead-man switch.

5) Can we swap modules without re-phasing the system?

Yes.

6) How many processors do you use - if more than one, how do they communicate to each other and the system - what programming language do you use – approximately how many lines of code are there?

We have two processors. They communicate via RS 485.

We use C code language. There are about hundred lines of code.

7) Do each of the amplifier units have a unique identifier/serial number in software? They need to have it in hardware

NO. they do not have identifier in software. But each PA module have a nameplate with an unique serial No. on it.

8) Can we change the fault threshold limits via ModBus?

Of course you can.