



SmartGen
ideas for power

HATC60
INTELLIGENT ATS CONTROLLER
COMMUNICATION PROTOCOL

SmartGen

SMARTGEN (ZHENGZHOU) TECHNOLOGY CO., LTD.



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SmartGen — make your generator *smart*

SmartGen Technology Co., Ltd.

No.28 Jinsuo Road

Zhengzhou

Henan Province

P. R. China

Tel: 0086-371-67988888/67981888

0086-371-67991553/67992951

0086-371-67981000(overseas)

Fax: 0086-371-67992952

Web: www.smartgen.com.cn

www.smartgen.cn

Email: sales@smartgen.cn

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Table 1 - Software Version

Date	Version	Note
2019-02-20	1.0	Original release.



CONTENT

1. INTRODUCTION.....	4
2. MODBUS BASIC RULES.....	4
3. DATA FRAME FORMAT.....	4
4. COMMUNICATION PROTOCOL.....	4
4.1 ILLUSTRATION.....	4
4.2 INFORMATION FRAME FORMAT.....	4
4.3 ADDRESS CODE.....	5
4.4 FUNCTION CODE.....	5
4.4.1 ILLUSTRATION.....	5
4.4.2 03H READ HOLDING REGISTERS.....	5
4.4.3 05H FORCE SINGLE COIL.....	5
4.4.4 06H WRITE SINGLE REGISTER.....	5
4.5 DATA FIELD.....	6
4.5.1 ILLUSTRATION.....	6
4.5.2 FUNCTION 03H –READ HOLDING REGISTERS.....	6
4.5.3 FUNCTION 05H –FORCE SINGLE COIL.....	6
4.5.4 FUNCTION 06H – WRITE SINGE REGISTER.....	6
4.6 ERROR CHECK CODE (CRC).....	7
4.7 EXAMPLES OF INFORMATION FRAME FORMAT.....	8
4.7.1 FUNCTION CODE 03H.....	8
4.7.2 FUNCTION CODE 05H.....	9
4.7.3 FUNCTION CODE 06H.....	9
4.8 ERROR HANDLING.....	11
5. ATTACHMENT: ADDRESS AND DATA.....	12
5.1 FUNCTION CODE 03H MAP DATA FIELD.....	12
5.2 FUNCTION CODE 05H MAP DATA FIELD.....	17
5.3 S1 VOLTAGE STATUS DESCRIPTION.....	17
5.4 S2 VOLTAGE STATUS DESCRIPTION.....	17
5.5 GENSET STATUS DESCRIPTION.....	18
5.6 BREAKER STATUS DESCRIPTION.....	18

1. INTRODUCTION

This protocol describes read and write command format of PC serial port and the definition of internal information data for the third-party to develop and use.

MODBUS communication protocol allows the module to transfer information and data effectively with PLC, RTU, SCADA system of international brands (such as, Schneider, Siemens, and Modicon), and DCS or third-party monitoring system compatible with MODBUS. The monitoring system can be set up if only adding central communication master software (such as Kingview, Intouch、FIX、Synal) basing on PC (or IPC).

2. MODBUS BASIC RULES

- 1) All communication loops should follow the master-slave mode. If so, data can be transferred between a master (e.g. PC) and 32 slaves.
- 2) No communication can start from slaves.
- 3) In communication loop, all communication should be transmitted in “information frame”.
- 4) If received information frame contains unknown command, no response will be given.

3. DATA FRAME FORMAT

Communication is asynchronously transferred, using byte (data frame) as unit. Between master and slave, every transmitted data frame is 10-bit (stop bit is 1-bit) or 11-bit (stop bit is 2-bit) serial data stream.

Table 2 - Data frame format

Item	Description
Start bit	1-bit
Data bit	8-bit
Parity bit	No parity
Stop bit	1-bit, 2-bit can be set
Baud rate	9600bps(2400/4800/9600/19200bps can be set)

4. COMMUNICATION PROTOCOL

4.1 ILLUSTRATION

When communication command is sent to the slave, corresponding slave receives the communication command, then removes address code, and read the information. If no mistakes, it will execute commands, and sends the result back to the master. Response information includes address code, function code, data and error check code (CRC). If an error occurred in receipt of the command, it will send no information.

4.2 INFORMATION FRAME FORMAT

Table 3 – Information Frame Format

Initiating structure	Address code	Function code	Data field	CRC	End structure
Delay (equivalent to 4 bytes)	1 byte 8-bit	1 byte 8-bit	N bytes N*8-bit	2 bytes 16-bit	Delay (equivalent to 4 bytes)

4.3 ADDRESS CODE

Address code is the first data frame (8-bit) in each transmitted information frame (from 0-255). Single device address range is 1–247; this byte shows that the slave defined by users will receive the information sent by the master. Each slave has a unique address code, and responses begin with the address code. A master addresses a slave by placing the slave address in the address field of the message. When the slave sends its response, it places its own address in this address field of the response to let the master know which slave is responding.

4.4 FUNCTION CODE

4.4.1 ILLUSTRATION

This is the second byte of each transmission. ModBus communication protocol defined function code as 1-255 (01H-0FFH). HATC60 controller uses part of it. Master sends the request and the slave executes actions according to the function code. If the function code sent by slave is same as that sent by master, it means the response is active. But if the function code MSB is 1 (function code range > 127), it means there is no response or response has error.

The following table shows the specific signification and operation of function code.

Table 4 - ModBus Partial Function Codes

Function code	Definition	Operation
03H	Read Holding Registers	Reads the contents of holding registers
05H	Force Single Coil	Forces a single coil to either ON or OFF.
06H	Write Single Register	Write a 16-bit binary data into register.

4.4.2 03H READ HOLDING REGISTERS

With function code 03H command, the master can read the numerical registers inside the device (numerical registers contains various analog and parameter setting values). Input register values of function code 03H mapping data field are 16 bits (2 bytes). So, from the device reads registers values are 2 bytes. Maximum number of readable registers is 125 each time.

The slave received command format is slave address, function code, data field and the CRC code. The data of data field is in double bytes with every two bytes for a group, and high byte is in advance.

4.4.3 05H FORCE SINGLE COIL

Master uses this command to save a single coil data into bit registers in the device (such as ATS transfer control). The slave also uses this function code to feedback information to the master.

4.4.4 06H WRITE SINGLE REGISTER

Master uses this command to save a single data into registers in the device. The register in the ModBus communication protocol is 16-bit (2 bytes), and high byte is in advance. Thus all the registers of the device are 2 bytes. Command format is slave address, function code, data area and CRC code.

4.5 DATA FIELD

4.5.1 ILLUSTRATION

Data field varies with different function codes.

4.5.2 FUNCTION 03H –READ HOLDING REGISTERS

Request:

Data Sequence	Data Signification	Byte Count
1	Starting address	2
2	Read registers	2

Response:

Data Sequence	Data Signification	Byte Count
1	Loopback byte count	1
2	N - register data	N

4.5.3 FUNCTION 05H –FORCE SINGLE COIL

Request:

Data Sequence	Data Signification	Byte Count
1	Coil address	2
2	Forced single coil value	2

Response:

Data Sequence	Data Signification	Byte Count
1	Coil address	2
2	Single coil value	2

4.5.4 FUNCTION 06H – WRITE SINGE REGISTER

Request:

Data Sequence	Data Signification	Byte Count
1	Register address	2
2	Register value(2 bytes)	2

Response:

Data Sequence	Data Signification	Byte Count
1	Register address	2
2	Register value(2 bytes)	2

4.6 ERROR CHECK CODE (CRC)

The Error Check Code allows the receiving device to detect a packet that has been corrupted with transmission errors. Sometimes, the transmission information occur imperceptible changes due to electronic noise and other interference and the CRC code ensure the error information does not work to increase the system's safety and efficiency. CRC adapts CRC-16 method of calibration.

When the CRC is appended to the message, the low-order byte is appended first, followed by the high-order byte.

▲Note: All information frame format are same: address code, function code, data area and CRC code.

The CRC field is two bytes, containing a 16-bit binary value. The CRC value is calculated by the transmitting device, which appends the CRC to the message. The receiving device recalculates a CRC during receipt of the message, and compares the calculated value to the actual value that received in the CRC field. If the two values are not equal, an error will result.

The CRC is started by first preloading a 16-bit register to all 1's. Then a process begins of applying successive 8-bit bytes of the message to the current contents of the register. Only the eight bits of data in each character are used for generating the CRC. Start and stop bits do not apply to the CRC.

During generation of the CRC, each 8-bit character is exclusive OR with the register contents. Then the result is shifted in the direction of the least significant bit (LSB), with a zero filled into the most significant bit (MSB) position. The LSB is extracted and examined. If the LSB was a 1, the register is then exclusive OR with a preset, fixed value. If the LSB was a 0, no exclusive OR takes place.

This process is repeated until eight shifts have been performed. After the last (eighth) shift, the next 8-bit byte is exclusive OR with the register's current value, and the process repeats for eight more shifts as described above. The final contents of the register, after all the bytes of the message have been applied, is the CRC value.

CRC-16 CALCULATIONPROCEDURE

- 1) Load a 16-bit register with FFFF hex (all 1's). Call this the CRC register.
- 2) Exclusive OR the first 8-bit byte of the message with the low-order byte of the CRC register, putting the result in the CRC register.
- 3) Shift the CRC register one bit to the right (toward the LSB), zero-filling the MSB. Extract and examine the LSB.
- 4) (If the LSB was 0): Repeat Step 3 (another shift).
(If the LSB was 1): Exclusive OR the CRC register with the polynomial value A001 hex (1010 0000 0000 0001).
- 5) Repeat Steps 3 and 4 until 8 shifts have been performed. When this is done, a complete 8-bit byte will have been processed.
- 6) Repeat Steps 2 through 5 for the next 8-bit byte of the message. Continue doing this until all bytes have been processed.
- 7) The final contents of the CRC register are the CRC value. Least Significant Byte first. When the 16-bit CRC (two 8-bit bytes) is transmitted in the message, the low-order byte will be transmitted first, followed by the high-order byte.

▲Note: The calculating of CRC code starts from <slave address> and except for all bytes of <CRC code>.

4.7 EXAMPLES OF INFORMATION FRAME FORMAT

4.7.1 FUNCTION CODE 03H

Slave address is 01 and starting address is 3 data of 0026H(each data is 2-byte).

Address	Data(Hex)
0026	0014
0028	0014
002A	0005

Request

Request	Bytes	Example (Hex)
Slave address	1	01 Send to the slave 01
Function code	1	03 Read Holding Registers
Starting address	2	00 Starting address is 0026H 26
No. of Points	2	00 Read 3 registers (total 6 bytes) 03
CRC code	2	E4 CRC code which calculated by PC. 00

Response

Response	Bytes	Example (Hex)
Slave address	1	01 Respond to the slave 01
Function code	1	03 Read register
Read count	1	06 3 registers (total 6 bytes)
Data 1	2	00 The content of address 0026H 14
Data 2	2	00 The content of address 0027H 14
Data 3	2	00 The content of address 0028H 05
CRC code	2	91 CRC code which calculated by slave. 71

4.7.2 FUNCTION CODE 05H

Read coil for slave address is 01 and starting address is 1 coil value of 0002H. 0002H unit is 1.

Address	Data(Hex)
0000	0
0001	1
0002	0

▲ Note: A value of 00FF hex requests the coil to be ON. A value of 00 0H requests it to be OFF. All other values are illegal and will not affect the coil.

Request

Request	Bytes	Example (Hex)
Slave address	1	01 Send to the slave 01
Function code	1	05 Force single coil
Starting address	2	00 Starting address for 0000H 00
Data	2	FF Set coil as 1 00
CRC code	2	04 CRC code which calculated by PC. 3A

Response

Slave Response	Bytes	For Example (Hex)
Slave address	1	01 Respond to the slave 01
Function code	1	05 Force single coil
Starting address	2	00 Starting address is 0000H 00
Data	2	FF Set coil as 1 00
CRC code	2	04 CRC code which calculated by slave. 3A

4.7.3 FUNCTION CODE 06H

Slave address is 01 and starting address is 0002H, which is 1 register of 00E3H.

Request

Request	Bytes	Example (Hex)
Slave address	1	01 Send to the slave 01
Function code	1	06 Write single register
Starting address	2	00 Starting address for 0026H 26
Data	2	00 Set 1 register (total 2 bytes) 14

Request	Bytes	Example (Hex)
CRC code	2	68 0E CRC code which calculated by PC.

Response

Slave Response	Bytes	For Example (Hex)
Slave address	1	01 Respond to the slave 01
Function code	1	06 Write single register
Starting address	2	00 26 Starting address is 0026H
Data	2	00 14 Set 1 register (total 2 bytes)
CRC code	2	68 0E CRC code which calculated by slave.

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4.8 ERROR HANDLING

When device detected other errors except the CRC code, the slave must send information to the master. The function code MSB is 1, which means the response function code by slave should add 128 based on the function code. The following codes show that unexpected errors have occurred.

CRC error received from the master will be ignored by the device.

The frame format of error code that responds by slave is as follows (CRC excluded):

Type	Byte
Address code	1 byte
Function code	1 byte (MSB is 1)
Error code	1 byte
CRC code	2 bytes

Error code:

01 illegal function code

The function code received in the query is not an allowable action for the slave.

02 illegal data address

The data address received in the query is not an allowable address for the slave.

03 illegal data value

A value contained in the query data field is not an allowable value for the slave.

5. ATTACHMENT: ADDRESS AND DATA

5.1 FUNCTION CODE 03H MAP DATA FIELD

Address (Decimalism)	Item	Description	Byte
00	Common Alarm	1 for active (LSB)	1bit
	Common Warning Alarm	1 for active	1bit
	Common Fault Alarm	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit
	Audible Alarm	1 for active	1bit
	Switch Output	1 for active	1bit
	Auto Mode	1 for active	1bit
	Reserved	1 for active	1bit
	S1 Main	1 for active	1bit
	S2 Main	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit
	Genset Start Output	1 for active(MSB)	1bit
01	S1 Voltage Normal	1 for active(LSB)	1bit
	S1 Voltage Abnormal	1 for active	1bit
	S1 Voltage Instant Abnormal	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit
	S1Genset Start Output	1 for active	1bit
	S1 No Voltage	1 for active	1bit
	S1 Over Voltage	1 for active	1bit
	S1 Under Voltage	1 for active	1bit
	S1 Over Frequency	1 for active	1bit
	S1 Under Frequency	1 for active	1bit
	S1 Loss of Phase	1 for active	1bit
	S1 Phase Sequence Wrong	1 for active	1bit
	Reserved	1 for active(MSB)	1bit
02	S2 Voltage Normal	1 for active(LSB)	1bit
	S2 Voltage Abnormal	1 for active	1bit
	S2 Voltage Instant Abnormal	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit

Address (Decimalism)	Item	Description	Byte
	S2 Genset Start Output	1 for active	1bit
	S2 No Voltage	1 for active	1bit
	S2 Over Voltage	1 for active	1bit
	S2 Under Voltage	1 for active	1bit
	S2 Over Frequency	1 for active	1bit
	S2 Under Frequency	1 for active	1bit
	S2 Loss of Phase	1 for active	1bit
	S2 Negative Phase Sequence	1 for active	1bit
	Reserved	1 for active(MSB)	1bit
03	Breaker Switch Fail	1 for active(LSB)	1bit
	QS1 Close Fail	1 for active	1bit
	QS1 Open Fail	1 for active	1bit
	QS2 Close Fail	1 for active	1bit
	QS2 Open Fail	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit
	Force Open Fault Alarm	1 for active	1bit
	S1 Genset Fault	1 for active	1bit
	S2 Genset Fault	1 for active	1bit
	Breaker Trip Alarm	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active(MSB)	1bit
04	Reserved	1 for active(LSB)	1bit
	Reserved	1 for active	1bit
	Force Open Warning	1 for active	1bit
	Battery Under Voltage Warning	1 for active	1bit
	Battery Over Voltage Warning	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active(MSB)	1bit
05	Digital Input Port 1 Status	1 for active(LSB)	1bit

Address (Decimalism)	Item	Description	Byte
	Balance Running Mode Start	1 for active	1bit
	Reserved	1 for active	1bit
	Reserved	1 for active	1bit
	Schedule Not Work	1 for active	1bit
	AutoTrans./Restore	1 for active(MSB)	1bit
1000	UAB1	Unsigned	2Bytes
1001	UBC1	Unsigned	2Bytes
1002	UCA1	Unsigned	2Bytes
1003	UA1	Unsigned	2Bytes
1004	UB1	Unsigned	2Bytes
1005	UC1	Unsigned	2Bytes
1006	UA1 Phase	Signed (*10)	2Bytes
1007	UB1 Phase	Signed (*10)	2Bytes
1008	UC1 Phase	Signed (*10)	2Bytes
1009	Frequency 1	Signed (*100)	2Bytes
1010	UAB2	Unsigned	2Bytes
1011	UBC2	Unsigned	2Bytes
1012	UCA2	Unsigned	2Bytes
1013	UA2	Unsigned	2Bytes
1014	UB2	Unsigned	2Bytes
1015	UC2	Unsigned	2Bytes
1016	UA2 Phase	Signed (*10)	2Bytes
1017	UB2 Phase	Signed (*10)	2Bytes
1018	UC2 Phase	Signed (*10)	2Bytes
1019	Frequency 2	Signed (*100)	2Bytes
1020	Reserved		2Bytes
1021	Reserved		2Bytes
1022	Reserved		2Bytes
1023	Reserved		2Bytes
1024	Reserved		2Bytes
1025	Reserved		2Bytes
1026	Battery Voltage	Signed (*10)	2Bytes
1027	MCU Temperature		2Bytes
1028	Reserved		2Bytes
1029	Reserved		2Bytes
1030	Reserved		2Bytes
1031	Reserved		2Bytes
1032	Reserved		2Bytes
1033	Reserved		2Bytes
1034	S1 Voltage Status	See <u>VOLTAGE</u> <u>STATUS</u> <u>DESCRIPTION</u>	2Bytes
1035	S1 Voltage Status Delay		2Bytes

Address (Decimalism)	Item	Description	Byte
1036	S2 Voltage Status	See <u>VOLTAGE STATUS DESCRIPTION</u>	2Bytes
1037	S2 Voltage Status Delay		2Bytes
1038	Genset Status	See <u>GENSET STATUS DESCRIPTION</u>	2Bytes
1039	Genset Status Delay		2Bytes
1040	ATS Status	See <u>ATS STATUS DESCRIPTION</u>	2Bytes
1041	ATS Status Delay		2Bytes
1042	Reserved		2Bytes
1043	Controller Time: Year	Unsigned	2Bytes
1044	Controller Time: Month	Unsigned	2Bytes
1045	Controller Time: Day	Unsigned	2Bytes
1046	Controller Time: Week	Unsigned	2Bytes
1047	Controller Time: Hour	Unsigned	2Bytes
1048	Controller Time: Minute	Unsigned	2Bytes
1049	Controller Time: Second	Unsigned	2Bytes
1050	Reserved		2Bytes
1051	Reserved		2Bytes
1052	Reserved		2Bytes
1053	Reserved		2Bytes
1054	Continuous Power Supply Time (hour)	Unsigned	2Bytes
1055	Continuous Power Supply Time (minute)	Unsigned	2Bytes
1056	Continuous Power Supply Time (second)	Unsigned	2Bytes
1057	Last Continuous Power Supply Time (hour)	Unsigned	2Bytes
1058	Last Continuous Power Supply Time (minute)	Unsigned	2Bytes
1059	Last Continuous Power Supply Time (second)	Unsigned	2Bytes
1060	S1 Total Power Supply Hours (LSB)	Unsigned	4Bytes
1061	S1 Total Power Supply Hours (MSB)		
1062	S1 Total Power Supply Minutes	Unsigned	2Bytes
1063	S1 Total Power Supply Seconds	Unsigned	2Bytes
1064	S2 Total Power Supply Hours (LSB)	Unsigned	2Bytes
1065	S2 Total Power Supply Hours (MSB)		2Bytes
1066	S2 Total Power Supply Minutes	Unsigned	2Bytes
1067	S2 Total Power Supply Seconds	Unsigned	2Bytes
1068	S1 Total Close Times (LSB)	Unsigned	2Bytes
1069	S1 Total Close Times (MSB)	Unsigned	2Bytes
1070	S2 Total Close Times (LSB)	Unsigned	2Bytes
1071	S2 Total Close Times (MSB)	Unsigned	2Bytes
1072	Reserved		
1073	Reserved		
1074	Reserved	Unsigned	4Bytes
1075	Reserved		2Bytes

5.2 FUNCTION CODE 05H MAP DATA FIELD

Address	Item	Description
15000	Remote control S1 close	1 for active
15001	Remote control breaker open	1 for active
15002	Remote control S2 close	1 for active
15003	Remote control breaker open (same as address 15001)	1 for active
15004	Auto/Manual	1 for active
15005	S1 main status set	1 for active
15006	S2 main status set	1 for active
15007	Alarm reset	1 for active
15008	Remote control genset 1 start	1 for active
15009	Remote control genset 1 stop	1 for active
15010	Remote control genset 2 start	1 for active
15011	Remote control genset 2 stop	1 for active
15012	Remote control output port 1 output	1 for active
15013	Remote control output port 2 output	1 for active
15014	Remote control output port 3 output	1 for active
15015	Remote control output port4 output	1 for active

5.3 S1 VOLTAGE STATUS DESCRIPTION

No.	Status	Delay	Description
0	S1 Available	Has delay time, unit: s	
1	S1 Unavailable	Has delay time, unit: s	
2	S1 Voltage Normal	No delay time	
3	S1 No Voltage	No delay time	
4	S1 Over Voltage	No delay time	
5	S1 Under Voltage	No delay time	
6	S1 Over Frequency	No delay time	
7	S1 Under Frequency	No delay time	
8	S1 Loss of Phase	No delay time	
9	S1 Phase Sequence Wrong	No delay time	

5.4 S2 VOLTAGE STATUS DESCRIPTION

No.	Status	Delay	Description
0	S2 Available	Has delay time, unit: s	
1	S2 Unavailable	Has delay time, unit: s	
2	S2 Voltage Normal	No delay time	
3	S2 No Voltage	No delay time	
4	S2 Over Voltage	No delay time	
5	S2 Under Voltage	No delay time	
6	S2 Over Frequency	No delay time	
7	S2 Under Frequency	No delay time	
8	S2 Loss of Phase	No delay time	
9	S2 Phase Sequence Wrong	No delay time	

5.5 GENSET STATUS DESCRIPTION

No.	Status	Delay	Description
0	Start Delay	Has delay time, unit: s	
1	Stop Delay	Has delay time, unit: s	
2	Schedule Not Work	Has delay time, unit: s	
3	Schedule Work	Has delay time, unit: s	
4	S1 Cycle Start	Has delay time, unit: s	
5	S2 Cycle Start	Has delay time, unit: s	
6	S1 Genset Start	No delay time	
7	S2 Genset Start	No delay time	
8	Genset Start	No delay time	
9	Genset Standby	No delay time	

5.6 BREAKER STATUS DESCRIPTION

No.	Status	Delay	Description
0	Ready to Transfer	No delay time	
1	QS1 is closing	Has delay time, unit: s	
2	QS1 is opening	Has delay time, unit: s	
3	QS2 is closing	Has delay time, unit: s	
4	QS2 is opening	Has delay time, unit: s	
5	Transfer Interval	Has delay time, unit: s	
6	Closing QS1 Again	Has delay time, unit: s	
7	Opening QS1 Again	Has delay time, unit: s	
8	Closing QS2 Again	Has delay time, unit: s	
9	Opening QS2c Again	Has delay time, unit: s	
16	S1 On Load	No delay time	
17	S2 On Load	No delay time	
18	Off Load	No delay time	