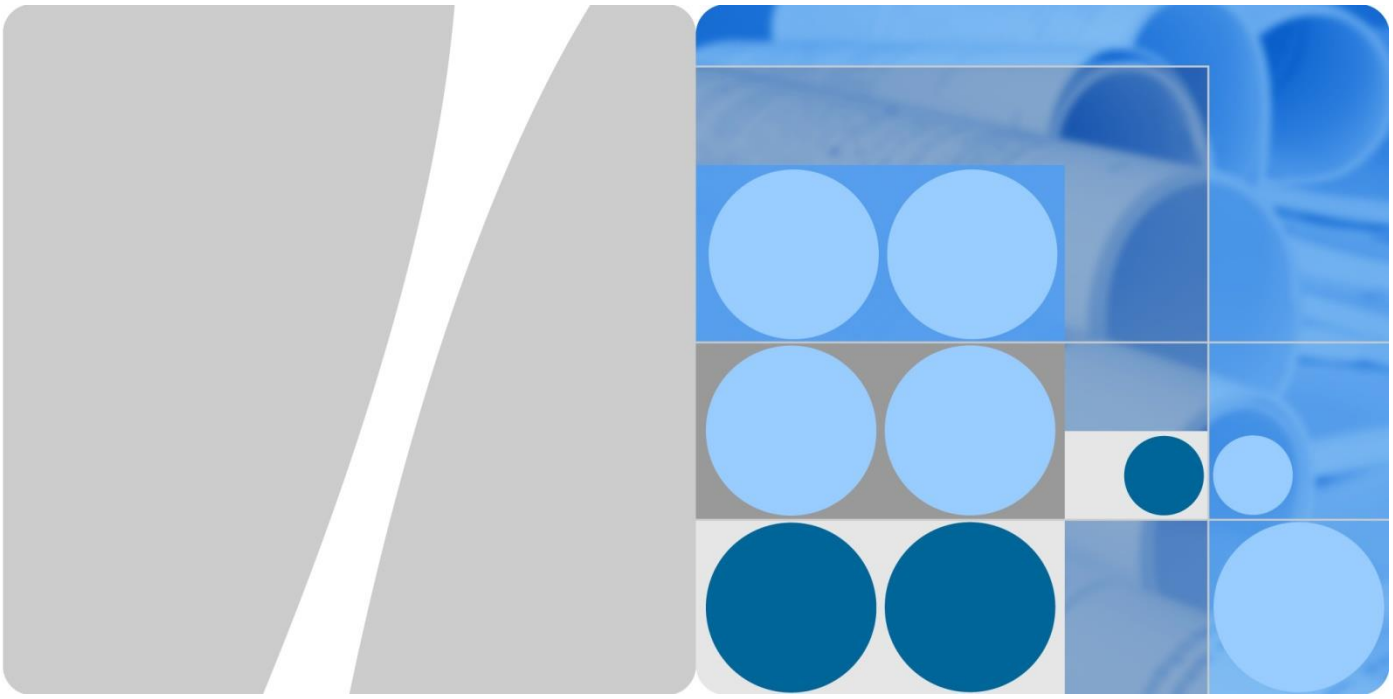

SUN2000 8–28KTL

MODBUS Interface Definitions

Issue 01

Date 2015-04-07

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Huawei Technologies Co., Ltd.

Address: Huawei Industrial Base
Bantian, Longgang
Shenzhen 518129
People's Republic of China

Website: http://www.huawei.com

Email: support@huawei.com

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2015-04-07	1.0	Initial draft completed.

Contents

1 Introduction

The ModBus-RTU protocol is a widely used industrial communications protocol. It is a common language for electrical communications terminals, and has become an industrial standard which enables inverters from different manufacturers to be networked and centrally monitored. By using this protocol, inverters can communicate with each other or with other devices in a network, such as through the RS485 bus. The protocol defines master and slave nodes, the processes in which the master node accesses other devices using various requests, how a slave node responds to requests from other devices, and how both parties involved in a communications process detect and record errors. It also specifies the message field formats and detailed data content.

As the Huawei inverter business continues to expand, more and more general and customized inverters use the ModBus protocol for communication. This document provides information about the ModBus protocol used in Huawei inverters, and can be used to regulate and restrict follow-up third-party integration R&D and customizations.

1.1 Terms and Abbreviations

Name	Description
Master node	During master-slave communication, the party that initiates a communication request is referred to as the master node.
Slave node	During master-slave communication, the party that responds to a communication request is referred to as the slave node.
Broadcast address	Fixed to 0.
Register address	The address of a register is recorded in two bytes.
U16	Unsigned integer (16 bits)
U32	Unsigned integer (32 bits)
I16	Signed integer (16 bits)
I32	Signed integer (32 bits)
MLD	Multiple bytes
N/A	Not applicable

1.2 System Requirements

Applicable model: SUN2000 8–28KTL

Firmware version: V100R001C11SPC409 or later

2 Register Definitions

2.1 Configuration Parameters

Configuration parameters involve permanent signals, and the data will be effective until updated the next time. All the signals are RW signals and support 0X03, 0X06, and 0X10 commands.

SN	Signal Name	Type	Unit	Gain	Address	Quantity	Range
1	Date and time synchronization	U32	N/A	1	40000	2	0–3155759999
2	Grid code	U16	N/A	1	40002	1	0–23
3	MPPT setting	U16	N/A	1	40004	1	0: Disable 1: Enable
4	Level-1 UF prot.	U16	Hz	100	40006	1	85%–100%Fn
5	Level-1 UF prot. time	U32	ms	1	40007	2	50–600000
6	Level-2 UF prot.	U16	Hz	100	40009	1	85%–100%Fn
7	Level-2 UF prot. time	U32	ms	1	40010	2	50–600000
8	10-min OV protec.	U16	V	100	40012	1	100%–140%Vn
9	10-min OV protec. time	U32	ms	1	40013	2	50–600000
10	MPPT scanning interval	U16	min	1	40015	1	5–30
11	Insulation res. protec.	U16	MΩ	1000	40022	1	0.033–1
12	Unbal. volt. protec.	U16	%	10	40023	1	0–50
13	Reactive power compensation (cosψ-P) trigger voltage	U16	%	1	40032	1	100–110
14	Reactive power compensation (cosψ-P) exit voltage	U16	%	1	40033	1	90–100
15	Overfrequency deration trigger threshold	U16	Hz	100	40034	1	50–52
16	Overfrequency deration exit threshold	U16	Hz	100	40035	1	49.9–51
17	Overfrequency deration recovery gradient	U16	%/min	1	40036	1	5–20
18	Q-U characteristic curve mode	U16	N/A	1	40037	1	0–1

19	Q-U dispatch trigger power percent	U16	%	1	40038	1	10–100
20	Soft startup time after grid failure	U16	Sec	1	40041	1	20–800
21	LVRT	U16	N/A	1	40051	1	00: Disable 01: Enable
22	Enable islanding detection setting	U16	N/A	1	40052	1	00: Disable 01: Enable
23	Soft start time	U16	Sec	1	40053	1	20–800
24	Feed grid recovery time	U16	Sec	1	40076	1	10–600
25	Level-1 OV prot.	U16	V	100	40054	1	100%–140%Vn
26	Level-1 OV prot. time	U32	ms	1	40055	2	50–600000
27	Level-2 OV prot.	U16	V	100	40057	1	100%–140%Vn
28	Level-2 OV prot. time	U32	ms	1	40058	2	50–600000
29	Level-1 UV prot.	U16	V	100	40060	1	10%–100%Vn
30	Level-1 UV prot. time	U32	ms	1	40061	2	50–600000
31	Level-2 UV prot.	U16	V	100	40063	1	10%–100%Vn
32	Level-2 UV prot. time	U32	ms	1	40064	2	50–600000
33	Level-1 OF prot.	U16	Hz	100	40066	1	100%–115%Fn
34	Level-2 OF prot. time	U32	ms	1	40067	2	50–600000
35	Level-2 OF prot.	U16	Hz	100	40069	1	100%–115%Fn
36	Level-2 OF prot. time	U32	ms	1	40070	2	50–600000
37	Reactive power compensation	U16	N/A	1	40117	1	0: Disable reactive power output 1: Communication adjustment power factor 2: Parameter setting Q/S 3: Parameter setting power factor 4: Q(u) characteristic curve 5: Power factor characteristic curve
38	Active power control	U16	N/A	1	40118	1	0: Disable active power limiting 1: Communication limit percentage (%) 2: Parameter setting absolute value kW 3: Parameter setting percentage
39	Active power deration setting [percentage]	U16	%	1	40119	1	0–100
40	Active power deration	U16	kW	10	40120	1	0–22

	setting [fixed value]						
41	Active power deration gradient	U16	%/s	10	40121	1	0.5–10
42	Reactive power compensation setting [power factor]	I16	N/A	1000	40122	1	0 <= |a| <= 1
43	Reactive power compensation setting [Q/S]	I16	N/A	1000	40123	1	–1 to 1
44	Reactive power adjustment time	U16	Sec	1	40124	1	5–120

2.2 System Commands

System command signals are WO signals. They do not support the 0X03 query command, but supports the 0X06 and 0X10 commands.

SN	Signal Name	Type	Unit	Gain	Address	Quantity	Range
1	Power on	NULL	N/A		40200	1	0
2	Power off	NULL	N/A		40201	1	0
3	Active power deration percent	U16	%	1	40234	1	0–100
4	Reactive power compensation factor instruction	I16	N/A	1000	40237	1	–1 to 1

2.3 Device Characteristics Information

Device characteristics information involves RO signals. They support only the 0X03 command but not the 0X06 or 0X10 command. This type of signal carries static inverter configuration information, which remains unchanged if there is no firmware update.

SN	Signal Name	Type	Unit	Gain	Address	Quantity	Range
1	Rated inverter power	U16	N/A	1	40710	1	
2	ESN	MLD	N/A	1	40713	10	
3	Hardware version	MLD	N/A	1	40789	15	
4	Software version	MLD	N/A	1	40819	15	
5	ModBus protocol version	MLD	N/A	1	40834	15	

Mapping Between Inverter Models and Rated Power				
SN	Model	Pmax	Qmax (kVar)	Rated Power (kW)
0	20KTL	22	13.2	20
1	17KTL	18.7	11.22	17
2	15KTL	16.5	9.9	15
3	12KTL	13.2	7.92	12
4	10KTL	11	6.6	10
5	8KTL	8.8	5.28	8
9	500KTL	600	300	500
16	24.5KTL	24.5	14.7	24.5
17	23KTL	23	13.8	23
18	28KTL	27.5	16.5	27.5
19	33KTL	33	19.8	30
20	40KTL	40	24	36

2.4 Real-time Sampling Information

Real-time sampling information involves RO signals. They support only the 0X03 command but not the 0X06 or 0X10 command. This type of signal carries dynamic update information, which reflects the inverter running status in real time.

SN	Signal Name	Type	Unit	Gain	Address	Quantity	Remarks
1	PV1 Voltage/PV1 V	I16	V	10	40500	1	For all power classes
2	PV2 Voltage/PV2 V	I16	V	10	40501	1	For all power classes
3	PV3 Voltage/PV3 V	I16	V	10	40502	1	For all power classes
4	PV4 Voltage/PV4 V	I16	V	10	40503	1	For all power classes
5	PV5 Voltage/PV5 V	I16	V	10	40504	1	For all power classes
6	PV6 Voltage/PV6 V	I16	V	10	40505	1	For all power classes
7	PV1 Current/PV1 I	I16	A	100	40506	1	For all power classes
8	PV2 Current/PV2 I	I16	A	100	40507	1	For all power classes
9	PV3 Current/PV3 I	I16	A	100	40508	1	For all power classes
10	PV4 Current/PV4 I	I16	A	100	40509	1	For all power classes
11	PV5 Current/PV5 I	I16	A	100	40510	1	For all power classes
12	PV6 Current/PV6 I	I16	A	100	40511	1	For all power classes
13	CO2 reduction	U32	kg	100	40523	2	
14	Active power	I32	kW	1000	40525	2	
15	Uab	U16	V	100	40527	1	
16	Ubc	U16	V	100	40528	1	
17	Uca	U16	V	100	40529	1	
18	Power factor	I16	N/A	1000	40532	1	
19	Cabinet temperature	I16	℃	10	40533	1	
20	Reactive output power	I32	kVar	1000	40544	2	
21	Frequency	U16	Hz	100	40546	1	
22	E-Total	U32	kWh	100	40560	2	
23	Current-day yield	U32	kWh	100	40562	2	
24	Ia	I16	A	100	40572	1	
25	Ib	I16	A	100	40573	1	
26	Ic	I16	A	100	40574	1	
27	Inverter start time	U32	Sec	1	40613	2	
28	Inverter shutdown time	U32	Sec	1	40615	2	
29	Inverter efficiency	U16	%	100	40685	1	
30	MPPT1 total input power	U32	kW	1000	40686	2	
31	MPPT2 total input power	U32	kW	1000	40688	2	
32	MPPT3 total input power	U32	kW	1000	40690	2	
33	Total input power	U32	kW	1000	40692	2	
34	Zero voltage ride through protection	U16	N/A	1	40696	1	0: no 1: yes
35	LVRT protection	U16	N/A	1	40697	1	0: no 1: yes
36	Anti-islanding	U16	N/A	1	40698	1	0: no 1: yes
37	Locking	U16	N/A	1	40699	1	0: lock

							1: not lock
38	Inverter on/off status	U16	N/A	1	40931	1	Bit 1: 1: grid-tied 0: shutdown
39	Inverter status	U16	N/A	1	40939	1	0x0000: Idle: Initializing 0x0001: Idle: ISO Detecting 0x0002: Idle: Irradiation Detecting 0x0100: Starting 0x0200: On-grid 0x0201: On-grid: Limited 0x0300: Shutdown: Abnormal 0x0301: Shutdown: Forced 0x0401: Grid Dispatch: cosψ-P Curve 0x0402: Grid Dispatch: Q-U Curve 0xA000: Idle: No Irradiation

2.5 Alarms

Address	Bit	Alarm Name	Alarm ID	Cause ID	Severity	Cause
50001	0X01	Software Ver. Unmatch	504	2	Minor	The upgrade fails.
50001	0X02	Software Ver. Unmatch	504	3	Minor	The upgrade fails.
50001	0X03	System Fault	400	1	Major	An unrecoverable fault occurs on a circuit inside the inverter.
50001	0X06	Abnormal Inv. Circuit	202	20	Major	The inverter output is short-circuited. As a result, the output current surges to

Address	Bit	Alarm Name	Alarm ID	Cause ID	Severity	Cause
						a value above the upper limit, and the inverter protection is triggered.
50001	0X07	Abnormal Resid. Cur.	318	1	Major	The input-to-ground insulation resistance has decreased during the running of the inverter.
50001	0X08	Cabinet Overtemp.	321	1	Major	• The inverter is installed in a place with poor ventilation. • The ambient temperature exceeds the upper threshold. • The internal fan is faulty.
50001	0X09	Cabinet Overtemp.	321	2	Major	• The inverter is installed in a place with poor ventilation. • The ambient temperature exceeds the upper threshold. • The internal fan is faulty.
50001	0X0F	System Fault	400	5	Major	An unrecoverable fault occurs on a circuit inside the inverter.
50002	0X00	Low Insulation Res.	313	1	Major	• A short circuit occurs between the PV arrays and the ground. • The ambient environment of PV arrays is moist.
50002	0X06	Cabinet Overtemp.	321	6	Major	• The inverter is installed in a place with poor ventilation. • The ambient temperature exceeds the upper threshold. • The internal fan is faulty.
50002	0X09	String 3 Reversed	122	1	Warning	String No. 3 is reversely connected.
50002	0X0F	System Fault	400	23	Major	An unrecoverable fault occurs on a circuit inside the inverter.
50003	0X01	String 1 Reversed	120	1	Warning	String No. 1 is reversely connected.

Address	Bit	Alarm Name	Alarm ID	Cause ID	Severity	Cause
50003	0X02	String 2 Reversed	121	1	Warning	String No. 2 is reversely connected.
50003	0X06	String 4 Reversed	123	1	Warning	String No. 4 is reversely connected.
50003	0X07	String 5 Reversed	124	1	Warning	String No. 5 is reversely connected.
50003	0X08	String 6 Reversed	125	1	Warning	String No. 6 is reversely connected.
50003	0X09	High DC Input Volt.	103	1	Major	Incorrect PV array configuration: Excessive PV arrays are configured in strings No. 1 and 2, causing the open-circuit voltage to be higher than the input voltage limit of the inverter.
50003	0X0A	High DC Input Volt.	103	2	Major	Incorrect PV array configuration: Excessive PV arrays are configured in strings No. 3 and 4, causing the open-circuit voltage to be higher than the input voltage limit of the inverter.
50003	0X0B	High DC Input Volt.	103	3	Major	Incorrect PV array configuration: Excessive PV arrays are configured in strings No. 5 and 6, causing the open-circuit voltage to be higher than the input voltage limit of the inverter.
50004	0X01	Cabinet Overtemp.	321	14	Major	• The inverter is installed in a place with poor ventilation. • The ambient temperature exceeds the upper threshold. • The internal fan is faulty.
50004	0X02	String 1 Reversed	120	2	Warning	• The inverter is installed in a place with poor ventilation. • The ambient temperature exceeds the upper threshold. • The internal fan is faulty.

Address	Bit	Alarm Name	Alarm ID	Cause ID	Severity	Cause
50004	0X03	String 2 Reversed	121	2	Warning	The number of PV modules in string No. 1 is insufficient. As a result, the end voltage is lower than that of other strings.
50004	0X0C	String 3 Reversed	122	2	Warning	
50004	0X0D	String 4 Reversed	123	2	Warning	The number of PV modules in string No. 3 is insufficient. As a result, the end voltage is lower than that of other strings.
50004	0X0E	String 5 Reversed	124	2	Warning	The number of PV modules in string No. 4 is insufficient. As a result, the end voltage is lower than that of other strings.
50004	0X0F	String 6 Reversed	125	2	Warning	The number of PV modules in string No. 5 is insufficient. As a result, the end voltage is lower than that of other strings.
50005	0X01	Abnormal DC Circuit	200	3	Major	• Input to the inverter is disconnected unexpectedly. • The PV arrays are shaded, resulting in sharp changes in the output power.
50005	0X02	Abnormal Auxiliary Power Supply	410	4	Major	The sampling control board has an abnormal supply voltage, which may be caused by the following: • The on-board power chip is faulty. • The detection circuit is faulty.
50005	0X04	Abnormal DC Circuit	200	10	Major	The three phases of the power grid are seriously unbalanced, which triggers the internal circuit protection for the inverter.
50005	0X05	Abnormal DC Circuit	200	11	Major	The power grid voltage changes sharply and the electricity in the inverter cannot discharge in a short time, which increases the internal voltage and

Address	Bit	Alarm Name	Alarm ID	Cause ID	Severity	Cause
						triggers overvoltage protection.
50006	0X00	Abnormal Inv. Circuit	202	4	Major	The power grid voltage drops dramatically or the power grid is short-circuited. As a result, the inverter output current becomes higher than the upper limit, and the inverter protection is triggered.
50006	0X06	System Fault	400	3	Major	An unrecoverable fault occurs on a circuit inside the inverter.
50006	0X0A	Abnormal Inv. Circuit	202	13	Major	The power grid voltage drops dramatically or the power grid is short-circuited, damaging the internal voltage detection circuit in the inverter.
50006	0X0C	Abnormal Inv. Circuit	202	14	Major	The power grid voltage drops dramatically or the power grid is short-circuited. As a result, the SUN2000 transient output current becomes higher than the maximum value, and the SUN2000 protection is triggered.
50007	0X01	Abnormal Inv. Circuit	202	16	Major	The DC current in the power grid exceeds the specified upper threshold.
50007	0X04	Anti-islanding	300	1	Warning	The power grid is abnormal.
50007	0X05	System Fault	400	21	Major	An unrecoverable fault occurs on a circuit inside the inverter.
50007	0X07	Abnormal Grid Volt.	301	7	Major	The AB line voltage of the power grid is below the lower limit.
50007	0X08	Abnormal Grid Volt.	301	8	Major	The BC line voltage of the power grid is below the lower limit.

Address	Bit	Alarm Name	Alarm ID	Cause ID	Severity	Cause
50007	0X09	Abnormal Grid Volt.	301	9	Major	The CA line voltage of the power grid is below the lower limit.
50008	0X00	Abnormal Grid Volt.	301	4	Major	The phase A voltage of the power grid is below the lower limit.
50008	0X01	Abnormal Grid Volt.	301	5	Major	The phase B voltage of the power grid is below the lower limit.
50008	0X02	Abnormal Grid Volt.	301	6	Major	The phase C voltage of the power grid is below the lower limit.
50008	0X03	Abnormal Grid Volt.	301	16	Major	The phase A voltage of the power grid is above the upper limit.
50008	0X04	Abnormal Grid Volt.	301	17	Major	The phase B voltage of the power grid is above the upper limit.
50008	0X05	Abnormal Grid Volt.	301	18	Major	The phase C voltage of the power grid is above the upper limit.
50008	0X06	Abnormal Grid Volt.	305	2	Major	Power grid exception: The actual power grid frequency is higher than the standard requirement for the local power grid.
50008	0X07	Abnormal Grid Volt.	305	4	Major	Power grid exception: The actual power grid frequency is lower than the standard requirement for the local power grid.
50008	0X08	Abnormal Grid Volt.	301	28	Major	The three phases of the power grid differ greatly in voltage.
50008	0X09	Abnormal Grid Volt.	301	29	Major	• The power grid fails. • The AC circuit is disconnected or an AC circuit breaker is off.
50008	0X0A	Abnormal Ground.	326	1	Major	• The N cable or ground cable is not connected. • When a PV array is grounded, the inverter output is not connected to

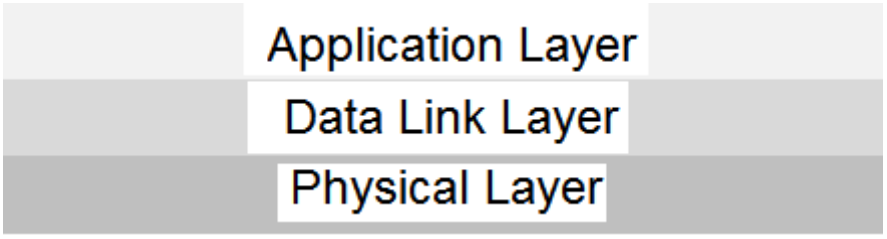
Address	Bit	Alarm Name	Alarm ID	Cause ID	Severity	Cause
						an isolation transformer.
50008	0X0B	Abnormal Grid Volt.	301	26	Major	The power grid voltage exceeds the specified upper threshold.
50009	0X00	Abnormal Grid Volt.	301	31	Major	The output A phase cable has a low impedance to PE or is short-circuited.
50009	0X01	Abnormal Grid Volt.	301	32	Major	The output B phase cable has a low impedance to PE or is short-circuited.
50009	0X02	Abnormal Grid Volt.	301	33	Major	The output C phase cable has a low impedance to PE or is short-circuited.
50009	0X06	System Fault	400	11	Major	An unrecoverable fault occurs on a circuit inside the inverter.
50009	0X08	Abnormal Grid Volt.	301	19	Major	The power grid voltage is above 10-minute overvoltage protection threshold.
50011	0X0A	Abnormal Grid Volt.	301	20	Major	The AB line voltage of the power grid is above the upper limit.
50011	0X0B	Abnormal Grid Volt.	301	21	Major	The BC line voltage of the power grid is above the upper limit.
50011	0X0C	Abnormal Grid Volt.	301	22	Major	The CA line voltage of the power grid is above the upper limit.
50000	0X01	Abnormal String 1	106	1	Warning	• String No. 1 is shielded for a long time. • String No. 1 has aged abnormally.
50000	0X02	Abnormal String 2	107	1	Warning	• String No. 2 is shielded for a long time. • String No. 2 has aged abnormally.
50000	0X03	Abnormal String 3	108	1	Warning	• String No. 2 is shielded for a long time. • String No. 3 has aged abnormally.

Address	Bit	Alarm Name	Alarm ID	Cause ID	Severity	Cause
50000	0X04	Abnormal String 4	109	1	Warning	• String No. 2 is shielded for a long time. • String No. 4 has aged abnormally.
50000	0X05	Abnormal String 5	110	1	Warning	• String No. 2 is shielded for a long time. • String No. 5 has aged abnormally.
50000	0X06	Abnormal String 6	111	1	Warning	• String No. 2 is shielded for a long time. • String No. 6 has aged abnormally.
50000	0X0A	Software Ver. Unmatch	504	1	Minor	The upgrade fails.
50000	0X0C	Upgrade Failed	505	1	Major	The upgrade is not completed normally.
50000	0X0D	Flash Fault	61440	1	Minor	• The flash memory is insufficient. • The flash memory has bad sectors.

3 Communications Protocol Overview

The ModBus communications protocol consists of the following layers:

Figure 3-1 Layers of the ModBus communications protocol



3.1 Physical Layer

Huawei inverters communicate in the two-line RS485 mode at baud rates of 4800 bps, 9600 bps, or 19200 bps

Data is transferred in asynchronous RTU mode. Each frame consists of one start bit, eight payload data bits, one CRC bit, and one stop bit (11 bits in total).

3.2 Data Link Layer

3.2.1 Addressing Mode

The protocol supports unicast and broadcast. The following table describes the address allocation rule:

Broadcast Address	Slave Node Address	Reserved
0	1–247	248–255

3.2.2 Frame Structure

Address	Function Code	Payload Data	CRC Code
1 byte	1 byte	2 x N byte	2 byte

NOTE

- A frame can contain a maximum of 256 bytes.
- In a CRC code, the bit on the leftmost is least significant.
- Frame structure definitions in this document include only the function code and payload data.

3.2.3 Data Encoding

ModBus uses a big-Endian to represent addresses and payload data. When multiple bytes are sent, the most significant payload bit is sent first.

Example:

Register Size	Value
16 bits	0x1234

The system sends 0x12, and then sends 0x34.

3.2.4 Interaction Process

A communication process is always initiated by a master node. Slave nodes do not initiate communication processes.

In unicast mode, a slave node returns one response for each request from the master node. If the master node does not receive any response from the slave node in 5s, the communication process is regarded as timed out.

In broadcast mode, slave nodes receive instructions from the master node, but do not respond to the instructions.

3.2.5 CRC Checking

CRC checking applies to all bytes in front of the CRC code which consists of 16 bits. The reference code is as follows:

static unsigned char auchCRCHi[] = {

0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81,

0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0,

0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01,

```
    0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01,  0xC0,
0x80, 0x41,

    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,  0x00,
0xC1, 0x81,

    0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80,  0x41,
0x01, 0xC0,

    0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0,  0x80,
0x41, 0x01,

    0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00,  0xC1,
0x81, 0x40,

    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,  0x00,
0xC1, 0x81,

    0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81,  0x40,
0x01, 0xC0,

    0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1,  0x81,
0x40, 0x01,

    0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01,  0xC0,
0x80, 0x41,

    0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,  0x00,
0xC1, 0x81,

    0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81,  0x40,
0x01, 0xC0,

    0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0,  0x80,
0x41, 0x01,

    0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01,  0xC0,
0x80, 0x41,

    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,  0x00,
0xC1, 0x81,

    0x40

};


/* Insignificant CRC bit*/

static char auchCRCLo[] = {

   0x00, 0xC0, 0xC1, 0x01, 0xC3, 0x03, 0x02, 0xC2, 0xC6, 0x06, 0x07, 0xC7, 0x05, 0xC5,
0xC4,

0x04, 0xCC, 0x0C, 0x0D, 0xCD, 0x0F, 0xCF, 0xCE, 0x0E, 0x0A, 0xCA, 0xCB, 0x0B, 0xC9,
0x09,

0x08, 0xC8, 0xD8, 0x18, 0x19, 0xD9, 0x1B, 0xDB, 0xDA, 0x1A, 0x1E, 0xDE, 0xDF, 0x1F,
0xDD,

0x1D, 0x1C, 0xDC, 0x14, 0xD4, 0xD5, 0x15, 0xD7, 0x17, 0x16, 0xD6, 0xD2, 0x12, 0x13,
0xD3,
```

```
0x11, 0xD1, 0xD0, 0x10, 0xF0, 0x30, 0x31, 0xF1, 0x33, 0xF3, 0xF2, 0x32, 0x36, 0xF6,
0xF7,

0x37, 0xF5, 0x35, 0x34, 0xF4, 0x3C, 0xFC, 0xFD, 0x3D, 0xFF, 0x3F, 0x3E, 0xFE, 0xFA,
0x3A,

0x3B, 0xFB, 0x39, 0xF9, 0xF8, 0x38, 0x28, 0xE8, 0xE9, 0x29, 0xEB, 0x2B, 0x2A, 0xEA,
0xEE,

0x2E, 0x2F, 0xEF, 0x2D, 0xED, 0xEC, 0x2C, 0xE4, 0x24, 0x25, 0xE5, 0x27, 0xE7, 0xE6,
0x26,

0x22, 0xE2, 0xE3, 0x23, 0xE1, 0x21, 0x20, 0xE0, 0xA0, 0x60, 0x61, 0xA1, 0x63, 0xA3,
0xA2,

0x62, 0x66, 0xA6, 0xA7, 0x67, 0xA5, 0x65, 0x64, 0xA4, 0x6C, 0xAC, 0xAD, 0x6D, 0xAF,
0x6F,

0x6E, 0xAE, 0xAA, 0x6A, 0x6B, 0xAB, 0x69, 0xA9, 0xA8, 0x68, 0x78, 0xB8, 0xB9, 0x79,
0xBB,

0x7B, 0x7A, 0xBA, 0xBE, 0x7E, 0x7F, 0xBF, 0x7D, 0xBD, 0xBC, 0x7C, 0xB4, 0x74, 0x75,
0xB5,

0x77, 0xB7, 0xB6, 0x76, 0x72, 0xB2, 0xB3, 0x73, 0xB1, 0x71, 0x70, 0xB0, 0x50, 0x90,
0x91,

0x51, 0x93, 0x53, 0x52, 0x92, 0x96, 0x56, 0x57, 0x97, 0x55, 0x95, 0x94, 0x54, 0x9C, 0x5C,

0x5D, 0x9D, 0x5F, 0x9F, 0x9E, 0x5E, 0x5A, 0x9A, 0x9B, 0x5B, 0x99, 0x59, 0x58, 0x98,
0x88,

0x48, 0x49, 0x89, 0x4B, 0x8B, 0x8A, 0x4A, 0x4E, 0x8E, 0x8F, 0x4F, 0x8D, 0x4D, 0x4C,
0x8C,

0x44, 0x84, 0x85, 0x45, 0x87, 0x47, 0x46, 0x86, 0x82, 0x42, 0x43, 0x83, 0x41, 0x81, 0x80,
0x40

};


unsigned short CRC16 (puchMsg, usDataLen) /* The function returns the CRC as an
unsigned short type */

unsigned char *puchMsg; /* message to calculate CRC upon */

unsigned short usDataLen; /* quantity of bytes in message */

{

unsigned char uchCRCHi = 0xFF; /* high byte of CRC initialized */

unsigned char uchCRCLo = 0xFF; /* low byte of CRC initialized */

unsigned uIndex; /* will index into CRC lookup table */

while (usDataLen--) /* pass through message buffer */

{

uIndex = uchCRCLo ^ *puchMsg++; /* calculate the CRC */

uchCRCLo = uchCRCHi ^ auchCRCHi[uIndex];
```

```
uchCRCHi = auchCRCLo[uIndex];
}
return (uchCRCHi << 8 | uchCRCLo);
}
```

Code source: *MODBUS over Serial Line Specification and Implementation Guide V1.02*

3.3 Application Layer

3.3.1 Function Code List

Table 3-1 Function code list

Function Code	Item	Remarks
0x03	Read registers.	Supports continuous reading of a single register or multiple registers.
0x06	Write a single register.	Supports writing into a single register.
0x10	Write multiple registers.	Supports continuous writing into multiple registers.
0x2B	Read device identifiers.	Obtains device types and version numbers.

3.3.2 Exception Code List

The exception codes must be unique for each NE type. The names and descriptions are provided in the NE interface document. Different versions of the same NE type must be backward compatible. Exception codes in use cannot be assigned to other exceptions.

Exception codes returned by an NE (0x00–0x8F are for common exception codes)

Code	Name	Item
0x01	ILLEGAL FUNCTION	The function code received in the query is not an allowable action for the server. This may be because the function code is only applicable to newer devices, and was not implemented in the unit selected. It could also indicate that the server is in the wrong state to process a request of this type, for example because it is not configured and is being asked to return register values.

Code	Name	Item
0x02	ILLEGAL DATA ADDRESS	The data address received in the query is not an allowable address for the server. More specifically, the combination of reference number and transfer length is invalid. For a controller with 100 registers, the PDU addresses the first register as 0, and the last one as 99. If a request is submitted with a starting register address of 96 and a quantity of registers of 4, then this request will successfully operate (address-wise at least) on registers 96, 97, 98, 99. If a request is submitted with a starting register address of 96 and a quantity of registers of 5, then this request will fail with Exception Code 0x02 "Illegal Data Address" since it attempts to perform operations on registers 96, 97, 98, 99 and 100, and there is no register with address 100.
0x03	ILLEGAL DATA VALUE	A value contained in the query data field is not an allowable value for server. This indicates a fault in the structure of the remainder of a complex request, such as that the implied length is incorrect. This does not mean that a register stores a value not expected by an application because the ModBus protocol does not understand the meaning of a special value in a register.
0x04	SERVER DEVICE FAILURE	An unrecoverable error occurred while the server was attempting to perform the requested action.
0x06	SERVER DEVICE BUSY	The server does not accept a ModBus request PDU. A client application determines when to resend the request.
0x08	MEMORY PARITY ERROR	Specialized use in conjunction with function codes 20 and 21 and reference type 6, to indicate that the extended file area failed to pass a consistency check. The server or slave node cannot read the file, but identifies a parity verification error in the register. The client can retry the request, but service may be required on the server device.
0x80	No permission	An operation is not allowed because of a permission authentication failure or permission expiration.

3.3.3 Reading Registers (0X03)

Frame Format for a Request from a Master Node

Data Field	Length (Byte)	Description
Slave node address	1	1–247
Function code	1	0x03
Register starting address	2	0x0000–0xFFFF
Number of registers	2	1–125

Data Field	Length (Byte)	Description
CRC	2	

Frame Format for a Normal Response from a Slave Node

Data Field	Length (Byte)	Description
Slave node address	1	1–247
Function code	1	0x03
Number of bytes	1	2 x N
Register value	2 x N	
CRC	2	

NOTE
N indicates the number of registers.

Frame Format for an Abnormal Response from a Slave Node

Data Field	Length (Byte)	Description
Slave node address	1	1–247
Function code	1	0x83
Exception code	1	See 0" Exception Code List."
CRC	2	

Example

A master node sends an instruction for querying the power grid standard code (register address: 40002/0X9C42) to a slave node whose address is 01. The frame format is as follows:

01 03 9c 42 00 01 0a 4e

Normal response from the slave node:

01 03 02 00 00 b8 44

Abnormal response from the slave node:

01 83 0a c1 37

3.3.4 Writing a Single Register (0X06)

Frame Format for a Request from a Master Node

Data Field	Length (Byte)	Description
Slave node address	1	0–247
Function code	1	0x06
Register address	2	0x0000–0xFFFF
Register value	2	0x0000–0xFFFF
CRC	2	

Frame Format for a Normal Response from a Slave Node

Data Field	Length (Byte)	Description
Slave node address	1	1–247
Function code	1	0x06
Register address	2	0x0000–0xFFFF
Register value	2	0x0000–0xFFFF
CRC	2	

Frame Format for an Abnormal Response from a Slave Node

Data Field	Length (Byte)	Description
Slave node address	1	1–247
Function code	1	0x86
Exception code	1	See 0" Exception Code List."
CRC	2	

Example

A master node sends an instruction for setting the power grid standard code (register address: 40002/0X9C42) to a slave node whose address is 01. The frame format is as follows:

01 06 9c 42 00 01 c6 4e

Normal response from the slave node:

01 06 9c 42 00 01 c6 4e

Abnormal response from the slave node:

01 86 41 82 50

3.3.5 Writing Multiple Registers (0X10)

Frame Format for a Request from a Master Node

Data Field	Length (Byte)	Description
Slave node address	1	0–247
Function code	1	0x10
Register starting address	2	0x0000–0xFFFF
Number of registers	2	0x0000–0x007b
Number of bytes	1	2 x N
Register value	N	Value
CRC	2	

NOTE
N indicates the number of registers.

Frame Format for a Normal Response from a Slave Node

Data Field	Length (Byte)	Description
Slave node address	1	1–247
Function code	1	0x10
Register address	2	0x0000–0xFFFF
Number of registers	2	0x0000–0x007b
CRC	2	

Frame Format for an Abnormal Response from a Slave Node

Data Field	Length (Byte)	Description
Slave node address	1	1–247
Function code	1	0x90
Exception code	1	See 0" Exception Code List."

Data Field	Length (Byte)	Description
CRC	2	

Example

A master node sends an instruction for setting the date & time (register address: 40000/0X9C40) and power grid standard code (register address: 40002/0X9C42) to a slave node whose address is 01. The frame format is as follows:

01 10 9c 40 00 03 06 00 00 00 00 00 00 26 06

Normal response from the slave node:

01 10 9c 40 00 03 af 8c

Abnormal response from the slave node:

01 90 41 8c 30

3.3.6 Reading Device Identifiers (0X2B)

This command code allows reading identifiers and added packets that are relevant to the physical and function description of the remote devices.

Simulate the port of the read device identifier as an address space. This address space consists of a set of addressable data elements. The data elements are objects to be read, and the object IDs determine these data elements.

A data element consists of three objects:

- Basic device identifier: All objects of this type are mandatory, such as the manufacturer name, product code, and revision version.
- Normal device identifier: Except the basic data objects, the device provides additional and optional identifiers and data object description. Normal device identifiers define all types of objects according to standard definitions, but the execution of this type of objects is optional.
- Extensive device identifier: Except the basic data objects, the device provides additional and optional identifiers and special data object description. All these data objects are related to the device.

Object ID	Object Name or Description	Type	M/O	Category
0x00	Manufacturer name	ASCII character string	M	Basic
0x01	Product code	ASCII character string	M	
0x02	Main revision	ASCII character string	M	
0x03–0x7F				Normal
0x80–0xFF				Extensive

Commands for Querying Device Identifiers

Request frame format

Data Field	Length (Byte)	Description
Slave node address	1	1–247
Function code	1	0x2B
MEI type	1	0x0E
ReadDeviId code	1	01
Object ID	1	0x00
CRC	2	

Frame format for a normal response

Data Field			Length (Byte)	Description
Slave node address			1	1–247
Function code			1	0x2B
MEI type			1	0x0E
ReadDeviId code			1	01
Consistency level			1	01
More			1	
Next object ID			1	
Number of objects			1	
Object list	First object	Object ID	1	0x00
		Object length	1	N
		Object value	N	
CRC			2	

Object ID	Object Name or Description	Description	Category
0x00	**Manufacturer name**	HUAWEI	**Basic**
0x01	**Product code**	SUN2000	

Object ID	Object Name or Description	Description	Category
0x02	**Main revision**	**ASCII character string, software version**	

Frame format for an abnormal response

Data Field	Length (Byte)	Description
Slave node address	1	1–247
Function code	1	0xAB
Exception code	**2**	See 0" Exception Code List."
CRC	2	

Command for Querying a Device List

Request frame format

Data Field	Length (Byte)	Description
Slave node address	1	1–247
Function code	1	0x2B
MEI type	1	0x0E
ReadDeviId code	1	03
Object ID	1	0x87
CRC	2	

Frame format for a normal response

Data Field	Length (Byte)	Description
Slave node address	1	1–247
Function code	1	0x2B
MEI type	1	0x0E
ReadDeviId code	1	03
Consistency level	1	03
More	1	

Data Field			Length (Byte)	Description
Next object ID			1	
Number of objects			1	
Object list	First object	Object ID	1	0x87
		Object length	1	N
		Object value	N	
	...			
CRC			2	

Object ID	Object Name	Type	Description
0x80-0x86	Reserved		Returns a null object with a length of 0.
0x87	Number of devices	int	Returns the number of devices connected to the RS485 address.
0x88	Information about the first device	ASCII character string See the device description definitions below.	Returns information only for the first device if a network element allows only one device to be connected to each RS485 address.
0x8A	Information about the second device		
.....			
0xFF	Information about the 120th device		

Device Description Definitions

Each device description consists of all "attribute = value" strings.

Attribute label=%s;attribute label=%s;…attribute label=%s

For example:
1=SUN2000000;2=V100R001C01SPC120;3=P1.0-D1.0;4=123232323;5=2;6=1.

Attribute definitions

Attribute Label	Attribute Name	Type	Description
1	Device Model	ASCII character string	SUN2000
2	Software version	ASCII character string	
3	Version of the communications protocol	ASCII character string	See the interface protocol version definitions.
4	ESN	ASCII character string	
5	Device number	int	0,1,2,3...(Assigned by NE; 0 indicates the master device to which the ModBus card is inserted)
6	Parallel network number	int	0, 1, 2, 3, … (assigned by NE) 0xFF: invalid value; indicates that a unit does not belong to any parallel system If not applicable, this attribute is not returned.

Frame format for an abnormal response

Data Field	Length (Byte)	Description
Slave node address	1	1–247
Function code	1	0xAB
Exception code	**2**	See 3.3.2 "Exception Code List."
CRC	2	