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RS485 communication protocol

for

Tough-3P PV inverters

AEC R&D Center

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This document describes the communication protocol of AEC inverters, **which is similar to Modbus RTU protocol.**

The maximum number of registers to be read at a time is 30.

The maximum number of registers to be written at a time is 1.

Accept standard MODBUS protocols (either with or without "**Start byte** and **Stop byte**").The "Start byte" and "Stop byte" should not be included when programming the CRC16 Calculation.

Byte format is 9600, N, 8, 1, which means, 9600 baud rate, no parity error checking, 8 data bits and 1 stop bit.

The Modbus communication is a master-slave communication. The maximum slave number is 32. The addresses of slave nods should be set in advance. A special communication address(0xFF) can be used to set inverter address if the inverter's address is unknown.

Data frame**:**

Slave address	**Function field**	**Data length or data content**	**CRC check**
1 byte	1 byte	N bytes, associated with the command	2 bytes
1~9,B~F7H, A is unavailable address, FFH is the universal address (Universal address is used for communication when the inverter address is unknown. If universal address is being used, the inverter will return data without address comparison. Universal address cannot be used in the multi-points communication)	**03H:read data** **CDH:write data** **06H:write data(Preset Single Register)** **6CH:write data(Write Single Register)** **Other: invalid**	/	/

Note: The result of CRC check is 16 bit. The low byte is transmitted first then followed by the high byte.

Read data format:

The master sends:

Slave address	Function field	Data field				CRC check
1 byte	1 byte	4 bytes				2 bytes
Inverter address	03H	Starting address, High byte	Starting address, low byte	Number of registers, High byte (this byte is always 00H)	Number of registers, Low byte (maximum number is 15)	

The slave responses:

Slave address	Function field	Data field	CRC check
1 byte	1 byte	2*N+1 bytes	2 bytes
Inverter address	03H	Refer the table below for data content	/

Data content					
1 byte	N registers，2*N bytes of data(low byte first sent)				
Byte count	Data high byte	Data low byte	.....	Data high byte	Data low byte

Write data format :(Write data to variable)

The master sends:

Slave address	Function field	Data field	CRC check
1 byte	1 byte	4 bytes	2 bytes
Inverter address	CDH	Refer the table below for data content	/

Data content			
1 byte	1 byte	1 byte	1 byte
High byte of starting address	Low byte of starting address	High byte of register data	Low byte of register data

The slave responses:

Slave address	Function field	Data field	CRC check
1 byte	1 byte	4 bytes	2bytes
Inverter address	CDH	Refer the table below for data content	/

Data content			
1 byte	1 byte	1 byte	1 byte
High byte of starting address	Low byte of starting address	High byte of register data	Low byte of register data

Write data format: (Write data to EEPROM)

The master sends:

Slave address	Function field	Data field	CRC check
1 byte	1 byte	4 bytes	2 bytes
Inverter address	06H	Refer the table below for data content	/

Data content			
1 byte	1 byte	1 byte	1 byte
High byte of starting address	Low byte of starting address	High byte of register data	Low byte of register data

The slave responses:

Slave address	Function field	Data field	CRC check
1 byte	1 byte	4 bytes	2bytes
Inverter address	06H	Refer the table below for data content	/

Data content			
1 byte	1 byte	1 byte	1 byte
High byte of starting address	Low byte of starting address	High byte of register data	Low byte of register data

Write data format: (Write data to EEPROM)

The master sends:

Slave address	Function field	Data field	CRC check
1 byte	1 byte	4 bytes	2 bytes
Inverter address	6CH	Refer the table below for data content	/

Data content			
1 byte	1 byte	1 byte	1 byte
High byte of starting address	Low byte of starting address	High byte of register data	Low byte of register data

The slave responses:

Slave address	Function field	Data field	CRC check
1 byte	1 byte	4 bytes	2bytes
Inverter address	6CH	Refer the table below for data content	/

Data content			
1 byte	1 byte	1 byte	1 byte
High byte of starting address	Low byte of starting address	High byte of register data	Low byte of register data

Determine the conditions of authority

Level	KEY				useful
Password level	WRITE_EN 924	CALI_REQ_FLG 923	MODEL_EN_KEY 937	MODEL_EN_KEY2 922	Command
0	x	x	x	x	3,6,CD
2	0x2478	0x0001	x	x	6C

x:don’t care

Relation between each parameter and their actual value

Items	Unit	Magnification	Description
Voltage(including AC/DC voltage)	V	10	16-bit unsigned integer, range is 0~65535, magnified 10 times, e.g. 3456 means the voltage is 345.6V
Current(including AC/DC current)	A	10	16-bit unsigned integer ranging from 0 to 65535, magnified 10 times, e.g. 123 means current is 12.3A
Frequency	Hz	100	16-bit unsigned integer, magnified 10 times, e.g. 5000 represents 50.00Hz
Power(including AC/DC power)	W	1	16-bit unsigned integer, the range is 0~0xFFFF, magnified 1 times, e.g. 5000 indicates 5.00KW
Output Apparent power	VA	1	16-bit unsigned integer, the range is 0~0xFFFF, magnified 1 times, e.g. 5000 indicates 5.00KVA
Power factor	PF	1000	16-bit signed integer, the range is -32767~32768, magnified 1000 times Actual range-1~+1, the negative is stored as 2's complement, the range: -1000~1000 For example: 998 is the power factor of 0.998 For example: 0xfc7c is the power factor of -0.900
Amount of electricity	KWh	10	32-bit unsigned integer, the range is 0~0xFFFF FFFF, 10 means 0.1KWh
Temperature	℃	10	16-bit signed integer, range: -32767~32768, magnified 10 times, the negative temperature is shown as 2's complement For example: 0xf63c is -25℃
Grounding resistor	KΩ	1	16-bit unsigned integer, range: 0~65535, magnified 1 times For example: 123 is the grounding resistor of 123k
CO^2	Kg	10	32-bit unsigned integer, range: 0~0xFFFFFFFF, 100 is 1kg

Note: Each 32-bit data occupies 2 registers, the high register is stored in low address, the low register is stored in high address.

Parameters address:

Each register is 16 bits wide and occupies 1 address.

Black: the user is allowed to access; Blue: the service provider is allowed to access; Red: the manufacturer is allowed to access.

1.**Monitoring data**

Address	Data	Register No.	Password Level	R/W
0x00C8	Current operation mode 10: INITIALIZE 12: STOP 20: ILLUMINATION 25: SELF TEST 31: WAIT_MODE 40: MONITORING 41: COUNTDOWN 42: CHECKRELAY 50: GRIDANDMPPT 60: SYSFAULT 61: SYSLOCK 81: FLASH 90: CALIBRATE	1	0	R
0x00C9	ERROR_CODE1(See Error defined)	1	0	R
0x00CA	ERROR_CODE2(See Error defined)	1	0	R
0x00CB	ERROR_CODE3(See Error defined)	1	0	R
0x00CC	ERROR_CODE4(See Error defined)	1	0	R
0x00CD	reserved for future use	1	0	R
0x00CE	reserved for future use	1	0	R
0x00CF	VR(R phase voltage)	1	0	R
0x00D0	VS(S phase voltage)	1	0	R
0x00D1	VT(T phase voltage)	1	0	R
0x00D2	VRS(RS Line voltage)	1	0	R
0x00D3	VST(ST Line voltage)	1	0	R
0x00D4	VTR(TR Line voltage)	1	0	R
0x00D5	IR(R phase current)	1	0	R
0x00D6	IS(S phase current)	1	0	R
0x00D7	IT(T phase current)	1	0	R
0x00D8	PR (R phase power)	1	0	R
0x00D9	PS (S phase power)	1	0	R
0x00DA	PT (T phase power)	1	0	R
0x00DB	Total Output Power	1	0	R
0x00DC	SR(R phase Apparent power)	1	0	R
0x00DD	SS(S phase Apparent power)	1	0	R

0x00DE	ST(T phase Apparent power)	1	0	R
0x00DF	Total Output Apparent power	1	0	R
0x00E0	FR(R phase frequency)	1	0	R
0x00E1	FS(S phase frequency)	1	0	R
0x00E2	FT(T phase frequency)	1	0	R
0x00E3	VPV1	1	0	R
0x00E4	VPV2	1	0	R
0x00E5	VBAT(reserved for future use)	1	0	R
0x00E6	IPV1	1	0	R
0x00E7	IPV2	1	0	R
0x00E8	IBAT(reserved for future use)	1	0	R
0x00E9	WPV1	1	0	R
0x00EA	WPV2	1	0	R
0x00EB	WBAT(reserved for future use)	1	0	R
0x00EC	Total Pin Power			
0x00ED	VBUS	1	0	R
0x00EE	VBUS+	1	0	R
0x00EF	VBUS-	1	0	R
0x00F0	Eac_H(High Word of Eac)	1	0	R
0x00F1	Eac_L(low Word of Eac)	1	0	R
0x00F2	Epv1_H(High Word of Epv1)	1	0	R
0x00F3	Epv1_L(low Word of Epv1)	1	0	R
0x00F4	Epv2_H(High Word of Epv2)	1	0	R
0x00F5	Epv2_L(low Word of Epv2)	1	0	R
0x00F6	BAT_SOC(reserved for future use)	1	0	R
0x00F7	BAT_AH(reserved for future use)	1	0	R
0x00F8	Grounding resistor 1	1	0	R
0x00F9	Grounding resistor 2	1	0	R
0x00FA	Hest sink_ Temperature	1	0	R
0x00FB	IGBT_A Temperature	1	0	R
0x00FC	IGBT_B Temperature	1	0	R
0x00FD	Eac_Today	1	0	R
0x00FE	CO^2_H(High Word of CO^2)	1	0	R
0x00FF	CO^2_L(low Word of CO^2)	1	0	R
0x0100	SW1 Function	1	0	R
0x0101	SW2 Function	1	0	R
0x0102	Total Output Power	1	0	R
0x0103	Total Output Apparent power	1	0	R
0x0104	Total Input Power	1	0	R
0x0105	reserved for future use	1	0	R
0x0106	reserved for future use	1	0	R
0x0107	reserved for future use	1	0	R

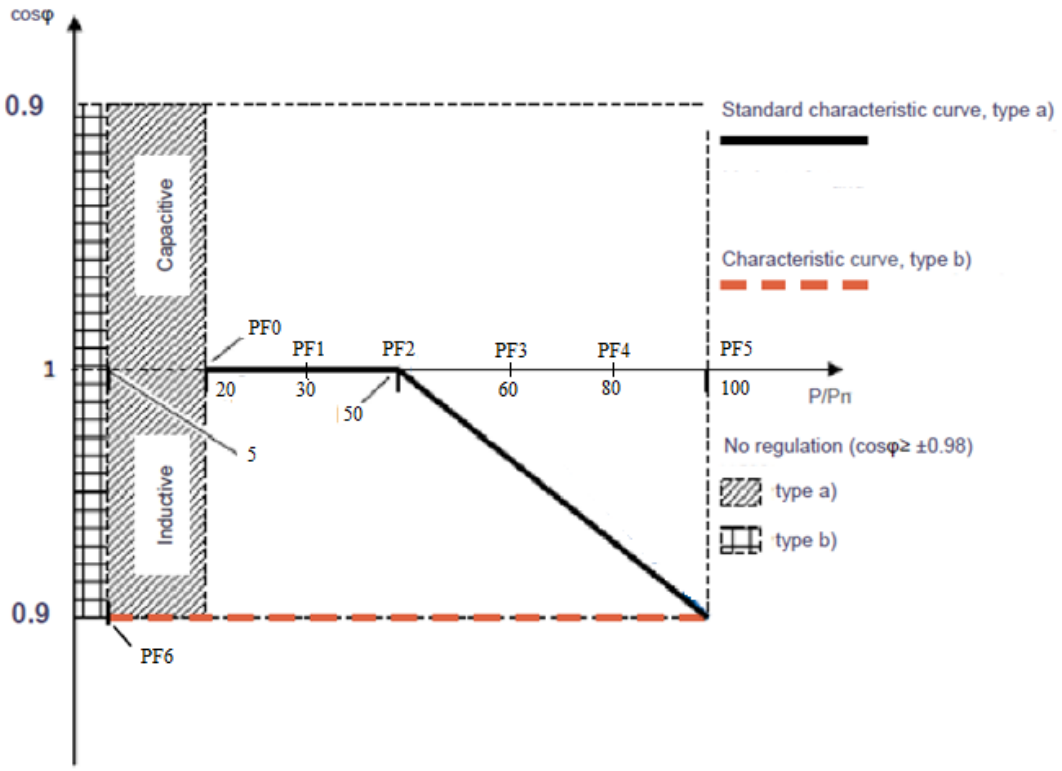
0x0108	reserved for future use	1	0	R
0x0109	reserved for future use	1	0	R
0x010A				

2.EEPROM data

Address	Data	Register No.	Password Level	R/W
0x0001	S2_Over_Freqency	1	2	R/W
0x0002	S2_Over_Freqency_disconnection_time	1	2	R/W
0x0003	S2_Under_Freqency	1	2	R/W
0x0004	S2_Under_Freqency_disconnection_time	1	2	R/W
0x0005	S2_Over_Voltage	1	2	R/W
0x0006	S2_Over_Voltage_disconnection_time	1	2	R/W
0x0007	S2_Under_Voltage	1	2	R/W
0x0008	S2_Under_Voltage_disconnection_time	1	2	R/W
0x0009	S1_Over_Freqency	1	2	R/W
0x000A	S1_Over_Freqency_disconnection_time	1	2	R/W
0x000B	S1_Under_Freqency	1	2	R/W
0x000C	S1_Under_Freqency_disconnection_time	1	2	R/W
0x000D	S1_Over_Voltage	1	2	R/W
0x000E	S1_Over_Voltage_disconnection_time	1	2	R/W
0x000F	S1_Under_Voltage	1	2	R/W
0x0010	S1_Under_Voltage_disconnection_time	1	2	R/W
0x0011	Islanding_disconnection_time	1	2	R/W
0x0012	IDC_injection_triping_current	1	2	R/W
0x0013	DC_injection_disconnection_time	1	2	R/W
0x0014	Insulation_resistance_trip_setting	1	2	R/W
0x0015	PV_Start_Voltage	1	2	R/W
0x0016	Reconnect_delay	1	2	R/W
0x0017	Safety standards: 0:Tiwain 1:Germeny	1	2	R/W
0x0018	ADDRESS(Inverter communication address) Integer, 1~255	1	2	R/W
0x0019	BAUDRATE	1	2	R/W
0x001A		1	6	R/W
0x001B		1	6	R/W
0x001C	SW1_Off_Reg	1	2	R/W
0x001D	SW2_On_Reg	1	2	R/W
0x001E		1	6	R/W

0x001F		1	6	R/W
0x0020		1	6	R/W
0x0021	Under_Freqency_Reconnection	1	6	R/W
0x0022	Over_Freqency_Reconnection	1	6	R/W
0x0023		1	6	R/W
0x0024	Curve_Selection 0: **cosφ** = 1.0 1:External control 2: **cosφ** = F(P) for type A 3: **cosφ** = F(P) for type B 4:Q = F(V) for Curve A 5:Q = F(V) for Curve B 6: **cosφ** = F(V)	1	2	R/W
0x0025	lock_in_AC_Frequency	1	6	R/W
0x0026	lock_out_AC_Frequency	1	6	R/W
0x0034	20%Pn(PF0 for type A)	1	2	R/W
0x0035	30%Pn(PF1 for type A)	1	2	R/W
0x0036	50%Pn (PF2 for type A)	1	2	R/W
0x0037	60%Pn (PF3 for type A)	1	2	R/W
0x0038	80%Pn(PF4 for type A)	1	2	R/W
0x0039	100%Pn (PF5 for type A)	1	2	R/W
0x003A	20%~100%Pn(PF6 for type B)	1	2	R/W
0x004A	PowerSetforVn	1	2	R/W
0x004B	cosφSetforVn	1	2	R/W
0x00B3	Device description, shown in form of character string, such as AEC Tough-3P 10~ 30Kw Each register is consist of two characters	8	6	R/W
0x00BB	Product serial No. (Each register stands for two characters)	8	6	R/W

Standard characteristic curve define:
Automatic supply of reactive power according to the characteristic curve cosφ = f(P)



3.Error code

Fault code	fault message	possible cause
ERROR CODE 1		
BIT0	No Utility	Not detected the AC voltage of the utility grid side.
BIT1	Uac High	The AC voltage of utility grid is beyond the upper limit.
BIT2	Uac Low	The AC voltage of utility grid is under the lower limit.
BIT3	Fac High	The AC frequency of the utility grid is beyond the upper limit.
BIT4	Fac Low	The AC frequency of the utility grid is under the lower limit.
BIT5	Fast Uac Low	The AC voltage of utility grid is under the lower limit.
BIT6	Fast Uac High	The AC voltage of utility grid is beyond the upper limit.
BIT7	Drift Fac	Islanding is detected.
BIT8	FastEarthCurrent	The drastic change of the leakage current has exceeded the allowable value.
BIT9	SlowEarthCurrent	The leakage current detected by inverter has exceeded the maximum permissible value.
BIT10	Idc-inj. High	The DC current injected into the utility grid side too high.
BIT11	Iac Max	The AC current has exceeded the maximum permissible value.
BIT12	Iac High	The AC current has exceeded the maximum permissible value.
BIT13	Phase Failure	phase loss
BIT14	Out Over Power	Output overload protection
BIT15		

ERROR CODE 2		
BIT0	Riso Low	The insulation resistance between PV array and the ground is below the allowable value.
BIT1	UpvA High	The DC voltage of PVA array is higher than the permissible value.
BIT2	UpvB High	The DC voltage of PVB array is higher than the permissible value.
BIT3	IpvA High	The DC current of PVA has exceeded the maximum permissible value.
BIT4	IpvB High	The DC current of PVB has exceeded the maximum permissible value.
BIT5	PpvA High	The DC power of PVA has exceeded the maximum permissible value.
BIT6	PpvB High	The DC power of PVB has exceeded the maximum permissible value.
BIT7	IpvA_Max	The DC current of PVA has exceeded the maximum permissible value.
BIT8	IpvB_Max	The DC current of PVB has exceeded the maximum permissible value.
BIT9	Vdcbus High	Internal DC bus voltage too high.
BIT10	Vdcbus Low	Internal DC bus voltage too low.
BIT11	Udcbus unbalance	Internal DC bus voltage is unbalance.
BIT12		
BIT13		
BIT14		
BIT15		
ERROR CODE 3		
BIT0	MRelay_Short	The output relay is failed.
BIT1	MRelay_Open	The output relay is failed.
BIT2	SRelay_Short	The output relay is failed.
BIT3	SRelay_Open	The output relay is failed.
BIT4	RCMU Fault	The residual current monitoring unit is abnormal.
BIT5	IpvA HCT Fault	The DC current of PVA sensor is abnormal.
BIT6	IpvB HCT Fault	The DC current of PVB sensor is abnormal.
BIT7	IacA HCT Fault	The AC current sensor is abnormal.
BIT8	IacB HCT Fault	The AC current sensor is abnormal.
BIT9	Idc-inj. Fault	The DC injection current monitoring function is fail.
BIT10	SPI Fault	Internal communication between MCU inside is abnormal.
BIT11	EEPROM Fault	An error occurred when reading or writing the EEPROM.
BIT12	Fan Fault	The fan is stopped abnormally. *warning message
BIT13	Comm. Fault	External communication is failed. *warning message
BIT14	Offset Fault	Internal reference voltage detection circuit is failed.
BIT15	RTC Fault	The RTC stops running or setting fail. *warning message
ERROR CODE 4		
BIT0	HS Temp. Low	The internal temperature of the heat sink is low than normal

		operating limit.
BIT1	HS Temp. High	The internal temperature of the heat sink is higher than normal operating limit.
BIT2	TMA Temp. Low	The internal temperature of the inverter is low than normal operating limit.
BIT3	TMA Temp. High	The internal temperature of the inverter is higher than normal operating limit.
BIT4	TMB Temp. Low	The internal temperature of the inverter is low than normal operating limit.
BIT5	TMB Temp. High	The internal temperature of the inverter is higher than normal operating limit.
BIT6	CalDataLoss	Calibration data is lost.
BIT7	Neg. Phase Seq.	phase reversal
BIT8	Version Error	The firmware version is not correct.
BIT9		
BIT10		
BIT11		
BIT12	Delta CPU	Internal communication between MCU inside is abnormal.
BIT13	Vac Offset Fault	The voltage offset is fail
BIT14		
BIT15		