Modbus Protocol Parameters

FDC Series 100 Temperature & Process Controls
9100/8100/4100

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Chapter 7 Modbus Communications

This chapter specifies the Modbus Communications protocol as RS-232 or RS-485 interface module is installed. Only RTU mode is supported. Data is transmitted as eight-bit binary bytes with 1 start bit, 1 stop bit and optional parity checking (None, Even or Odd). Baud rate may be set to 2400, 4800, 9600, 14400, 19200, 28800 and 38400.

7-1 Functions Supported

Only function 03, 06 and 16 are available for this series of controllers. The message formats for each function are described as follows:

Function 03: Read Holding Registers

Query (from master)	**Response** (from slave)
Slave address (0-255)	←
Function code (3)	←
Starting address of register Hi (0)	Byte count
Starting address of register Lo (0-79, 128-131)	Data 1 Hi
	Data 1 Lo
No. of words Hi (0)	Data 2 Hi
No. of words Lo (1-79)	Data 2 Lo
CRC16 Hi	⋮
CRC16 Lo	CRC16 Hi
	CRC16 Lo

Function 06: Preset single Register

Query (from master)	**Response** (from slave)
Slave address (0-255)	←
Function code (6)	←
Register address Hi (0)	←
Register address Lo (0-79, 128-131)	←
Data Hi	←
Data Lo	←
CRC16 Hi	←
CRC16 Lo	←

Function 16: Preset Multiple Registers

Query (from master)	**Response** (from slave)
Slave address (0-255)	◄——
Function code (16)	◄——
Starting address of register Hi (0)	◄——
Starting address of register Lo (0-79, 128-131)	◄——
No. of words Hi (0)	◄——
No. of words Lo (1-79)	◄——
Byte count (2-158)	CRC16 Hi
Data 1 Hi	CRC16 Lo
Data 1 Lo	
Data 2 Hi	
Data 2 Lo	
•	
•	
•	
•	
CRC16 Hi	
CRC16 Lo	

7-2 Exception Responses

If the controller receives a message which contains a corrupted character (parity check error, framing error etc.), or if the CRC16 check fails, the controller ignores the message.
However, if the controller receives a syntactically correct message which contains an illegal value, it will send an exception response, consisting of five bytes as follows:

slave address +offset function code + exception code + CRC16 Hi + CRC16 Lo

Where the offset function code is obtained by adding the function code with 128 (ie. function 3 becomes H'83), and the exception code is equal to the value contained in the following table:

Exception Code	Name	Cause
1	Bad function code	Function code is not supported by the controller
2	Illegal data address	Register address out of range
3	Illegal data value	Data value out of range or attempt to write a read-only or protected data

7-3 Parameter Table

Register Address	Parameter Notation	Parameter	Scale Low	Scale High	Notes
0	SP1	Set point 1	*4	*4	R/W
1	SP2	Set point 2	*7	*7	R/W
2	SP3	Set point 3	*6	*6	R/W
3	LOCK	Lock code	0	65535	R/W
4	INPT	Input sensor selection	0	65535	R/W
5	UNIT	Measuring unit	0	65535	R/W
6	DP	Decimal point position	0	65535	R/W
7	INLO	Low scale value for linear input	*4	*4	R/W
8	INHI	High scale value for linear input	*4	*4	R/W
9	SP1L	Low limit of SP1	*4	*4	R/W
10	SP1H	High limit of SP1	*4	*4	R/W
11	SHIF	PV shift value	*4	*4	R/W
12	FILT	Filter time constant	0	65535	R/W
13	DISP	Display form (for C21)	0	65535	R/W
14	PB	P (proportional) band	*5	*5	R/W
15	TI	Integral time	0	65535	R/W
16	TD	Derivative time	0.0	6553.5	R/W
17	OUT1	Output 1 function	0	65535	R/W
18	O1TY	Output 1 signal type	0	65535	R/W
19	O1FT	Output 1 failure transfer	-1999.9	4553.6	R/W
20	O1HY	Output 1 ON-OFF hysteresis	*5	*5	R/W
21	CYC1	Output 1 cycle time	0.0	6553.5	R/W
22	OFST	Offset value for P control	0.0	6553.5	R/W
23	RAMP	Ramp function	0	65535	R/W
24	RR	Ramp rate	*5	*5	R/W
25	OUT2	Output 2 function	0	65535	R/W
26	RELO	Retransmission low scale value	*4	*4	R/W
27	O2TY	Output 2 signal type	0	65535	R/W
28	O2FT	Output 2 failure transfer	-1999.9	4553.6	R/W
29	O2HY	Output 2 ON-OFF hysteresis	*5	*5	R/W

Register Address	Parameter Notation	Parameter	Scale Low	Scale High	Notes
30	CYC2	Output 2 cycle time	0.0	6553.5	R/W
31	CPB	Cooling P band	0	65535	R/W
32	DB	Heating-cooling dead band	-1999.9	4553.6	R/W
33	ALFN	Alarm function	0	65535	R/W
34	REHI	Retransmission high scale value	*4	*4	R/W
35	ALMD	Alarm opertion mode	0	65535	R/W
36	ALHY	Alarm hysteresis	*5	*5	R/W
37	ALFT	Alarm failure transfer	0	65535	R/W
38	COMM	Communication function	0	65535	R/W
39	ADDR	Address	0	65535	R/W
40	BAUD	Baud rate	0	65535	R/W
41	DATA	Data bit count	0	65535	R/W
42	PARI	Parity bit	0	65535	R/W
43	STOP	Stop bit count	0	65535	R/W
44	SEL1	Selection 1	0	65535	R/W
45	SEL2	Selection 2	0	65535	R/W
46	SEL3	Selection 3	0	65535	R/W
47	SEL4	Selection 4	0	65535	R/W
48	SEL5	Selection 5	0	65535	R/W
49	SEL6	Selection 6	0	65535	R/W
50	SEL7	Selection 7	0	65535	R/W
51	SEL8	Selection 8	0	65535	R/W
52	ADLO	mV calibration low coefficient	-1999.9	4553.6	R/W
53	ADHI	mV calibration high coefficient	-1999.9	4553.6	R/W
54	RTDL	RTD calibration low coefficient	-1999.9	4553.6	R/W
55	RTDH	RTD calibration high coefficient	-1999.9	4553.6	R/W
56	CJLO	Cold junction calibration low coefficient	-199.99	455.36	R/W
57	CJHI	Cold junction calibration high coefficient	-1999.9	4553.6	R/W
58	DATE	Date Code	0	65535	R/W
59	SRNO	Serial Number	0	65535	R/W
60	HOUR	Working hours of the controller	0	65535	R/W

Register Address	Parameter Notation	Parameter	Scale Low	Scale High	Notes
61	BPL1	Bumpless transfer of OP1	0.00	655.35	R
62	BPL2	Bumpless transfer of OP2	0.00	655.35	R
63	CJCL	Cold junction signal low	0.000	65.535	R
64, 128	PV	Process value	*4	*4	R
65, 129	SV	Current set point value	*4	*4	R
66 130	MV1	OP1 control output value	0.00	655.35	Read only, unless in manual control
67 131	MV2	OP2 control output value	0.00	655.35	Read only, unless in manual control
68	TIMER	Remaining time of dwell timer	-1999.9	4553.6	R
69	EROR	Error code *1	0	65535	R
70	MODE	Operation mode & alarm status *2	0	65535	R
71, 140	PROG	Program code *3	0.00	655.35	R
72	CMND	Command code	0	65535	R/W
73	JOB1	Job code	0	65535	R/W
74	JOB2	Job code	0	65535	R/W
75	JOB3	Job code	0	65535	R/W
76	CJCT	Cold Junction Temperature	-199.99	455.36	R
77		Reserved	0	65535	R
78		Reserved	0	65535	R
79		Reserved	0	65535	R

*1: The error code is show in the first column of Table A.1.

*2: Definition for the value of MODE register

H'000X = Normal mode
H'010X = Calibration mode
H'020X = Auto-tuning mode
H'030X = Manual control mode
H'040X = Failure mode

H'0X00 = Alarm status is off
H'0x01 = Alarm status is on

The alarm status is shown in MV2 instead of MODE for models C21 and C91.

*3: The PROG Code is defined in the following table:

Model No.	BTC-9100	BTC-8100	BTC-4100	BTC-7100	C21	C91
PROG Code	6.XX	11.XX	12.XX	13.XX	33.XX	34.XX

Where XX denotes the software version number. For example: PROG=34.18 means that the controller is C91 with software version 18.

*4: The scale high/low values are defined in the following table for SP1, INLO, INHI, SP1L, SP1H, SHIF, PV, SV, RELO and REHI:

Conditions	Non-linear input	Linear input DP = 0	Linear input DP = 1	Linear input DP = 2	Linear input DP = 3
Scale low	-1999.9	-19999	-1999.9	-199.99	-19.999
Scale high	4553.6	45536	4553.6	455.36	45.536

*5: The scale high/low values are defined in the following table for PB, O1HY, RR, O2HY and ALHY:

Conditions	Non-linear input	Linear input DP = 0	Linear input DP = 1	Linear input DP = 2	Linear input DP = 3
Scale low	0.0	0	0.0	0.00	0.000
Scale high	6553.5	65535	6553.5	655.35	65.535

*6: The scale high/low values are defined in the following table for SP3:

Conditions	ALFN=1 (TIMR)	Non-linear input	Linear input DP = 0	Linear input DP = 1	Linear input DP = 2	Linear input DP = 3
Scale low	-1999.9	-1999.9	-19999	-1999.9	-199.99	-19.999
Scale high	4553.6	4553.6	45536	4553.6	455.36	45.536

*7: The scale high/low values are defined in the following table for SP2: For C21 and C91.

Conditions	OUT2=1 (TIMR)	Non-linear input	Linear input DP = 0	Linear input DP = 1	Linear input DP = 2	Linear input DP = 3
Scale low	-1999.9	-1999.9	-19999	-1999.9	-199.99	-19.999
Scale high	4553.6	4553.6	45536	4553.6	455.36	45.536

For BTC-9100, BTC-8100, BTC-7100 and BTC-4100

Conditions	Non-linear input	Linear input DP = 0	Linear input DP = 1	Linear input DP = 2	Linear input DP = 3
Scale low	-1999.9	-19999	-1999.9	-199.99	-19.999
Scale high	4553.6	45536	4553.6	455.36	45.536

7-4 Data Conversion

The word data are regarded as unsigned (positive) data in the Modbus message. However, the actual value of the parameter may be negative value with decimal point. The high/low scale values for each parameter are used for the purpose of such conversion.

Let M = Value of Modbus message
A = Actual value of the parameter
SL = Scale low value of the parameter
SH = Scale high value of the parameter

The conversion formulas are as follows:

$$M = \frac{65535}{SH\text{-}SL} \bullet (A - SL)$$

$$A = \frac{SH\text{-}SL}{65535} \bullet M + SL$$

7-5 Communication Examples :

Example 1: Down load the default values via the programming port

The programming port can perform Modbus communications regardless of the incorrect setup values of address, baud, parity, stop bit etc. It is especially useful during the first time configuration for the controller. The host must be set with 9600 baud rate, 8 data bits, even parity and 1 stop bit.

The Modbus message frame with hexadecimal values is shown as follows:

01	10	00	00	00	34	68	4F	19	4E	83	4E	83
Addr.	Func.	Starting Addr.		No. of words		Bytes	SP1=25.0		SP2=10.0		SP3=10.0	

00	00	00	01	00	00	00	01	4D	6D	51	C4
LOCK=0		INPT=1		UNIT=0		DP=1		INLO=-17.8		INHI=93.3	

4D	6D	63	21	4E	1F	00	02	00	00	00	64
SP1L=-17.8		SP1H=537.8		SHIF=0.0		FILT=2		DISP=0		PB=10.0	

00	64	00	FA	00	00	00	00	4E	1F	00	01
TI=100		TD=25.0		OUT1=0		O1TY=0		O1FT=0		O1HY=0.1	

00	B4	00	FA	00	00	00	00	00	02	4E	1F
CYC1=18.0		OFST=25.0		RAMP=0		RR=0.0		OUT2=2		RELO=0.0	

00	00	4E	1F	00	01	00	B4	00	64	4E	1F
O2TY=0		O2FT=0		O2HY=0.1		CYC2=18.0		CPB=100		DB=0	

00	02	52	07	00	00	00	01	00	00	00	01
ALFN=2		REHI=100.0		ALMD=0		ALHY=0.1		ALFT=0		COMM=1	

00	01	00	02	00	01	00	00	00	00	00	02
ADDR=1		BAUD=2		DATA=1		PARI=0		STOP=0		SEL1=2	

00	03	00	04	00	06	00	07	00	08	00	0A
SEL2=3		SEL3=4		SEL4=6		SEL5=7		SEL6=8		SEL7=10	

00	11	Hi	Lo
SEL8=17		CRC16	

Example 2: Read PV, SV, MV1 and MV2.

Send the following message to the controller via the COMM port or programming port:

	03	00	H'40 H'80	00	04	Hi	Lo
Addr.	Func.	Starting Addr.		No. of words		CRC16	

Example 3: Perform Reset Function (same effect as pressing R key)

Query

	06	00	H'48	H'68	H'25	Hi	Lo
Addr.	Func.	Register Addr.		Data Hi/Lo		CRC16	

Example 4: Enter Auto-tuning Mode

Query

	06	00	H'48	H'68	H'28	Hi	Lo
Addr.	Func.	Register Addr.		Data Hi/Lo		CRC16	

Example 5: Enter Manual Control Mode

Query

	06	00	H'48	H'68	H'27	Hi	Lo
Addr.	Func.	Register Addr.		Data Hi/Lo		CRC16	

Example 6: Read All Parameters

Query

	03	00	00	00	H'50	Hi	Lo
Addr.	Func.	Starting Addr.		No. of words		CRC16	

Example 7: Modify the Calibration Coefficient

Preset the CMND register with 26669 before attempting to change the calibration coefficient.

	06	00	H'48	H'68	H'2D	Hi	Lo
Addr.	Func.	Register Addr.		Data Hi / Lo		CRC16	

Table A.1 Error Codes and Corrective Actions

Error Code	Display Symbol	Error Description	Corrective Action
4	Er04	Illegal setup values been used: Before COOL is used for OUT2, DIRT (cooling action) has already been used for OUT1, or PID mode is not used for OUT1 (that is PB = 0, and / or TI = 0)	Check and correct setup values of OUT2, PB, TI and OUT1. IF OUT2 is required for cooling control, the control should use PID mode (PB ≠ 0, TI ≠ 0) and OUT1 should use reverse mode (heating action) , otherwise, don't use OUT2 for cooling control.
10	Er 10	Communication error: bad function code	Correct the communication software to meet the protocol requirements.
11	Er 11	Communication error: register address out of range	Don't issue an over-range register address to the slave.
14	Er 14	Communication error: attempt to write a read-only data or a protected data	Don't write a read-only data or a protected data to the slave.
15	Er 15	Communication error: write a value which is out of range to a register	Don't write an over-range data to the slave register.
26	AtEr	Fail to perform auto-tuning function	1.The PID values obtained after auto-tuning procedure are out of range. Retry auto-tuning. 2.Don't change set point value during auto-tuning procedure. 3.Use manual tuning instead of auto-tuning. 4. Don't set a zero value for PB. 5. Don't set a zero value for TI. 6. Touch RESET key
29	EEPE	EEPROM can't be written correctly	Return to factory for repair.
30	CJEr	Cold junction compensation for thermocouple malfunction	Return to factory for repair.
39	SbEr	Input sensor break, or input current below 1 mA if 4-20 mA is selected, or input voltage below 0.25V if 1 - 5V is selected	Replace input sensor.
40	AdEr	A to D converter or related component(s) malfunction	Return to factory for repair.