Chapter 4 Communication

Introducing Modbus Protocol

Format of Communication

Data Address Table

K-Tech Inc.
487 Leslie Ct. Suite 201
Des Plaines, IL. 60016
www.K-tech.com
meters@k-tech.com

This chapter will mainly discuss how to operate the meter via communication port using software. To master this chapter, you should be familiar with Modbus and read other chapters of this manual to make sure that you have generously mastered the function and application of this product.

This chapter includes: Modbus protocol, format of communication and data address table and Acuvim-L application details.

4.1 Introducing Modbus protocol

The Modbus RTU protocol is used for communication in Acuvim-L. The data format and error check methods are defined in Modbus protocol. The half duplex query and respond mode is adopted in Modbus protocol. There is only one master device in the communication net. The others are slave devices, waiting for the query of the master.

Transmission mode

The mode of transmission defines the data structure within a frame and the rules used to transmit data. The mode is defined in the following which is compatible with Modbus RTU Mode*.

* Modbus is trademark of Modicon, Inc.

Coding system	8-bit binary
Start bit	1
Data bits	8
Parity	No parity
Stop bit	1
Error checking	CRC check

4.2 Modbus Protocol

Framing

Address	Function	Data	Check
8-bit	8-bit	N×8-bit	16-bit

Table 4-1 data frame format

Address field

The address field of a message frame contains eight bits. Valid slave device addresses are in the range of 0~247 decimal. 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.

Function field

The function code field of a message frame contains eight bits. Valid codes are in the range of 1~255 decimal. When a message is sent from a master to a slave device the function code field tells the slave what kind of action to perform.

Code	Meaning	Action
03	Read data	Obtain current binary value in one or more registers
16	Preset multiple-registers	Place specific value into a series of consecutive multiple-registers

Table 4-2 Function code

Data field

The data field is constructed using sets of two hexadecimal digits, in the range of 00 to FF hexadecimal. The data field of messages sent from a master to slave devices contains additional information which the slave must use to take the action defined by the function code. This can include items like discrete and register addresses, the quantity of items to be handled, and the count of actual data bytes in the field. For example, if the master requests a slave to read a group of holding registers (function code 03), the data field specifies the starting register and how many registers are to be read. If the master writes to a group of registers in the slave (function code 10 hexadecimal), the data field specifies the starting register, how many registers to write, the count of data bytes to follow in the data field, and the data to be written into the registers.

If no error occurs, the data field of a response from a slave to a master contains the data requested. If an error occurs, the field contains an exception code that the master application can use to determine the next action to be taken. The data field can be nonexistent (of zero length) in certain kinds of messages.6.

Error Check Field

Messages include an error-checking field that is based on a Cyclical Redundancy Check (CRC) method. The CRC field checks the contents of the entire message. It is applied regardless of any parity check method used for the individual characters of the message. 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 it

received in the CRC field. An error results if the two values are not equal. 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, and the parity bit, do not apply to the CRC.

During generation of the CRC, each 8-bit character is exclusive ORed 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 a1, the register is then exclusive ORed 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 ORed with the register 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. When the CRC is appended to the message, the low-order byte is appended first, followed by the high-order byte.

4.3 Format of communication

Explanation of frame

Addr	Fun	Data start reg hi	Data start reg lo	Data #of regs hi	Data #of regs lo	CRC16 Hi	CRC16 Lo
06H	03H	00H	00H	00H	21H	84H	65H

Table 4-3 Explanation of a frame

As shown in table 4-3 the meaning of each abbreviated word is:

Addr: address of slave device

Fun: function code

Data start reg hi: start register address high byte
Data start reg lo: start register address low byte
Data #of reg hi: number of register high byte
Data #of reg lo: number of register low byte
CRC16 Hi: CRC high byte
CRC16 Lo: CRC low byte

1. Read Data (Function Code 03)

Query

This function allows the master to obtain the measurement results of Acuvim-L. Table 4-4 is an example to read the 3 measured data (F, V1 and V2) from slave device number 17, the data address of F is 0130H, V1 is 0131H and V2 is 0132H.

Addr	Fun	Data start addr hi	Data start Addr Lo	Data #of Regs hi	Data #of Regs lo	CRC16 hi	CRC16 lo
11H	03H	01H	30H	00H	03H	06H	A8H

Table 4-4 Read F, V1 and V2 Query Message

Response

The Acuvim-L response includes the address code, function code, quantity of data byte, data, and error checking. An example response to read F, V1 and V2 (F=1388H (50.00Hz), V1=03E7H (99.9V), V2=03E9H (100.1V) is shown as Table4.9.

Addr	Fun	Byte count	Data1 hi	Data1 Lo	Data 2 hi	Data2 lo	Data3 hi	Data3 Lo	CRC16 hi	CRC16 lo
11H	03H	06H	13H	88H	03H	E7H	03H	E9H	7FH	04H

Table 4-5 Read F, V1 and V2 Message of response

2. Preset / Reset Multi-Register (Function Code 16)

Query

Function 16 allows the user to modify the contents of a Multi-Register. Any Register that exists within the Acuvim-L can have its contents changed by this message. The example below is a request to an Acuvim-L number 17 to Preset Ep_imp = (17807783.3KWH), while its Hex Value 0A9D4089H. Ep_imp data address is 0156H and 0157H.

Addr	Fun	Data start reg hi	Data start reg lo	Data #of reg hi	Data #of reg lo	Byte Count
11H	10H	01H	56H	00H	02H	04H

Value Hi	Value Lo	Value Hi	Value lo	CRC hi	CRC Lo
0AH	9DH	40H	89H	4DH	B9H

Table 4-6 Preset KWH Query Message

Response

The normal response to a preset Multi-Register request includes the Acuvim-L address, function code, data start register, the number of registers, and error checking.

Addr	Fun	Data start reg hi	Data start reg lo	Data #of reg hi	Data #of Reg lo	CRC16 hi	CRC16 lo
11H	10H	01H	0CH	00H	02H	A2H	B4H

Table 4-7 Preset Multi-Registers Message of Response

4.4 Data address table of Acuvim-L

Basis measurements

The data address of basis measurements includes primary data address and secondary data address. Function code: 03 read.

Address	Parameter	Range	Data type	Type of access
0130H	Frequency F	0～65535	word	R
0131H	phase voltage V1	0～65535	word	R
0132H	phase voltage V2	0～65535	word	R
0133H	phase voltage V3	0～65535	word	R
0134H	Line voltage V12	0～65535	word	R
0135H	Line voltage V23	0～65535	word	R
0136H	Line voltage V31	0～65535	word	R
0137H	Phase(line)current I1	0～65535	word	R
0138H	Phase(line)current I2	0～65535	word	R
0139H	Phase(line)current I3	0～65535	word	R
013AH	Neutral line current In	0～65535	word	R
013BH	Phase power Pa	-32768～32767	Integer	R
013CH	Phase power Pb	-32768～32767	Integer	R
013DH	Phase power Pc	-32768～32767	Integer	R
013EH	System power Pcon	-32768～32767	Integer	R
013FH	Phase reactive power Qa	-32768～32767	Integer	R
0140H	Phase reactive power Qa	-32768～32767	Integer	R
0141H	Phase reactive power Qb	-32768～32767	Integer	R
0142H	System reactive power Qcon	-32768～32767	Integer	R
0143H	System Apparent power Scon	0～65535	word	R
0144H	Phase power factor PFa	-1000～1000	Integer	R
0145H	Phase power factor PFb	-1000～1000	Integer	R
0146H	Phase power factor PFc	-1000～1000	Integer	R
0147H	System power factor PFcon	-1000～1000	Integer	R
0148H	Voltage unbalance factor U_unbl	0～1000	word	R
0149H	Current unbalance factor I_unbl	0～1000	word	R
014AH	Load nature RT（L/C/R）	76/67/82	word	R
014BH	reserved	---	---	---
014CH	reserved	---	---	---

014DH	reserved	---	---	---
014EH	reserved	---	---	---
014FH	reserved	---	---	---
0150H	power demand P_DEMA	-32768~32767	Integer	R
0151H	reactive power demand Q_DEMA	-32768~32767	Integer	R
0152H	Phase A current demand Ia_DEMA	0~65535	word	R
0153H	Phase B current demand Ib_DEMA	0~65535	word	R
0154H	Phase C current demand Ic_DEMA	0~65535	word	R
0155H	reserved	---	---	---

Table 4-8 data address of basic measurements

The relationship between numerical value in register of Acuvim-L and the real physical value is as following table. (Rx is numerical value in register of Acuvim-L)

Parameter	Relationship	Unit
Voltage V1,V2,V3,V12,V23,V31	U＝Rx × (PT1 / PT2) /10	Volt(V)
Current I1,I2,I3, In	I＝Rx ×(CT1/CT2) /1000	Amp（A）
Power Pa, Pb, Pc, Psum	P＝Rx × (PT1 / PT2) × (CT1/ CT2)	Watt（W）
Reactive power Qa, Qb, Qc, Qsum	Q＝Rx × (PT1 / PT2) × (CT1/ CT2)	Var
Apparent power Ssum	S＝Rx × (PT1 / PT2) × (CT1/ CT2)	VA
Power factor PFa, PFb, PFc, PFsum	PF＝Rx / 1000	NA
Frequency	F＝Rx / 100	Hz
Load nature（R/L/C）	76/67/82	NA
Voltage or current unbalance factor U_unbl, I_unbl	Unbl=(Rx/1000)×100%	NA

Table 4-9 Conversion relationship of basic measurements

Address	Parameter	Data type	Data of access
0600H~0601H	Frequency F	Float	R
0602H~0603H	Phase voltage V1	Float	R
0604H~0605H	Phase voltage V2	Float	R
0606H~0607H	Phase voltage V3	Float	R
0608H~0609H	Line voltage V12	Float	R
060AH~060BH	Line voltage V23	Float	R
060CH~060DH	Line voltage V31	Float	R
060EH~060FH	Phase (line) current I1	Float	R
0610H~0611H	Phase (line) current I2	Float	R
0612H~0613H	Phase (line) current I3	Float	R
0614H~0615H	Neutral line current In	Float	R
0616H~0617H	Phase power Pa	Float	R
0618H~0619H	Phase power Pb	Float	R
061AH~061BH	Phase power Pc	Float	R
061CH~061DH	System power Pcon	Float	R
061EH~061FH	Phase reactive power Qa	Float	R
0620H~0621H	Phase reactive power Qb	Float	R
0622H~0623H	Phase reactive power Qc	Float	R
0624H~0625H	System reactive power Qcon	Float	R
0626H~0627H	System apparent Scon	Float	R
0628H~0629H	Phase power factor PFa	Float	R
062AH~062BH	Phase power factor PFb	Float	R
062CH~062DH	Phase power factor PFc	Float	R
062EH~062FH	System power PFcon	Float	R
0630H~0631H	Voltage unbalance factor U_unbl	Float	R
0632H~0633H	Current unbalance factor I_unbl	Float	R
0634H~0635H	Reserved		

0636H~0637H	Reserved		
0638H~0639H	Reserved		
063AH~063BH	Reserved		
063CH~063DH	Reserved		
063EH~063FH	Reserved		
0640H~0641H	power demand P_DEMA	Float	R
0642H~0643H	reactive power demand Q_DEMA	Float	R
0644H~0645H	Phase A current demand Ia_DEMA	Float	R
0646H~0647H	Phase B current demand Ib_DEMA	Float	R
0648H~0649H	Phase C current demand Ic_DEMA	Float	R
064AH~064BH	Reserved		

Table 4-10 primary data address of basic measurements

Energy measurements

Function code: 03 read; 16 Pre-set

Address	Parameter	Range	Data type	Type of access
0156H (High 16 bit) 0157H (Low 16 bit)	Import Energy Ep_imp	0-99999999.9	DWord	R/W
0158H (High 16 bit) 0159H (Low 16 bit)	Export Energy Ep_exp	0-99999999.9	DWord	R/W
015AH (High 16 bit) 015BH (Low 16 bit)	Import reactive energy Eq_imp	0-99999999.9	DWord	R/W
015CH (High 16 bit) 015DH (Low 16 bit)	Export reactive energy Eq_imp	0-99999999.9	DWord	R/W
015EH (High 16 bit) 015FH (Low 16 bit)	Apparent energy Es	0-99999999.9	Dword	R/W

Table 4-11 Data address of energy measurements

The relationship between numerical value in register of Acuvim-L and the real physical value is as following table. (Rx is numerical value in register of Acuvim-L).

Parameter	Relationship	Unit
Energy Ep_imp, Ep_exp	Ep=Rx/10	kWh
Reactive energy Eq_imp, Eq_exp	Eq=Rx/10	kvarh
Apparent energy Es	Es=Rx/10	kVAh

Table 4-12 Conversion relationship of Energy dada

Power quality measurements

Function code: 03 read

Address	Parameter	Range	Data type	Type of access
0400H	Total harmonic distortion of V1 or V12 THD_V1	0～10000	word	R
0401H	Total harmonic distortion of V2 or V23 THD_V2	0～10000	word	R
0402H	Total harmonic distortion of V3 or V31 THD_V3	0～10000	word	R
0403H	Total harmonic distortion of I1 THD_ I1	0～10000	word	R
0404H	Total harmonic distortion of I2 THD_ I2	0～10000	word	R
0405H	Total harmonic distortion of I3 THD_ I3	0～10000	word	R
0406H~0413H	Harmonic content of V1 or V12 （2nd ~15th ）	0～10000	word	R
0414H~0421H	Harmonic content of V2 or V23 （2nd ~15th ）	0～10000	word	R
0422H~042FH	Harmonic content of V3 or V31 （2nd ~15th ）	0～10000	word	R
0430H~043DH	Harmonic content of I1 （2nd ~15th ）	0～10000	word	R
043EH~044BH	Harmonic content of I2 （2nd ~15th ）	0～10000	word	R
044CH~0459H	Harmonic content of I3 （2nd ~15th ）	0～10000	word	R

Table 4-13 Data table of Power quality measurements

The relationship between numerical value in register of Acuvim-L and the real physical value is as following table. (Rx is numerical value in register of Acuvim-L)

Parameter	Relationship	Unit
THD	THD＝Rx/10000×100%	NA
Harmonic content	THDn＝Rx/10000×100%	NA

Table 4-14 Conversion relationship of Power quality measurements

Statistics measurements

The data address of Statistics measurements includes primary data address and secondary data address. Function code: 03 read

Address	Parameter	Range	Data type	Type of access
0460H	Max of V1 V1_max	0~65535	word	R
0461H	Max of V2 V2_max	0~65535	word	R
0462H	Max of V3 V3_max	0~65535	word	R
0463H	Max of V12 V12_max	0~65535	word	R
0464H	Max of V23 V23_max	0~65535	word	R
0465H	Max of V31 V31_max	0~65535	word	R
0466H	Max of I1 I1_max	0~65535	word	R
0467H	Max of I2 I2_max	0~65535	word	R
0468H	Max of I3 I3_max	0~65535	word	R
0469H	Max of power demand PDmd_max	-32768~32767	integer	R
046AH	Max of reactive power demand QDmd_max	-32768~32767	integer	R
046BH	Max of current demand Ia IaDEMA_max	0~65535	word	R
046CH	Max of current demand Ib IbDEMA_max	0~65535	word	R
046DH	Max of current demand Ic IcDEMA_max	0~65535	word	R

046EH	reserved	---	---	---
046FH	reserved	---	---	---
0470H	Min of V1 V1_min	0~65535	word	R
0471H	Min of V2 V2_min	0~65535	word	R
0472H	Min of V3 V3_min	0~65535	word	R
0473H	Min of V12 V12_min	0~65535	word	R
0474H	Min of V23 V23_min	0~65535	word	R
0475H	Min of V31 V31_min	0~65535	word	R
0476H	Min of I1 I1_min	0~65535	word	R
0477H	Min of I2 I2_min	0~65535	word	R
0478H	Min of I3 I3_min	0~65535	word	R
0479H	reserved	---	---	---
047AH	reserved	---	---	---
047BH	reserved	---	---	---
047CH	Run time (High 16 bit)	0~99999999.9	DWord	R
047DH	Run time (Low 16 bit)			

Table 4-15 Secondary data address of Statistics measurements

The relationship between numerical value in register of Acuvim-L and the real physical value is as following table. (Rx is numerical value in register of Acuvim-L)

The data formant of statistics measurements is the same as that of Basis measurements except for run time of meter; the conversion relationship refers to Table 4-8.

The table below is the conversion relationship for run time.

Parameter	relationship	Unit
Run time of meter	Run_Hour＝Rx/10	Hour

Table 4-16 Conversion relationship of run time

Address	Parameter	Data type	Data of access
064CH~064DH	Max of V1 V1_max	Float	R
064EH~064FH	Max of V2 V2_max	Float	R
0650H~0651H	Max of V3 V3_max	Float	R
0652H~0653H	Max of V12 V12_max	Float	R
0654H~0655H	Max of V23 V23_max	Float	R
0656H~0657H	Max of V31 V31_max	Float	R
0658H~0659H	Max of I1 I1_max	Float	R
065AH~065BH	Max of I2 I2_max	Float	R
065CH~065DH	Max of I3 I3_max	Float	R
065EH~065FH	Max of power demand PDmd_max	Float	R
0660H~0661H	Max of reactive power demand QDmd_max	Float	R
0662H~0663H	Max of current demand Ia IaDEMA_max	Float	R
0664H~0665H	Max of current demand Ib IbDEMA_max	Float	R
0366H~0667H	Max of current demand Ic IcDEMA_max	Float	R
0368H~0669H	Reserved		
036AH~066BH	Reserved		
066CH~066DH	Min of V1 V1_min	Float	R
066EH~066FH	Min of V2 V2_min	Float	R
0670H~0671H	Min of V3 V3_min	Float	R
0672H~0673H	Min of V12 V12_min	Float	R
0674H~0675H	Min of V23 V23_min	Float	R
0676H~0677H	Min of V31 V31_min	Float	R
0678H~0679H	Min of I1 I1_min	Float	R
067AH~067BH	Min of I2 I2_min	Float	R
067CH~067DH	Min of I3 I3_min	Float	R
067EH~067FH	Reserved		

0680H~0681H	Reserved		
0682H~0683H	Reserved		

Table 4-17 primary data address of Statistics measurements

Parameter setting

Function code: 03 read; 16 preset

Address	Parameter	Data type	Range	default	Type of access
0100H	Access code	word	0~9999	0	R/W
0101H	Comm address	word	0~247	1	R/W
0102H	Baud rate	word	1200-38400	19200	R/W
0103H	Voltage wiring type	word	0:3Ln;1:2ln;2:2LL;3:3LL	0	R/W
0104H	Current wiring type	word	0:3CT;1:1CT;2:2CT	0	R/W
0105H	PT1(High 16 bit)	DWord	50.0~1000000.0	400	R/W
0106H	PT1(Low 16 bit)				
0107H	PT2	Word	50.0~400.0	400	R/W
0108H	CT1	Word	1~50000	5	R/W
0109H	CT2	Word	5	5	R/W
010AH	Definition of reactive power	word	0: Sinusoidal; 1: Nonsinusoidal	0	R/W
010BH	backlight time	word	0~120	1	R/W
010CH	Time of Demand slid window	word	1~30	15	R/W
010DH	Clear Max	Word	0aH: clear	0	R/W
010EH	Clear energy enable	Word	0:disable；1：enable	0	R/W
010FH	Clear energy	Word	0: do not clear； 0aH: clear	0	R/W
0110H	Clear run time	Word	0aH: clear	0	R/W

Table 4-18 Data address of setting parameter

Note：

1. data type:

Word: unsigned integer of 16 bit;
Integer: signed integer of 16 bit;
DWord: unsigned integer of 32 bit;
Float: float data of 32 bit.

2. type of access

R: read only, data read by using function code 03.

R/W: read and write, data read by using function 03 and written by using function code 16.

It is forbidden to write data address which dose not possesses property to be written.

3. Energy and run time

Energy and run time data is represented in 32 bit. Both high 16 bit and low 16 bit have successive address alone. The high 16 bit should be multiplied by 65535 and plus low 16 bit data to get the energy and run time data in master software. The unit is 0.1kWh, 0.1kVarh and 0.1hour. The energy register can be cleared or preset via communication. The register of run time can be cleared and can not be preset.