PAC46 Series
THYRISTOR THREE-PHASE POWER REGULATOR
COMMUNICATION INTERFACE
(RS-485)
Instruction Manual

Notice

Ensure that this instruction manual is handed to the final user of the instrument.

Introduction

This instruction manual describes the basic function and operating procedure of the PAC46 series communication interface (RS-485).

For the product overview, details on built-in functions, and wiring, installation, operation, and daily maintenance of the PAC46 series (hereinafter referred to as “the instrument”), please refer to the separate PAC46 SERIES THYRISTOR THREE-PHASE POWER REGULATOR INSTRUCTION MANUAL (hereinafter referred to as “the regulator instruction manual”).

SHIMADEN CO., LTD.

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1. Important safety instructions

The following symbols appear with instructions for safety and for equipment/facility damage prevention, as well as for additional explanations and notes on exceptions.

⚠ **WARNING:** ◎Failure to comply may result in personal injury or death.
⚠ **CAUTION:** ◎Failure to comply may result in damage to equipment and/or facilities.
NOTE: ◎Additional explanations, notes on exceptions, and other necessary information.

⚠ WARNING

The instrument is a control device designed for industrial use.
Never use it for control systems that may have a serious impact on human life.
Furthermore, taking adequate safety measures before use is at the responsibility of the user.
Please understand that we assume no responsibility for any accident that may occur as a result of use without safety measures.

- When installing the instrument to the control panel or the like, be careful not to allow your body to touch the terminals.
- Do not touch the circuit board or put your hand and/or conductive materials inside the instrument housing by opening it. Never repair or modify the instrument yourself. There is a risk of electric shock, which may cause fatal or serious injury.

⚠ CAUTION

Where the failure of this instrument may cause damage to nearby devices, equipment, products, etc., take safety measures, such as installing a fuse or an anti-overheating device, before use. We shall not be held responsible or liable for any accident that may occur due to the failure of the user to take safety measures.
If the instrument has the communication function, and data is written from the master equipment, trimmer adjusters and control input terminals may be disabled, making output adjustment by the trimmer adjusters or by input signals from the control input terminals impossible. To be prepared in case the communication settings are incorrect, provide safety measures, such as a circuit breaker, on the power supply input side before using the instrument.
Data written by the master equipment is retained even after power is cut off. Write data carefully to prevent incorrect communication settings.
To enable input to trimmer adjusters and control input terminals, you need to write and then set the data again from the master equipment.
Read also the safety precautions provided in the separate regulator instruction manual carefully and thoroughly understand them before using the instrument.

2. Overview

2-1. Communication interface

The instrument optionally supports RS-485 communication.
Using a personal computer (hereinafter referred to as "the PC"), PLC, or other equipment as the master and the instrument as a slave, you can perform master-slave communication to set various parameters and read data.
RS-485 is a data communication standard defined by the Electronic Industries Alliance (EIA) in the United States. The standard provides hardware specifications, but does not define the software aspects of data transmission procedures. Therefore, it does not allow for unconditional communication even between equipment with the same interface.
For this reason, the user should fully understand the data transfer specifications and data transmission procedures in advance.
By using the RS-485 communication function, you can connect multiple units of the instrument in parallel.
If using a PC/PLC or other equipment as the communication master, you can use a commercial RS-485 converter to perform RS-485 communication. When using a converter, please note the following:

Note 1: Turn off the echo back function if the converter has a switch for this function.
Note 2: Use a converter model that does not require the setting of communication speed and communication parity parameters by DIP switches or the like.
If your converter requires the setting of DIP switches or the like, the search function of the configuration tool may not function normally.
Note 3: Converter that has been tested for compatibility
HUMANDATA: USB-003; LINEEYE: SI-35USB

2-2. Communication protocol and specifications

The instrument supports the MODBUS protocol (RTU mode).

Signal level	EIA RS-485-compliant
Communication system	RS-485 (Two-wire, half-duplex, multi-drop system)
Synchronization system	Half-duplex, start-stop synchronous system
Communication distance	500 m max. in total length of RS-485 cables (depending on connection conditions)
Communication speed	9600 bps / 19200 bps
Transmission procedure	No procedure
Communication delay time	10ms / 20ms / 40ms / 80ms / 120ms / 200ms
Number of communication nodes	Up to 31 nodes supported (depending on connection conditions)
Communication address	1 to 99

Data format	Data length: 8 bits Parity: NON, EVEN , or ODD selectable Stop bit: 1 bit (fixed)
Communication encoding	Binary data
Control code	None
Error check	CRC-16

3. Connection between PAC46 and PC/PLC

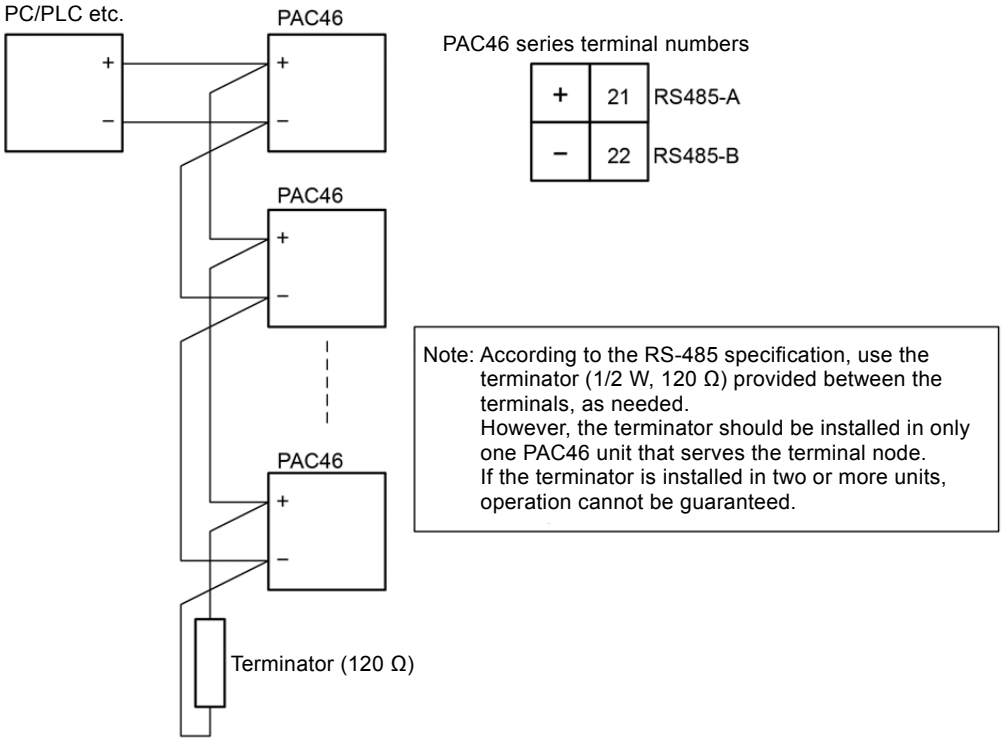
Establish a two-line connection between the PC/PLC and the RS-485-A (+) and RS-485-B (-) terminals of the instrument.
A connection example is shown below.

3-1. RS-485

The input/output logic levels of the terminals are basically as shown below.

MARK Negative (-) terminal < positive (+) terminal
SPACE Negative (-) terminal > positive (+) terminal

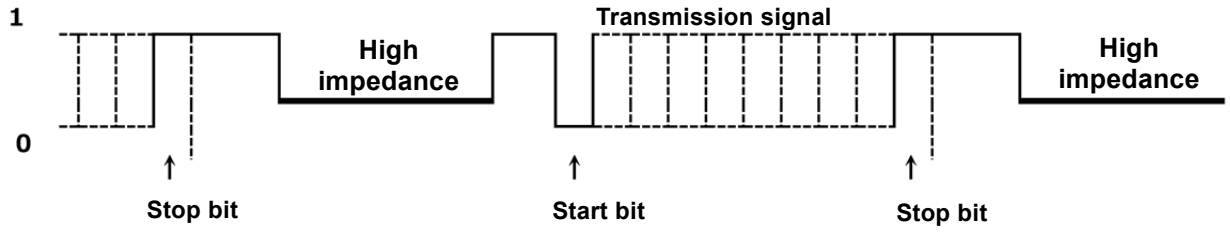
However, the positive (+) and negative (-) terminals of the instrument have high impedance until just before the instrument starts transmission, and therefore the above levels are output just before the start of transmission.



Note 4: If multiple units of the instrument are connected, you need to set a unique communication address for each unit.

3-2. Three-state output control

Since RS-485 is a multi-drop system, in order to prevent collision of transmission signals, transmission output normally has high impedance when the instrument is not communicating or when it is receiving data. It is controlled to switch from high impedance to normal output state just before the start of transmission, and come back to high impedance again simultaneously at the end of transmission.
However, under three-state control, a delay of about 1 ms occurs after the stop bit of the last data is transmitted. Therefore, in order to start transmission immediately after data is received by the host, provide a delay time of about a few milliseconds (ms).



4. Communication settings

The instrument uses four different communication parameters as described below.
You can change these parameters with a dedicated configuration tool.

4-1. Communication address

Initial value: 1
Setting range: 1 to 99

4-2. Communication speed

Initial value: 19200 bps
Setting range: 9600 / 19200 bps

4-3. Communication parity

Initial value: NON
Setting range: NON / EVEN / ODD

4-4. Delay time

Set the delay time before the start of transmission after a command is received.
Initial value: 20 ms
Setting range: 10 / 20 / 40 / 80 / 120 / 200 ms

4-5. Configuration tool

The configuration tool, *PAC46 Configurator*, is available for download from our website.
After connecting the instrument to the PC, use this configuration tool to set the communication address, communication speed, communication parity, and delay time.
(To connect the instrument to the PC, a commercial RS-485 converter is required.)

(1) Installation

(i) Download *PAC46_config_v***.zip* from our website into an appropriate folder on the PC in use and decompress the compressed file.
Note 5: The portion *v**** of the file name represents the version number.

(ii) Double-click **Setup.exe** in the extracted folder to start installation.
By default, in the *Program Files(x86)* folder on drive C, a folder named *Shimaden* is created and the *PAC46_config_v**** is found in it. The executable file is installed in the *PAC46_config_v**** folder. However, you can specify the installation folder as desired.

The tool may not function normally depending on the operating environment (such as the system) and utilization.
Please note in advance that we cannot guarantee the tool's operation on PCs that are not purchased from a manufacturer (such as custom-made PCs).

■ Recommended operating environment
Supported OS: Windows 10 and Windows 7
Available hard disk space: 1 MB or more
Memory capacity: Recommended for Windows
Note 6: Windows 10 and Windows 7 are either trademarks or registered trademarks of Microsoft Corporation in the United States and/or other countries.

(2) Removal

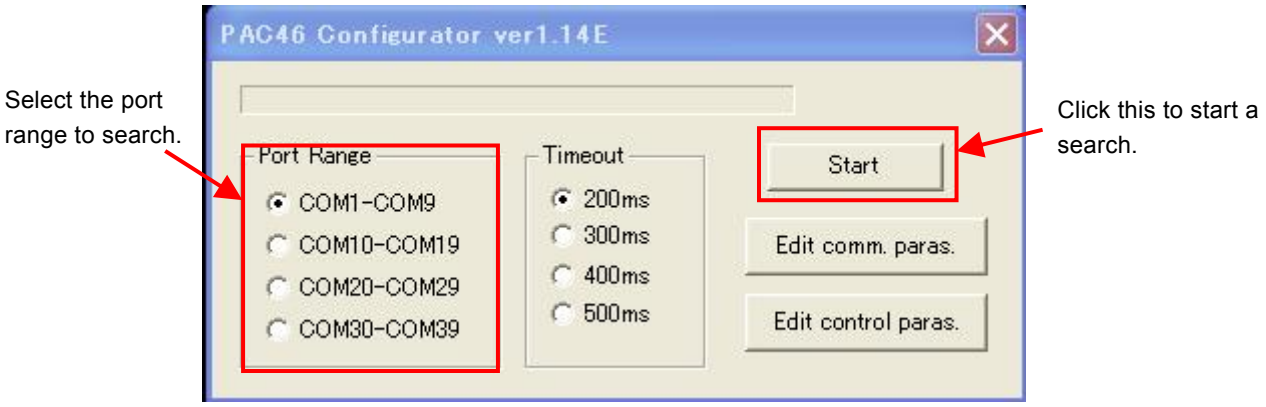
The configuration tool *PAC46 Configurator* can be removed through one of the following two methods:

(i) Double-click **Setup.exe**, which is the executable file that was used when installing the tool. To remove the tool, select **Remove**.

(ii) From Control Panel, execute **Add or Remove Programs** to remove *PAC46_config_v****.

(3) Operation

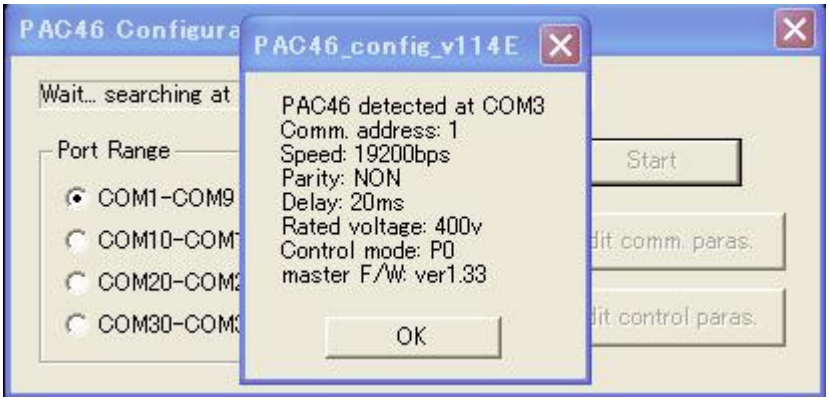
Connect the PC, RS-485 converter, and PAC46 in advance.
Be sure to connect only one PAC46 unit. It is not possible to set multiple units at the same time.
Start the configuration tool. The screen as shown in Fig-1 appears.
Check that the PAC46 is powered on. Then, specify the port range to search and click **Start Search**.



(Fig-1)

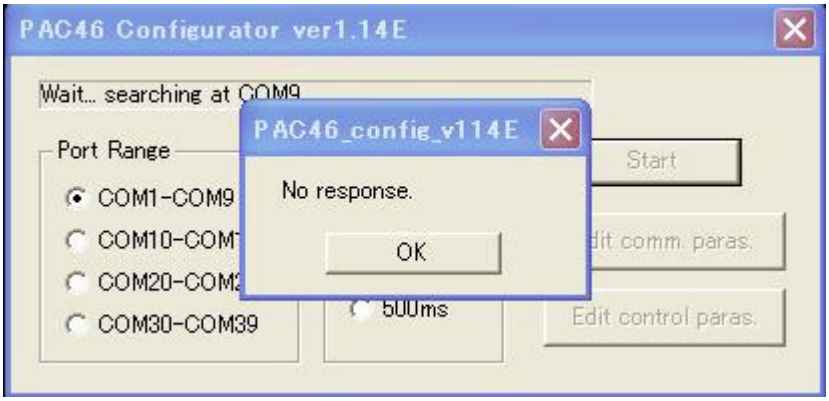
Before selecting the port range to search, click **Control Panel** -> **Hardware and Sound** -> **Device Manager** -> **Ports (COM & LPT)** on the PC and check the port number assigned to the RS-485 converter. (Windows 7)

When the PAC46 is detected by the PC, the screen is as shown in Fig-2.



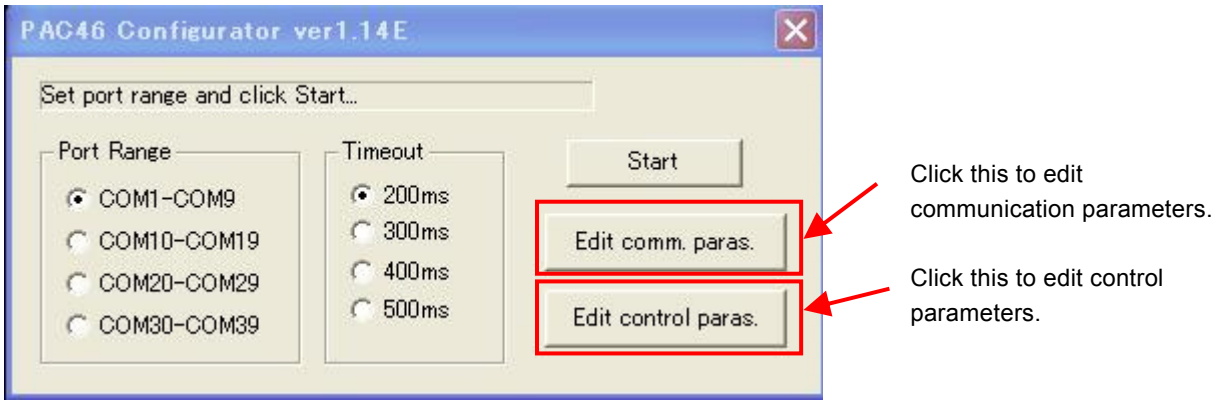
(Fig-2)

When the PAC46 cannot be detected by the PC, the screen is as shown in Fig-3.
In this case, check the PC, RS-485 converter, and PAC46 for connection and errors.



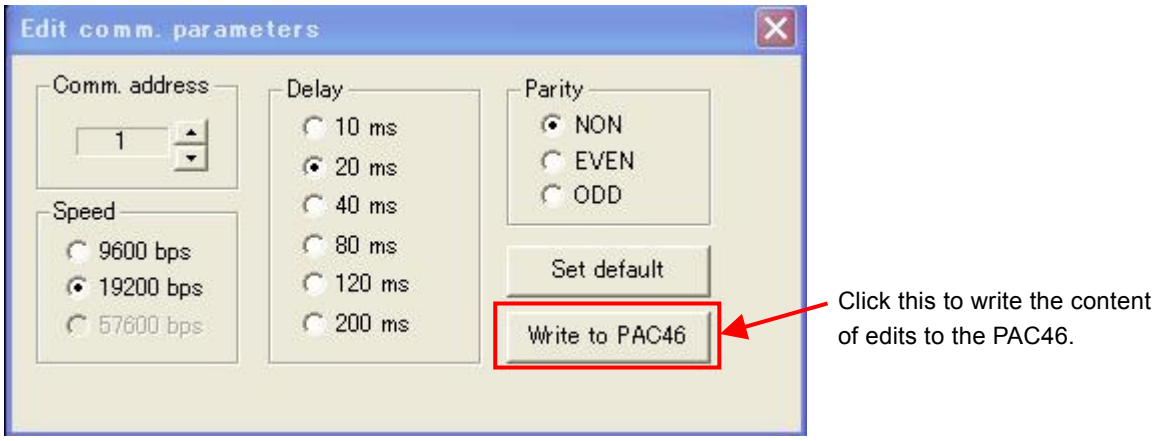
(Fig-3)

Click **OK** on the screen shown in Fig-2. You are now ready to edit communication parameters and control parameters.



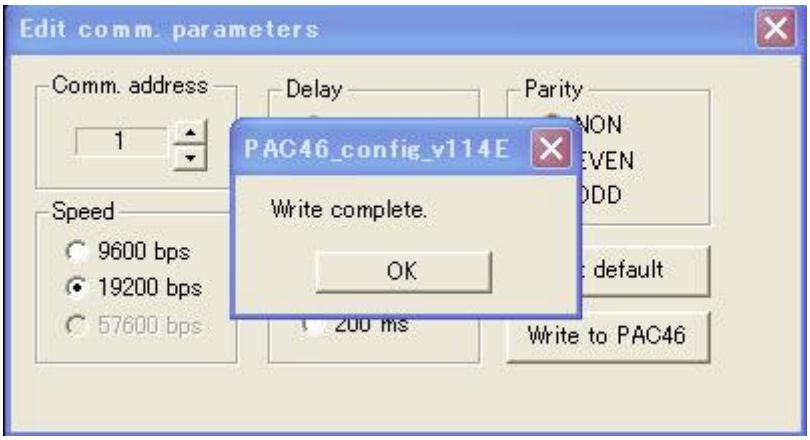
(Fig-4)

Click **Edit Communication Parameters** on the screen shown in Fig-4 to go to the screen shown in Fig-5.



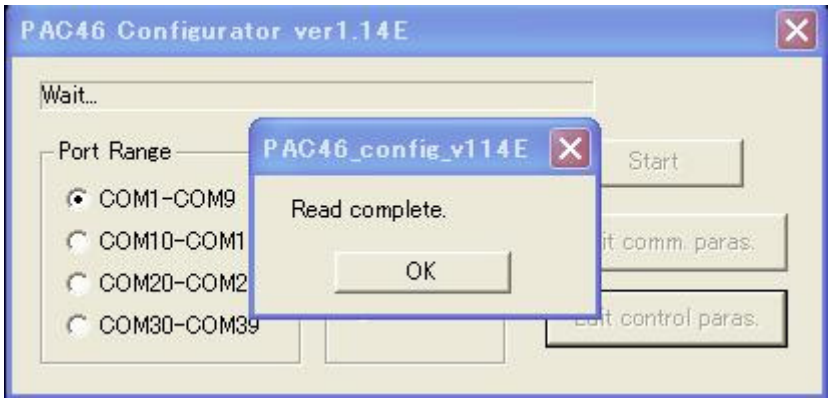
(Fig-5)

Edit the communication address, communication speed, communication delay, and communication parity, as needed. If multiple units of PAC46 are connected on the same communication line, assign a unique communication address to each of them.
After editing the settings, click **Write to PAC46**. If the data is successfully written, the screen is as shown in Fig-6.
To restore the default settings, click **Restore Defaults** and then click **Write to PAC46**.
Note that clicking only **Restore Defaults** does not restore the default PAC46 communication parameters.



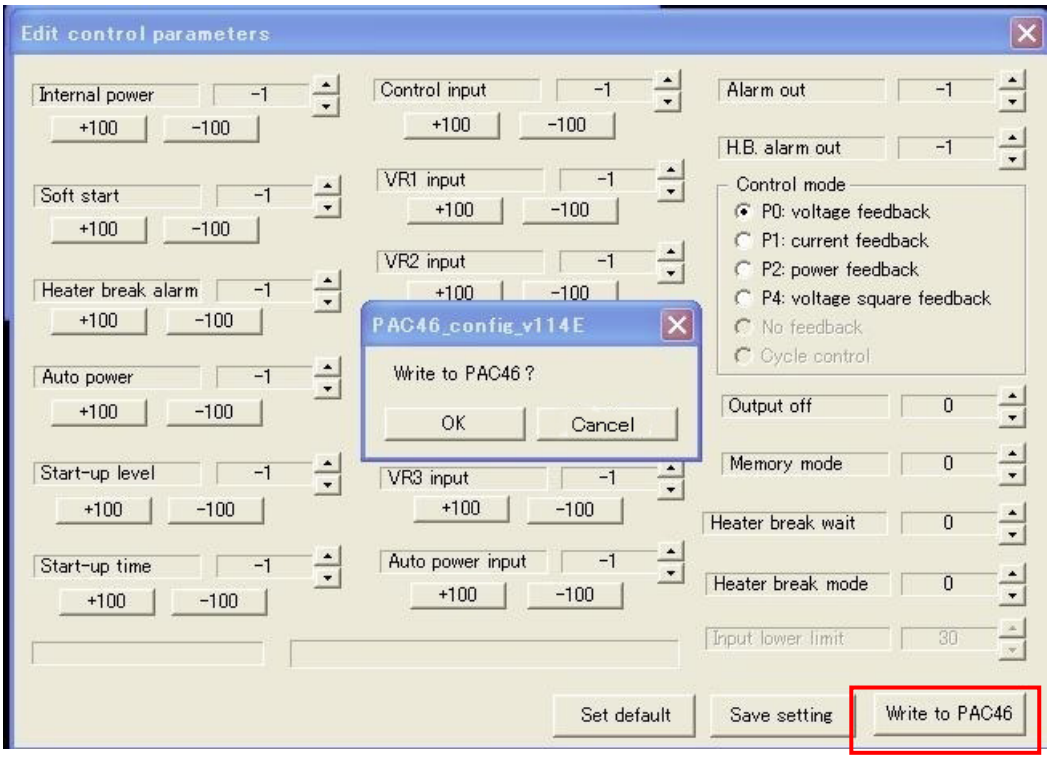
(Fig-6)

Click **Edit Control Parameters** on the screen shown in Fig-4 to go to the screen shown in Fig-7.



(Fig-7)

Edit the control parameters, as needed.
After editing the settings, click **Write to PAC46**. Now, the screen is as shown in Fig-8.
To restore the default settings, click **Set Default** and then click **Write to PAC46**.
Note that clicking only **Set Default** does not restore the default PAC46 control parameters.



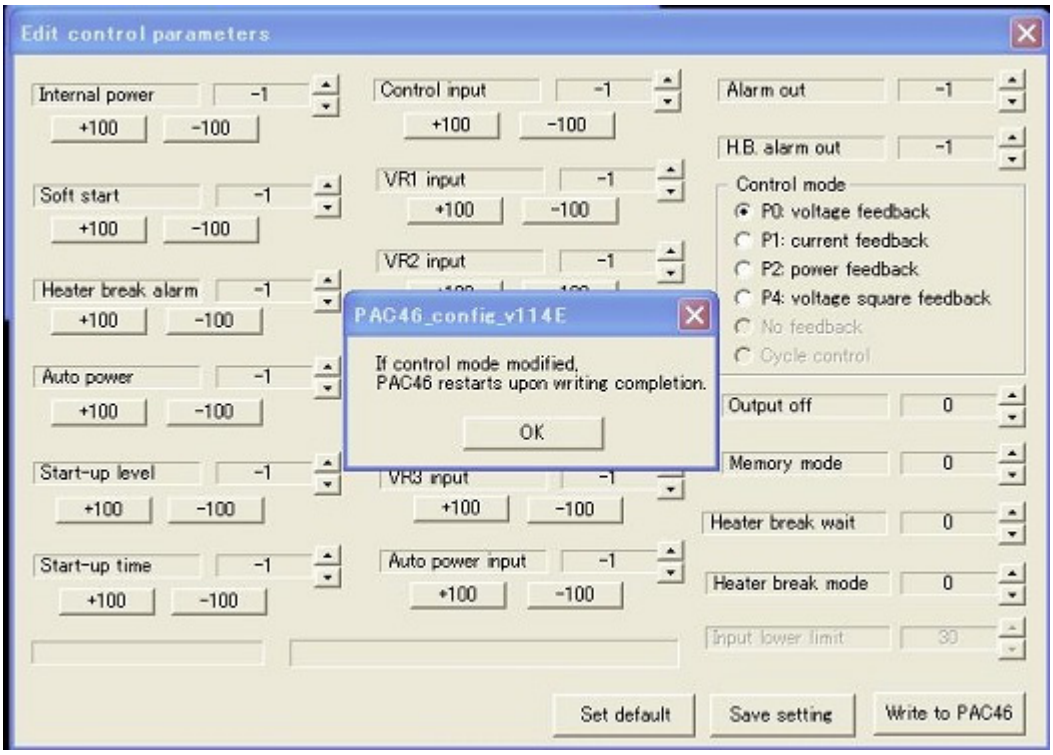
(Fig-8)

Click this to write the content of edits to the PAC46.

⚠CAUTION

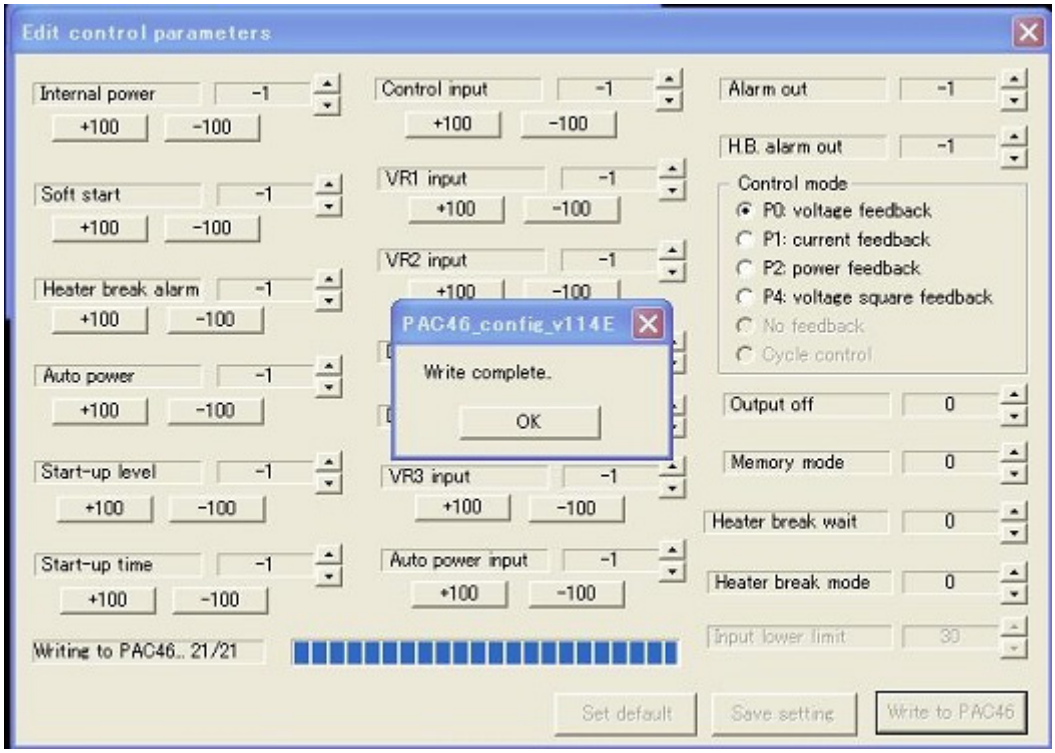
Data written by the master equipment is retained even after power is cut off. Write data carefully to prevent incorrect communication settings. To enable input to trimmer adjusters and control input terminals (by setting -1), you need to write and then set the data again from the master equipment.

If the control mode has been changed, the PAC46 is reset and output stops temporarily.



(Fig-9)

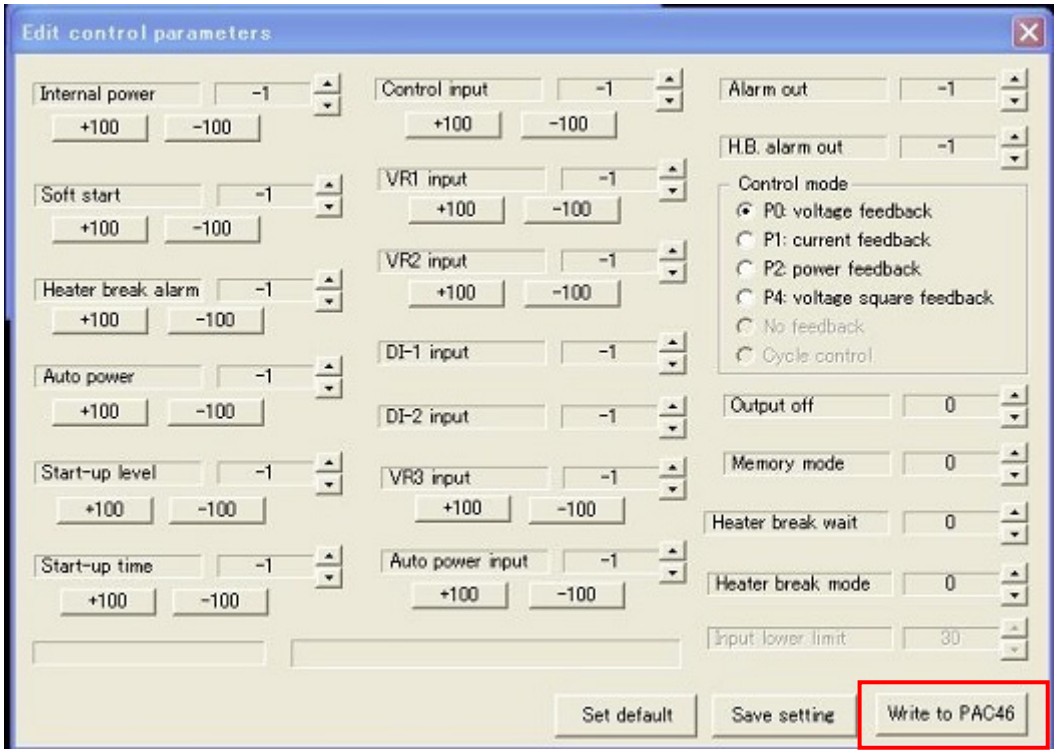
If the control parameter data is successfully written, the screen is as shown in Fig-10.



(Fig-10)

To record the data set on the *Edit Control Parameters* screen to a csv file, click **Save Setting** on the screen shown in Fig-11.

Note 7: If you do not click **Write to PAC46** after editing the control parameters, the settings that were written from the PAC46 will be recorded.



(Fig-11)

Click this to record the settings.

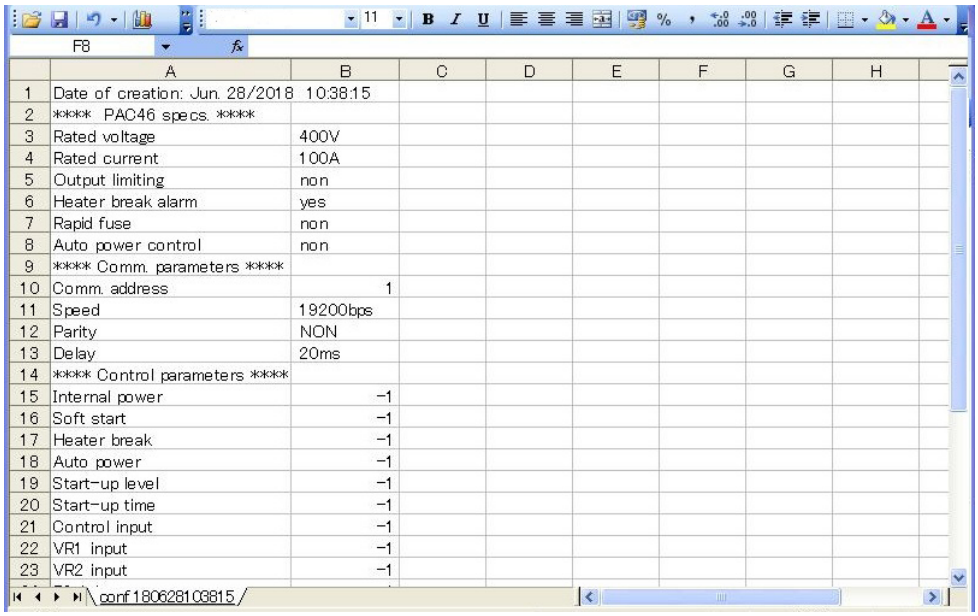
The csv file is stored in the *Documents* folder of the user who has logged in to the PC.

The created csv file name has a time stamp that indicates the date and time at which its recording was started.

Example: *conf_160606175312.csv* indicates that the recording of file was started at 17:53:12 on June 6, 2016.

If you have a spreadsheet application or the like installed on the PC, you can check the recorded data by double-clicking the csv file.

Alternatively, you may open the csv file in Notepad to check the data.



	A	B
1	Date of creation: Jun. 28/2018 10:38:15	
2	**** PAC46 specs. ****	
3	Rated voltage	400V
4	Rated current	100A
5	Output limiting	non
6	Heater break alarm	yes
7	Rapid fuse	non
8	Auto power control	non
9	**** Comm. parameters ****	
10	Comm. address	1
11	Speed	19200bps
12	Parity	NON
13	Delay	20ms
14	**** Control parameters ****	
15	Internal power	-1
16	Soft start	-1
17	Heater break	-1
18	Auto power	-1
19	Start-up level	-1
20	Start-up time	-1
21	Control input	-1
22	VR1 input	-1
23	VR2 input	-1

5. Overview of MODBUS protocol

The instrument supports the MODBUS protocol (RTU mode).

5-1. Overview of transmission mode

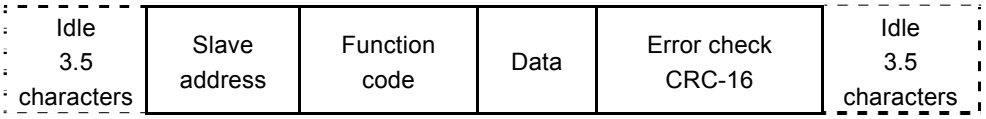
In this mode, 8-bit binary data in commands will be transmitted as is.

■ Data format

Error check	CRC-16 (Cyclic Redundancy Check) method
Data communication interval	3.5 character transmission time or less

5-2. Message format

A message is formatted so that it begins and ends with an idle time of 3.5 characters transmission time or more.



5-3. Slave address

Slave address refers to the communication address of the instrument, which can be set in the range of 1 to 99.
The master specifies this communication address in a request message to identify each slave.
Each slave sets its slave address in a response message and returns it to let the master know which slave is responding.

5-4. Function code

A function code specifies the type of operation that a slave should perform.

Function code	Details
03 (03H)	Instructs slave to read set values and information
06 (06H)	Instructs slave to write data

Function codes are also used when a slave returns a response message to the master to indicate whether it is a normal response (acknowledgment) or a response to indicate the occurrence of an error (negative acknowledgment).

An acknowledgment is returned with the original function code set in it.

A negative acknowledgment is returned with the most significant bit of the original function code set to 1.
For example, if the master transmits a request message with an incorrect function code 10H to a slave, since it is a non-existent function code, the slave sets the most significant bit to 1 and returns it as 90H.
Moreover, in the case of a negative acknowledgment, the slave sets an error code in the response message to let the master know what type of error has occurred.

Error code	Details
1 (01H)	Non-existent function
2 (02H)	Non-existent data address
3 (03H)	Value out of setting range

5-5. Data

The format of data varies depending on the function code.
A request message from the master consists of a data item, the number of data bytes, and set data.
A response message from a slave consists of the number of bytes and data to be returned in response, and an error code or the like if it is a negative acknowledgment.
The valid range of data is -32768 to +32767.

5-6. Error check

In the RTU mode, an error check is performed by calculating the CRC-16 data from the slave address to the end of data and setting the calculated 16-bit data after the data, in order from the low-order bit to the high-order bit.

■ Calculation of CRC-16 data

The CRC method divides the information to be sent by a generating polynomial and appends the remainder to the end of that information.

Generating polynomial: $X^{16} + X^{15} + X^2 + 1$

1. Initialize the CRC data (which is assumed to be X). (FFFFH)
2. Take the exclusive OR (XOR) of the first data and X, and substitute it for X.
3. Shift X one bit to the right, and substitute it for X.
4. If there is a carry as a result of the shift, take the XOR of the result X in **3.** and the fixed value (A001H), and substitute it for X.
   If there is no carry, go to ***5.***
5. Repeat ***3.*** and ***4.*** to shift X eight times.
6. Take the XOR of the next data and X, and substitute it for X.
7. Repeat **3.** to ***5.***
8. Repeat ***3.*** to ***5.*** up to the last data.
   Set X as the CRC-16 data in the message after the data, in order from the low-order bit to the high-order bit.

5-7. Message example

■ Reading average voltage from slave address 1

• Request message from master

Idle 3.5 characters	Slave address	Function code	Data address	Number of data	Error check CRC	Idle 3.5 characters
	(01H)	(03H)	(0100H)	(0001H)	(85F6H)	
	1	1	2	2	2	← Number of characters (8)

• Normal response message from slave (07D0H (hexadecimal) → 2000 (decimal) → Read value: 200.0 V)

Idle 3.5 characters	Slave address	Function code	Response Number of bytes	Data	Error Check CRC	Idle 3.5 characters
	(01H)	(03H)	(02H)	(07D0H)	(xxxxH)	
	1	1	1	2	2	← Number of characters (7)

• Error response message from slave (for incorrect data address)

Idle 3.5 characters	Slave address	Function code	Error code	Error check CRC	Idle 3.5 characters
	(01H)	(83H)	(02H)	(xxxxH)	
	1	1	1	2	→ Number of characters (5)

In a response message in case of an error, 1 is set as the most significant bit of the function code (83H).
An error response message, the error code 02H (*Non-existent data address*), is returned.

6. Communication data address

6-1. Details of communication data address

(1) Data address and read/write command

- The data address range is 0100H to 011B and 0300H to 0314H.
- RW stands for data that can be read and written.
- R stands for read-only data.
- W stands for write-only data.
- If the read command (R) is used to specify a write-only data address, or if the write command (W) is used to specify a read-only address, a data address error occurs and the error response code (02H) *Data address/number of data bytes error* is returned.

(2) Data address and number of data bytes

- If a data address that is not included in the PAC46 communication data address list is specified as the first data address, a data address error occurs and the error code (02H) *Data address/number of data bytes error* is returned.
- The number of data bytes that can be read is 10 or less. It is not possible to read more than 10 data bytes at the same time.
- The number of data bytes that can be written is 1. It is not possible to write multiple data bytes at the same time.

(3) Note on data

- Because each data byte represents a16-bit value without a decimal point, the data type, the presence/absence of decimal points, and the like must be checked.
  Example: Average voltage (Data address: 0100H)

				Hexadecimal data
200 V	→	200.0 V	→	07D0H

6-2. Communication data address list

6-2-1. Accessing data addresses 0100 to 0108 to enable reading of present output voltage, output current, heater resistance, etc.

Data Address	Read / Write	Data name	Details
0100	R	Output voltage	Average of phase-to-phase output voltage values Unit: 0.1 V (Example: 1732 → 173.2V)
0101	R	Output current*1	Average of phase-to-phase output current values Unit: 0.1 A
0102	R	Output power*1	Three-phase output power (√3 x Output voltage x Output current) Unit: 10 VA when current capacity is 20 A to 300 A Unit: 100 VA when current capacity is 500 A or 600 A
0103	R	Heater resistance*1	Approximate heater resistance when output current is 20% or above of rated current and three heaters with same rating are connected by delta connection. Unit: 0.01 Ω However, 0 is always returned if output current is below 10% of rated current.
0104	R	Power supply abnormal	0x00: Normal 0x01: Open phase or phase sequence abnormal 0x02: Frequency abnormal (out of 45 to 65 Hz range) Logical disjunction of above values if there are two or more causes. Open phase may be evaluated as open phase and frequency abnormal.
0105	R	Over-current	0: Normal 1: Over-current
0106	R	Fuse blown	0: Normal 1: Fuse blown
0107	R	Heater break	0: Normal 1: Heater break
0108	R	Temperature abnormal	0: Normal 1: Temperature abnormal

*1 Accuracy is degraded if the output current is lower than the rated current.

6-2-2. Accessing data addresses 0109 to 0115 to enable reading of control terminal input status, trimmer adjuster setting, etc.

Data Address	Read / Write	Data name	Details
0109	R	Control terminal, DI1 input	0: Input open 1: Input short-circuited
010A	R	Control terminal, DI2 input	
010B	R	Control terminal, Control signal input	Unit: 0.1% Example: 0 at 0% input or below Example: About 500 at 50% input Example: 1000 at 100% input or above
010C	R	Control terminal, Automatic power control input	
010D	R	Control terminal, VR1 input	Unit: 0.1% Example: 0 at minimum Example: About 500 at middle Example: 1000 at maximum
010E	R	Control terminal, VR2 input	
010F	R	Control terminal, VR3 input	
0110	R	Control terminal, trimmer input (POWER: Internal power)	
0111	R	Control terminal, trimmer input (SOFT START: Softstart)	
0112	R	Control terminal, trimmer input (H/B SET: Heater break alarm setting)	
0113	R	Control terminal, trimmer input (AUTO POWER: Automatic power)	
0114	R	Control terminal, trimmer input (STARTUP LEV.: Start-up time output limit level	
0115	R	Control terminal, trimmer input (STARTUP TIM.: Start-up time output limit time)	

6-2-3. Accessing data address 0116 to 011B to enable reading of phase-to-phase voltage and phase-to-phase output current

Data Address	Read / Write	Data name	Details
0116	R	U-V phase-to-phase voltage	Unit: 0.1 V Example: 2000 → 200.0 V
0117	R	V-W phase-to-phase voltage	
0118	R	W-U phase-to-phase voltage	
0119	R	U phase current*1	Unit: 0.1 A Example: 100 → 10.0 A
011 A	R	V phase current*1	
011 B	R	W phase current*1	

*1 Accuracy is degraded if the output current is lower than the rated current.

6-2-4. Accessing data addresses 0300 to 030C to enable changing of input to trimmer adjusters and control terminals provided on front panel via communication from master equipment

Data Address	Read / Write	Data name	Setting range	Details
0300	RW	Internal power adjustment communication setting	-1/0 to 1000	-1: Trimmer enabled (default) 0 to 1000: Communication setting enabled Example: 0 at minimum Example: 500 at middle Example: 1000 at maximum
0301	RW	Soft start time adjustment communication setting		
0302	RW	Heater break alarm communication setting		
0303	RW	Automatic power communication setting		
0304	RW	Start-up time output limit level communication setting		
0305	RW	Start-up time output limit time communication setting		
0306	RW	Control signal input communication setting	-1/0 to 1000	-1: Control terminals enabled (default) 0 to 1000: Communication setting enabled Example: 0% input at 0 Example: 50% input at 500 Example: 100% input at 1000
0307	RW	VR1 input communication setting		
0308	RW	VR2 input communication setting		
0309	RW	DI1 input communication setting	-1/0/1	-1: Control terminals enabled (default) 0/1: Communication setting enabled Example: Open at 0 Example: Short-circuited at 1
030A	RW	DI2 input communication setting		
030B	RW	VR3 input communication setting	-1/0 to 1000	-1: Control terminals enabled (default) 0 to 1000: Communication setting enabled Example: 0% input at 0 Example: 50% input at 500 Example: 100% input at 1000
030C	RW	Automatic power input communication setting		

6-2-5. Accessing data addresses 030D or 030E to enable operation of alarm output independent of regulator control

Data Address	Read / Write	Data name	Setting range	Details
030D	RW	Alarm output communication setting	-1/0/1	-1: Alarm output by regulator enabled (default) 0/1: Communication setting enabled Example: Forced to off at 0 Example: Forced to on at 1
030E	RW	Alarm break alarm output communication setting		

6-2-6. Accessing data address 030F to enable change of control mode

Data Address	Read / Write	Data name	Setting range	Details
030F	RW	Control mode communication setting[*2]	0/1/2/3/4	0: Voltage feedback 1: Current feedback 2: Power feedback 3: Voltage square feedback 4: No feedback[*3] (Factory-set default is initial value.)
0310	RW	Stop output communication setting	0/1	0: Continue output (default) 1: Force-stop output
0311	RW	Communication memory mode	0/1	0: Save all settings to EEPROM (default) 1: Save all but control signal input (0306) (It is recommended that this be set to 1 if control signal input is frequently rewritten.)
0312	RW	Heater break output delay time	0 to 1000 (Unit: seconds)	Turn on alarm output when set time has elapsed after heater break detection. (Default: 0 seconds)
0313	RW	Heater break output mode	0/1	0: Turn alarm output from on back to off when heater alarm is resolved after heater break detection. (Default) 1: Continue alarm output until power is turned off after heater alarm detection.
0314	RW	Control input scale lower limit	0 to 200	Example: When set to 30, the PAC46 starts output when control signal input has risen to 3.1%. (Default: 30)
0315	W	Reset parameters	Enabled only when 1 is written. 0 is always returned when data is read.	Reset all of settings 0300 to 030E and 0310 to 0314 to default values when 1 is written. Control mode is not changed, however.

*2 If the control mode is changed, the PAC46 is reset and output stops temporarily.

*3 Caution! The feedback control function is disabled if 4 is written to the data address 030F.

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The contents of this manual are subject to change without notice.

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