

TOHO ELECTRONICS INC.

**Operation Manual, Communications
(TOHO protocol and MODBUS)**

Model: TTM-000 Series
Designation: Digital Controller

Thank you very much for purchasing a TTM-000 Series (with communications). Please read this operation manual carefully and use this product correctly.

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1. Before using the product

1.1 On this operation manual

This is an operation manual regarding communications with a TTM-000 Series (hereinafter referred to as "this product").

1.2 Conditions for communications

The communications function of this product is optionally specified. For that reason, you should specify a communications option (RS-485) in purchasing this product.

1.3 What can be done with communications

With this product, users can write and read items specified in "9. Table of identifiers (codes)," such as "reconfiguring, starting, or stopping items that are operable with the front keys" and "reading information displayable on the display."

However, reading and writing with ordinary commands are performed with regarding to the RAM in this product. Written data can be turned back into the values before the writing (the values stored on the EEPROM) by turning power off and on again. To store the written data on the EEPROM of this product, execute a store request message. (See "Communications precautions." in chapter 3.6, 6.6 and 6.11.)

Settings regarding options not added and other unnecessary settings cannot be read or written.

1.4 Positioning communications (priority ranking)

Data and parameters in this product can be changed with keys while in operation in the communications mode.

While this product is in operation in the RO (read-only) mode, no data or parameter setting can be changed by communications. (Provided that communications modes can be changed.)

1.5 Setting before communications

Before performing communications, this product must be set. See "2. Settings regarding TOHO communications" and "5. Settings regarding MODBUS communications."

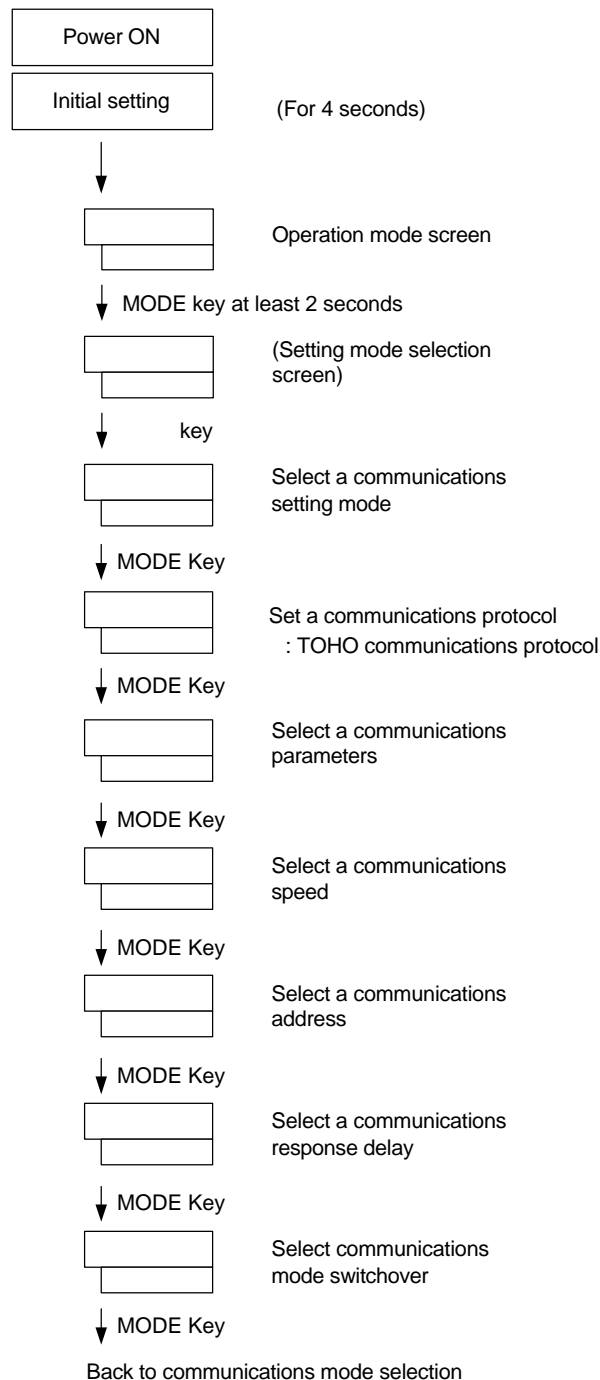
2. Settings regarding TOHO communications

2.1 Overview

Before communications is performed, initial settings must be made on this product. Enter such settings with the keys on the front panel.

To switch to a series of setting screens, take the steps described below.

For details, see the operation manual furnished with this product.



When the settings are over, press the MODE key at least 2 seconds to go back to the operation mode. The parameters indicated above are initial values.

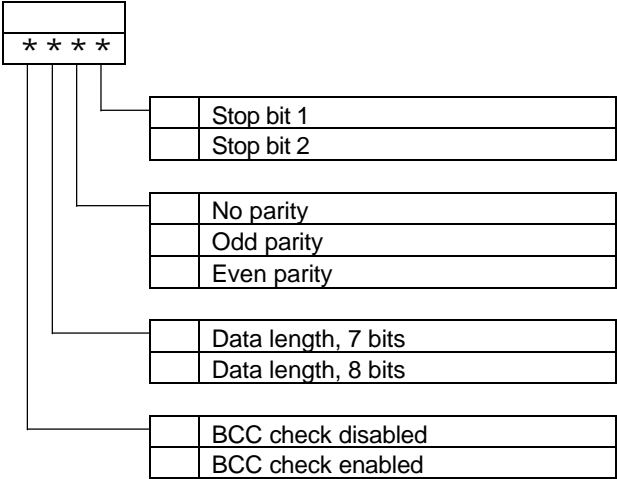
2.2 Setting a data length

2.3 Setting a stop bit length

2.4 Setting a parity

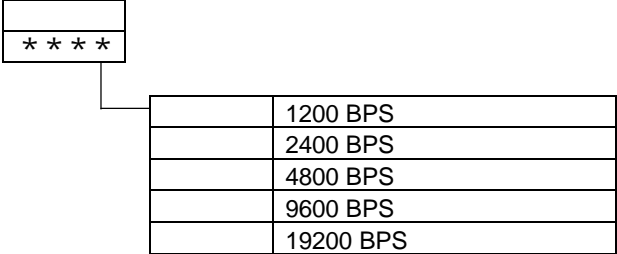
2.5 Setting whether to conduct a BCC check

While in the "Set a communications parameter" screen on the preceding page, operate the and keys to make the settings. The initial value is .



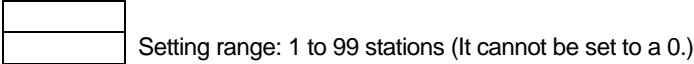
2.6 Setting a communications speed

While in the "Set a communications speed" screen on the preceding page, operate the and keys to make the settings. The initial value is .



2.7 Setting an address

While in the "Set a communications address" screen on the preceding page, operate the and keys to make the settings. The initial value is .



2.8 Setting a response delay

Set a time from the time when the high-level computer finished sending a "request message" until the time when it delivers the line and enters an input state.

While in the "Set a response delay" on the preceding page, operate the and keys to make the settings. The initial value is 0.

| |
|----------------------|
| <input type="text"/> |
| <input type="text"/> |

 Setting range: 0 to 250msec

- * If the response delay is set to a short setting, the communications may not be conducted normally.
- * In a real operation, the processing time for this product will be added, in addition to the response delay.

2.9 Switching communications mode

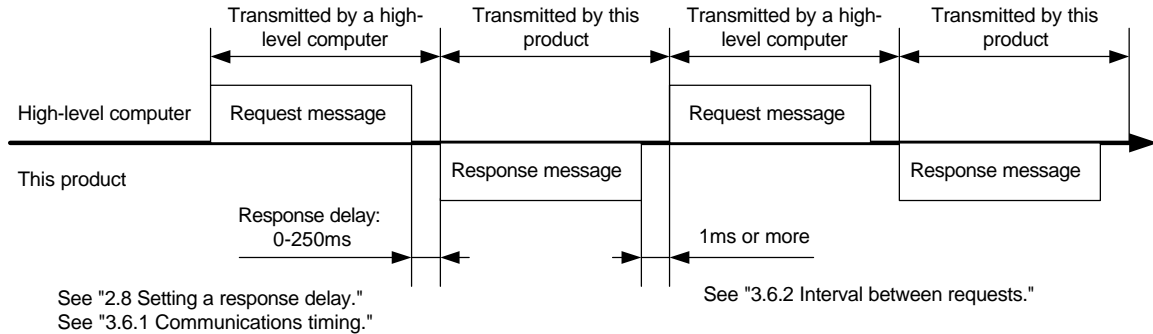
While in the "Set communications mode switchover" screen on the preceding page, operate the and keys to make the settings.

| | | |
|----------------------|----------------------|----------------|
| <input type="text"/> | <input type="text"/> | Read and write |
| * * * * | <input type="text"/> | Read-only |

3. TOHO communications control

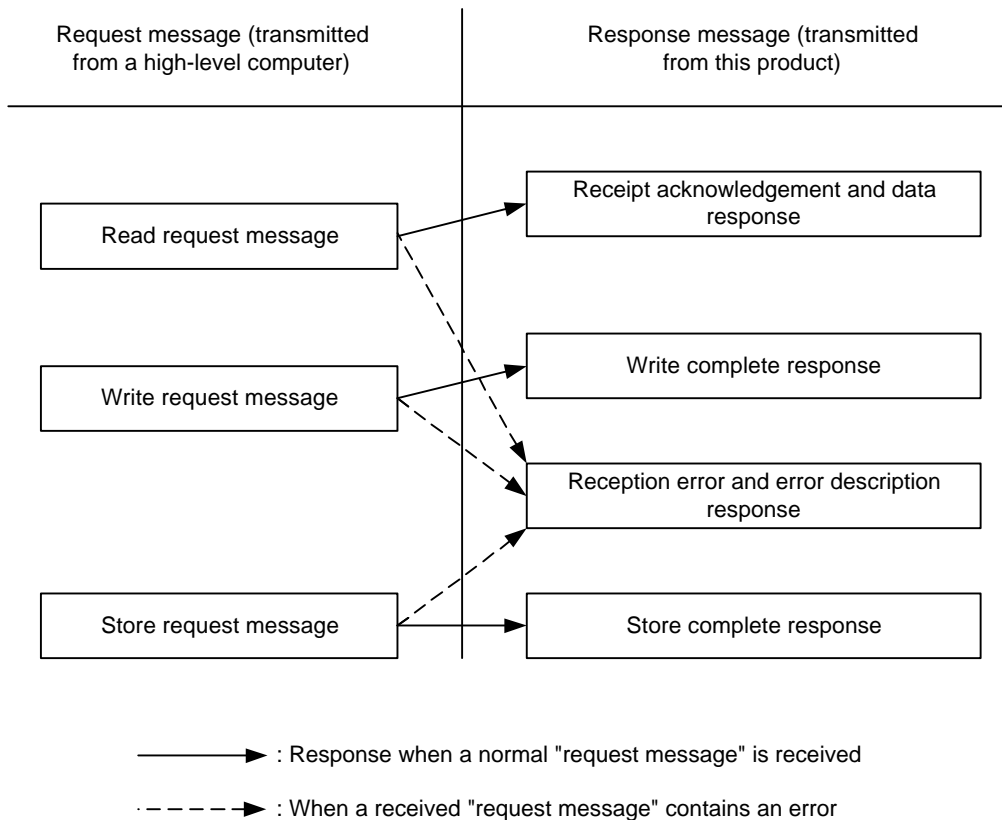
3.1 Communications procedure

This product returns a "response message" in response to a "request message" from a high-level computer. It therefore does not initiate a transmission.



3.2 Message types

- Messages are roughly divided into the following types:

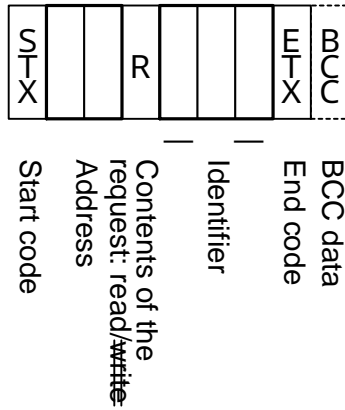


- All codes (except for BCC) from STX and data to ETX are expressed in ASCII codes.
- In assembling a program for a high-level computer, see "9. Table of identifiers (codes)" and "10. Table of ASCII codes" at the end of the book.

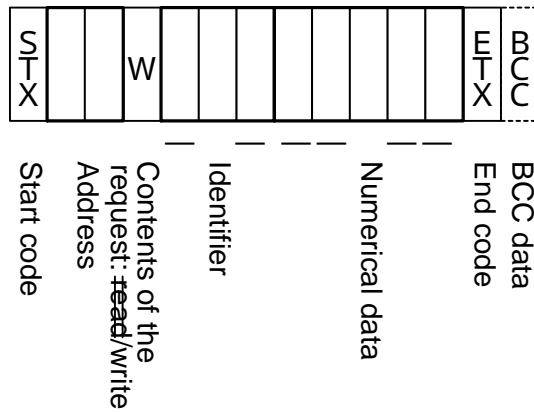
3.3 Composition of a request message (transmitted from a high-level computer to this product)

- For codes to , see "3.5 Description of codes."
- For specific examples of request messages, see "4.1 Examples of communications to be read" and "4.2 Examples of communications to be written."

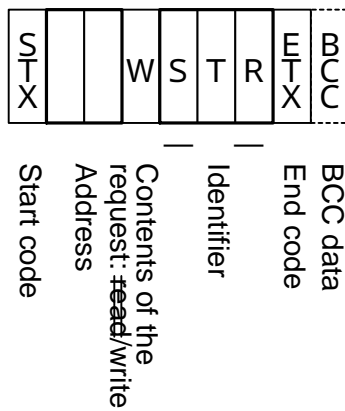
3.3.1 Composition of a read request message



3.3.2 Composition of a write request message



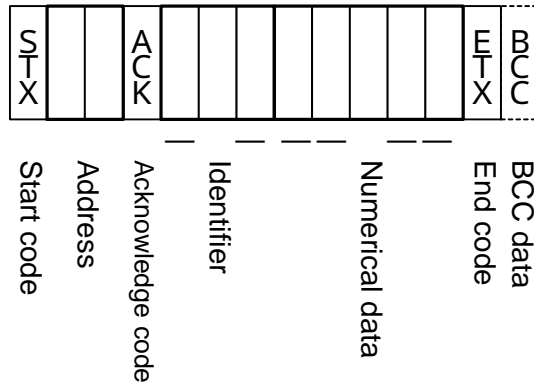
3.3.3 Composition of a store request message



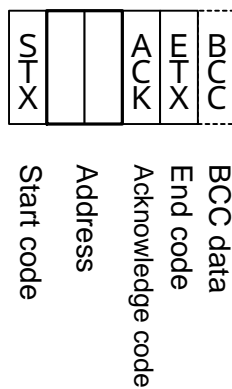
3.4 Composition of a response message (transmitted from this product to a high-level computer)

- For codes to , see "3.5 Description of codes."
- For specific examples of request messages, see "4.1 Examples of communications to be read" and "4.2 Examples of communications to be written."

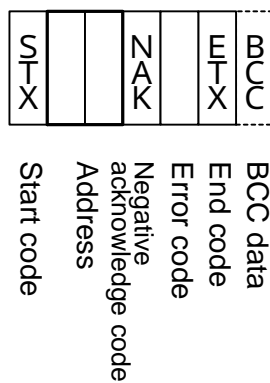
3.4.1 Response message in response to a read request message



3.4.2 Response message in response to a write/store request message



3.4.3 Response message in the case of an error



3.5 Description of codes

- The codes from STX, address to ERR type as indicated below are expressed in ASCII codes.
- For the ASCII codes, see "10. Table of ASCII codes."
- For conversion to ASCII codes, see "4. Examples of TOHO communications."

STX

This code is needed for the receiver to detect the top of the message. It is affixed to the top of a character string to be sent.

Address

This is the address of the party (this product) with whom a high-level computer communicates. The address in the response message from this product indicates the sender of the response message.

Contents requested

Enter a code R or W.

R: to read data from this product

W: to write or store data in this product

Identifier

An identifier is a classification code (identifier) for data to be read or written and expressed in a three-digit alphanumeric ASCII code. See "9. Table of identifiers (codes)."

Numerical data

These are data to be read or written, and are all expressed in five digits regardless of the type.

Negative data: The "-" (minus) sign is in a single digit at the largest digit.

Position of the decimal point: 5-digit data does not include a decimal point.

Example: The table below indicates the significances of 5-digit numerical data 00010.

| Example | Significance of the value |
|--|---------------------------|
| Proportional band (P) | →1.0% |
| Data (PV), etc, whose decimal point can be shifted | |
| When the decimal point setting (DP) is 0 | →10 |
| When the decimal point setting (DP) is 0.1 | →1.0 |

ETX

This code is needed for the receiver to detect the end of a message. It is affixed to the end of a character string to be sent (except for BCC).

BCC

This is a check code for error detection and is the exclusive OR (EX-OR) of all characters from STX to ETX.

If the BCC check is set to "Disabled" in the communications settings in this product, this code (BCC) will not be incorporated in the response message. See "2. Settings regarding TOHO communications."

ACK

It is an acknowledge code. If a message received by this product is error-free, this code will be incorporated in the "response message" from this product and returned.

NAK

It is a negative acknowledge code. If a "request message" received by this product is error-ridden, this code will be incorporated in the "response message" from this product and returned.

If the "request message" received is error-ridden, the error contents (ERR type) will be incorporated in the "response message" from this product, following NAK.

ERR type

If a "request message" received from this product is error-ridden, the error contents (either of the numbers in the table below) will be incorporated in the "response message" from this product, following "NAK."

The error number 0 is an instrument error (memory error or A/D conversion error). It will be incorporated in the "response message" regardless of whether there is an error in the "request message."

The error number 9 is an AT error. It will therefore be incorporated in the "response message" regardless of whether there is an error in the "request message." Remove the cause of the error immediately and start the AT again.

If there are two or more errors occurring at the same time, the largest error number will be incorporated.

The table below indicates the error contents and classifications.

| Error No. | Error contents in the "request message" received by this product |
|-----------|--|
| 0 | Instrument error (memory error or A/D conversion error) |
| 1 | The numerical data deviated from the "range of settings designated specifically with setting items." |
| 2 | The change of requested items is disabled or there are no items to be read. |
| 3 | An ASCII code other than the numerical data was specified in the field of numerical data. An ASCII code other than "0" and "-" was specified in the field of codes. |
| 4 | Format error |
| 5 | BCC error |
| 6 | Overrun error |
| 7 | Framing error |
| 8 | Parity error |
| 9 | A PV error occurred during AT. Or AT will not end 3 hours later. |

3.6 Communications precautions

3.6.1 Communications timing

Set a sufficient response delay to make sure that this product is switched over from transmission to reception with regard to a high-level computer in using an RS-485.

See the figure in "3.1 Communications procedure" and "2.8 Setting a response delay."

3.6.2 Interval between requests

In transmitting a series of "request messages" from a high-level computer, allow for an interval of 1msec or more from the reception of a "response message" from this product to a next transmission.

3.6.3 Response conditions

This product will not return a "response message" unless it receives a "request message" containing an STX and ETX (BCC).

If, therefore, the "request message" is error-ridden, this product will not return a "response message" (error reply) containing a NAK and ERR unless the conditions mentioned above are met.

Therefore, the high-level computer transmits the necessary "request message" again if a "request message" is sent to this product but the latter does not return a "response message" at the end of an appropriate period.

The moment this product receives an STX, it clears all codes received before that.

3.6.4 Errors in address specification

This product will not respond to any "request message" that specifies an address other than that specified for itself. If, therefore, the address portion of a "request message" is error-ridden, none of the mobile units will return a "response message."

Therefore, the high-level computer transmits the necessary "request message" again if a "request message" is sent to this product but the latter does not return a "response message" at the end of an appropriate period.

The moment this product receives an STX, it clears all codes received before that.

3.6.5 Number of digits in data and the decimal position

See "3.5 Description of codes, Numerical data."

3.6.6 Operation after receiving a store request message

This product starts to store data after correctly receiving a store request message from a high-level computer.

This product only stores data different from the contents of the EEPROM (data that is changed). The time (TW) required for storing data is within 6 seconds.

This product transmits a storage-complete reply (ACK) when the data is stored.

This product will not guarantee that the data is stored if this product is turned off during a storage operation. Do not turn off this product for 6 seconds after transmitting a store request message.

3.6.7 Operation after turning on the power

This product will not perform communications (no response) for about 4 seconds after it is turned on. Allow for a delay until communications is started after this product is turned on.

3.6.8 Storing data other than a store request message

Store all parameters in the EEPROM in either of the two cases described below, even if no store request message is received.

- 1) If a parameter is changed by key operation
- 2) If auto-tuning is started and ends normally.

3.6.9 Changing the settings (SV or SV2) by communications during auto-tuning

Even if the settings (SV or SV2) used in control for auto-tuning are changed by communications, the settings (SV or SV2) will not be changed until the auto-tuning ends.

4. Examples of TOHO communications

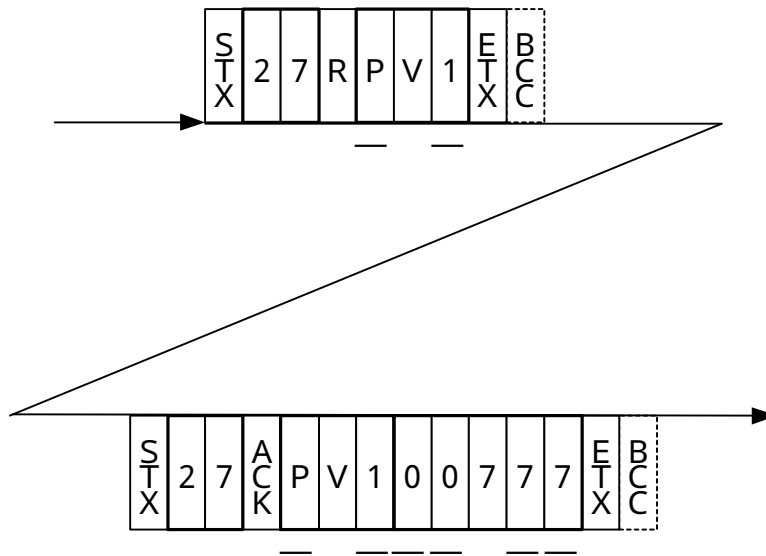
4.1 Examples of communications to be read

Example: Request message: This requests this product set at address 27 to read the PV.
(High-level computer)



Response message: This returns PV data (00777).
(This product)

Read request message (transmitted from the high-level computer)



| Code | Code, data | ASCII code, note 2) |
|---------------------|------------|---------------------|
| Start code | STX | 02H |
| Address | 27 | 32H 37H |
| Request contents | R (Read) | 52H |
| Identifier, note 1) | PV1 | 50H 56H 31H |
| Numerical data | 00777 | 30H 30H 37H 37H 37H |
| End code | ETX | 03H |
| BCC data request | | 61H |
| response | | 02H |
| Acknowledge code | ACK | 06H |

Note 1): See "9. Table of identifiers (codes)."

Note 2): For the ASCII codes, see "10. Table of ASCII codes."

4.2 Examples of communications to be written

Example: Request message: This requests this product set at address 03 to set "the E1F setting to 011" (write 011).
(High-level computer)

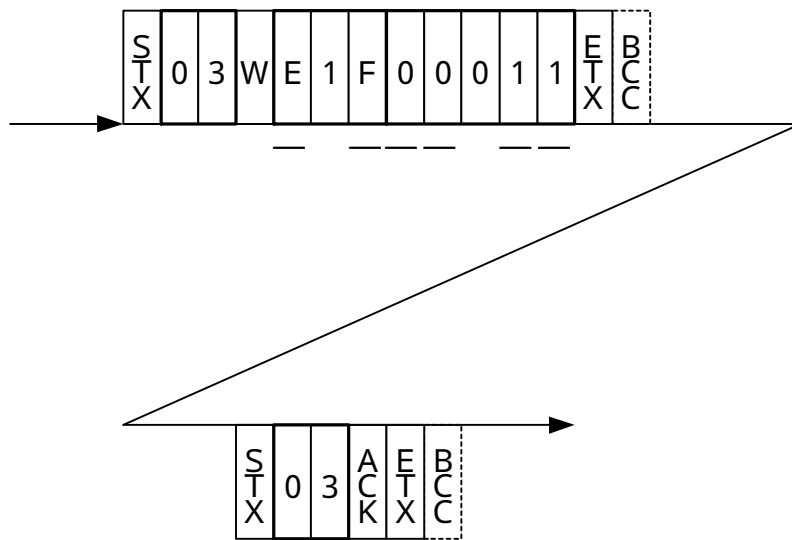
(This sets the function in event 1 to the deviation upper and lower limits + hold.)

In response to that,

Response message: This returns a notice that the request message has been received.
(This product)

*Check that it has been written by reading the data separately.

Write request message (transmitted from a high-level computer)



| Code | Code, data | ASCII code, note 2) |
|---------------------|------------|---------------------|
| Start code | STX | 02H |
| Address | 03 | 30H 33H |
| Request contents | W (Write) | 57H |
| Identifier, note 1) | E1F | 41H 34H 46H |
| Numerical data | 00135 | 30H 30H 30H 31H 31H |
| End code | ETX | 03H |
| BCC data request | | 53H |
| response | | 04H |
| Acknowledge code | ACK | 06H |

Note 1): See "9. Table of identifiers (codes)."

Note 2): For the ASCII codes, see "10. Table of ASCII codes."

5. Settings regarding MODBUS communications

5.1 Overview

Before communications is performed, initial settings must be made on this product. Enter such settings with the keys on the front panel.

To switch to a series of setting screens, take the steps described below.

For details, see the operation manual furnished with this product.

For MODBUS (RTU)

Power ON

Initial setting (for 4 seconds)

Operation mode

MODE key at least 2 seconds

Setting mode selection screen

key

Communications setting mode

MODE key

Set a communications protocol
: MODBUS (RTU) (Initial value:)

MODE key

Set a communications parameter

MODE key

Set a communications speed

MODE key

Set a communications address

MODE key

Set a communications response delay

MODE key

Set communication mode changeover
*The changeover setting is disabled.

MODE key

Back to communications setting mode

For MODBUS (ASCII)

Power ON

Initial setting (for 4 seconds)

Operation mode

MODE key at least 2 seconds

Setting mode selection screen

key

Communications setting mode

MODE key

Set a communications protocol
: MODBUS (ASCII) (Initial value:)

MODE key

Set a communications parameter

MODE key

Set a communications speed

MODE key

Set a communications address

MODE key

Set a communications response delay

MODE key

Set communication mode changeover
*The changeover setting is disabled.

MODE key

Back to communications setting mode

When the settings are over, press the MODE key at least 2 seconds to go back to the operation mode.

5.2 Setting a data length

5.3 Setting a stop bit length

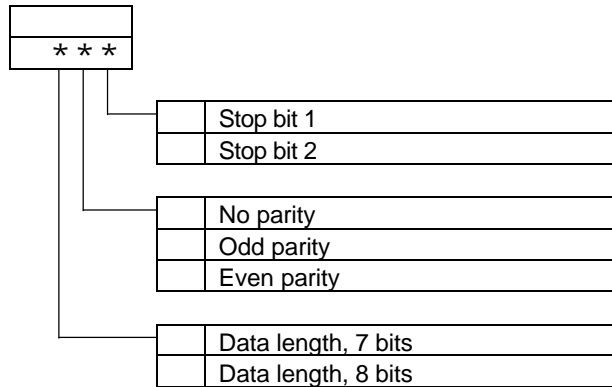
5.4 Setting a parity

5.5 Setting a BCC check

The BCC check is disabled.

Initial value of MODBUS (RTU):

Initial value of MODBUS (ASCII):

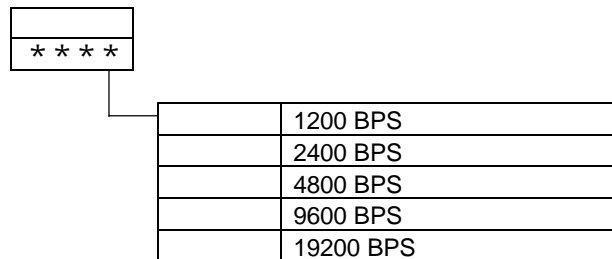


* The RTU mode settings come only in three types: 、 、 .

The ASCII mode settings come only in three types: 、 、 .

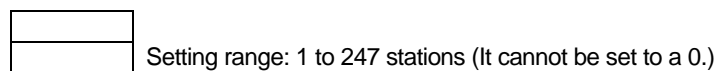
5.6 Setting a communications speed

While in the "Set a communications speed" screen on the preceding page, operate the and keys to make the settings. The initial value is .



5.7 Setting an address

While in the "Set a communications address" screen on the preceding page, operate the and keys to make the settings. The initial value is .



5.8 Setting a response delay

Set a time from the time when the high-level computer finished sending a "request message" until the time when it delivers the line and enters an input state.

While in the "Set a response delay" on the preceding page, operate the and keys to make the settings. The initial value is 0.

| |
|----------------------|
| <input type="text"/> |
| <input type="text"/> |

 Setting range: 0 to 250msec

- * If the response delay is set to a short setting, the communications may not be conducted normally.
- * In a real operation, the processing time for this product will be added, in addition to the response delay.

5.9 Switching communications mode

While in the "Set communication mode changeover" screen on page 17, operate the and keys and make a setting.

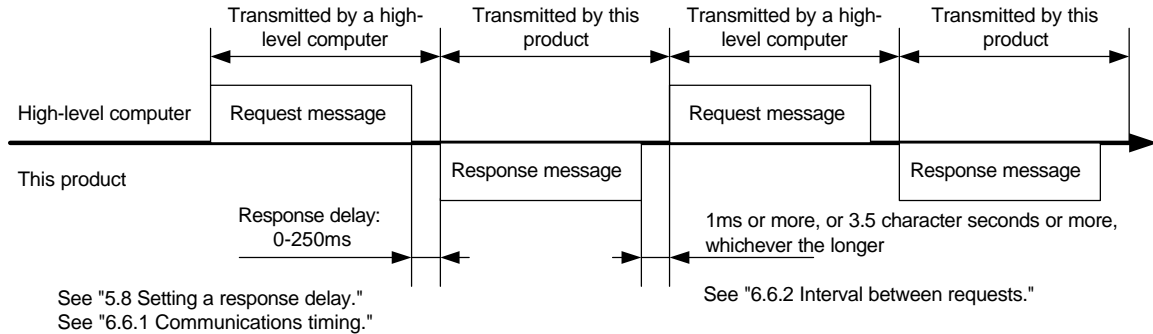
| | |
|----------------------|----------------------|
| <input type="text"/> | <input type="text"/> |
| <input type="text"/> | Read/Write |
| | Read-only |

- * The changeover setting is disabled.

6. MODBUS communications control

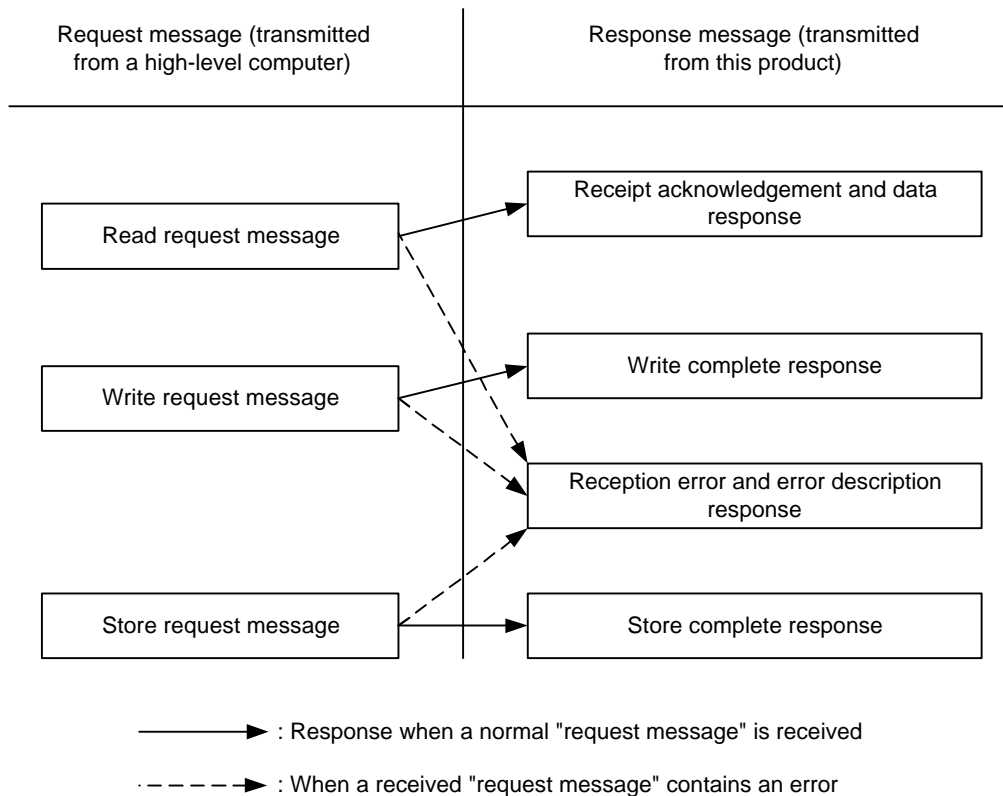
6.1 Communications procedure

This product returns a "response message" in response to a "request message" from a high-level computer. It therefore does not initiate a transmission.



6.2 Message types

- Messages are roughly divided into the following types:



- In RTU codes, the data is binary.
- In ASCII codes, all codes are expressed in ASCII codes.
- In assembling a program for a high-level computer, see "9. Table of identifiers (codes)" and "10. Table of ASCII codes" at the end of the book.

6.3 Composition of an RTU request message (transmitted from a high-level computer to this product)

- For codes a) through i), see "6.5 Description of RTU codes."

6.3.1 Composition of a read request message

| | | | | |
|----|---------------------|------------|-----|------------------------|
| a) | Slave address | | 1BH | |
| b) | Function code | | 03H | |
| c) | Register address | High level | 00H | First register address |
| | | Low level | 00H | |
| d) | Number of registers | High level | 00H | Fixed at 2 |
| | | Low level | 02H | |
| e) | CRC-16 | High level | C6H | |
| | | Low level | 31H | |

6.3.2 Composition of a write request message

| | | | | |
|----|--|------------|-----|--|
| a) | Slave address | | 03H | |
| b) | Function code | | 10H | |
| c) | Register address | High level | 00H | First register address |
| | | Low level | C0H | |
| d) | Number of registers | High level | 00H | Fixed at 2 |
| | | Low level | 02H | |
| f) | Number of data items | | 04H | Number of registers × 2 |
| g) | Data for the first register (a low-level word) | High level | 00H | When writing , , , and H in the data, write them in the order described on the left-hand side. (represents 1 byte.) |
| | | Low level | 6FH | |
| g) | Data for the first register + 1 (a high-level word) | High level | 00H | |
| | | Low level | 00H | |
| e) | CRC-16 | High level | C4H | |
| | | Low level | 5AH | |

6.3.3 Composition of a store request message

| | | | | |
|----|--|------------|-----|---|
| a) | Slave address | | 03H | |
| b) | Function code | | 10H | |
| c) | Register address | High level | 02H | First register address |
| | | Low level | 0EH | |
| d) | Number of registers | High level | 00H | Fixed at 2 |
| | | Low level | 02H | |
| f) | Number of data items | | 04H | Number of registers × 2 |
| g) | Data for the first register (a low-level word) | High level | 00H | The data about the storage of settings is arbitrary. |
| | | Low level | 00H | |
| g) | Data for the first register + 1 (a high-level word) | High level | 00H | |
| | | Low level | 00H | |
| e) | CRC-16 | High level | 60H | |
| | | Low level | FBH | |

6.4 Composition of an RTU response message (transmitted from this product to a high-level computer)

- For codes a) through h), see "6.5 Description of RTU codes."

6.4.1 Response message for a read request message

| | | | | |
|----|--|------------|-----|--|
| a) | Slave address | | 1BH | |
| b) | Function code | | 03H | |
| d) | Number of data items | | 04H | Number of registers × 2 |
| g) | Data for the first register (a low-level word) | High level | 03H | When writing , , , and H in the data, write them in the order described on the left-hand side. (represents 1 byte.) |
| | | Low level | 09H | |
| g) | Data for the first register + 1 (a high-level word) | High level | 00H | |
| | | Low level | 00H | |
| e) | CRC-16 | High level | 91H | |
| | | Low level | B4H | |

6.4.2 Response message for a write/store request message

| | | | | |
|----|---------------------|------------|-----|------------------------|
| a) | Slave address | | 03H | |
| b) | Function code | | 10H | |
| c) | Register address | High level | 00H | First register address |
| | | Low level | 00H | |
| d) | Number of registers | High level | 00H | Fixed at 2 |
| | | Low level | 02H | |
| e) | CRC-16 | High level | 40H | |
| | | Low level | 2AH | |

6.4.3 Response message in the case of an error

| | | |
|----|---------------|------------|
| a) | Slave address | 1BH |
| b) | Function code | 83H |
| h) | Error code | 02H |
| e) | CRC-16 | High level |
| | | Low level |
| | | E1H |
| | | 36H |

← In the case of an error, the function code for the request message + 80H is entered.

6.5 Description of RTU codes

- The codes from a) slave address to b) function code to h) error code shown below are expressed in 8-bit binary numbers.

a) Slave address

This is the address of the party (this product) with which the high-level computer communicates. The address in the response message from this product represents the source of the response message. Note that, when CH2 is used, 2 addresses are occupied. (When the ADR is set to 1, addresses 1 and 2 are occupied.)

b) Function code

Enter a code 03H or 10H.

03H: To read data from this product

10H: To write or store data in this product

c) Register address

The locations of the data to be read or that to be written are specified in 2 bytes.

For the addresses of the commands, see "9. Table of identifiers (codes)."

The data is written in the holding register.

d) Number of registers

This specifies the number of registers to be written in. Since this product has a fixed number of registers (which is 2), specify 0002H.

e) CRC-16

This error check code is for detecting message errors. This transmits a CRC-16 (four redundancy code).

The multinomial for generating a CRC-16 used in this product is $X^{16}+X^{15}+X^2+1$.

To learn how to calculate the CRC-16, see "6.7 Example of CRC-16 calculations."

To affix an error code at the end of the message, affix the low-level byte first, then the high-level byte of the CRC.

f) Number of data

This specifies the number of registers to be read and written x 2. Since the number of registers in this product is fixed at 2, specify 04H here.

g) Data portion

This specifies data to be written in the register. The data is fixed at 4 bytes. This product will write data without the decimal point.

Example: In the case of numerical data

| Example | Significance of the value |
|-------------------------------|---------------------------|
| Proportional band (P) = 1.0 % | 0000000AH |
| PV = 1200.0°C | 00002EE0H |
| SV = -10.00°C | FFFFFC18H |

In the case of text data, write the ASCII code " INP" (is a space): 20494E50H.

h) Error code

If a message from a high-level computer is error-ridden, it will be incorporated in the "response message" from this product and returned.

The error number "04" is an instrument error (memory error or A/D conversion error, AT error). It will be incorporated in the "response message" regardless of whether there is an error in the "request message."

If there are two or more errors occurring at the same time, the largest error number will be incorporated.

The table below indicates the error contents and classifications.

| Error No. | Error contents in the "request message" received by this product |
|-----------|--|
| 01 | Received an unsupported function code. |
| 02 | Received an address other than the specified one. |
| 03 | The numerical data deviated from the "range of settings designated specifically with setting items." |
| 04 | Instrument error (memory error or A/D conversion error, AT error) |

6.6 Precautions on RTU communications

6.6.1 Communications timing

Set a sufficient response delay to make sure that this product is switched over from transmission to reception with regard to a high-level computer in using an RS-485.

See the figure in "6.1 Communications procedure" and "5.8 Setting a response delay."

6.6.2 Interval between requests

In transmitting a series of "request messages" from a high-level computer, allow for an interval of 1msec or more or 3.5 character minutes, whichever the longer, from the reception of a "response message" from this product to a next transmission.

6.6.3 Response conditions

If there is a time interval of 3.5 characters or more between data items constituting a "request message," this product cannot recognize it as a "request message." It will therefore not return a "response message." If, therefore, the "request message" contains an error, this product will not return a "response message" (error reply) containing an ERR unless the above conditions are met. Therefore, the high-level computer transmits the necessary "request message" again if a "request message" is sent to this product but the latter does not return a "response message" at the end of an appropriate period.

The moment a period of 3.5 characters or more has elapsed, it clears all codes received before that.

6.6.4 Errors in address specification

This product will not respond to any "request message" that specifies an address other than that specified for itself. If, therefore, the address portion of a "request message" is error-ridden, none of the mobile units will return a "response message."

Therefore, the high-level computer transmits the necessary "request message" again if a "request message" is sent to this product but the latter does not return a "response message" at the end of an appropriate period.

6.6.5 Number of digits in data and the decimal position

See "6.5 Description of RTU codes, g) Data portion."

6.6.6 Operation after receiving a store request message

This product starts to store data after correctly receiving a store request message from a high-level computer.

This product only stores data different from the contents of the EEPROM (data that is changed). The time (TW) required for storing data is within 6 seconds.

This product transmits a storage-complete reply after the data is stored.

This product will not guarantee that the data is stored if this product is turned off during a storage operation. Do not turn off this product for 6 seconds after transmitting a store request message.

6.6.7 Operation after turning on the power

This product will not perform communications (no response) for about 4 seconds after it is turned on. Allow for a delay until communications is started after this product is turned on.

6.6.8 Storing data other than a store request message

This product will store all parameters in the EEPROM in either of the two cases described below, even if no store request message is received.

- 1) If a parameter is changed by key operation
- 2) If auto-tuning is started and ends normally.

6.6.9 Changing the settings (SV or SV2) by communications during auto-tuning

Even if the settings (SV or SV2) used in control for auto-tuning are changed by communications, the settings (SV or SV2) will not be changed until the auto-tuning ends.

6.7 Example of CRC-16 calculations

Following is an example of calculating CRC-16 with VisualBasic6.0.

Variables are declared as shown below.

VisualBasic6.0 cannot use code-free variables. It therefore uses code-equipped 16-bit integer variables as data. Similarly, the CRC calculation results are entered into code-equipped 32-bit integer variables.

```
Dim CRC As Long
Dim i, j, array_count As Integer

Dim c_next, c_carry As Long
Dim crc_array(64) As Integer
```

Then enter calculable data into the `crc_array()`, and enter the number of data items into the `array_count`. After that, run the following program to cause the calculation results to enter the CRC.

```
i = 0
CRC = 65535
For i = 0 To array_count
    c_next = crc_array(i)
    CRC = (CRC Xor c_next) And 65535
    For j = 0 To 7
        c_carry = CRC And 1
        CRC = CRC ¥ 2
        If c_carry Then
            CRC = (CRC Xor &HA001) And 65535
        End If
    Next
Next
```

To affix an error code to the end of the message, affix first the low-level byte and then the high-level byte of the CRC.

6.8 Composition of an ASCII request message (transmitted from a high-level computer to this product)

- For the codes a) through g), see "6.10 Description of ASCII codes."

6.8.1 Composition of a read request message

| | | | | |
|----|---------------------|------------|----------|------------------------|
| a) | Start code | | “.” | |
| b) | Slave address | | “1”, “B” | |
| c) | Function code | | “0”, “3” | |
| d) | Register address | High level | “0”, “0” | First register address |
| | | Low level | “0”, “0” | |
| e) | Number of registers | High level | “0”, “0” | Fixed at 2 |
| | | Low level | “0”, “2” | |
| f) | LRC | | “E”, “0” | |
| g) | End code | | CR, LF | |

6.8.2 Composition of a write request message

| | | | | |
|----|--|------------|----------|--|
| a) | Start code | | “.” | |
| b) | Slave address | | “0”, “3” | |
| c) | Function code | | “1”, “0” | |
| d) | Register address | High level | “0”, “0” | First register address |
| | | Low level | “C”, “0” | |
| e) | Number of registers | High level | “0”, “0” | Fixed at 2 |
| | | Low level | “0”, “2” | |
| h) | Number of data items | | “0”, “4” | Number of registers × 2 |
| i) | Data for the first register (a low-level word) | High level | “0”, “0” | When writing , , , and H in the data, write them in the order described on the left-hand side. (represents 1 byte.) |
| | | Low level | “6”, “F” | |
| i) | Data for the first register + 1 (a high-level word) | High level | “0”, “0” | |
| | | Low level | “0”, “0” | |
| f) | LRC | | “E”, “0” | |
| g) | End code | | CR, LF | |

6.8.3 Composition of a store request message

| | | | | |
|----|--|------------|----------|---|
| a) | Start code | | “.” | |
| b) | Slave address | | “0”, “3” | |
| c) | Function code | | “1”, “0” | |
| d) | Register address | High level | “0”, “2” | First register address |
| | | Low level | “0”, “E” | |
| e) | Number of registers | High level | “0”, “0” | Fixed at 2 |
| | | Low level | “0”, “2” | |
| h) | Number of data items | | “0”, “4” | Number of registers × 2 |
| i) | Data for the first register (a low-level word) | High level | “0”, “0” | The data about the storage of settings is arbitrary. |
| | | Low level | “0”, “0” | |
| | Data for the first register + 1 (a high-level word) | High level | “0”, “0” | |
| | | Low level | “0”, “0” | |
| f) | LRC | | “D”, “7” | |
| g) | End code | | CR, LF | |

6.9 Composition of ASCII response messages (transmitted from this product to a high-level computer)

- For the codes a) through g), see "6.10 Description of ASCII codes."

6.9.1 Response message for a read request message

| | | | | |
|----|--|------------|----------|--|
| a) | Start code | | “.” | |
| b) | Slave address | | “1”, “B” | |
| c) | Function code | | “0”, “3” | |
| h) | Number of data items | | “0”, “4” | Number of registers × 2 |
| i) | Data for the first register (a low-level word) | High level | “0”, “3” | When writing , , , and H in the data, write them in the order described on the left-hand side. (represents 1 byte.) |
| | | Low level | “0”, “9” | |
| | Data for the first register + 1 (a high-level word) | High level | “0”, “0” | |
| | | Low level | “0”, “0” | |
| f) | LRC | | “D”, “2” | |
| g) | End code | | CR, LF | |

6.9.2 Response message for a write/store request message

| | | | | |
|----|---------------------|------------|----------|------------------------|
| a) | Start code | | "." | |
| b) | Slave address | | "0", "3" | |
| c) | Function code | | "1", "0" | |
| d) | Register address | High level | "0", "0" | First register address |
| | | Low level | "0", "0" | |
| e) | Number of registers | High level | "0", "0" | Fixed at 2 |
| | | Low level | "0", "2" | |
| f) | LRC | | "E", "B" | |
| g) | End code | | CR, LF | |

6.9.3 Response message in the case of an error

| | | | | |
|----|---------------|--|----------|--|
| a) | Start code | | "." | |
| b) | Slave address | | "1", "B" | |
| h) | Function code | | "8", "3" | ← In the case of an error, the function code for the request message + 80H is entered. |
| j) | Error code | | "0", "2" | |
| f) | LRC | | "6", "0" | |
| g) | End code | | CR, LF | |

6.10 Description of ASCII codes

- The codes from a) start code to b) slave address to j) error type described below are expressed in ASCII codes.
- For ASCII codes, see "10. Table of ASCII codes."
- For converting to ASCII codes, see 6.8 and 6.9 "Message composition."

a) Start code

The receiver side is the code required for detecting the top of the message. It is affixed to the top of a character string to be transmitted.

b) Slave address

This is the address of the party (this product) with which the high-level computer communicates. The address in the response message from this product represents the source of the response message. Note that, when CH2 is used, 2 addresses are occupied. (When the ADR is set to 1, addresses 1 and 2 are occupied.)

c) Function code

Enter a code 03H or 10H.

03H: To read data from this product

10H: To write or store data in this product

- d) Number of registers
This specifies the number of registers to be written in. Since this product has a fixed number of registers (which is 2), specify 0002H.
- e) Register address
The locations of the data to be read or that to be written are specified in 2 bytes. For the addresses of the commands, see "9. Table of identifiers (codes)."
- f) LRC
LRC is an error check code for detecting message errors. An LRC is transmitted. The LRC used in this product is the 2-complement of the sum of the data portions without a carry, except for the start code and end code of the message.
The parts of the data portions expressed as a "1" and "B" are considered as "1BH."
To learn how to calculate the LRC, see "6.12 Example of LRC calculations."
If 12H is calculated as an error code, affix a "1" or "2" at the end of the message.
- g) End code
This code is required for the receiver to detect the end of a message. Affix CR (0DH) and LF (0AH) at the end of a character string to be transmitted.
- h) Number of data
This specifies the number of registers to be read and written x 2. Since the number of registers in this product is fixed at 2, specify 04H here.
- i) Data portion
This specifies data to be written in the register. The data is fixed at 4 bytes. This product will write data without the decimal point.

Example: In the case of numerical data

| Example | Significance of the value |
|-------------------------------|---------------------------|
| Proportional band (P) = 1.0 % | 0000000AH |
| PV = 1200.0°C | 00002EE0H |
| SV = -10.00°C | FFFFFFC18H |

In the case of text data, write the ASCII code " INP" (is a space): 20494E50H.

j) Error code

If a message from a high-level computer is error-ridden, it will be incorporated in the "response message" from this product and returned.

The error number "0" is an instrument error (memory error or A/D conversion error). It will be incorporated in the "response message" regardless of whether there is an error in the "request message."

Error number "9" is an AT error. It is therefore incorporated into the "response message" regardless of whether the "request message" is error-ridden. Remove the cause of the error immediately and start the AT again.

If there are two or more errors occurring at the same time, the largest error number will be incorporated.

The table below indicates the error contents and classifications.

| Error No. | Error contents in the "request message" received by this product |
|-----------|--|
| 0 | Instrument failure (memory error or A/D conversion error) |
| 1 | The numerical data was out of a "specific setting range specified with a setting item." |
| 2 | The required modification in an item is prohibited, or such an item to be read does not exist. |
| 3 | Reservation number |
| 4 | Format error |
| 5 | LRC error |
| 6 | Overrun error |
| 7 | Framing error |
| 8 | Parity error |
| 9 | A PV error occurred during AT. Or AT does not end 3 hours later. |

6.11 Precautions on ASCII communications

6.11.1 Communications timing

Set a sufficient response delay to make sure that this product is switched over from transmission to reception with regard to a high-level computer in using an RS-485.

See the figure in "6.1 Communications procedure" and "5.8 Setting a response delay."

6.11.2 Interval between requests

In transmitting a series of "request messages" from a high-level computer, allow for an interval of 1msec or more or 3.5 character minutes, whichever the longer, from the reception of a "response message" from this product to a next transmission.

6.11.3 Response conditions

This product will not return a "response message" unless the "request message" contains a start code and end code.

If, therefore, the "request message" contains an error, this product will not return a "response message" (error reply) containing an error code unless the above conditions are met.

Therefore, high-level computer transmits the necessary "request message" again if a "request message" is sent to this product but the latter does not return a "response message" at the end of an appropriate period.

The moment a start code is received, this product clears all codes received before that.

6.11.4 Errors in address specification

This product will not respond to any "request message" that specifies an address other than that specified for itself. If, therefore, the address portion of a "request message" is error-ridden, none of the mobile units will return a "response message."

Therefore, the high-level computer transmits the necessary "request message" again if a "request message" is sent to this product but the latter does not return a "response message" at the end of an appropriate period.

The moment a start is received, this product clears all codes received before that.

6.11.5 Number of digits in data and the decimal position

See "6.10 Description of ASCII codes, i) Data portion."

6.11.6 Operation after receiving a store request message

This product starts to store data after correctly receiving a store request message from a high-level computer.

This product only stores data different from the contents of the EEPROM (data that is changed). The time (TW) required for storing data is within 6 seconds.

This product transmits a storage-complete reply after the data is stored.

This product will not guarantee that the data is stored if this product is turned off during a storage operation. Do not turn off this product for 6 seconds after transmitting a store request message.

6.11.7 Operation after turning on the power

This product will not perform communications (no response) for about 4 seconds after it is turned on. Allow for a delay until communications is started after this product is turned on.

6.11.8 Storing data other than a store request message

This product will store all parameters in the EEPROM in either of the two cases described below, even if no store request message is received.

- 1) If a parameter is changed by key operation
- 2) If auto-tuning is started and ends normally.

6.11.9 Changing the settings (SV or SV2) by communications during auto-tuning

Even if the settings (SV or SV2) used in control for auto-tuning are changed by communications, the settings (SV or SV2) will not be changed until the auto-tuning ends.

6.12 Example of LRC calculations

Following is an example of calculating LRC with VisualBasic6.0.

Variables are declared as shown below.

VisualBasic6.0 cannot use code-free variables. It therefore uses code-equipped 16-bit integer variables as data. Similarly, the LRC calculation results are entered into code-equipped 16-bit integer variables.

```
Dim LRC As Integer
Dim i, array_count As Integer

Dim lrc_array(128) As Integer
```

Then enter calculable data into the `lrc_array()`, and enter the number of data items into the `array_count`. After that, run the following program to cause the calculation results to enter the LRC.

```
For i = 0 To array_count
    LRC = (LRC + lrc_array(i)) And &HFF
Next
```

```
LRC = ((Not LRC) + 1) And &HFF
```

If the error code is calculated as 12H as an example, affix a "1" or "2" at the end of the message.

7. Specifications

7.1 Communications standard category

Compliant with EIA standard RS-485

7.2 Communications specifications

7.2.1 Communications system

Network: Multi-drop system (up to 1 pair, 31 stations)
Direction of information: Half duplex
Synchronization system: Asynchronous
Transmission code: ASCII, 7 bit code, except for BBC data
(highest-level bit = 0 in 8-bit code)

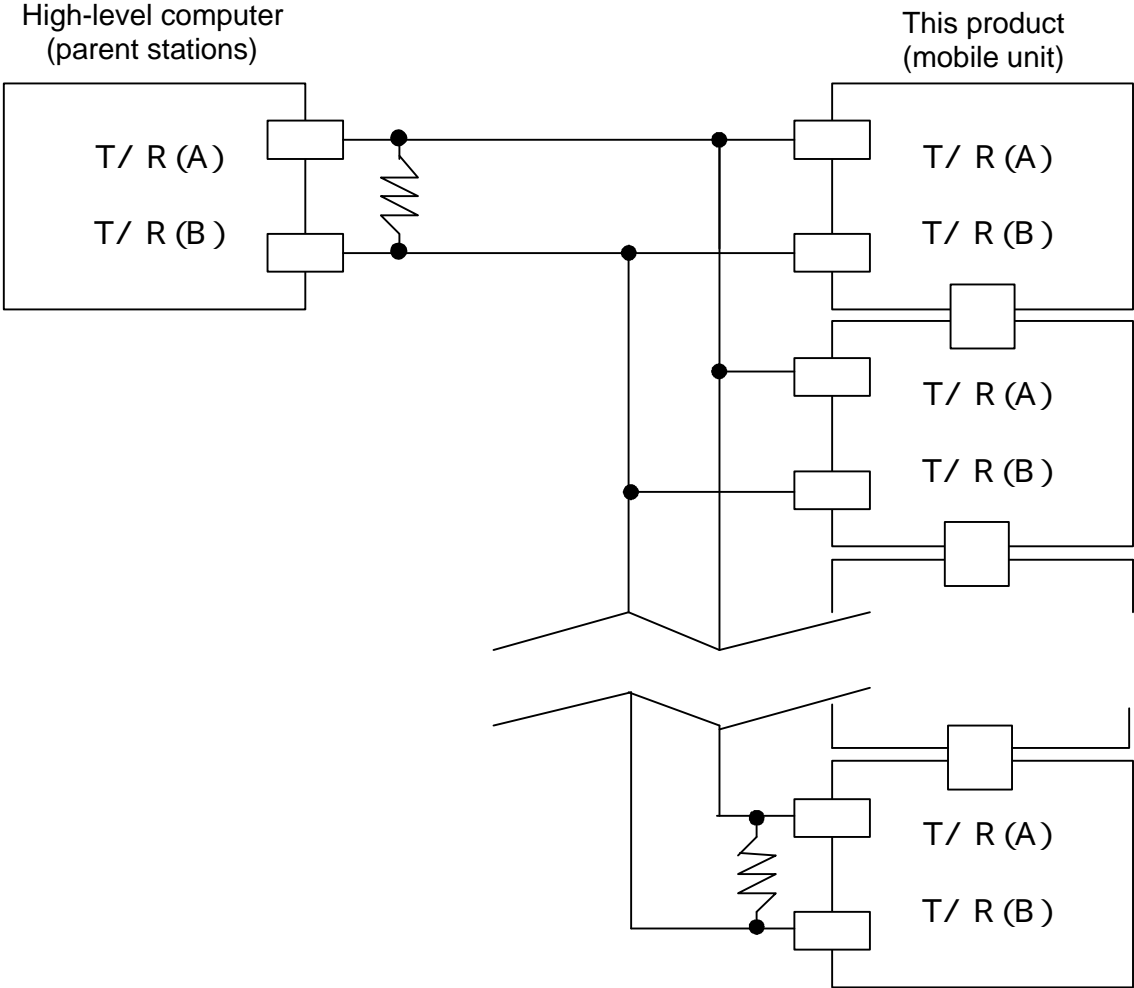
7.2.2 Interface system

Signal line: 2 lines for transmission and reception
Communications speed: 1,200, 2,400, 4,800, 9,600 and 19,200 bps and this product is set to it.
Communications distance: 500m maximum
Provided that it varies somewhat depending on the cable and other ambient conditions.

7.2.3 Character

- 1) TOHO communications protocols
Start bit length: Fixed at 1 bit
Stop bit length: Either 1 or 2 bit is selected and this product is set to it.
Data length: Either 7 or 8 bit is selected and this product is set to it.
Parity: No. Either odd or even is selected and this product is set to it.
BCC check: Yes or no is selected and this product is set to it.
Communications address: 1-99
- 2) MODBUS communications (RTU) protocols
Start bit length: Fixed at 1 bit
Stop bit length: Either 1 or 2 bit is selected and this product is set to it. (If parity-equipped, fixed at 1 bit.)
Data length: Fixed at 8 bit.
Parity: No. Either odd or even is selected and this product is set to it.
CRC-16 check: Fixed at yes.
Communications address: 1-247
- 3) MODBUS communications (ASCII) protocols
Start bit length: Fixed at 1 bit
Stop bit length: Either 1 or 2 bit is selected and this product is set to it. (If parity-equipped, fixed at 1 bit.)
Data length: Fixed at 7 bit.
Parity: No. Either odd or even is selected and this product is set to it.
LRC check: Fixed at yes.
Communications address: 1-247
- 4) MODBUS communications (RTU/ASCII) function codes
03H (reading the contents of the holding register)
10H (writing the contents of two or more holding registers)

8. Connections



Install an end of line resistor at both of the farthest devices in the parent station and the mobile unit. For a resistance value, use one that matches the characteristic impedance of the cable. Provided that the synthesis is set to at least 75Ω.

9. Table of identifiers (codes)

■ For the setting range, options, initial values, and similar parameters, see the operation manual for this system.

- a) Identifier: This code represents an item. Enter this code in the identifier field in the message. The in the frame represents an SP (ASCII code: 20H).
- b) Character: The character to be displayed on the system screen.
- c) Name: Item name
- d) R/W: This specifies which is possible: reading, writing, or both.
- e) Description:

Note: The R/W to characters that do not meet the display conditions responds with "NAK2."

Example: If no EV2 option is selected, the R/W to the EV2 character becomes "NAK2."

| Identifier | Relative address | Absolute address | Character | Name | R/W | Description |
|------------|------------------|------------------|-----------|------------------------------------|-----|---|
| PV1 | 0000h | 40001 | | Setting value (PV) | R | Use it as monitor for measurements (PV). When overscale: HHHH When underscale: LLLL |
| SV1 | 0002h | 40003 | | Setting value (SV) | R/W | R/W the setting value (SV) |
| PR1 | 0004h | 40005 | | Priority screen function setting 1 | R/W | RW the priority screen function setting 1 Example: □□ INP (identifier) |
| PR2 | 0006h | 40007 | | Priority screen function setting 2 | R/W | RW the priority screen function setting 2 Example: INP (identifier) |
| PR3 | 0008h | 40009 | | Priority screen function setting 3 | R/W | RW the priority screen function setting 3 Example: INP (identifier) |
| PR4 | 000Ah | 40011 | | Priority screen function setting 4 | R/W | RW the priority screen function setting 4 Example: INP (identifier) |
| PR5 | 000Ch | 40013 | | Priority screen function setting 5 | R/W | RW the priority screen function setting 5 Example: INP (identifier) |
| PR6 | 000Eh | 40015 | | Priority screen function setting 6 | R/W | RW the priority screen function setting 6 Example: INP (identifier) |
| PR7 | 0010h | 40017 | | Priority screen function setting 7 | R/W | RW the priority screen function setting 7 Example: INP (identifier) |
| PR8 | 0012h | 40019 | | Priority screen function setting 8 | R/W | RW the priority screen function setting 8 Example: INP (identifier) |
| PR9 | 0014h | 40021 | | Priority screen function setting 9 | R/W | RW the priority screen function setting 9 Example: INP (identifier) |
| INP | 0016h | 40023 | | Set a input type | R/W | R/W the input type setting |
| PVG | 0018h | 40025 | | Set a PV corrected gain | R/W | R/W the PV corrected gain setting |
| PVS | 001Ah | 40027 | | Set a PV corrected zero point | R/W | R/W the PV corrected zero point setting |
| PDF | 001Ch | 40029 | | Set an input filter | R/W | R/W the input filter setting |
| DP | 001Eh | 40031 | | Set a decimal position | R/W | R/W the decimal position setting No decimal point: 00000 Decimal point: 00001 |
| FU | 0020h | 40033 | | Set a function key function | R/W | R/W the function key function setting |
| LOC | 0022h | 40035 | | Set a key lock | R/W | R/W the key lock setting |
| SLH | 0024h | 40037 | | Set an SV limiter upper limit | R/W | R/W the SV limiter upper limit setting |
| SLL | 0026h | 40039 | | Set an SV limiter lower limit | R/W | R/W the SV limiter lower limit setting |

| Identifier | Relative address | Absolute address | Character | Name | R/W | Description |
|------------|------------------|------------------|-----------|--|-----|--|
| MD | 0028h | 40041 | | Set control mode | R/W | R/W the control mode setting Control execution: 00000 Manual control: 00001 Control stop: 00002 Auto-tuning in progress: 00003 |
| CNT | 002Ah | 40043 | | Set a control type | R/W | R/W the control type setting |
| DIR | 002Ch | 40045 | | Set forward/reverse operation switchover | R/W | R/W the forward/reverse operation switchover setting |
| MV1 | 002Eh | 40047 | | Output 1 operation amount | R/W | R/W the output 1 operation amount |
| TUN | 0030h | 40049 | | Set a tuning type | R/W | R/W the tuning type setting |
| ATG | 0032h | 40051 | | AT factor | R/W | R/W the AT factor |
| ATC | 0034h | 40053 | | AT sensitivity | R/W | R/W the AT sensitivity |
| P1 | 0036h | 40055 | | Set an output 1 proportional band | R/W | R/W the output 1 proportional band setting |
| I1 | 0038h | 40057 | | Set an integral time | R/W | R/W the integral time setting |
| D1 | 003Ah | 40059 | | Set a derivative time | R/W | R/W the derivative time setting |
| T1 | 003Ch | 40061 | | Set an output 1 proportional frequency | R/W | R/W the output 1 proportional frequency setting |
| ARW | 003Eh | 40063 | | Anti-reset windup | R/W | R/W the anti-reset windup |
| MH1 | 0040h | 40065 | | Set an amount-of-operation limiter upper limit | R/W | R/W the amount-of-operation limiter upper limit setting |
| ML1 | 0042h | 40067 | | Set an amount-of-operation limiter lower limit | R/W | R/W the amount-of-operation limiter lower limit setting |
| C1 | 0044h | 40069 | | Set an output 1 control sensitivity | R/W | R/W the output 1 control sensitivity setting |
| CP1 | 0046h | 40071 | | Set an output 1 off-point position | R/W | R/W the output 1 off-point position setting |
| MV2 | 0048h | 40073 | | Output 2 operation amount | R/W | R/W the output 2 operation amount |
| P2 | 004Ah | 40075 | | Set an output 2 proportional band | R/W | R/W the output 2 proportional band setting |
| T2 | 004Ch | 40077 | | Set an output 2 proportional frequency | R/W | R/W the output 2 proportional frequency setting |
| MH2 | 004Eh | 40079 | | Set an amount-of-operation limiter upper limit | R/W | R/W the amount-of-operation limiter upper limit setting |
| ML2 | 0050h | 40081 | | Set an amount-of-operation limiter lower limit | R/W | R/W the amount-of-operation limiter lower limit setting |
| C2 | 0052h | 40083 | | Set an output 2 control sensitivity | R/W | R/W the output 2 control sensitivity setting |
| CP2 | 0054h | 40085 | | Set an output 2 off-point position | R/W | R/W the output 2 off-point position setting |
| PBB | 0056h | 40087 | | Manual reset | R/W | R/W the manual reset |
| DB | 0058h | 40089 | | Set a dead band | R/W | R/W the dead band setting |
| RP1 | 005Ah | 40091 | | Set an SV lamp time | R/W | R/W the SV lamp time setting |
| RP2 | 005Ch | 40093 | | Set an SV2 lamp time | R/W | R/W the SV2 lamp time setting |
| E1F | 005Eh | 40095 | | Set a PV event output 1 function | R/W | R/W the PV event output 1 function setting |
| E1H | 0060h | 40097 | | Set an event output 1 upper limit | R/W | R/W the event output 1 upper limit setting |
| E1L | 0062h | 40099 | | Set an event output 1 lower limit | R/W | R/W the event output 1 lower limit setting |
| E1C | 0064h | 40101 | | Set an event output 1 sensitivity | R/W | R/W the event output 1 sensitivity setting |
| E1T | 0066h | 40103 | | Set an event output 1 delay timer | R/W | R/W the event output 1 delay timer setting |

| Identifier | Relative address | Absolute address | Character | Name | R/W | Description |
|------------|------------------|------------------|-----------|---|-----|--|
| E1B | 0068h | 40105 | | Set a special event output 1 function | R/W | R/W the special event output 1 function setting |
| E1P | 006Ah | 40107 | | Set an event output 1 polarity | R/W | R/W the event output 1 polarity setting |
| CM1 | 006Ch | 40109 | | CT input monitor | R | Read the CT input monitor |
| CT1 | 006Eh | 40111 | | Set an event output 1 current abnormality | R/W | R/W the event output 1 current abnormality setting |
| E2F | 0070h | 40113 | | Set a PV event output 2 function | R/W | R/W the PV event output 2 function setting |
| E2H | 0072h | 40115 | | Set an event output 2 upper limit | R/W | R/W the event output 2 upper limit setting |
| E2L | 0074h | 40117 | | Set an event output 2 lower limit | R/W | R/W the event output 2 lower limit setting |
| E2C | 0076h | 40119 | | Set an event output 2 sensitivity | R/W | R/W the event output 2 sensitivity setting |
| E2T | 0078h | 40121 | | Set an event output 2 delay timer | R/W | R/W the event output 2 delay timer setting |
| E2B | 007Ah | 40123 | | Set a special event output 2 function | R/W | R/W the special event output 2 function setting |
| E2P | 007Ch | 40125 | | Set an event output 2 polarity | R/W | R/W the event output 2 polarity setting |
| CM2 | 007Eh | 40127 | | CT input monitor | R | Read the CT input monitor |
| CT2 | 0080h | 40129 | | Set an event output 2 current abnormality | R/W | R/W the event output 2 current abnormality setting |
| DIF | 0082h | 40131 | | Set a DI input function | R/W | R/W the DI input function setting |
| DIP | 0084h | 40133 | | Set a DI polarity | R/W | R/W the DI polarity setting |
| SV2 | 0086h | 40135 | | Control setting 2 | R/W | R/W the control setting 2 |
| PRT | 0088h | 40137 | | Set a communications protocol | R/W | R/W the communications protocol setting Special-purpose protocol: 00000 MODBUS (RTU): 00001 MODBUS (ASCII): 00002 |
| COM | 008Ah | 40139 | | Set a communications parameter | R/W | R/W the communications parameter setting Example: B8N2 |
| BPS | 008Ch | 40141 | | Set a communications speed | R/W | R/W the communications speed setting Example: 00096 (if 9600 bps) |
| ADR | 008Eh | 40143 | | Set a communications address | R/W | R/W the communications address setting |
| AWT | 0090h | 40145 | | Set a response delay | R/W | R/W the response delay setting |
| MOD | 0092h | 40147 | | Set communications mode switchover | R/W | R/W the communications mode switchover setting RO: 00000 RW: 00001 |
| TMO | 0094h | 40149 | | Set a timer output destination | R/W | R/W the timer output destination setting |
| TMF | 0096h | 40151 | | Set a timer function | R/W | R/W the timer function setting |
| H/M | 0098h | 40153 | | Timer unit switchover | R/W | R/W the timer unit switchover setting |
| TSV | 009Ah | 40155 | | Set a timer SV start tolerance | R/W | R/W the timer SV start tolerance setting |
| TIM | 009Ch | 40157 | | Set a timer time | R/W | R/W the timer time setting |
| TIA | 009Eh | 40159 | | Set a timer remaining time monitor | R | Read the timer remaining time monitor |
| TRF | 00A0h | 40161 | | Set a transmission output function | R/W | R/W the transmission output function setting |

| Identifier | Relative address | Absolute address | Character | Name | R/W | Description |
|------------|------------------|------------------|-----------|--|-----|---|
| TRP | 00A2h | 40163 | | Set a forward/reverse operation switchover for transmission output | R/W | R/W the forward/reverse operation switchover setting for transmission output |
| TRH | 00A4h | 40165 | | Set an upper limit for transmission output scaling | R/W | R/W the upper limit setting for transmission output scaling |
| TRL | 00A6h | 40167 | | Set an lower limit for transmission output scaling | R/W | R/W the lower limit setting for transmission output scaling |
| TST | 00A8h | 40169 | | Timer start/stop | R/W | R/W the timer start/stop Start: 00001 Stop: 00000 |
| OM1 | 00AAh | 40171 | | Output status monitor | R | Read the output monitor : OUT1 (1:ON 0:OFF) : OUT2 (1:ON 0:OFF) : EV1 (1:ON 0:OFF) : EV2 (1:ON 0:OFF) |
| EM1 | 00ACh | 40173 | | DI status monitor | R | Read the DI monitor ON: 00001 OFF: 00000 |
| AT | 00AEh | 40175 | | Start/release AT | R/W | R/W the start/release AT |
| STR | 00B0h | 40177 | | Store data | w | Store data |

Identifiers used only in blind setting

| Identifier | Relative address | Absolute address | Character | Name | L/B | Description |
|------------|------------------|------------------|-----------|------|-----|---|
| 000 | | | | SET0 | L/B | Blinding enabled: 00000 Blinding disabled: 00001 |
| 001 | | | | SET1 | L/B | Blinding enabled: 00000 Blinding disabled: 00001 |
| 002 | | | | SET2 | L/B | Blinding enabled: 00000 Blinding disabled: 00001 |
| 003 | | | | SET3 | L/B | Blinding enabled: 00000 Blinding disabled: 00001 |
| 004 | | | | SET4 | L/B | Blinding enabled: 00000 Blinding disabled: 00001 |
| 005 | | | | SET5 | L/B | Blinding enabled: 00000 Blinding disabled: 00001 |
| 006 | | | | SET6 | L/B | Blinding enabled: 00000 Blinding disabled: 00001 |
| 007 | | | | SET7 | L/B | Blinding enabled: 00000 Blinding disabled: 00001 |
| 008 | | | | SET8 | L/B | Blinding enabled: 00000 Blinding disabled: 00001 |

10. Table of ASCII codes

| | | | | | | | | |
|------------|-------------------|-----|-----|-----|-----|-----|-----|-----|
| ASCII code | 00H | 01H | 02H | 03H | 04H | 05H | 06H | 07H |
| Code used | NUL | SOH | STX | ETX | EOT | ENQ | ACK | BEL |
| ASCII code | 08H | 09H | 0AH | 0BH | 0CH | 0DH | 0EH | 0FH |
| Code used | BS | HT | LF | VT | FF | CR | SO | SI |
| ASCII code | 10H | 11H | 12H | 13H | 14H | 15H | 16H | 17H |
| Code used | DLE | DC1 | DC2 | DC3 | DC4 | NAK | SYM | ETB |
| ASCII code | 18H | 19H | 1AH | 1BH | 1CH | 1DH | 1EH | 1FH |
| Code used | CAN | EM | SUB | ESC | FS | GS | RS | US |
| ASCII code | 20H | 21H | 22H | 23H | 24H | 25H | 26H | 27H |
| Code used | λ [°] -λ | ! | " | # | \$ | % | & | ' |
| ASCII code | 28H | 29H | 2AH | 2BH | 2CH | 2DH | 2EH | 2FH |
| Code used | (|) | * | + | , | - | . | / |
| ASCII code | 30H | 31H | 32H | 33H | 34H | 35H | 36H | 37H |
| Code used | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ASCII code | 38H | 39H | 3AH | 3BH | 3CH | 3DH | 3EH | 3FH |
| Code used | 8 | 9 | : | ; | < | = | > | ? |
| ASCII code | 40H | 41H | 42H | 43H | 44H | 45H | 46H | 47H |
| Code used | @ | A | B | C | D | E | F | G |
| ASCII code | 48H | 49H | 4AH | 4BH | 4CH | 4DH | 4EH | 4FH |
| Code used | H | I | J | K | L | M | N | O |
| ASCII code | 50H | 51H | 52H | 53H | 54H | 55H | 56H | 57H |
| Code used | P | Q | R | S | T | U | V | W |
| ASCII code | 58H | 59H | 5AH | 5BH | 5CH | 5DH | 5EH | 5FH |
| Code used | X | Y | Z | [| ¥ |] | ^ | _ |
| ASCII code | 60H | 61H | 62H | 63H | 64H | 65H | 66H | 67H |
| Code used | ' | a | b | c | d | e | f | g |
| ASCII code | 68H | 69H | 6AH | 6BH | 6CH | 6DH | 6EH | 6FH |
| Code used | h | i | j | k | l | m | n | o |
| ASCII code | 70H | 71H | 72H | 73H | 74H | 75H | 76H | 77H |
| Code used | p | q | r | s | t | u | v | w |
| ASCII code | 78H | 79H | 7AH | 7BH | 7CH | 7DH | 7EH | 7FH |
| Code used | x | y | z | { | | } | ~ | DEL |



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