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Rev. 2.01

Hitachi Finger Vein Authentication Device H2E

Serial Interface Specification

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All the information contained in this document is subject to change without prior notice.

Urban Planning and Development Systems Company,

Hitachi, Ltd.

Revision History

No.	Date	Chapter	Description	Remarks
2.0	Oct. 2, 2010	-	New release	Based on Japanese Ver. 2.00
2.1	June 17,2011	-	Added firmware version table	Based on Japanese Ver. 2.01

Firmware version

No.	Model name	Firmware version	Remarks
1	PCT-KCC5031/PCT-KCC9031	02-00	New release
2	PCT-KCC5031/PCT-KCC9031	02-01	Fixed wrong detection of flash ROM error (i.e. 7Ch).

1. Introduction

This document describes the communication and command interface of the embedded type Hitachi Finger Vein Authentication Device (hereafter referred to as "H2E"). H2E is able to store the template data of finger vein in either a non-volatile memory (i.e. flash ROM) or a volatile memory (i.e. SDRAM) installed inside the H2E itself. Therefore, the host system is not required to store the template data.

1.1 Scope of the document

Fig. 1-1 shows the scope of this document.

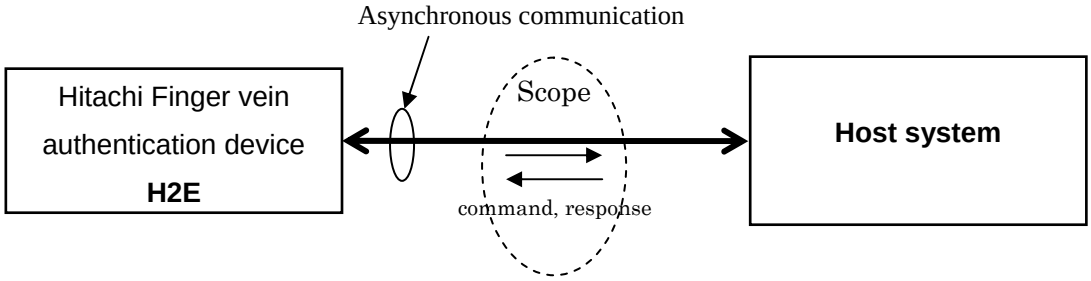


Fig.1-1 Scope of the document

1.2 Description

(1) A subscripted suffix “h” (e.g. “1234h”) means that the numeral is hexadecimal.

(2) Definition of symbols

No.	Symbol	Meaning
1	BYTE	8 bit unsigned integer
2	WORD	16 bit unsigned integer in big-endian format
3	DWORD	32 bit unsigned integer in big-endian format

The number in brackets after any of the symbols shown above represents the total length of data. For example, “BYTE[3]” means there are 3 bytes of data.

(3) A bit is shown as “bit”. The number after the “bit” will represent the numeral of the bit referred. The very right end bit is bit0. Counting right to left from bit0, the very left bit in the case of “BYTE” will be bit7, “WORD” will be bit15 and “DWORD” will be bit31. Therefore, the binary data “00100000” will be shown as “bit5 is ON”.

1.3 Related document

(1) Hitachi Finger Vein Authentication Device (PCT-KCC50*1/PCT-KCC90*1) Application Notes

2. Interface Specification

2.1 Communication specification

H2E communicates with the host system by an asynchronous serial interface. Table 1 shows the serial interface specification.

Table 1 Serial communication specification

No.	Item	Specification
1	Signal level	3.3V CMOS level
2	Speed	57,600bps or 19,200bps (Factory setting)
3	Flow control	None (The communication line consists of Tx and Rx only)
4	Parity	Odd
5	Data length	8 bit
6	Start bit length	1 bit
7	Stop bit length	1 bit
8	Character code	Binary
9	Synchronization method	Asynchronous communication

2.2 通信协议

(1) 当H2E上电准备好后，会向主机发送如下数据。

主机收到这条数据后，允许向H2E发送命令进行通信。

Offset	Size	Description
0	BYTE	00h
1	WORD	0003h (Byte length of the following data, Big endian)
3	BYTE[3]	4Fh, 4Bh, 0Dh　(“OK”CR (carriage return))

(2) 如果主机与H2E同时上电，那么主机有可能正在进行内部处理而收不到上面这条命令。如果一秒后没有反应，主机可以通过“Get Information”命令检查H2E是否已经准备好。参考2.3.8。

(3) 如果H2E从接受到第一个字节起1.2秒内没有接收完所有数据，那么H2E会清空所有收到的数据，并发送一条错误信息给主机。

(4) 在收到H2E回复之前，主机不会向H2E发送命令。

(5) H2E在收到任何命令后都会在10秒内回复一条命令，因此主机可以在10秒后判断H2E是否有回复。

(6) 当H2E检测到一个异常状态后，会自己进行内部复位，并发送一个上电时的“OK”CR（回车）命令。因此当主机在非上电时检测到这样一个命令，那么表明H2E内部一定是发生了一个非正常情况。

2.3 命令格式详细说明

2.3.1 组模板数据

(1) 在H2E的存储器中，指静脉的模板数据是由组号与模板好组成的。

每一号的数据长度是16位大端数据格式。

(2) 最有效位表示物理存储器，组号0000h到7FFFh的模板数据存储在非易失存储器中，(i.e. flash ROM), 组号8000h到FFFFh的模板数据存储在易失存储器中 (i.e. SDRAM).

(3) 存储在存储器中的模板数据的总数在2.3.6中有描述.

当制定 1:N 认证方式时，认证是分别在不同的组中执行的。

(4)下面是分组的一个例子，例如组号0000h包含若干个模板数据。在不同可组中可以使用相同的模板号。

组号	存储器	模板号
0000h	Flash ROM	0001h
		0020h
		0030h
		0032h
0202h	Flash ROM	0001h
8303h	SDRAM	0001h

再次声明，在不同的组中，有可能有相同的模板号。

2.3.2 模板质量信息

如果选中 “Enroll template data” 命令中的一个可选位，可以获得模板数据的质量信息。准备进行认证的模板数据质量信息分为1到5个等级，数越大代表质量越好。请参考本文中的1.3节。

2.3.3 认证等级信息

如果选中 “Verification” 命令中的一个可选位，就可以获得认证等级信息。认证等级是一个1到3的数字，用来表示扫描的手指与登记的手指的相似度。越大的数字表明相似度越高。请参考本文中的1.3节。

2.3.4 命令格式

下面的表格是主机发往H2E的命令格式。

表 2-2 命令格式

Offset	Size	Description
0	BYTE	命令号
1	WORD	随后的数据长度，必须以大端格式表示。
3	BYTE[n]	随后的数据

2.3.5 回复数据

(1) 下面的表格是H2E发往主机的回复数据格式。

表 2-3 一般回复格式

Offset	Size	Description
0	BYTE	结果 00h:正常结尾 01h:错误
1	WORD	随后的数据长度，必须以大端格式表示。
3	BYTE[n]	随后的数据

(2) 如果一个命令被接受，H2E会恢复如下数据格式，一些其他命令也许会增加命令偏置

Table 2-4 正常回复格式

Offset	Size	Description
0	BYTE	00h:正常结尾
1	WORD	0000h (big endian)

(3) 如果发生错误，H2E回复如下命令格式。

Table 2-5 错误回复格式

Offset	Size	Description
0	BYTE	01h:Error
1	WORD	0001h (big endian)
3	BYTE	Error code. Refer to 3. Error code list.

(4) 一些命令是有可选位的，为了表示扫描完成后还有数据发送。可选位用来通知用户移开手指，以获得足够的处理时间。

(e.g. N is big in 1:N verification. Enroll a template data in a group where many templates are already stored.)

The following table shows a response format of scanning completion.

Table 2-6 扫描完成回复

Offset	Size	Description
0	BYTE	00h:
1	WORD	0001h (big endian)
2	BYTE	AAh

即使可选位被选中，H2E也有可能不发送扫描完成回复，而是发送一个错误回复表示扫描没有完成。例如，模板没有找到，或者命令发生错误。因此如果可选位被选择，主机系统的软件必须设计成可以处理一下任何一种情况。

(a) 扫描完成回复+错误回复

(b) 扫描完成回复+正常回复

(c) 错误回复

2.3.6 初始化模板区域

指静脉团扫描完成后，转换成模板数据，模板数据存储在H2E 的Flash ROM和SDRAM中。这个区域在使用前需要使用2.3.14中的“Initialize template data area”命令初始化。

初始化模板区域需要先指定为登记模式。表 2-7中包含了两个命令。1：N认证模式中的N和存储的最大模版数是不同的。

Table 2-7 Enrollment mode and maximum N of 1:N verification

No.	Enroll mode	Max. N	Max. Enroll template data	
			Flash ROM	SDRAM
1	C2h: Twice scanning and twice enrollment	15	360	15
2	C3h: Three times scanning and three times enrollment	10	230	10

要改变等级模式需要先初始化。其他模式登记的模板数据不能兼容使用。

2.3.7 主机到H2E的命令

The following table shows commands sent from the host system to H2E.

Table 2-8 Command list

No.	Command code	Function
1	12h	Get Information
2	13h	Hardware reset
3	14h	Release PASS_DRIVER
4	21h	Enroll template data
5	16h	Delete template data (Individual)
6	17h	Delete template data (Group)
7	18h	Initialize template area
8	19h	1:1 verification
9	1Ah	1:N verification (Group)
10	1Fh	1:N verification (All)
11	1Bh	Get group and template list
12	1Ch	Upload template data
13	1Dh	Download template data
14	1Eh	Set template ID
15	23h	Change template ID
16	20h	Check template data in flash ROM
17	22h	Set security level
18	24h	Set capture mode

2.3.8 Get information

获取固件版本和序列号

(1) Command format

Offset	Size	Description
0	BYTE	12h
1	WORD	0001h
3	BYTE	Indicates information to get 00h: Firmware version 01h: Serial number

(2) Normal response from H2E

Offset	Size	Description
0	BYTE	00h
1	WORD	n (Byte length of the following data, Big endian)
3	BYTE[n]	Information data

(3) Error response from H2E

Refer to Table 2-5.

(4) Format of information data

Information	Length (n)	Description
00h	13	“H2E/ver/VV/RR”, where “VV” means version, “RR” means revision. The other data is constant.
01h	12	This shows manufacturing serial number of H2E. This is described by 12 bytes character code. It does not include null-termination code.

H2E 会在收到“Get information” 命令后7ms内回复。

2.3.9 Hardware reset

This command is used to reset H2E.

(1) Command format

Offset	Size	Description
0	BYTE	13h
1	WORD	0000h

(2) Normal response from H2E

Refer to Table 2-4.

(3) Error response from H2E

Refer to Table 2-5.

2.3.10 Release PASS_DRIVER

这个命令用于释放 PASS_DRIVER 引脚以恢复开状态（高阻状态）。

When a finger vein data is verified against the enrolled template data, PASS_DRIVER signal goes GND level. To verify the finger vein data, the “Verification” command is used.

收到命令后会在3ms后恢复开状态。

(1) Command format

Offset	Size	Description
0	BYTE	14h
1	WORD	0000h

(2) Normal response from H2E

Refer to Table 2-4.

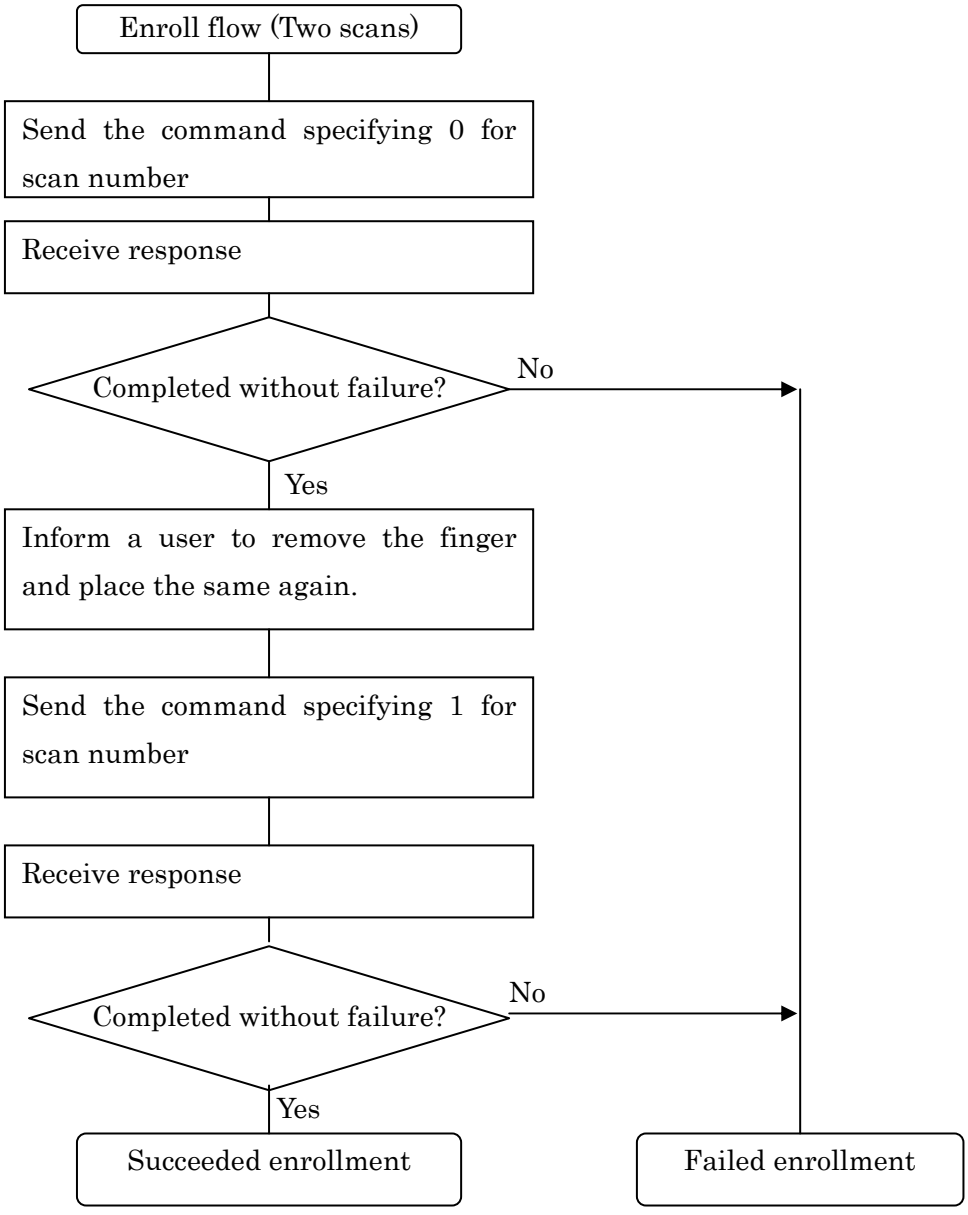
(3) Error response from H2E

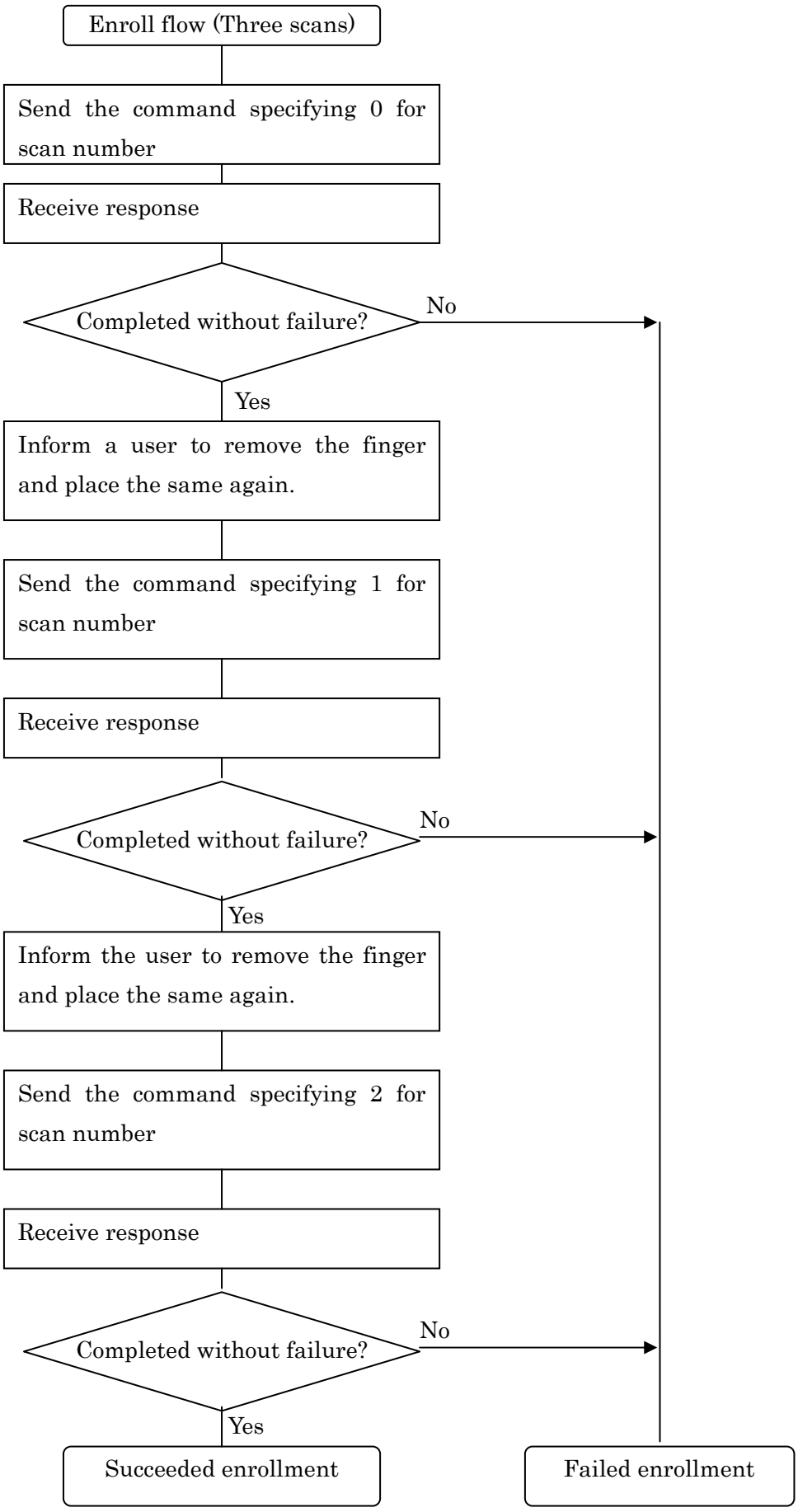
Refer to Table 2-5.

2.3.11 登记模板数据

这个命令用于采集指静脉图样，制作模板数据，并处处在H2E的flash ROM或SDRAM中。模板数据会存储并指定一个用于识别的由组号和模板号的组合。

登记模板数据需要扫描两次或三次手指。下面的流程图显示了如何登记一个模板。




Enroll flow (Three scans)
Send the command specifying 0 for scan number
Receive response
Completed without failure?
No
Yes
Inform a user to remove the finger and place the same again.
Send the command specifying 1 for scan number
Receive response
Completed without failure?
No
Yes
Inform the user to remove the finger and place the same again.
Send the command specifying 2 for scan number
Receive response
Completed without failure?
No
Yes
Succeeded enrollment
Failed enrollment

扫描号必须从0开始，第二次扫描是1。三次扫描模式是 0 → 1→ 2 。接收回复后用户必须移开他的手指。

(1) Command format

Offset	Size	Description
0	BYTE	21h
1	WORD	0005h (Byte length of the following data, Big endian)
3	BYTE	bit 0 to 1:Scan number (0 to2) bit 2 :If this bit is ON, H2E sends response shown in Table 2-6 after scanning and sends response (2) or (3). If a scan is not executed, H2E does not send scan response. Refer to 2.3.5 (4) bit 3: OFF: Scan twice. ON: Scan three times. bit 4 to 6 must be kept OFF bit 7: ON Response with template quality information
4	WORD	Group number 0000h to 7FFFh: Template data stored in flash ROM 8000h to FFFFh: Template data stored in SDRAM
6	WORD	Template number (0000h to FFFFh)

(2) Normal response from H2E (Other than the last scan and template quality information bit is OFF)

Offset	Size	Description
0	BYTE	00h (Normal end)
1	WORD	0001h (Byte length of the following data, Big endian)
3	BYTE	55h

(3) Normal response from H2E (Other than the last scan and template quality information bit is ON)

Offset	Size	Description
0	BYTE	00h (Normal end)
1	WORD	0001h (Byte length of the following data, Big endian)
3	BYTE	55h
4	BYTE	Template quality between 1 to 5 (The best is 5)

(4) Normal response from H2E (The last scan and template quality information bit is OFF)

Offset	Size	Description
0	BYTE	00h (Normal end)
1	WORD	0005h (Byte length of the following data, Big endian)
3	BYTE	00h
4	WORD	Enrolled group number
6	WORD	Enrolled template number

(5) Normal response from H2E (The last scan and template quality information bit is ON)

Offset	Size	Description
0	BYTE	00h (Normal end)
1	WORD	0005h (Byte length of the following data, Big endian)
3	BYTE	Template quality between 1 to 5 (The best is 5)
4	WORD	Enrolled group number
6	WORD	Enrolled template number

(6) Error response from H2E

Offset	Size	Description
0	BYTE	01h (Error)
1	WORD	0005h (Byte length of the following data, Big endian)
3	BYTE	Error code. Refer to error code list.
4	WORD	Group number
6	WORD	Template number

2.3.12 删除模板数据 (单个)

This command is used to delete a template data specified by the group number and the template number.

(1) Command format

Offset	Size	Description
0	BYTE	16h
1	WORD	0005h (Byte length of the following data, Big endian)
3	BYTE	00h
4	WORD	Group number 0000h to 7FFFh: Template data stored in flash ROM 8000h to FFFFh: Template data stored in SDRAM
6	WORD	Template number

(2) Normal response from H2E

Refer to Table 2-4.

(3) Error response from H2E

Refer to Table 2-5.

2.3.13 删除模板数据 (组)

This command is used to delete template data specified by group number.

Command format

Offset	Size	Description
0	BYTE	17h
1	WORD	0003h (Byte length of the following data, Big endian)
3	BYTE	00h
4	WORD	Group number 0000h to 7FFFh: Template data stored in flash ROM 8000h to FFFFh: Template data stored in SDRAM

(2) Normal response from H2E

Refer to Table 2-4.

(3) Error response from H2E

Refer to Table 2-5.

2.3.14 初始化模板数据区域

删除所有模板数据并初始化flash ROM和SDRAM中的模板数据存储区域。 (See note 1)
删除存储在flash ROM中的模板数据最多大约需要6s。

(1) Command format

Offset	Size	Description
0	BYTE	18h
1	WORD	0002h (Byte length of the following data, Big endian)
3	BYTE	Storage area flag 01h: Delete all the template data stored in flash ROM. (See note 2) 02h: Delete all the template data stored in SDRAM. (See note 3and 4) 03h: Delete all the template data stored in both the flash ROM and in SDRAM.
4	BYTE	Specify enrollment mode. Refer to 2.3.11 for commands. Refer to Table 2-7 of 2.3.6 for value. C2h: Scan twice and enroll two templates. C3h: Scan three times and enroll three templates.

Note 1: The template data storage area is consists of flash ROM and SDRAM. If the flash ROM area is not initialized, template data cannot be written in both the flash ROM and in SDRAM.

Note 2: When the flash ROM area is initialized by specifying 01h to storage area flag, SDRAM area will be initialized as well if enrollment mode (refer to 2.3.6) is different from previous one. It includes when the flash ROM is not initialized.

Note 3: It is impossible to initialize only SDARM if flash ROM area is not initialized.

Note 4: When only SDRAM area is specified, it is impossible to initialize other than the current enroll mode.

(2) Normal response from H2E

Refer to Table 2-4.

(3) Error response from H2E

Refer to Table 2-5.

2.3.15 1:1 Verification

This command is used to verify the captured finger vein pattern against the enrolled template data identified by group number and template number. Maximum 6 enrolled templates can be specified.

A user must place the enrolled finger right after the command is issued.

Once verified, PASS_DRIVER signal goes GND level. To return it to open state, use the “Release PASS_DRIVER” command.

(1) Command format

Offset	Size	Description
0	BYTE	19h
1	WORD	1+4 x n (Byte length of the following data, Big endian) “n” is from 1 to 6.
3	BYTE	bit0～bit6 : must be kept OFF bit7: ON Response with velification level information
4	WORD	Group number 0000h to 7FFFh: Template data stored in flash ROM 8000h to FFFFh: Template data stored in SDRAM
6	WORD	Template number
7	(n-1) pairs of a group number and a template number are specified.	

(2) Normal response from H2E (Verification level information bit is OFF)

Offset	Size	Description
0	BYTE	00h (Normal end)
1	WORD	0002h (Byte length of the following data, Big endian)
3	BYTE	00h
4	BYTE	The index number of verified template. "0" means the first template was verified.

(3) Normal response from H2E (Verification level information bit is ON)

Offset	Size	Description
0	BYTE	00h (Normal end)
1	WORD	0002h (Byte length of the following data, Big endian)
3	BYTE	Verification level between 1 and 3 (The best is 3)
4	BYTE	The index number of verified template. "0" means the first template was verified.

(4) Error response from H2E

Refer to Table 2-5.

2.3.16 1:N Verification (Group)

This command is used to verify captured finger vein pattern against the template data identified by group number only. A user must place the enrolled finger right after the command is issued.

Plural groups can be specified. For example, [1Ah 00h, 0Bh, 00h, 22h, 22h, 11h, 11h, 44h, 44h, 55h, 55h, 33h, 33h] are sent, H2E will execute 1:N verification in a group by the order of 2222h, 1111h, 4444h, 5555h, 3333h. If plural groups are specified, H2E responds when the verification is succeeded and the rest of the groups are not verified. For example, if verification is succeeded in the group 2222h, H2E won't verify the group 1111h, 4444h, 5555h and 3333h.

When the verification succeeds, PASS_DRIVER signal goes GND level. To return it to open state, use the "Release PASS_DRIVER" command.

(1) Command format

Offset	Size	Description
0	BYTE	1Ah
1	WORD	1+2 x n (Byte length of the following data, Big endian)
3	BYTE	Option setting bit 0=ON: Send the response shown in the Table 2-6 after a scan is completed and sends response between (2) and (4). If the scan is not executed, scan end response will not be sent. (Refer to 2.3.5(4)) bit 1 to 6 must be kept OFF. bit7: ON Response with velification level information (The information is available when verification was succeeded)
4	WORD	Group number 0000h to 7FFFh: Template data stored in flash ROM 8000h to FFFFh: Template data stored in SDRAM

(2) Normal response from H2E (Verification level information bit is OFF)

Offset	Size	Description
0	BYTE	00h (Succeeded verification)
1	WORD	0005h (Byte length of the following data, Big endian)
3	BYTE	00h
4	WORD	Verified group number
6	WORD	Verified template number

(3) Normal response from H2E (Verification level information bit is ON)

Offset	Size	Description
0	BYTE	00h (Succeeded verification)
1	WORD	0005h (Byte length of the following data, Big endian)
3	BYTE	Verification level between 1 and 3 (The best is 3)
4	WORD	Verified group number
6	WORD	Verified template number

(4) Error response from H2E

Refer to Table 2-5.

2.3.17 1:N Verification (All)

This command is used to verify the captured finger vein pattern against all the template data in flash ROM and SDRAM. A user must place the enrolled finger right after the command is issued.

H2E can execute the command if the total enrolled template data in both flash ROM and SDRAM is less than max. N in Table 2-7. If it exceeds max. N, H2E responds an error.

When the verification succeeds, PASS_DRIVER signal goes GND level. To return it to open state, use the “Release PASS_DRIVER” command.

(1) Command format

Offset	Size	Description
0	BYTE	1Fh
1	WORD	0001h (Byte length of the following data, Big-endian)
3	BYTE	Option setting bit 0=ON: Send the response shown in the table 2-6 after a scan is completed and sends response (2) or (3). If the scan is not executed, scan end response will not be sent. (Refer to 2.3.5(4)) bit 1 to 6 must be kept OFF. bit7: ON Response with velification level information (The information is available when verification was succeeded)

(2) Normal response from H2E (Verification level information bit is OFF)

Offset	Size	Description
0	BYTE	00h (Succeeded verification)
1	WORD	0005h (Byte length of the following data, Big-endian)
3	BYTE	00h
4	WORD	Verified group number
6	WORD	Verified template number

(3) Normal response from H2E (Verification level information bit is ON)

Offset	Size	Description
0	BYTE	00h (Succeeded verification)
1	WORD	0005h (Byte length of the following data, Big-endian)
3	BYTE	Verification level between 1 to 3 (The best is 3)
4	WORD	Verified group number
6	WORD	Verified template number

(4) Error response from H2E

Refer to Table 2-5.

2.3.18 Get group and template list

This command is used to acquire the group number and template number list.

(1) Command format

Offset	Size	Description
0	BYTE	1Bh
1	WORD	0000h (Byte length of the following data, Big endian)

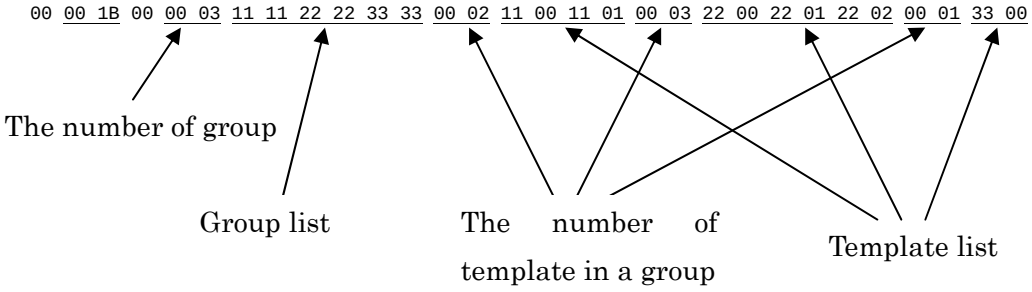
(2) Normal response from H2E

Offset	Size	Description
0	BYTE	00h
1	WORD	xxxxh (Byte length of the following data, Big endian) This number varies and depends on the enrolled template number.
3	BYTE	00h
4	WORD	**G**: Number of group
6	WORD[**G**]	Group number list consists of **G** groups. H2E transmits the enrolled group number by 2 bytes each.
6+(2 x **G**)	WORD	$\mathbf{T_0}$: The number of enrolled template data in a group
8+(2 x **G**)+2	WORD[$\mathbf{T_0}$]	Template number list in a group consists of $\mathbf{T_0}$ template data. H2E transmits the enrolled template number by 2 bytes each.
	WORD	$\mathbf{T_1}$: The number of enrolled template data in a group
	WORD[$\mathbf{T_1}$]	Template number list in a group consists of $\mathbf{T_1}$ template data. H2E transmits the enrolled template number by 2 bytes each.
		Repeat the data above

Example of the list

Group number	Template number
1111h	1100h
	1101h
2222h	2200h
	2201h
	2202h
3333h	3300h

If the template data is enrolled in H2E as above, H2E transmits the following data.



(3) Error response from H2E

Refer to Table 2-5.

2.3.19 Upload template data

This command is to upload the template data stored in H2E to the host system. The template data can be uploaded by identifying the template ID. The uploaded template data can be downloaded back to H2E by using the “Download template data” command. In this case, the same template ID must be identified and used for both data upload and data download. To set the template ID, refer to the “Set template ID” command. Although the setting of template ID is not always necessary, we recommend using an ID for security reasons.

Note: The template data will be encrypted regardless of whether setting or not setting a template ID.

(1) Command format

Offset	Size	Description
0	BYTE	1Ch
1	WORD	0005h (Byte length of the following data, Big-endian)
3	BYTE	00h
4	WORD	Group number 0000h to 7FFFh: Template data stored in flash ROM 8000h to FFFFh: Template data stored in SDRAM
6	WORD	Template number

(2) Normal response from H2E

In case of enroll mode C2h

Offset	Size	Description
0	BYTE	00h
1	WORD	0439h (Byte length of the following data, Big-endian)
3	BYTE	00h
4	BYTE[1072]	Template data
1076	DWORD	ADD check sum. Divide the uploaded template data into 4 byte data. Therefore the original BYTE[1072] template data will be divided into 268 data blocks. Add all 268 data blocks and store the least significant 32bit data from the calculation result.
1080	DWORD	XOR check sum. Divide the uploaded template data into 4 byte data. Therefore the original BYTE[1072] template data will be divided into 268 data blocks. Execute XOR all 268 data and store the result from the calculation result.

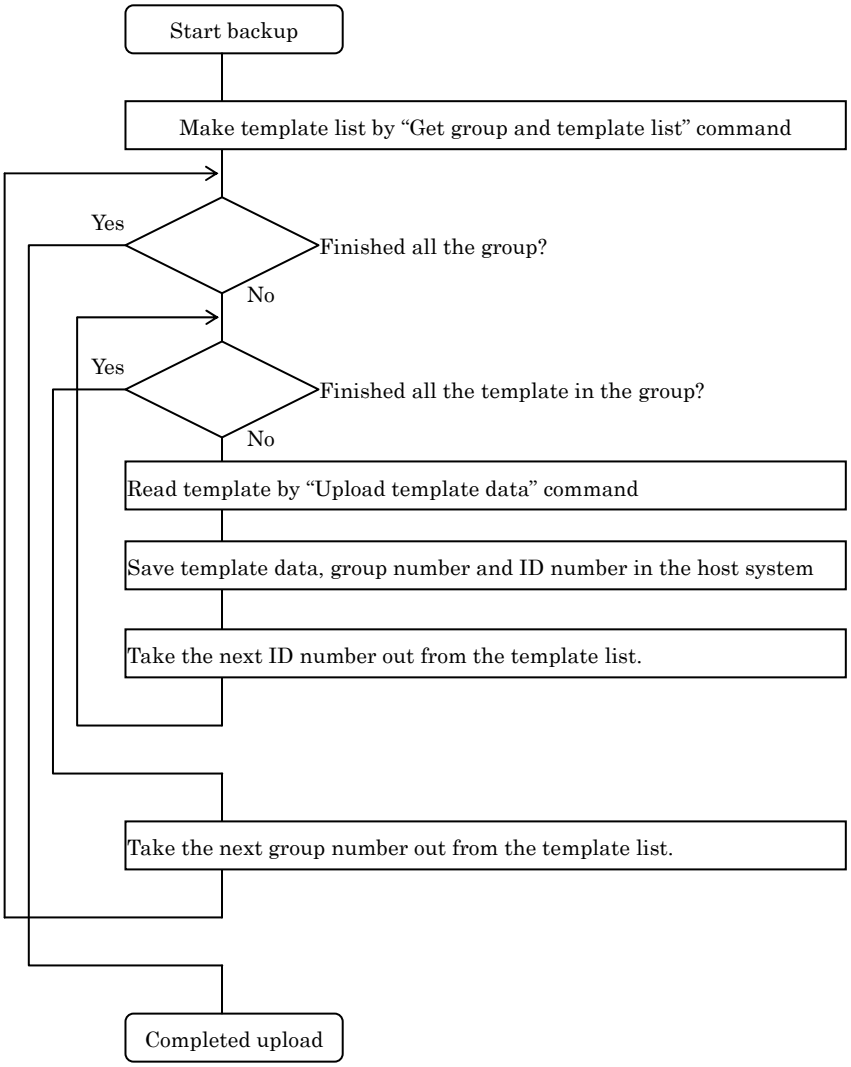
In case of enroll mode C3h

Offset	Size	Description
0	BYTE	00h
1	WORD	0639h (Byte length of the following data, Big-endian)
3	BYTE	00h
4	BYTE[1584]	Template data
1588	DWORD	ADD check sum. Divide the uploaded template data into 4 byte data. Therefore the original BYTE[1584] template data will be divided into 396 data blocks. Add all 396 data blocks and store the least significant 32bit data from the calculation result.
1592	DWORD	XOR check sum. Divide the uploaded template data into 4 byte data. Therefore the original BYTE[1584] template data will be divided into 396 data blocks. Execute XOR all 396 data and store the result from the calculation result.

(3) Error response from H2E

Refer to Table 2-5.

The following flow chart shows an example how to upload all the template data in H2E.



2.3.20 Download template data

This command is used to download template data from the host system back to H2E. If the template data in the system was uploaded to the host system by specifying the template ID, the same template ID must be set before downloading the template data back to H2E. To set the template ID, refer to the “Set template ID” command.

It is impossible to write template data if “enroll mode” does not match. The enroll mode is specified to initialize template storage area. For example, template data is uploaded after template area is initialized by enroll mode C2, it is impossible to write the template data if the template area is initialized by enroll mode C3.

(1) Command format

In case of enroll mode C2h

Offset	Size	Description
0	BYTE	1Dh
1	WORD	043Dh (Byte length of the following data, Big-endian)
3	BYTE	Option byte bit0: This is an option bit to check if the same finger is already enrolled. 0:Check 1: No check The other bit must be kept 0.
4	WORD	Group number 0000h to 7FFFh: Template data stored in flash ROM 8000h to FFFFh: Template data stored in SDRAM
6	WORD	Template number
8	BYTE[1072]	Template data, which is uploaded to the host system by using the “Upload template data” command.
1080	DWORD	ADD check sum. Divide the downloaded template data into 4 byte data. Therefore the original BYTE[1072] template data will be divided into 268 data blocks. Add all 268 data blocks and store the least significant 32bit data from the calculation result.
1084	DWORD	XOR check sum. Divide the downloaded template data into 4 byte data. Therefore the original BYTE[1072] template data will be divided into 268 data blocks. Execute XOR all 268 data and store the result from the calculation result.

In case of enroll mode C3h

Offset	Size	Description
0	BYTE	1Dh
1	WORD	063Dh (Byte length of the following data, Big-endian)
3	BYTE	Option byte bit0: This is an option bit to check if the same finger is already enrolled. 0:Check 1: No check The other bit must be kept 0.
4	WORD	Group number 0000h to 7FFFh: Template data stored in flash ROM 8000h to FFFFh: Template data stored in SDRAM
6	WORD	Template number
8	BYTE[1584]	Template data, which is uploaded to the host system by using the “Upload template data” command.
1592	DWORD	ADD check sum. Divide the downloaded template data into 4 byte data. Therefore the original BYTE[1584] template data will be divided into 396 data blocks. Add all 396 data blocks and store the least significant 32bit data from the calculation result.
1596	DWORD	XOR check sum. Divide the downloaded template data into 4 byte data. Therefore the original BYTE[1584] template data will be divided into 396 data blocks. Execute XOR all 396 data and store the result from the calculation result.

If bit0:0 is specified, it takes long time to write template data if a lot of template data already exist. It is recommended to initialize template area in advance and download data with bit0:1 if a lot of template data should be downloaded.

(2) Normal response from H2E

Refer to Table 2-4.

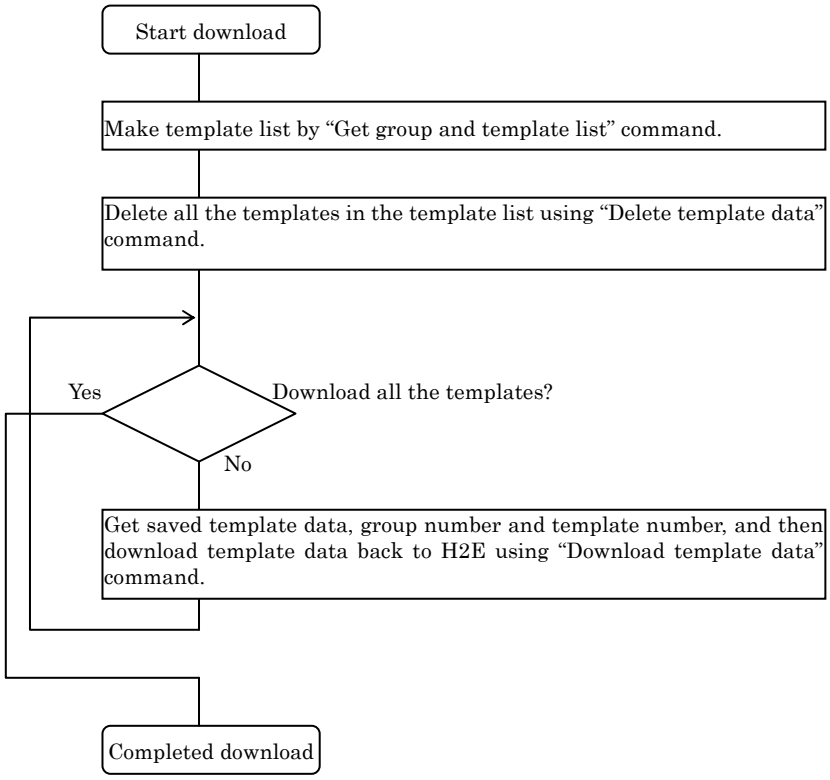
(3) Error response from H2E (If the same template or same finger was already enrolled in the specified group.)

Offset	Size	Description
0	BYTE	01h (Error)
1	WORD	0005h (Byte length of the following data, Big-endian)
3	BYTE	Error code (76h or 79h)
4	WORD	Group number where same template or same finger is enrolled.
5	WORD	Template number where same template or same finger is enrolled.

(4) Error response from H2E (Other than (3))

Refer to Table 2-5.

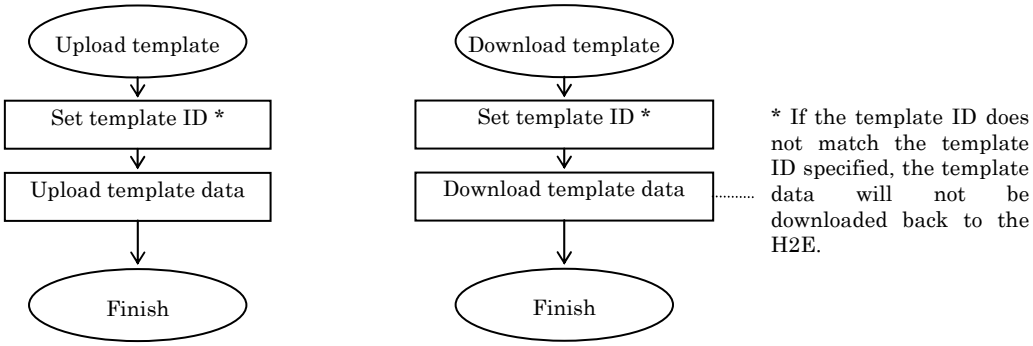
The following flow chart shows an example how to download all the template data back to H2E.



2.3.21 Set template ID

This command is used for security purposes to keep template data secure during uploading and downloading back the data between the host system and H2E. By using this command, if the template data in H2E is uploaded after setting template ID, the template data can only be downloaded back to H2E if the same template ID is specified.

The following flow chart shows how to download or upload the template data.



Note: Once the “Set template ID” command is executed, the template ID is applied for all “Upload template” or “Download template “ command thereafter.

The template ID is initialized to default status when hardware reset command is executed or when the power supply is turned off.

(1) Command format

Offset	Size	Description
0	BYTE	1Eh
1	WORD	0009h (Byte length of the following data, Big-endian)
3	BYTE	00h
4	BYTE[8]	Template ID consists of 8 bytes. If all bits of the data are “0”, it is treated as there is no template ID.

(2) Normal response from H2E

Refer to Table 2-4.

(3) Error response from H2E

Refer to Table 2-5.

2.3.22 Change template ID

Template data is specified by a group number and a template number. This command is to change these numbers. If the most significant bit of the group number is changed, storage area (i.e. flash ROM or SDARM) is changed. Refer to 2.3.1 for storage area.

(1) Command format

Offset	Size	Description
0	BYTE	23h
1	WORD	0009h (Byte length of the following data, Big-endian)
3	BYTE	00h
4	WORD	Current group number to be changed.
6	WORD	Current template number to be changed.
8	WORD	New group number
10	WORD	New template number

(2) Normal response from H2E

Refer to Table 2-4.

(3) Error response from H2E

Refer to Table 2-5.

2.3.23 Check template data in flash ROM

This command is to check if the template data in flash ROM is correct.

If the power supply of H2E is discontinued while saving template data in flash ROM, the template data may become invalid.

(1) Command format

Offset	Size	Description
0	BYTE	20h
1	WORD	0000h (Byte length of the following data, Big-endian)

(2) Normal response from H2E

Offset	Size	Description
0	BYTE	00h (Normal end)
1	WORD	0001h (Byte length of the following data, Big-endian)
3	BYTE	Enroll mode (Refer to 2.3.6) C2h: Scan twice and enroll two templates. C3h: Scan three times and enroll three templates. If the mode number is other than above, initialization may not be done correctly.

(3) Error response from H2E

Refer to Table 2-5.

2.3.24 Set security level

This command is to set security level for enrollment or verification. False Acceptance Rate and False Rejection Rate can be changed by setting the security level. The command enables to select the most appropriate level for each operating purpose, like strict security is necessary or easy operation is necessary.

(1) Command format

Offset	Size	Description
0	BYTE	22h
1	WORD	0001h (Byte length of the following data, Big-endian)
3	BYTE	Security level 00h:High, 01h:Mid-High, 02h:Middle, 03h:Mid-Low, 04h:Low

(2) Normal response from H2E

Refer to Table 2-4.

(3) Error response from H2E

Refer to Table 2-5.

2.3.25 Set capture mode

This command is to set capture mode for light condition where H2E is installed and used. There are two modes, normal mode and strong light mode. The normal mode is used when there is no strong light such as usage in a room. The default mode is normal.

(1) Command format

Offset	Size	Description
0	BYTE	24h
1	WORD	0001h (Byte length of the following data, Big-endian)
3	BYTE	Capture mode 00h: Normal mode 01h: Strong light mode

(2) Normal response from H2E

Refer to Table 2-4.

(3) Error response from H2E

Refer to Table 2-5.

3. Error code list

No.	Error code	Description of error and possible causes	
1	01h	Error	The command code or parameter is invalid
		Possible causes	(1) Sent command code is not supported. (2) The byte number followed by the command is wrong.
2	02h	Error	The length of the command parameter is invalid
		Possible causes	Command parameter may be incorrect.
3	04h	Error	Parity error or framing error occurred on serial communication.
		Possible causes	(1) Incorrect parameters set for serial communication specification. (2) Incorrect connection of the serial cable. (3) Noise effecting the serial cables.
4	05h	Error	The contents of template data is invalid
		Possible causes	The template ID to download template data is different from when it was uploaded.
5	06h	Error	Finger is not detected within a specific time frame.

		Possible causes	(1) The finger was not placed on the scanning device within 3 seconds after sending the “Verification” command. (2) The fingertip was not placed into the groove of H2E device.
6	07h	Error	Failed to control brightness of infrared LED in a specific time.
		Possible causes	(1) Items, such as bandages, covering the finger could have been interfering. (2) Object interference.
7	08h	Error	Finger not stably place during a specific time frame.
		Possible causes	(1) The host system not designed physically stable preventing stabile scanning process during verification. (2) Installed equipment vibration.
8	0Ah	Error	Verification failure (1:1 verification)
		Possible causes	(1) Finger position is different from when the finger was enrolled. (2) Finger was exceptionally pressed down onto the device during the scanning process. (3) Finger touching the scanning area when scanning.
9	0Bh	Error	Verification failure (1:N verification)
		Possible causes	Refer to error code 0Ah.
10	0Dh	Error	H2E could not receive total command in a specified time frame.
		Possible causes	(1) Incorrect command parameters. (2) The number of data followed by a command code is not described by big endian.
11	0Fh	Error	Verification or enrollment was cancelled because the quality of the scanned image was insufficient for enrollment or verification.
		Possible causes	(1) Finger was exceptionally pressed down onto the device. → Place the finer lightly. (2) The finger is dirty or has foreign object such as adhesive bandages. (3) Foreign object was attached on H2E.
12	70h	Error	Failed to erase a sector of a flash ROM.
		Possible causes	Device failure. → replace H2E.
13	71h	Error	Failed to store data into the flash ROM.

		Possible causes	Device failure. → replace H2E.
14	72h	Error	Specified template data does not exist.
		Possible causes	The template data does not exist. → Check by using the "Get group and template list" command.
15	73h	Error	The enrollment template number already exists in the specified group.
		Possible causes	Enroll the new template data after deleting existing one.
16	74h	Error	Capacity overflow of the template data.
		Possible causes	Storage of unnecessary template data.
17	75h	Error	The number of the template data in a group exceeded the limit.
		Possible causes	Storage of unnecessary template data in the group.
18	76h	Error	The finger vein data already exists in the group.
		Possible causes	Enrolled finger previously scanned.
19	77h	Error	Could not find encryption key
		Possible causes	Device failure. → replace H2E.
20	78h	Error	Checksum error
		Possible causes	(1) Checksum is incorrect. (2) Error during serial communication.
21	79h	Error	The downloading template data already exists in the same group.
		Possible causes	(1) Delete the existing template. (2) Download to another group.
22	7Ah	Error	Could not find group number
		Possible causes	The group does not exist in template data.
23	7Bh	Error	Capacity over flow of template data for 1:N verification.
		Possible causes	The "1:N Verification" command was sent when the template data in flash ROM exceeded max. N.
24	7Ch	Error	Invalid template data saved in flash ROM. There is invalid template data in flash ROM.

		Possible causes	The power supply of H2E may be discontinued while saving template data in flash ROM. → Delete all the template data and enroll template data again.
25	7Dh	Error	Different finger was placed in enroll template data command with plural scanning.
		Possible causes	User's error operation. → Place the same finger.
26	7Eh	Error	Invalid scanning number was specified in enroll command with plural scanning.
		Possible causes	Command parameter is incorrect.
27	7Fh	Error	The finger was not removed after completion of scanning in enroll template data command with plural scanning
		Possible causes	User's error operation. → Inform user to remove the finger.
28	80h	Error	Impossible to take image because of too strong outside light.
		Possible causes	Strong light.
29	82h	Error	The received command cannot be executed in the current enroll mode.
		Possible causes	Refer to 2.3.6 and 2.3.14.
30	83h	Error	Template storage area is not initialized in flash ROM.
		Possible causes	→ Initialize flash ROM with initialize command.

4. Remarks

4.1 Power cut during writing flash memory

The template data in flash ROM may become invalid when the power supply of H2E is discontinued while saving template data in flash ROM.

The “Check template data in flash ROM” command is used to check if the template data in flash ROM is correct. It is recommend for the host system to using this command to check template data.

The following table shows the commands that effect the data in the flash ROM.

No.	Command code	Function
1	16h	Delete template data (Individual)
2	17h	Delete template data (Group)
3	18h	Initialize template area
4	1Dh	Download template data
5	21h	Enroll template (Plural scan)
6	23h	Change template ID

4.2 Timeout of verification

If the scan is not completed within five seconds after enroll or verify command, H2E sends timeout error response.

4.3 How to check template quality without enrollment

If you want to know template quality without enrolling template data in H2E, please proceed the following procedure using “2.3.11 Enroll template data” command.

(1) Send Enroll template data command specifying 80h to offset 3. The group number and the template number can be any number.
(2) Receive the response with template quality information.
(3) Send Enroll template data command specifying FFh to offset 3. The group number and the template number can be any number.
(4) Receive the error response (Error code 01h).

Because of the failure command format described in (3), enrollment will not be executed.