BM70/71 Device Firmware Update Process User's Guide

Introduction

The BM70 and BM71 modules from Microchip are Bluetooth low energy modules designed for easy integration of Bluetooth low energy operation into a wide variety of applications. Microchip provides a Bluetooth low energy software stack programmed directly into the internal memory of the BM70/71 devices.

Microchip releases periodic updates to the application firmware to include new features and fix any bugs reported in previous releases. These updates are provided with a release note along with the firmware files in the BM70/71 webpage. This document explains the process of executing a UART-based device firmware update.

Microchip provides PC-based tools for programming the modules, which are available on the BM70/71 webpage. For the rest of this document, it is assumed the user cannot use the PC Tool provided by Microchip to perform firmware update.

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1. Quick References

1.1 Reference Documentation

For further details, refer to the Bluetooth specification:

- *Volume 2, Part E, “Host Controller Interface Functional Specification”*
- *Volume 4, Part A, “UART Transport Layer”*
- *Volume 2, Part E, Section 5, “HCI Data Formats”*

2. Memory

The IS187x chip contained within the BM70/71 module has a Harvard architecture, with separate code memory and data memory. The memory within the code and data space has a segmented architecture, with each segment or bank being 64 Kbytes in size. There are four banks allocated for the code memory.

Note: The programmer needs to have good knowledge of the format of the data in this memory area to properly use the programming protocol and prevent incorrect updates of the flash memory. An incorrect flash memory update may lead to undefined device operation.

The firmware files required for the device firmware update process are available in the BM70/71 webpage. The firmware size is 262 Kbytes. If the application requires device firmware update capability by the external host microcontroller, then the designer needs to consider (and incorporate into their design) the memory requirements for storing the BM70/71 firmware (262 kB) during the device firmware update process.

2.1 Memory Programming

To flash a new firmware revision into the modules, the user needs to follow the command protocol as described in 3. Commands. In general, the commands and responses for memory programming of the BM70/71 can be classified into three categories:

- HCI Command packets
- HCI-ISDAP Flash commands
- HCI Event responses

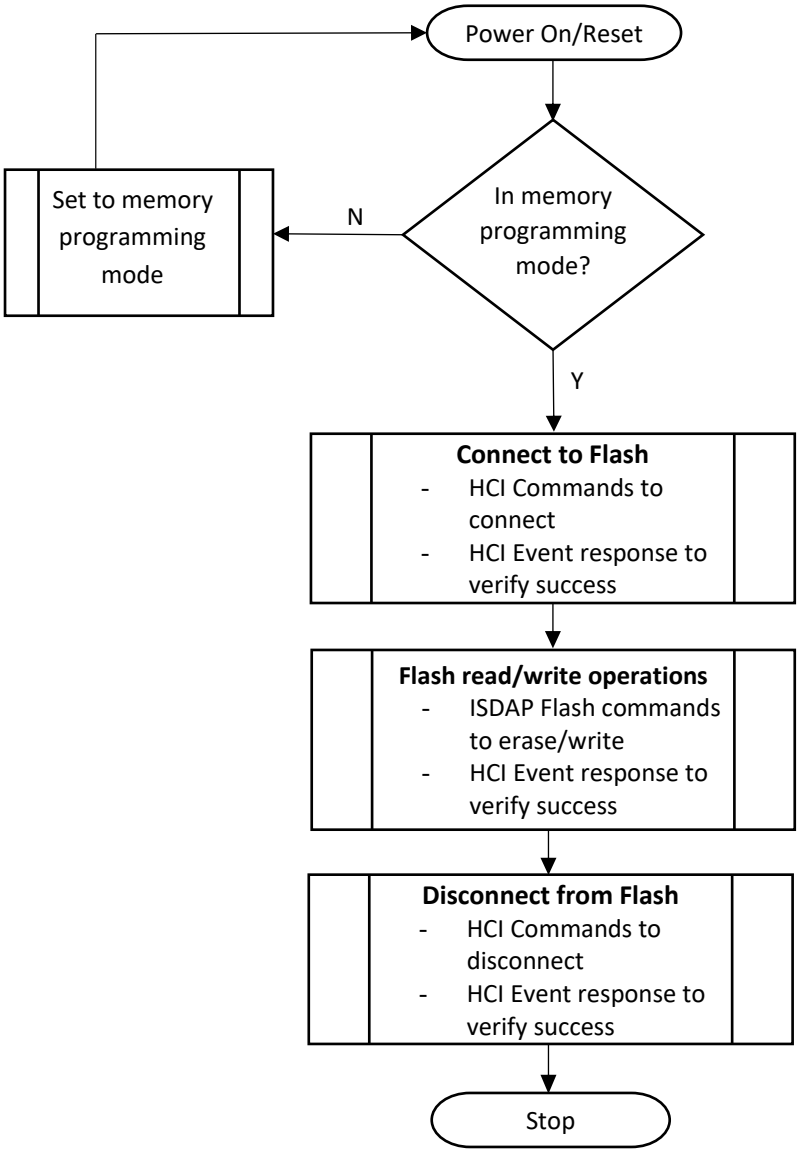
To perform any memory programming operation, the user needs to follow the process flow in Figure 2-1 with respect to the command protocols. The steps are as follows:

1. Enter the memory programming Mode – Set the module into the Flash programming mode. Set the P2_0 pin to ‘0’ via hardware. After entering the mode, in the next subsequent steps, the host uses the UART transport layer to communicate the HCI Commands and HCI-ISDAP Flash commands to read, write or erase data in the memory. For more details, see 2.3 Firmware Files Overview.
2. Connect to Flash – Using the HCI commands, the external host can connect to the Flash of the BM70/71. The HCI event responses from the BM70/71, the user can verify the successful connection established with the Flash.
3. Flash operations – Using the HCI-ISDAP Flash commands, the user can perform read, write and erase operations on Flash.
4. Disconnect from Flash – After the successful execution of flash memory operations, the external host needs to disconnect from the Flash by sending the relevant HCI commands to the BM70/71. The user can use the HCI event responses from the BM70/71 to verify the operation.

Connect to Flash

- HCI Commands to connect
- HCI Event response to verify success

Figure 2-1. Overview of Memory Programming Process



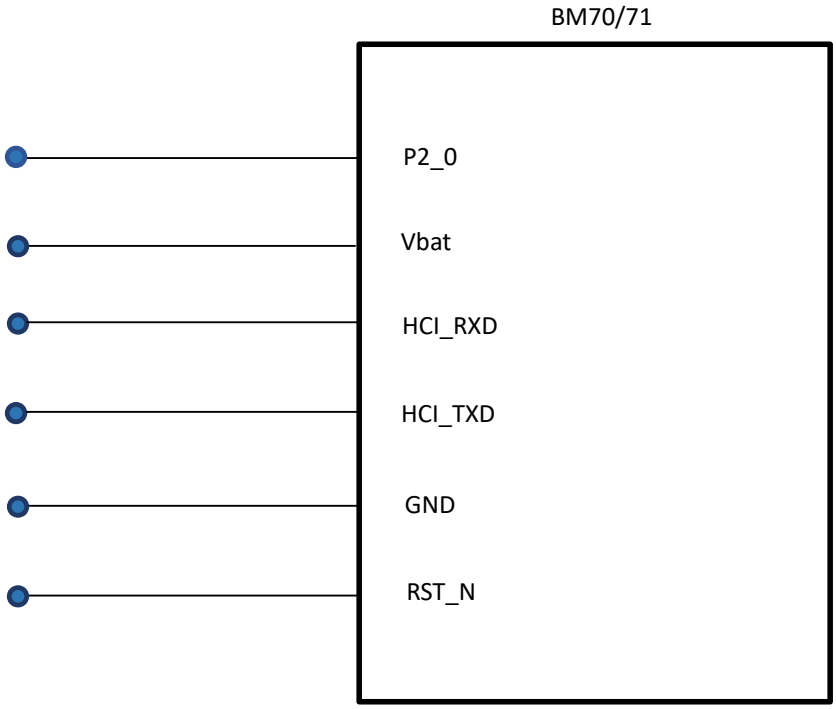
2.2 Device Firmware Upgrade Process

This section describes each step of the device firmware upgrade process.

2.2.1 Step 1: Entering Flash Programming Mode

For memory programming, the minimum set of hardware connections required to interface an external host to the BM70/71 is illustrated in the following figure. These hardware connections between the host and BM70/71 will allow the host to control the behavior (in other words, to enter the memory programming mode, test mode, communicate and calibrate) of the BM70/71.

Figure 2-2. Required Hardware Interface for Memory Programming



The BM70/71 operation, or mode, is determined by the level of a hardware pin, P2_0. This pin is sampled when the RST_N pin goes active. The RST_N signal must be active for the minimum time, to make sure the pin P2_0 logic level is latched into the IC correctly. Once the BM70/711 enters the applicable mode, communication over the UART interface becomes active. The data or protocol that is used to communicate between the host and BM70/71 is based on the mode the BM70/71 enters after a reset.

To summarize: The memory programming mode is entered when pin P2_0 is latched by the BM70/71 at a logic level '0'.

The application, or run mode, where general Bluetooth low energy operation is available, is entered when pin P2_0 is latched by the BM70/71 at a logic level '1'. The following table summarizes the use of the P2_0 pin.

Table 2-1. Summary of Modes available based on Pin P2_0

Pin P2_0 Logic Level	Mode	Protocols Enabled
0 – Low	• Memory programming • RF Calibration/RF testing	• HCI commands • HCI-ISDAP commands
1 – High	Application or Run	BM70 command set

The following figures illustrate the timing diagram for the P2_0 pin with respect to the Reset pin and the Input Voltage pin, respectively.

Figure 2-3. Timing Diagram for Pin P2_0 with Respect to Reset Pin

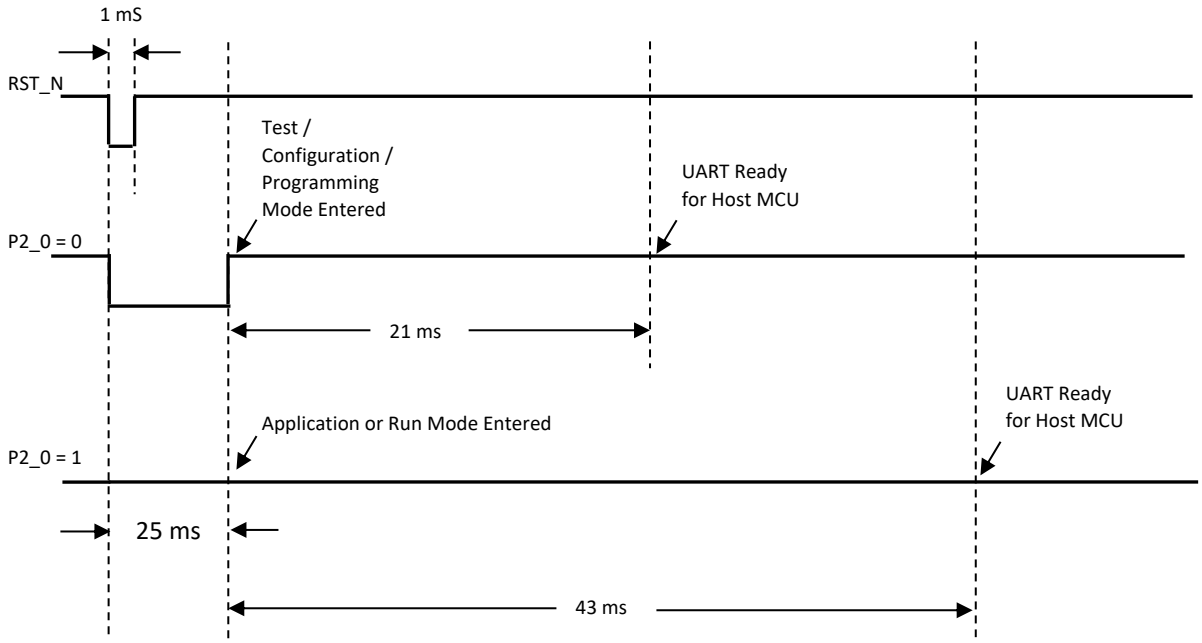
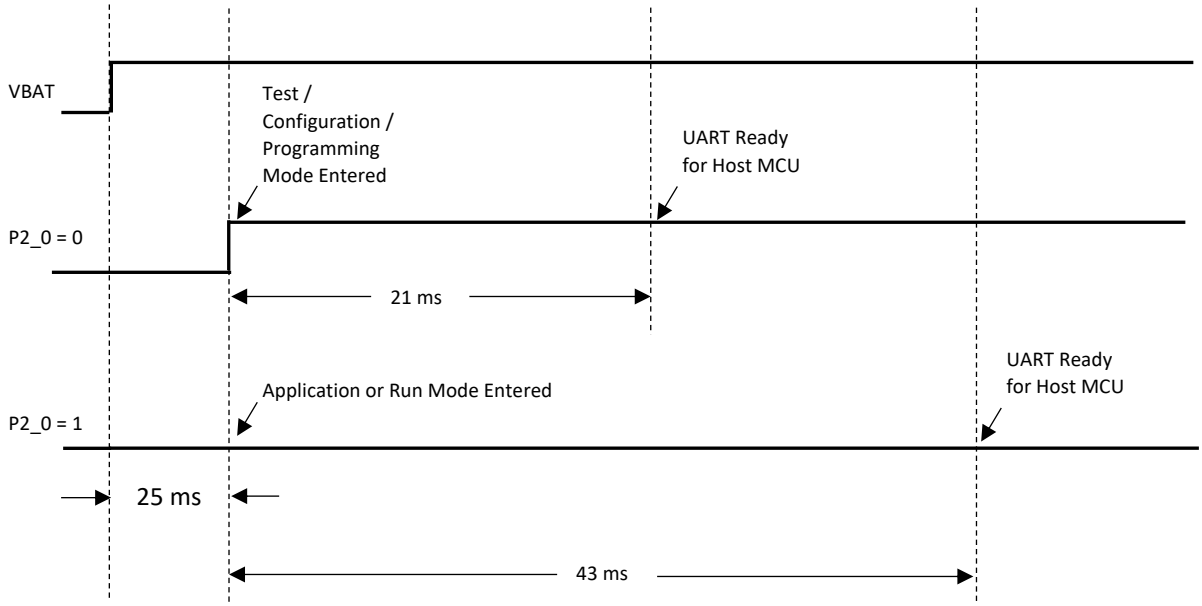


Figure 2-4. Timing Diagram for Pin P2_0 with Respect to Input Voltage



2.2.2 Step 2: Connecting to the Flash

To connect to the Flash via UART in memory programming mode, use the HCI commands. For more details on the HCI command protocol, see 3.1 General Format of HCI Command Packets (Host to BM70/71). The following commands are primarily used for the Device Firmware update process:

2.2.2.1 Read Buffer Size

The opcode to read the buffer size is 0x1005. This command discovers the maximum number of bytes of data that can be sent to the BM70/71 device in a HCI command or HCI-ISDAP Flash command. For more details, see 3.2 General Format of HCI-ISDAP Flash Commands (Host to BM70/71).

2.2.2.2 Create Connection

The opcode to create connection is 0x0405. The host uses this command to establish a flash memory programming session with the BM70/71 module. For more details on commands, see 3. Commands.

2.2.3 Step 3: Flash Operations

After creating a programming session, the host proceeds to execute flash operations using the HCI-ISDAP commands. The following commands are primarily used for the device firmware update process:

2.2.3.1 Flash Erase Memory

The opcode to erase flash memory is 0x0112. This command erases pages in the internal memory of the BM70/71. For more details on commands, see 3. Commands.

2.2.3.2 Write Memory

The opcode to write memory is 0x0111. The write memory command allows the host to write values in the Flash of the BM70/71 module. For more details on commands, see 3. Commands.

2.2.3.3 Write Continue

The opcode to continue write is 0x0111. The write continue command functions as the write memory command, which also allows the host to write values into the flash. However, the write continue command uses a smaller command packet and has lesser overhead to improve programming throughput. For more details on commands, see 3. Commands.

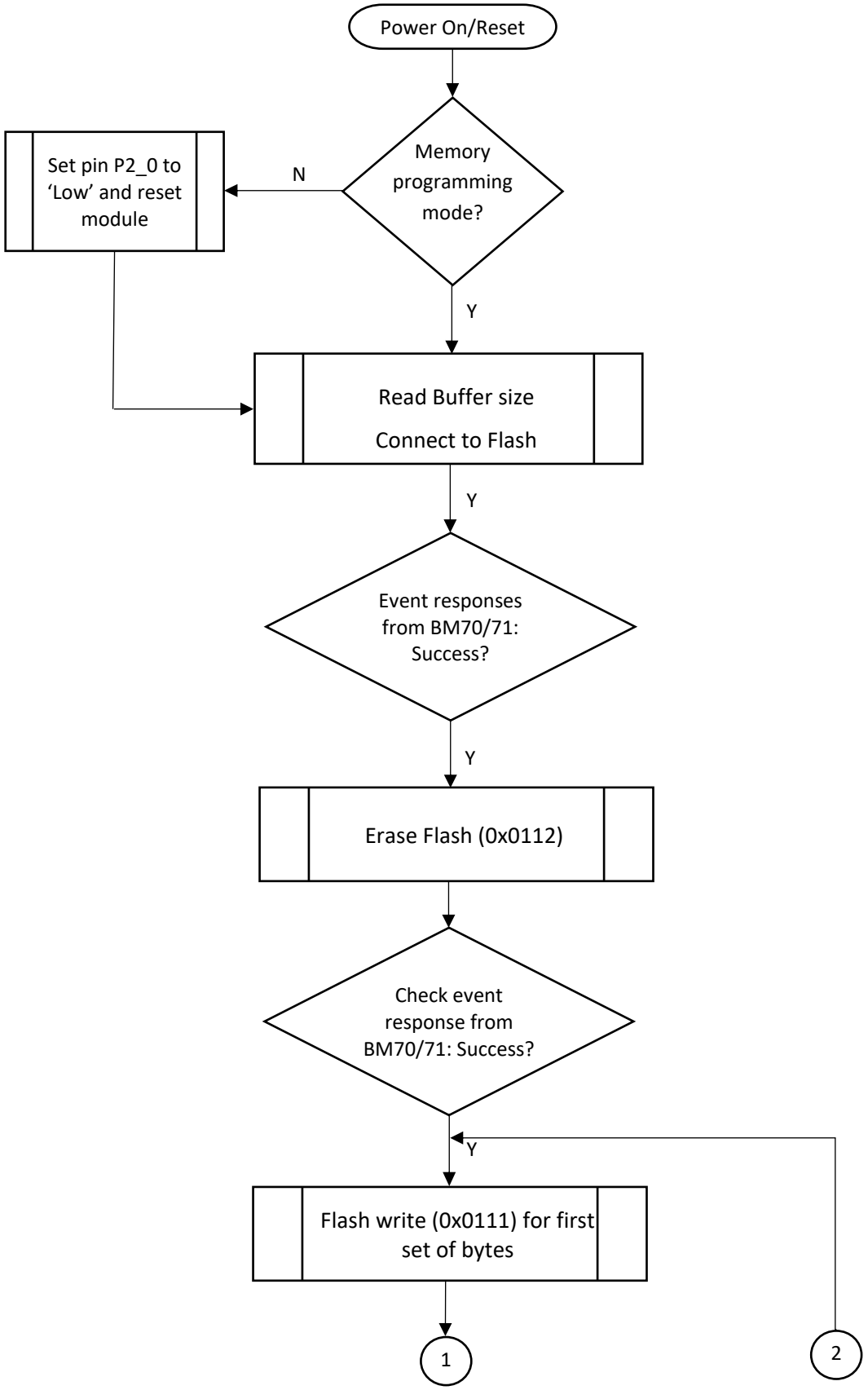
2.2.4 Step 4: Disconnect

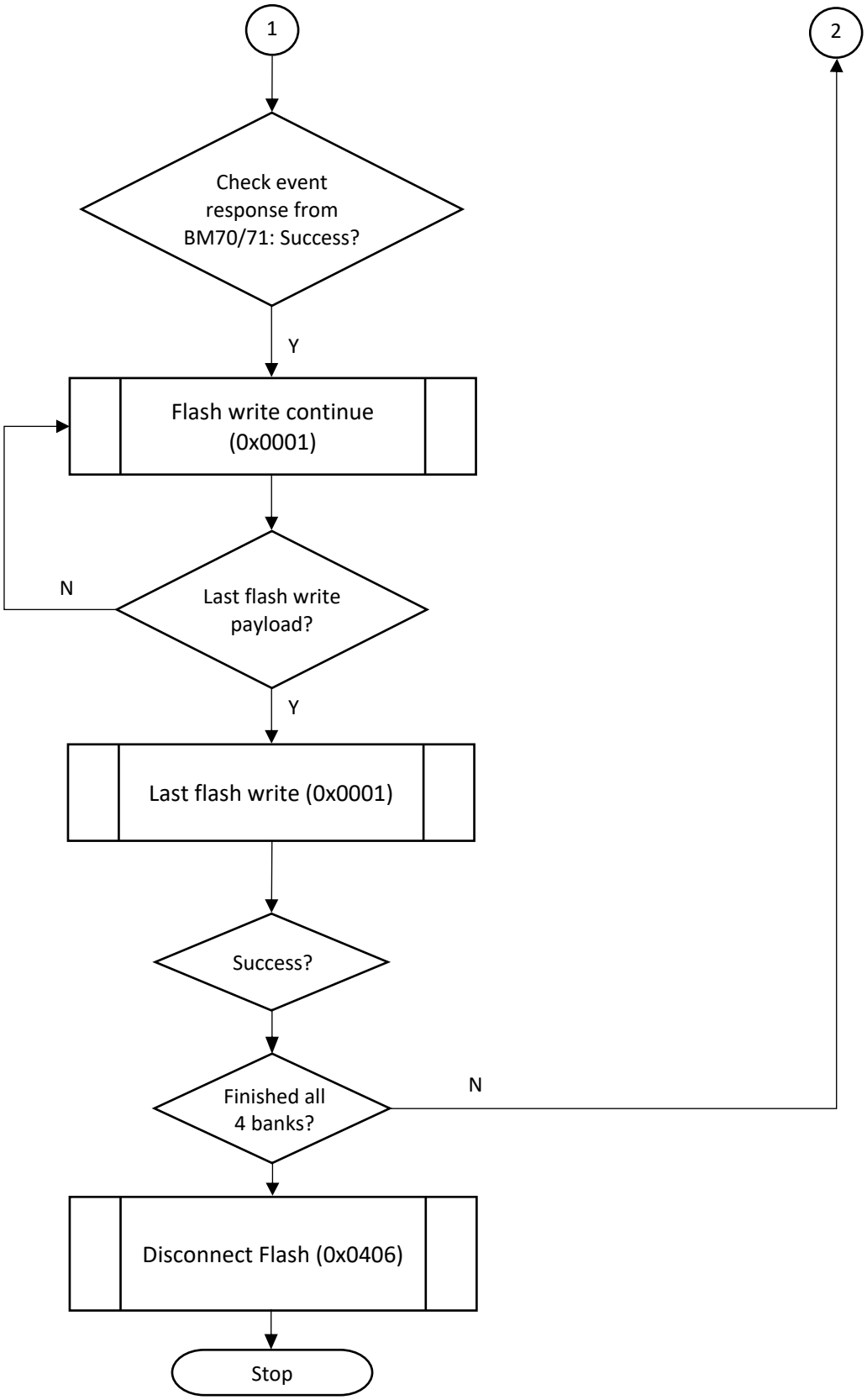
After completing the flash write process to flash the firmware files, the host needs to disconnect from the flash using the following command to end the programming session.

The opcode to disconnect the connection is 0x0406. The disconnect command terminates an existing connection. For more details on commands, see 3. Commands.

The following flowchart provides a pictorial representation of the steps listed above.

Figure 2-5. Device Firmware Upgrade Process




1
2
Check event response from BM70/71: Success?
Y
Flash write continue (0x0001)
Last flash write payload?
N
Y
Last flash write (0x0001)
Success?
Finished all 4 banks?
N
Disconnect Flash (0x0406)
Stop

2.3 Firmware Files Overview

A firmware update process requires four firmware files: one corresponding to each memory bank that needs to be updated. Each bank is 64 Kbytes in size. The firmware files corresponding to each firmware revision are available for download in the BM70/71 webpage.

The data in each firmware file is broken down in chunks of 32 bytes, with a header and a footer between each of these 32 bytes. The format for each chunk of data is shown in the following table.

Table 2-2. Data Format of Firmware File

	Start	Data Length	Starting address	Category	Data	Checksum	End
Nibble value	0	1-2	3-6	7-8	9..n	n + 1	n+2
Value	:	0xNN	0x0000 – 0xFFE0	0x04: Start of bank 0x00: Data 0x01: End of Bank	Data; can be up to 32 bytes	0xXX	'\n'

Before starting the flash write process, the user must remove the header and footer information from the hex files and concatenate the data. For memory addresses, the user must enter the value 0xFF, where no bytes are provided. The user must complete this process for all four firmware files.

3. Commands

This section describes the command protocol with which the user needs to flash a new firmware revision into the Flash. The protocol is partly based on the HCI command protocol outlined in the Bluetooth specification (www.bluetooth.org) volume 2, Part E, “Host Controller Interface Functional Specification” and Volume 4, Part A, “UART Transport Layer”.

The BM70/71 uses some of the HCI packet protocol documented in the Bluetooth specification for programming the device. In addition to the HCI commands, the BM70/71 also implements the reserved Opcode Group Field (OGF) value (0x3F) for vendor-specific debug commands, as described in Volume 2, Part E, Section 5, “HCI Data Formats”, within the HCI Command Packet.

In general, the commands and responses for the memory programming of the BM70/71 can be classified into three categories:

- HCI Command packets
- HCI-ISDAP Flash commands
- HCI Event responses

3.1 General Format of HCI Command Packets (Host to BM70/71)

The following figure illustrates the general message format of the HCI Command packet. The HCI Command Packet format and encoding of data is fully documented in the Bluetooth specification, but is briefly listed for completeness. All messages from the host (PC, host microcontroller and so on) to the BM70/71 IC (Device Under Test) follow this format.

Figure 3-1. HCI Command Packet Format

	START	OPCODE		LENGTH	DATA
BYTE NO.	0	1 - 2		3	4 - XX
Size (BYTES)	1	2		1	0 ...
VALUE	0x01	OCF <bits 9:0>	OGF <bits 15:10>	0xNN	Command Parameters
	Packet Indicator				LENGTH 0xNN bytes

Note: The OPCODE field for the HCI Command is transmitted over the UART LSB first. For example, the OPCODE (0xFC20), byte[1] is 0x20, byte[2] is 0xFC. See 3.4 HCI Command Packets for the list of HCI commands that are used for the firmware upgrade on the BM70/71.

3.2 General Format of HCI-ISDAP Flash Commands (Host to BM70/71)

The following figure illustrates the general message format of the HCI-ISDAP Flash. This command protocol is based on the HCI ACL Data packet as documented in the Bluetooth specification. Normally, the HCI Asynchronous Connection-Less (ACL) Data packet is used to exchange raw data between the host and controller. The data within the HCI ACL Data packet is destined for, or coming from, a peer device. However, in the case of BM70/71 programming, the raw data in the HCI ACL Data Packet is repurposed into the HCI-ISDAP Flash commands for the task of memory programming. The HCI-ISDAP command protocol is divided into information for memory programming commands, values to be programmed into memory and status of memory programming tasks.

Figure 3-2. HCI-ISDAP Flash Command Packet Format

				ISDAP OPCODE	ISDAP DATA LENGTH	ISDAP DATA
	START	HANDLE	LENGTH	DATA		
BYTE NO.	0	1 - 2	3 - 4	5-6	7-8	9 – XX
Size (BYTES)	1	2	2	2	2	0 ...
VALUE	0x02	0xYYYY	0xNNNN	0xMMMM	0xZZZZ	Memory Data
	Packet Indicator			Length: 0xNNNN bytes		
						Length: 0xZZZZ bytes

Note: The Handle field for the HCI ACL packet is formatted as little endian. For example, the handle (0x0FFF) is split as: byte[1] is 0xFF, byte[2] is 0x0F.

3.3 General Format of HCI Event Responses (BM70/71 to Host)

The following figure illustrates the general message format of the HCI Event packet. All HCI Event packet messages from the IS8170/71 IC to the host follow this format.

Figure 3-3. HCI Event Response Format

	START	EVENT CODE	LENGTH	DATA
BYTE NO.	0	1	2	3 - XX
Size (BYTES)	1	1	1	0 ...
VALUE	0x04	0xXX	0xNN	Event Parameters
	PACKET INDICATOR			LENGTH 0xNN bytes

The type of event code message sent from the BM70/71 to the host is dependent on the type of HCI Command packet or HCI-ISDAP Flash commands sent by the host. For each HCI Command packet or HCI-ISDAP Flash packet, the BM70/71 responds to the host MCU with an event response(s) based on the received command. The meaning and values of the parameters in the HCI Event packet are described in detail in the Bluetooth specification. For brief information on the HCI command packets, see 3.4 HCI Command Packets. Microchip recommends the user study and understand the information covered in the Bluetooth Specification regarding HCI Event packets.

3.4 HCI Command Packets

3.4.1 Read Buffer Size

For the purposes of programming, this HCI command packet is used:

1. To make sure the BM70/71 is functioning and ready for programming; a valid HCI Event packet response indicates this.
2. To discover the number of bytes of data that can be sent to the BM70/71 device in an HCI command or HCI-ISDAP Flash command.

For the external programmer or host, this command effectively provides the size of the internal buffer available in the BM70/71, which is used for receiving packets. The host must not send any HCI command packet or HCI-ISDAP command packet greater in total length than the value returned by the BM70/71 from this command. Not obeying this buffer size limitation will result in undefined device operation. When starting a programming flow, Microchip recommends that the programmer send this HCI command packet as the first message sent to the BM70/71.

3.4.1.1 Command Format (Host to BM70/71)

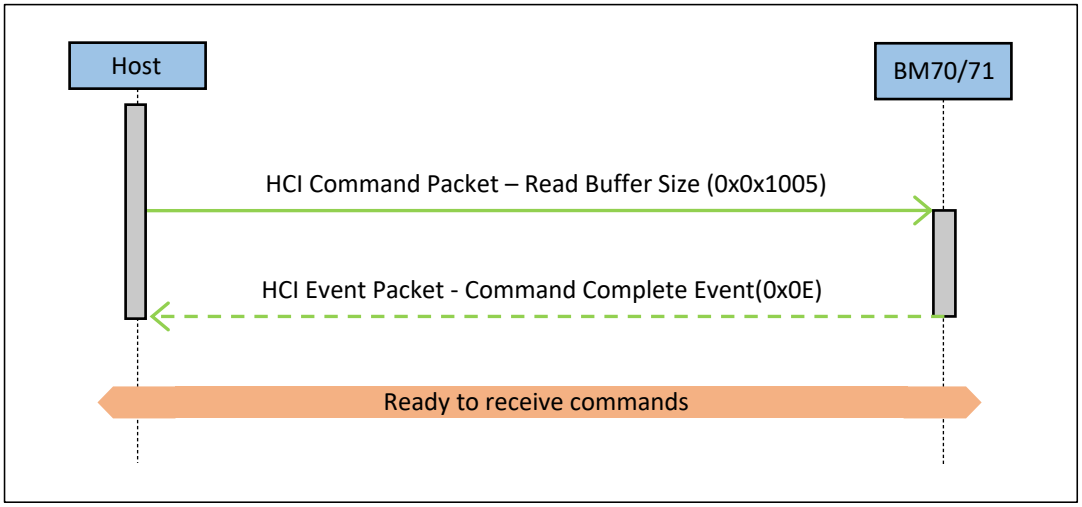
Figure 3-4. Read Buffer Size Command Format

	START	OPCODE	LENGTH
BYTE NO.	0	1 - 2	3
Size (BYTES)	1	2	1
VALUE	0x01	0x1005	0

Note: The OPCODE field for the HCI Vendor command is formatted as little endian. For the OPCODE (0x1005), byte[1] is 0x05, byte[2] is 0x10.

3.4.1.2 Example

Figure 3-5. Message Sequence for Read Buffer Size



3.4.1.3 Response Format (BM70/71 to Host)

The BM70/71 responds to the Read Buffer Size command with an HCI Command complete message (3.6 HCI Event Responses) with additional parameters appended to indicate the BM70/71 internal buffer sizes. These additional parameters indicate the packet length or buffer size, as well as the total number of buffers available in the BM70/71 device. The following figure illustrates the format, and the tables list the response for various values.

Figure 3-6. Read Buffer Size Event Response

	START	EVENT CODE	LENGTH	DATA
BYTE NO.	0	1	2	3 - 13
VALUE	0x04	0x0E	0x0B	See following tables

Value of Parameter (3)	Parameter Description	Length – 1 Byte
0xXX	Number of HCI command packets which can be sent to the BM70/71 from the host	—

Value of Parameter (4...5)	Parameter Description	Length – 2 Bytes
0x1005	HCI command opcode which is processed by the BM70/71	Format is little endian

Value of Parameter (6)	Parameter Description	Length – 1 Byte
0xXX	0x00 - Success 0x01...0xFF - For more details on error codes, see 4. Error Code Table Reference	—

Value of Parameter (7...8)	Parameter Description	Length – 2 Bytes
0xXXXX	HCI-ISDAP command packet length. Maximum length, in bytes, of HCI-ISDAP command packet the BM70/71 can accept. The user must not send any total message size that exceeds this length.	Format is little endian

Value of Parameter (9)	Parameter Description	Length – 1 Byte
0xXX	Synchronous data packet length. For the purposes of programming, the user can ignore this field.	—

Value of Parameter (10...11)	Parameter Description	Length – 2 Bytes
0xXXXX	Total number of HCI-ISDAP command packets. This is the number buffers in the BM70/71 device.	Format is little endian

Value of Parameter (12...13)	Parameter Description	Length – 2 Bytes
0xXXXX	Total number of Synchronous Data packets. For the purposes of programming, the user can ignore this field.	Format is little endian

3.4.1.4 Example of Use

Bytes sent from host: `01 05 10 00`

Response from BM70/71 : `04 0E 0B 01 05 10 00 00 01 30 0C 00 0A 00`

3.4.2 Create Connection Command

This command is used to create a connection to a remote device. With regards to memory programming, the host uses this packet to establish a programming session with BM70/71. The parameters in the packet are all set to zero, which indicates to the BM70/71 device that a programming connection is requested by the host.

3.4.2.1 Command Format (Host to BM70/71)

Figure 3-7. Create Connection Command Format

	START	OPCODE	LENGTH	DATA
BYTE NO.	0	1 - 2	3	4 - 16
Size (BYTES)	1	2	1	13
VALUE	0x01	0x0405	0x0D	See following tables

Note: The OPCODE field for the HCI vendor command is formatted as little endian. For the OPCODE (0x0405), byte[1] is 0x05, byte[2] is 0x04.

Value of Parameter (4...9)	Parameter Description	Length – 6 Bytes
0x00 0x00 0x00 0x00 0x00 0x00	Bluetooth Address The host uses a value of zero to indicate to the BM70/71 that a programming session is requested.	—

Value of Parameter (10...11)	Parameter Description	Length – 2 Bytes
0x0000	Packet type	—

Value of Parameter (12)	Parameter Description	Length – 1 Byte
0x00	Page scan repetition mode	—

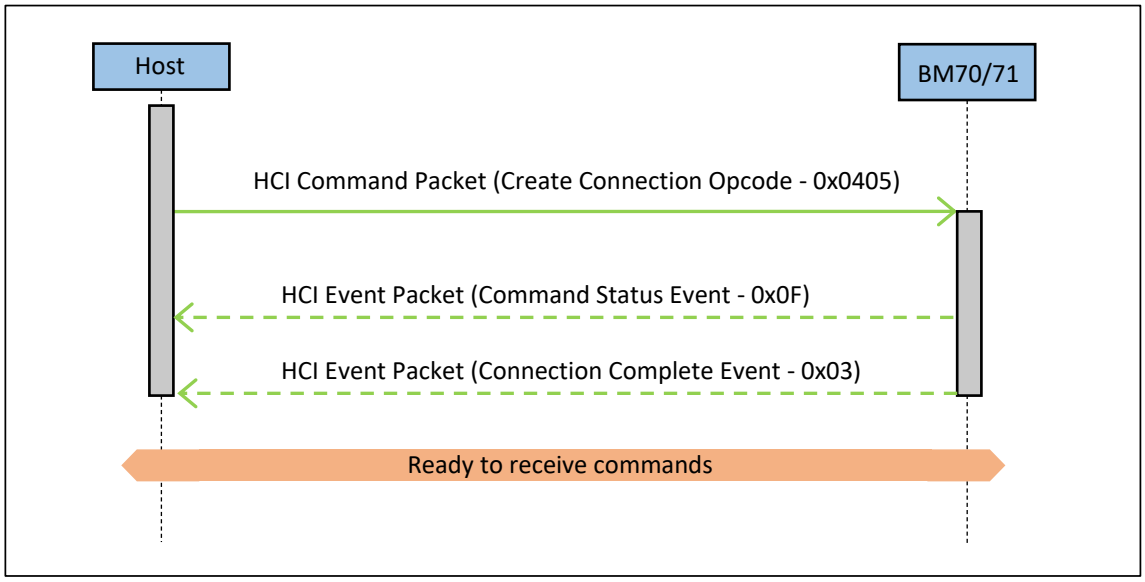
Value of Parameter (13)	Parameter Description	Length – 1 Byte
0x00	Reserved, must be set to zero	—

Value of Parameter (14...15)	Parameter Description	Length – 2 Bytes
0x0000	Clock offset	—

Value of Parameter (16)	Parameter Description	Length – 1 Byte
0x00	Role switch enable	—

3.4.2.2 Example

Figure 3-8. Message Sequence for Create Connection Command



3.4.2.3 Response Format (BM70/71 to Host)

The BM70/71 responds to the Create Connection command with an HCI Event Response for Command Status Event (opcode - 0x0F) and an HCI Event Response for Connection Complete Event (opcode - 0x03) packet. The BM70/71 does not append additional data to these responses. See 3.5 HCI-ISDAP Flash Commands Overview and 3.6 HCI Event Responses for base format of both of these responses.

3.4.2.4 Example of Use

Bytes sent by host: `01 05 04 0D 00 00 00 00 00 00 00 00 00 00 00 00 00 00`

Event responses from BM70/71:

```
04 0F 04 00 01 05 04
```

```
04 03 0B 00 FF 0F 00 00 00 00 00 00 00 00
```

3.4.3 Disconnect Command

This command is used to terminate an existing connection. The connection handle field identifies the connection to terminate, and the reason parameter indicates the reason for the host requesting disconnect. With respect to programming memory, this command is used by the host to terminate the programming connection. Once this command is processed by the BM70/71, the only way to restart programming operations is by sending the HCI Command Packet – Create Connection Command (opcode - 0x0405) to establish programming flow again. If any HCI-ISDAP commands are active when this Disconnect command is received by the BM70/71, undefined device operation may occur.

3.4.3.1 Command Format (Host to BM70/71)

Figure 3-9. Disconnect Command Format

	START	OPCODE	LENGTH	DATA
BYTE NO.	0	1 - 2	3	4 - 6
Size (BYTES)	1	2	1	3
VALUE	0x01	0x0406	0x03	See following tables

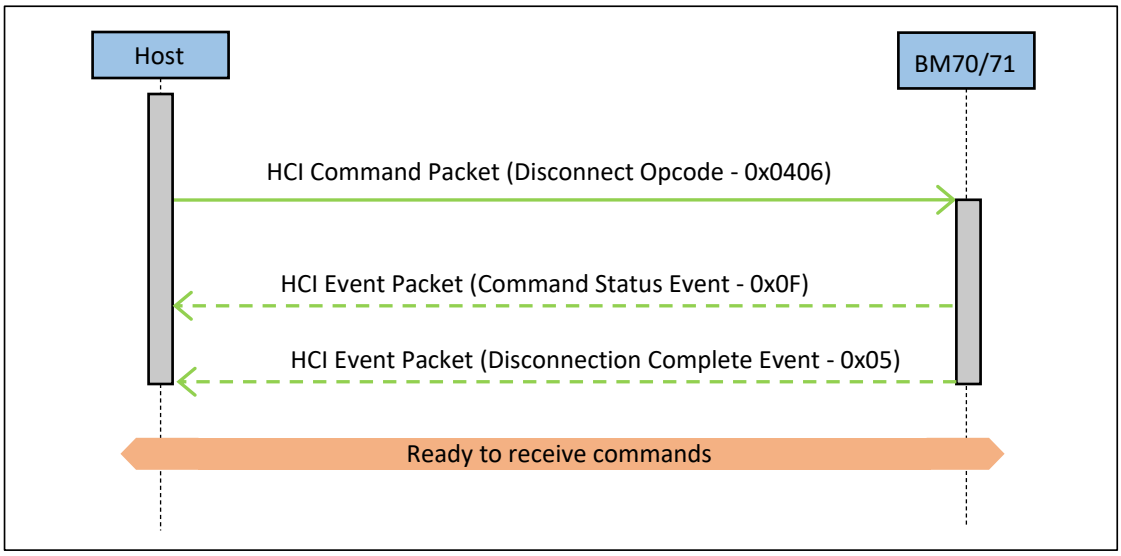
Note: The OPCODE field for the HCI Vendor command is formatted as little endian. For the OPCODE (0x0406), byte[1] is 0x06, byte[2] is 0x04.

Value of Parameter (4...5)	Parameter Description	Length – 2 Bytes
0x0FFF	Connection handle	Format is little endian

Value of Parameter (6)	Parameter Description	Length – 1 Byte
0x00	0x00 – Programming complete 0x01 ... 0xFF – For more details on error codes, see 4. Error Code Table Reference. With respect to programming, this value must always be zero from the host.	—

3.4.3.2 Example

Figure 3-10. Message Sequence for Disconnect Command



3.4.3.3 Response Format (BM70/71 to Host)

The BM70/71 responds to the Disconnect command with an HCI Event Response for Command Status Event (opcode - 0x0F) and an HCI Event Response for Disconnection Complete Event (opcode - 0x05) packet. No additional parameters are appended to these packets. See 3.5 HCI-ISDAP Flash Commands Overview and 3.6 HCI Event Responses for format of these responses.

3.4.3.4 Example of Use

Bytes sent by host: `01 06 04 03 FF 0F 00`

Responses from BM70/71:

`04 0F 04 00 01 06 04`

`5 04 00 FF 0F 00`

3.5 HCI-ISDAP Flash Commands Overview

This section describes the HCI-ISDAP Flash commands that can be used for the BM70/71 device.

3.5.1 Lock/Unlock Memory Command (HCI-ISDAP Opcode - 0x0100)

This HCI-ISDAP command allows the host to lock or unlock the internal memory of the BM70/71 device. Unlocking of the device memory is usually followed by a read, write or erase HCI-ISDAP command. Unlocking must occur before any read, write or erase operation can execute. Locking the device memory prevents a successful read, write or erase operation from occurring. This may be useful to prevent unauthorized access of private data contained within a GATT service table.

The lock and unlock operation are simply executed by setting the appropriate value within this command.

3.5.1.1 Command Format (Host to BM70/71)

Figure 3-11. Lock/Unlock Memory Command Format

				ISDAP OPCODE	ISDAP DATA LENGTH	ISDAP DATA
	START	HANDLE	LENGTH	DATA		
BYTE NO.	0	1 - 2	3 - 4	5-6	7-8	9 - 11
Size (BYTES)	1	2	2	2	2	3
VALUE	0x02	0x0FFF	0x0007	0x0100	0x0003	see following table

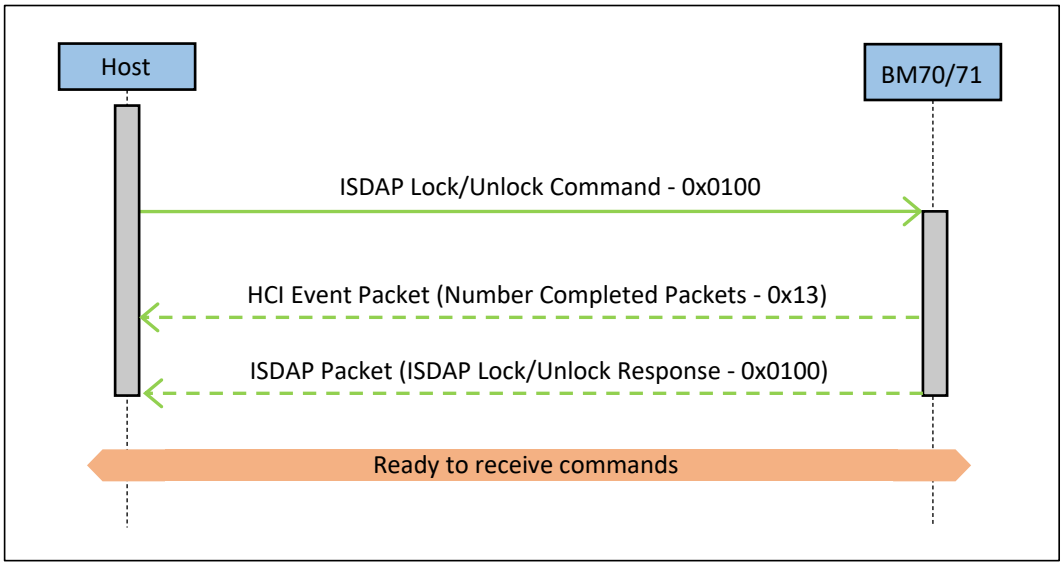
Value of Parameter (9)	Parameter Description	Length – 1 Byte
0x03	Memory type For the BM70/71, this value is set to three, indicating flash memory	—

Value of Parameter (10)	Parameter Description	Length – 1 Byte
0x00	Sub-memory type For the BM70/71, this value is set to zero, indicating EFLASH memory	—

Value of Parameter (11)	Parameter Description	Length – 1 Byte
0xXX	0 – Unlock memory 1 – Lock memory	—

3.5.1.2 Example

Figure 3-12. Message Sequence for Lock/Unlock Memory Command



3.5.1.3 Response Format (BM70/71 to Host)

The BM70/71 device returns the HCI Event Response for Number of Completed Packets Event (opcode - 0x13) and the HCI ACL Data Packet for ISDAP Command Response (ISDAP opcode - 0xXXXX) with no additional values appended to the packet.

The BM70/71 returns the HCI Event Response for Number of Completed Packets Event (opcode - 0x13) when it has successfully received a formatted HCI-ISDAP command. This lets the host know the HCI-ISDAP command is accepted and is being processed. For general format and details, see 3.6 HCI Event Responses. The BM70/71 returns an HCI-ISDAP packet with an embedded HCI-ISDAP Lock/Unlock command response to let the host know the status of the operation (success or failure). This response does not append any additional data to the response packet. For more details on the format and values of the packet, see 3.6 HCI Event Responses.

3.5.1.4 Example of Use

Bytes sent by host: `02 FF 0F 07 00 00 01 03 00 03 00 00`

Responses sent by BM70/71:

`04 13 05 01 FF 0F 01 00`

```
02 FF 0F 06 00 00 01 02 00 00 00
```

3.5.2 Write Memory Command

This HCI-ISDAP command allows the host to write values to the internal nonvolatile memory of the BM70/71 device. The BM70/71 contains a Harvard memory architecture (separate code and data address spaces) with segmented memory. Each of the four-memory bank or segments in the code space, and two memory bank or segments in the data space are 64 Kbytes in size. The most significant 16 bits of the address value are used to identify the target memory bank/segments, starting at a logical value of zero. The least significant 16 bits are used to address a specific memory location with the memory bank or segment.

When the host or programmer is initially setting up communication with the BM70/71, the host discovers the maximum packet (HCI ACL Data or HCI Command packets) length the BM70/71 can process (see section 3.4.1 Read Buffer Size). The host must not exceed this packet length value when sending programming data to the BM70/71 using HCI-ISDAP packets. In most cases, it is common for the maximum packet length of the BM70/71 device to be a smaller value than the maximum size of an HCI-ISDAP packet. Generally, the maximum packet length the BM70/71 can process is approximately 250 bytes. Whereas, the maximum allowable packet length of an HCI ACL Data packet can be up to 65535 bytes, including a few bytes of overhead. (Embedding HCI-ISDAP programming protocol in a HCI Data Packet reduces this value to 32767 bytes of data in a single packet.) This means, even though the user can technically send up to 65535 bytes of programming data in a single packet, the BM70/71 device can only receive a packet length of approximately 250 bytes.

To reduce communication overhead when performing large write operations where entire banks of memory will be programmed, the HCI-ISDAP write command has a setting embedded in the HCI-ISDAP Data Length field. The most significant bit in the 16-bit field represents a flag, referred to as the continue flag. If this flag is set to a '1', all subsequent write messages must be sent as Write Continue Command (HCI-ISDAP opcode - 0x0001) packets. The rest of the 16-bit ISDAP Data Length field (Bit[14:0]) represents the total amount of data in this packet. The size field of the HCI-ISDAP Write Command indicates the total amount of data to be programmed into the device (this includes all subsequent HCI-ISDAP Write Continue packets). With Write Continue operations, the BM70/71 device assumes all writes to memory are sequential, starting from the address value originally sent by the host in the first HCI-ISDAP Write Memory Command packet. These write continue operations allow the user to use the smaller Write Continue packet (see 3.5.3 Write Continue Command) to reduce communication overhead.

3.5.2.1 Command Format (Host to BM70/71)

Figure 3-13. Write Memory Command Format

				ISDAP OPCODE	ISDAP DATA LENGTH	ISDAP DATA
	START	HANDLE	LENGTH	DATA		
BYTE NO.	0	1 - 2	3 - 4	5-6	7-8	9 - n
Size (BYTES)	1	2	2	2	2	11 ... n
VALUE	0x02	0x0FFF	0xXXXX	0x0111	0xXXXX	See following tables

Value of Parameter (7...8)	Parameter Description	Length – 2 Bytes
0xXXXX	HCI-ISDAP Data Length field Bit 15 1 – Start write continue operation 0 – Normal write operation Bit[14:0] 0x0001:0x7FFF - Packet data length	The Most Significant Bit is repurposed for the continue flag. The maximum value for any HCI-ISDAP write operation can be 32767 bytes in length, but the data sent in each packet is limited based on the packet the BM70/71 can receive (see 3.4.1 Read Buffer Size).

Value of Parameter (9)	Parameter Description	Length – 1 Byte
0x03	Memory type For the BM70/71, this value is fixed to three, indicating flash memory	—

Value of Parameter (10)	Parameter Description	Length – 1 Byte
0x00	Sub-memory type For the BM70/71, this value is fixed to zero, indicating EFLASH memory	—

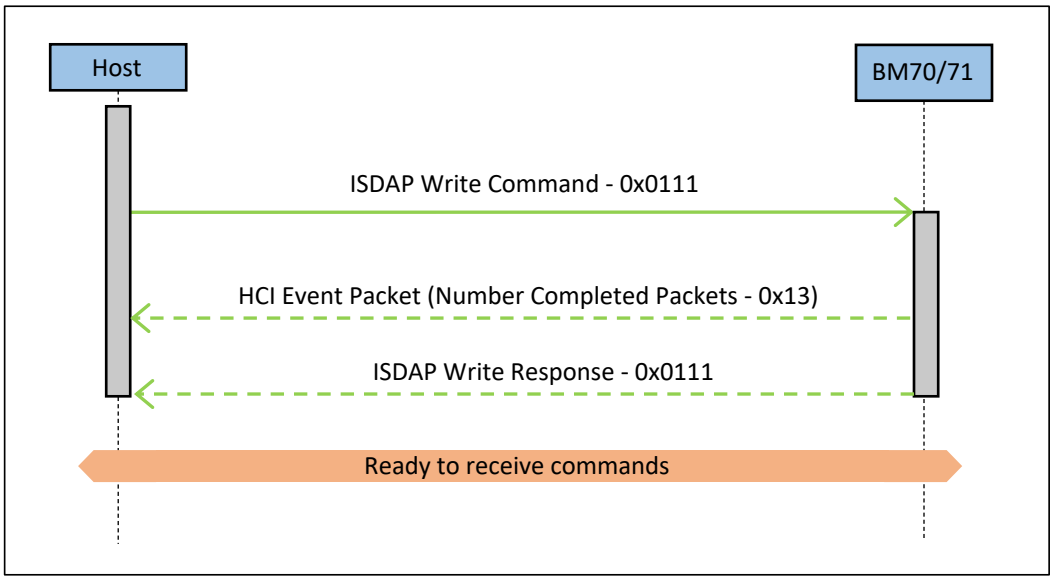
Value of Parameter (11...14)	Parameter Description	Length – 4 Bytes
0xXXXX_XXXX	Starting address of memory within the specified bank where write operations will begin. The most significant 16 bits of the address value represent the bank number. The least significant 16 bits represent the address within the specified bank.	Format is little endian. Example: For an address of `0x0000_1234`, the value is sent to the BM70/71 LSB first, 0x34 0x12 0x00 0x00

Value of Parameter (15...18)	Parameter Description	Length – 4 Bytes
0xXXXX_XXXX	HCI-ISDAP data length bit 15 0 – This field represents the number of bytes to write to memory from only this packet. 1 – This field represents the total number of bytes to write to memory in all subsequent write packets.	Format is little endian. Example: For a size of `0x0000_0800`, the value is sent to the BM70/71 LSB first, 0x00 0x08 0x00 0x00

Value of Parameter (19...n)	Parameter Description	Length – 1 ... n Bytes
0xXX	Any data to be written to memory.	The length of this field depends on the amount of data the user will write

3.5.2.2 Example

Figure 3-14. Message Sequence for Write Memory Command



3.5.2.3 Response Format (BM70/71 to Host)

The BM70/71 device returns the HCI Event Response for Number of Completed Packets Event (opcode - 0x13) and the HCI-ISDAP Command Response (HCI-ISDAP opcode - 0x0111) with no additional values appended to the packet.

The BM70/71 returns the HCI Event Response for Number of Completed Packets Event (opcode - 0x13) when it has successfully received a properly formatted HCI-ISDAP Command. This lets the host know the HCI-ISDAP command is accepted and is being processed. For general format and details, see 3.6 HCI Event Responses. The BM70/71 returns the HCI-ISDAP Command Response (HCI-ISDAP opcode - 0x0111) with a value to indicate the status of the write operation (i.e., success or failure). This response does not append any additional HCI-ISDAP Write Command-specific data to the response packet.

3.5.2.4 Example of Use

The following example shows how to write four bytes of data:

Bytes sent by host: `02 FF 0F 12 00 11 01 0E 00 03 00 00 08 00 00 04 00 00 00 01 02 03 04`

Response received from BM70/71:

```
04 13 05 01 FF 0F 01 00
02 FF 0F 06 00 11 01 02 00 00 00
```

3.5.3 Write Continue Command

This HCI-ISDAP command allows the host to write values to the internal memory of the BM70/71 device. This Write Continue command uses a smaller packet with less overhead to improve programming throughput. The BM70/71 must have received a previous Write response message before processing this HCI-ISDAP command. Undefined device operation will occur if proper message sequence is not followed. To understand how this HCI-ISDAP command fits in with the programming flow, see 2.2.3 Step 3: Flash Operations.

To terminate Write Continue operations, clear the 'Continue' flag in the HCI-ISDAP Data Length field of this HCI-ISDAP command to complete Write Continue operations. The BM70/71 device programs the data from this final Write Continue message and terminates sequential writes.

3.5.3.1 Command Format (Host to BM70/71)

Figure 3-15. Write Continue Memory Command Format

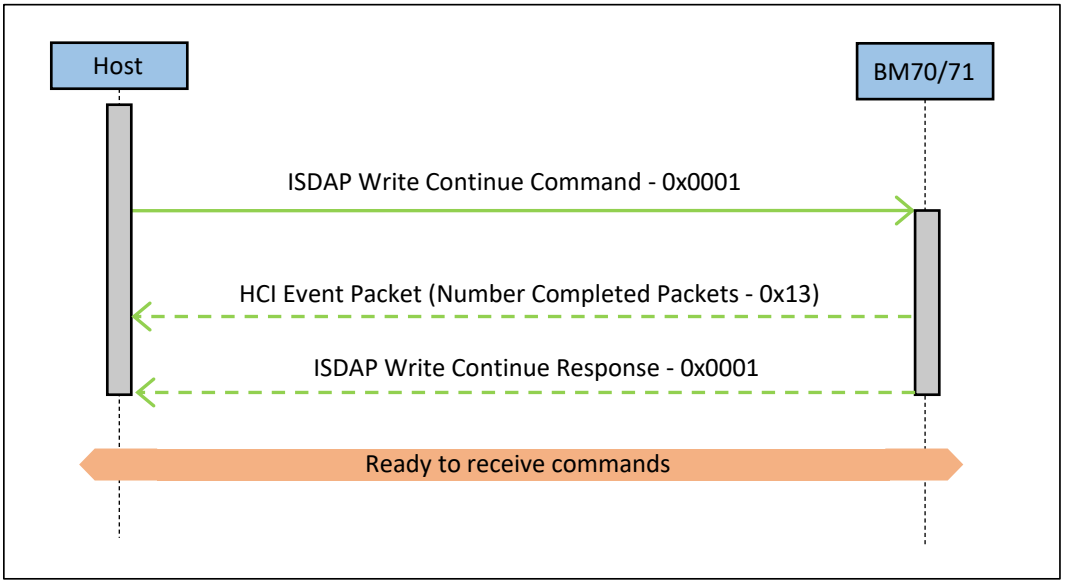
				ISDAP OPCODE	ISDAP DATA LENGTH	ISDAP DATA
	START	HANDLE	LENGTH	DATA		
BYTE NO.	0	1 - 2	3 - 4	5-6	7-8	9 ... n
Size (BYTES)	1	2	2	2	2	1 ... n
VALUE	0x02	0x0FFF	0xXXXX	0x0001	0xXXXX	See following tables

Value of Parameter (7...8)	Parameter Description	Length – 2 Bytes
0xXXXX	HCI-ISDAP Data Length field Bit 15 0 – Terminate Write Continue operation. Next write command must be a HCI-ISDAP Write Command (see 3.5.2 Write Memory Command) or undefined device operation will occur. 1 – Write Continue Operation active. Bit[14:0] 0x0001:0x7FFF – Packet Data Length	The Most Significant Bit is repurposed for the continue flag. The maximum value for any HCI-ISDAP write operation can be 32767 bytes in length, but the data sent in each packet is limited based on the packet the BM70/71 can receive (see 3.4.1 Read Buffer Size).

Value of Parameter (9 ... n)	Parameter Description	Length – 1 ... n Bytes
0xXX	Data to write to memory	The length of this field depends on amount data the user will write

3.5.3.2 Example

Figure 3-16. Message Sequence for Write Continue Command



3.5.3.3 Response Format (BM70/71 to Host)

The BM70/71 returns the HCI response when it successfully receives a properly formatted HCI ACL Data Packet with an embedded HCI-ISDAP Command. This lets the host know the HCI-ISDAP command is accepted and is being processed. For general format and details, see 3.6 HCI Event Responses. The BM70/71 returns the HCI event response with a value to indicate the status of the write continue operation (success or failure). This response does not append any additional HCI-ISDAP Write Continue Command-specific data to the response packet.

3.5.3.4 Example of Use

The following example shows how to write four bytes of data using the write continue command:

Bytes sent by host: `02 FF 0F 08 00 01 00 04 00 05 06 07 08`

Responses sent by BM70/71:

```
04 13 05 01 FF 0F 01 00
02 FF 0F 06 00 01 00 02 00 00 00
```

3.5.4 Erase Memory Command

This HCI-ISDAP command allows pages to be erased in the internal memory of the BM70/71 device. The memory architecture of the BM70/71 is designed to erase the smallest erasable page size of 2 Kbytes (2048 bytes). The user must only pass in an address aligned to a 2K boundary. Undefined device operation will occur if an address value is not aligned to a 2-Kbyte boundary.

3.5.4.1 Command Format (Host to BM70/71)

Figure 3-17. Erase Memory Command Format

				ISDAP OPCODE	ISDAP DATA LENGTH	ISDAP DATA
	START	HANDLE	LENGTH	DATA		
BYTE NO.	0	1 - 2	3 - 4	5-6	7-8	9 - 18
Size (BYTES)	1	2	2	2	2	10
VALUE	0x02	0x0FFF	0x000E	0x0112	0x000A	See following tables

Value of Parameter (9)	Parameter Description	Length – 1 Byte
0x03	Memory Type For the BM70/71, this value is set to 0x03, indicating flash memory	—

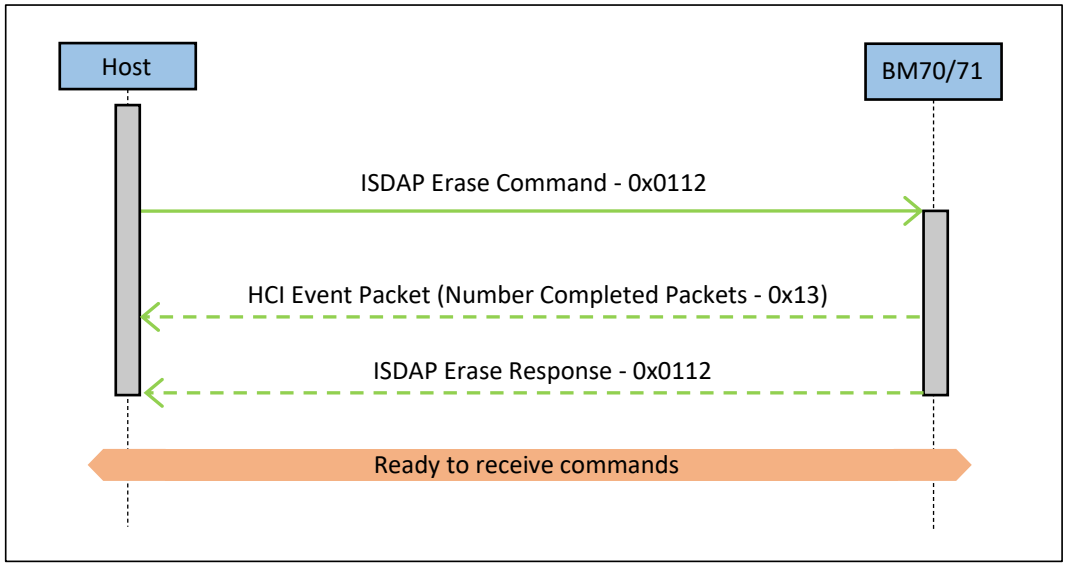
Value of Parameter (10)	Parameter Description	Length – 1 Byte
0x00	Sub-memory type For the BM70/71, this value is fixed to 0x00, indicating embedded flash (EFlash) memory	—

Value of Parameter (11...14)	Parameter Description	Length – 4 Bytes
0xXXXX_XXXX	Starting address of memory page to erase The Most Significant 16 bits of the address value represent the bank number. The least significant 16 bits represent the address within the specified bank and must be aligned to a 2-Kbyte boundary	Format is little endian. Example: For an address of 0x0000_0800, the value is sent to the BM70/71 LSB first, 0x00 0x08 0x00 0x00

Value of Parameter (15...18)	Parameter Description	Length – 4 Bytes
0xXXXX_XXXX	Number of bytes to erase Size value must be a multiple of 2048 (2 Kbytes). If both the address value and the size value are set equal to zero, the entire flash memory will be erased.	Format is little endian. Example: For a size of 0x0000_0800, the value is sent to the BM70/71 LSB first, 0x00 0x08 0x00 0x00

3.5.4.2 Example

Figure 3-18. Message Sequence for Erase Memory Command



3.5.4.3 Response Format (BM70/71 to Host)

The BM70/71 device returns the HCI event response and the command response with values specific to the erase command.

The BM70/71 returns the HCI event response when it successfully receives an HCI-ISDAP command. This lets the host know the HCI-ISDAP command is accepted and is being processed. For general format and details, see 3.6 HCI Event Responses. The BM70/71 returns the command response packet with values specific to the HCI-ISDAP Erase Command operation. The host can get the status of the erase operation (success or failure) and determine the memory areas that are successfully erased from this packet. See the following table for values specific to this response.

Figure 3-19. Erase Memory Command Response Format

				ISDAP OPCODE	ISDAP DATA LENGTH	ISDAP DATA
	START	HANDLE	LENGTH	DATA		
BYTE NO.	0	1 - 2	3 - 4	5-6	7-8	9 - 18
Size (BYTES)	1	2	2	2	2	10
VALUE	0x02	0x0FFF	0x000E	0x0112	0x000A	See following tables

Value of Parameter (9...10)	Parameter Description	Length – 2 Bytes
0xXXXX	HCI-ISDAP Erase command result 0x0000 – Success 0x0001 ... 0xFFFF – Failure	—

Value of Parameter (11...14)	Parameter Description	Length – 4 Bytes
0xXXXX_XXXX	Starting address of memory segment erased	Format is little endian

Value of Parameter (15...18)	Parameter Description	Length – 4 Bytes
0xXXXX_XXXX	Number of bytes erased	Format is little endian

3.5.4.4 Example of Use

Bytes sent by host: `02 FF 0F 0E 00 12 01 0A 00 03 00 00 08 00 00 00 10 00 00`

Responses from BM70/71:

```
04 13 05 01 FF 0F 01 00
02 FF 0F 0E 00 12 01 0A 00 00 00 00 08 00 00 00 10 00 00
```

3.6 HCI Event Responses

3.6.1 Disconnection Complete Event

An opcode for the Disconnection Complete event is 0x05. The BM70/71 sends this event response to indicate that the connection is terminated. The status within this command indicates whether the disconnection is successful or not. With respect to programming, the BM70/71 sends this event response to inform the host whether the BM70/71 device has exited programming mode successfully or not.

3.6.1.1 Response Format (BM70/71 to Host)

The following figure and tables illustrate the format and information returned to the host.

Figure 3-20. Disconnect Complete Event Response Format

	START	EVENT CODE	LENGTH	DATA
BYTE NO.	0	1	2	3 - 6
VALUE	0x04	0x05	0x04	See following tables

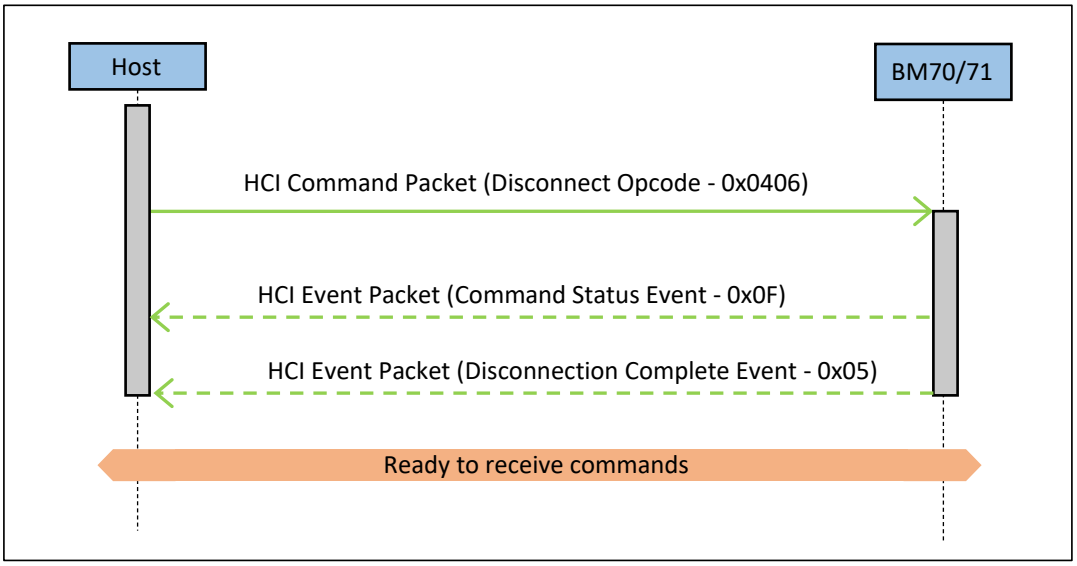
Value of Parameter (3)	Parameter Description	Length – 1 Byte
0xXX	Disconnect status 0x00 – Disconnect completed 0x01 ... 0xFF – For more details on error codes, see 4. Error Code Table Reference.	—

Value of Parameter (4...5)	Parameter Description	Length – 2 Bytes
0x0FFF	Connection handle that is disconnected. For programming, this handle value must be set as 0x0FFF	Format is little endian

Value of Parameter (6)	Parameter Description	Length – 1 Byte
0xXX	Reason for disconnect 0x00 – Host requested disconnect 0x01...0xFF – For more details on error codes, see 4. Error Code Table Reference	—

3.6.1.2 Example

Figure 3-21. Message Sequence for Disconnect Complete Event



3.6.2 Connection Complete Event

An opcode for the Connection Complete event is 0x03. The BM70/71 sends this event response to indicate that the connection is created. The status within this command indicates whether the connection is successful or not.

3.6.2.1 Response Format (BM70/71 to Host)

The following figure and tables illustrate the format and information returned to the host.

Figure 3-22. Connection Complete Event Response Format

	START	EVENT CODE	LENGTH	DATA
BYTE NO.	0	1	2	3 - 13
VALUE	0x04	0x03	0x0B	See following tables

Value of Parameter (3)	Parameter Description	Length – 1 Byte
0xXX	Connection operation status 0x00 – Connection is created 0x01 ... 0xFF – For more details on error codes, see 4. Error Code Table Reference.	—

Value of Parameter (4...5)	Parameter Description	Length – 2 Bytes
0x0FFF	Connection handle that is created for the connection. For programming, this handle value must be set as 0x0FFF	Format is little endian

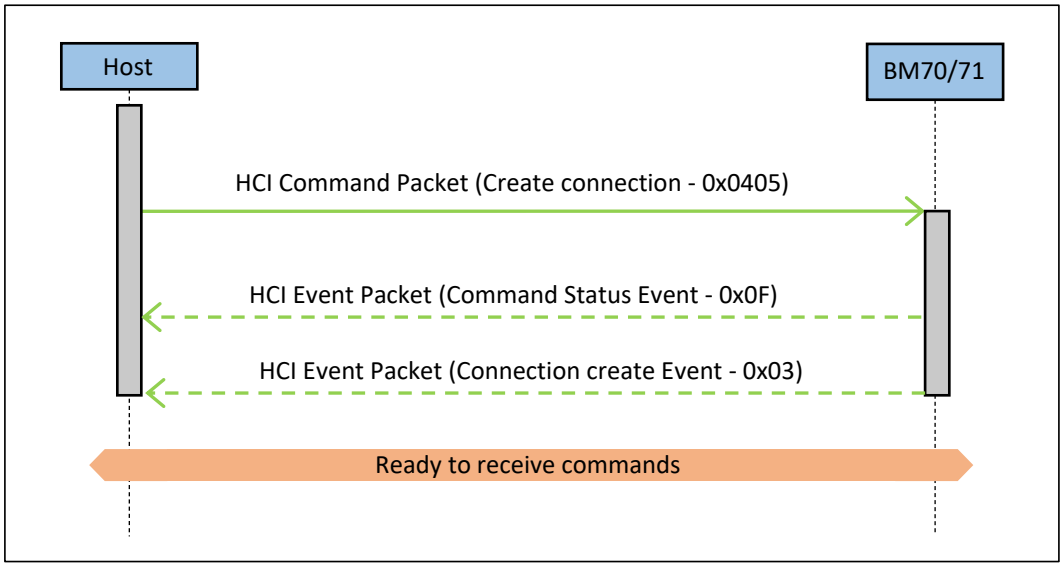
Value of Parameter (6..11)	Parameter Description	Length – 6 Bytes
0xXXXXXXXXXXXX	Bluetooth address For creating connection with the BM70/71, this parameter is set to all zeros.	0x00 00 00 00 00 00

Value of Parameter (12)	Parameter Description	Length – 1 Byte
0xXX	Link type 0x00 – Synchronous Connection-Oriented (SCO) 0x01 – Asynchronous Connection-Less (ACL)	0x01

Value of Parameter (13)	Parameter Description	Length – 1 Byte
0xXX	Encryption mode 0x00 – Disable 0x01 – Enable	—

3.6.2.2 Example

Figure 3-23. Message Sequence for Connection Create Event



3.6.3 Command Complete

An opcode for the Command Complete event is 0x0E. The BM70/71 sends this event response to inform the host that the command received is processed and complete. This event has a general format and is based on the HCI command the host issued; additional parameters may be added to the event response.

3.6.3.1 Response Format (BM70/71 to Host)

The following figure and tables illustrate the format and information returned to the host.

Figure 3-24. Command Complete Event Response Format

	START	EVENT CODE	LENGTH	DATA
BYTE NO.	0	1	2	3 - 6
VALUE	0x04	0x0E	0x04	See following tables

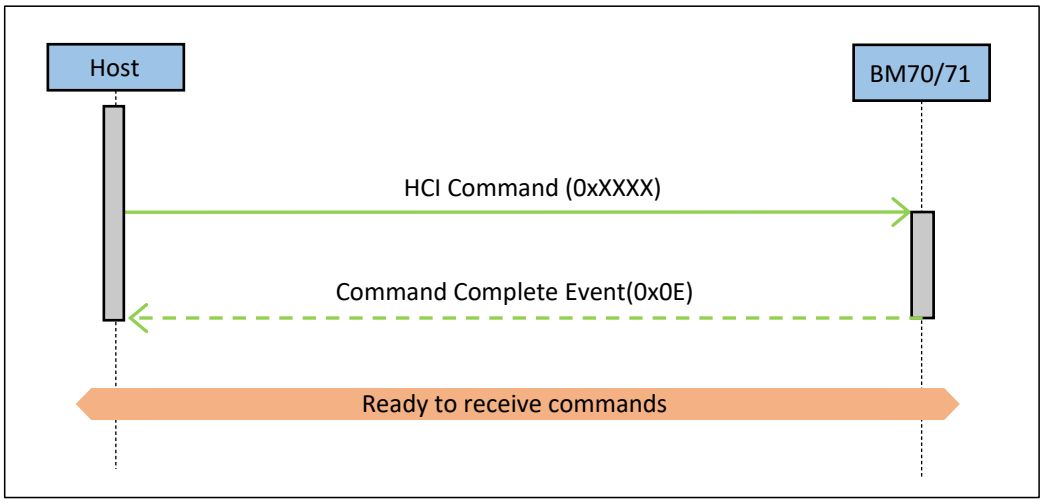
Value of Parameter (3)	Parameter Description	Length – 1 Byte
0xXX	Number of HCI command packets that can be sent to the BM70/71 from the host	—

Value of Parameter (4...5)	Parameter Description	Length – 2 Bytes
0xXXXX	HCI Command opcode that is processed by the BM70/71	Format is little endian

Value of Parameter (6)	Parameter Description	Length – 1 Byte
0xXX	For more details on error codes, see 4. Error Code Table Reference	—

3.6.3.2 Example

Figure 3-25. Message Sequence for Command Complete Event



3.6.4 Command Status Event

An opcode for the Command Status event is 0x0F. The BM70/71 sends this event response to indicate the command described by the command opcode parameter is received, and the BM70/71 device is performing the task associated with this command. Some HCI Command or HCI ACL Data packets (in this case HCI-ISDAP commands) take time to complete. This event response makes it possible to prevent the host from waiting for the command to finish. If the command cannot begin to execute, the status event parameter will contain a relevant error code and no command complete event will follow. With respect to programming, the host can use this event response to get the status on the HCI-ISDAP commands, which may take time to complete.

3.6.4.1 Response Format (BM70/71 to Host)

The following figure and tables illustrate the format and information returned to the host.

Figure 3-26. Command Status Event Response Format

	START	EVENT CODE	LENGTH	DATA
BYTE NO.	0	1	2	3 - 6
VALUE	0x04	0x0F	0x04	See following tables

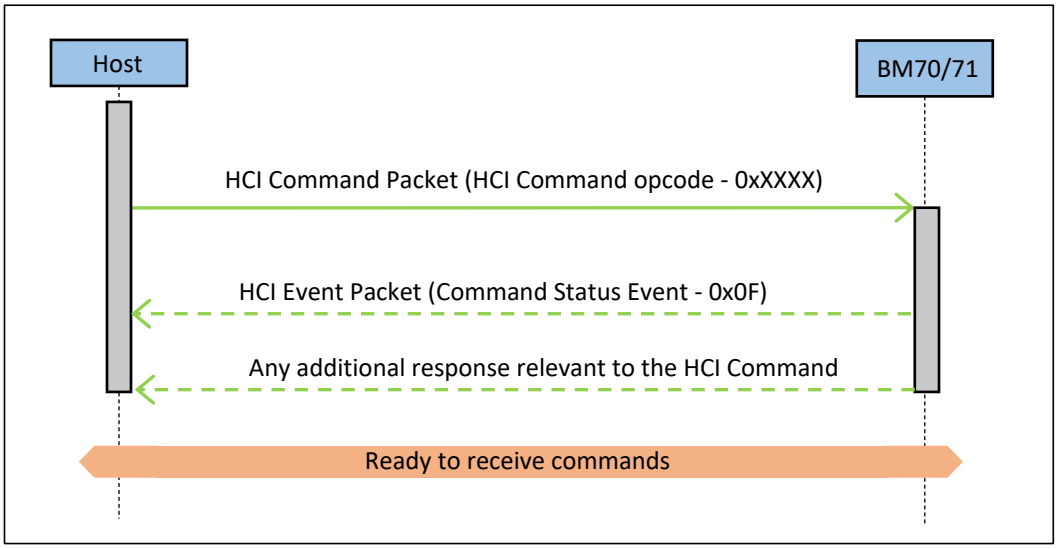
Value of Parameter (3)	Parameter Description	Length – 1 Byte
0xXX	0x00 – Command is pending, but successfully received 0x01 ... 0xFF – For more details on error codes, see 4. Error Code Table Reference.	—

Value of Parameter (4)	Parameter Description	Length – 1 Byte
0xXX	Number of HCI command packets that are allowed to be sent to the BM70/71 device by the host.	—

Value of Parameter (5...6)	Parameter Description	Length – 2 Bytes
0xXXXX	Opcode of the command that caused this event and is pending completion	Format is little endian

3.6.4.2 Example

Figure 3-27. Message Sequence for Command Status Event



3.6.5 Number of Completed Packets Event

An opcode for the Completed Packets event is 0x13. The BM70/71 sends this event response to inform the host about the number of data packets for each connection handle since the last time this event was sent to the host. For the HCI-ISDAP commands, this event is used to indicate the BM70/71 completed processing of the message (in other words, format acceptable) but does not indicate the HCI-ISDAP command operation is finished. The host can use the information in this event response to determine if the device can accept another HCI-ISDAP command.

3.6.5.1 Response Format (BM70/71 to Host)

The following figure and tables illustrate the format and information returned to the host.

Figure 3-28. Number of Completed Packet Event Response Format

	START	EVENT CODE	LENGTH	DATA
BYTE NO.	0	1	2	3 - 7
VALUE	0x04	0x13	0x05	See following tables

Value of Parameter (3)	Parameter Description	Length – 1 Byte
0x01	Number of connection handles and number of HCI-ISDAP data packets parameter pairs contained in this event. For BM70/71, this is always 0x01	—

Value of Parameter (4...5)	Parameter Description	Length – 2 Bytes
0x0FFF	Connection handle For HCI-ISDAP Commands, the handle field is always 0x0FFF	Format is little endian

Value of Parameter (6...7)	Parameter Description	Length – 2 Bytes
0x0001	Number of HCI-ISDAP packets that are completed for the associated connection handle value since the previous time this event was sent to the host.	Format is little endian

3.6.6 HCI-ISDAP Command Response

The host sends HCI-ISDAP commands to accomplish programming of memory. When the BM70/71 device completes processing the HCI-ISDAP command, status of the HCI-ISDAP command execution is sent back to the host. The parameter values sent by the BM70/71 device to the host are based on the HCI-ISDAP command received. However, the general format of the packet is the same for all HCI-ISDAP Command Response packets.

3.6.6.1 Command Format (BM70/71 to Host)

Figure 3-29. HCI-ISDAP Command Response Format

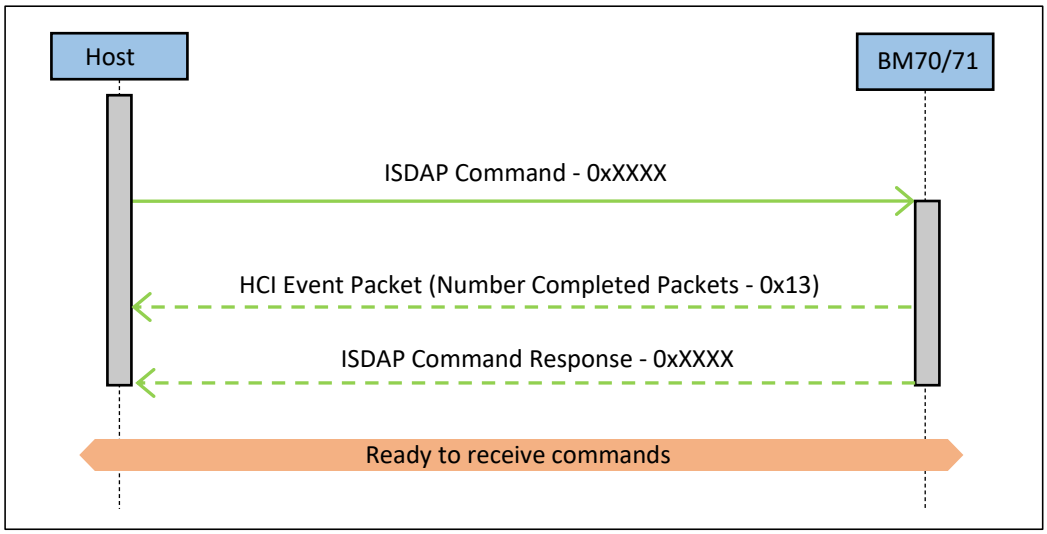
				ISDAP OPCODE	ISDAP DATA LENGTH	ISDAP DATA
	START	HANDLE	LENGTH	DATA		
BYTE NO.	0	1 - 2	3 - 4	5-6	7-8	9 - XX
Size (BYTES)	1	2	2	2	2	0 ...
VALUE	0x02	0x0FFF	0x000E	0xXXXX	0xNNNN	See following tables

Value of Parameter (9...10)	Parameter Description	Length – 2 Bytes
0xXXXX	HCI-ISDAP command result 0x0000 – Success 0x0001 ... 0xFFFF – Failure	—

Value of Parameter (11...n)	Parameter Description	Length = (0xNNNN – 2) Bytes
0xXX	Any data that is associated with a successfully executed command. **Note:** All HCI-ISDAP command responses do not always have this parameter field. Example: For an HCI-ISDAP Read command, the requested memory values read are returned	—

3.6.6.2 Example

Figure 3-30. Message Sequence for ICI-ISDAP Command Response Event



4. Error Code Table Reference

The following table acts as a quick reference to the error codes used to indicate the status for several HCI command packets and HCI event responses.

Note: The length of each parameter is one byte.

Table 4-1. Error Codes

Value of Parameter (6)	Parameter Description
0x00	Command successful
0x01	Unknown HCI command
0x02	Unknown connection identifier
0x03	Hardware failure
0x04	Page timeout
0x05	Authentication failure
0x06	PIN or Key missing
0x07	Memory capacity exceeded
0x08	Connection timeout
0x09	Connection limit exceeded
0x0A	Synchronous connection limit to a device exceeded
0x0B	ACL connection already exists
0x0C	Command disallowed
0x0D	Connection rejected due to limited resources
0x0E	Connection rejected due to security reasons
0x0F	Connection rejected due to unacceptable BD_ADDR
0x10	Connection accept timeout exceeded
0x11	Unsupported feature or parameter value
0x12	Invalid HCI command parameters
0x13	Remote user terminated connection
0x14	Remote device terminated connection due to low Resources
0x15	Remote device terminated connection due to power Off
0x16	Connection terminated by local host
0x17	Repeated attempts
0x18	Pairing not allowed
0x19	Unknown LMP PDU
0x1A	Unsupported remote feature / unsupported LMP feature
0x1B	SCO offset rejected
0x1C	SCO interval rejected
0x1D	SCO air mode rejected

.....continued

Value of Parameter (6)	Parameter Description
0x1E	Invalid LMP parameters / invalid LL parameters
0x1F	Unspecified error
0x20	Unsupported LMP parameter value / unsupported LL parameter value
0x21	Role change not Allowed
0x22	LMP response timeout / LL response timeout
0x23	LMP error transaction collision
0x24	LMP PDU not allowed
0x25	Encryption mode not acceptable
0x26	Link key cannot be changed
0x27	Requested QoS not supported
0x28	Instant passed
0x29	Pairing with unit key not supported
0x2A	Different transaction collision
0x2B	Reserved
0x2C	QoS unacceptable parameter
0x2D	QoS rejected
0x2E	Channel classification not supported
0x2F	Insufficient security
0x30	Parameter out of mandatory range
0x31	Reserved
0x32	Role switch pending
0x33	Reserved
0x34	Reserved slot violation
0x35	Role switch failed
0x36	Extended inquiry response too large
0x37	Secure simple pairing not supported by host
0x38	Host busy - pairing
0x39	Connection rejected due to no suitable channel found
0x3A	Controller busy
0x3B	Unacceptable connection parameters
0x3C	Directed advertising timeout
0x3D	Connection terminated due to MIC failure
0x3E	Connection failed to be established
0x3F	MAC connection failed
0x40	Coarse clock adjustment rejected but will try to adjust using clock dragging

Note: '6' indicates the location of the byte in the response sequence.

5. Document Revision History

Revision	Date	Section	Description
A	03/2021	Document	Initial Revision

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Technical support is available through the website at: www.microchip.com/support

Microchip Devices Code Protection Feature

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specifications contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is secure when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods being used in attempts to breach the code protection features of the Microchip devices. We believe that these methods require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Attempts to breach these code protection features, most likely, cannot be accomplished without violating Microchip's intellectual property rights.
- Microchip is willing to work with any customer who is concerned about the integrity of its code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of its code. Code protection does not mean that we are guaranteeing the product is "unbreakable." Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

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Quality Management System

For information regarding Microchip's Quality Management Systems, please visit www.microchip.com/quality.

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