TI BLE Vendor Specific HCI Reference Guide

Version 1.4

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1. Purpose

The purpose of this document is to describe the Texas Instruments Inc. (TI) vendor specific Host Controller Interface (HCI) for *Bluetooth*® low energy (BLE). This document is intended for customer product software engineers and field application engineers working with the TI BLE stack software.

2. Functional Overview

In BLE, there is a logical distinction between the Host software (often referred to as the higher layer stack) and the Controller software (please see Figure 1).

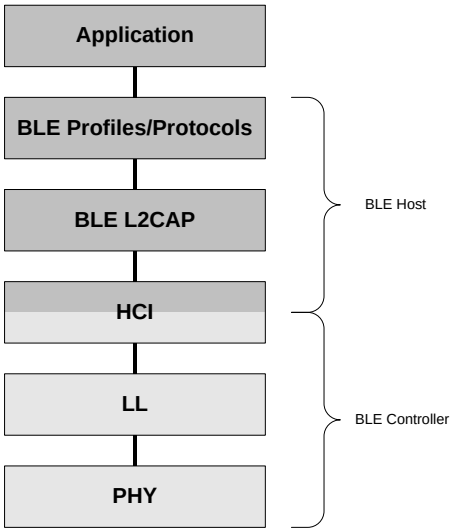


Figure 1: Logical Organization of Application and BLE Stack

These components can either exist on the same device (single-device configuration), or be placed on separate devices (dual-device configuration) utilizing a Host Controller Interface (HCI) for communication (see section 7 for more detail). In the single-device configuration, there is obviously only one device, and the application software would execute on top of the BLE profiles and stack (please see Figure 2).

Figure 2: Single Device Configuration

In the a dual-device configuration, the application software would also execute on top of the BLE profiles and stack, and only the controller would be located on a separate device (please see Figure 3).

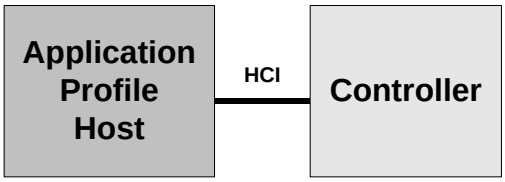


Figure 3: Dual Device Configuration

However, allowing an application to be developed on one device while communicating with the BLE stack executing on another allows access to the BLE stack that would not normally be available (please see Figure 4).

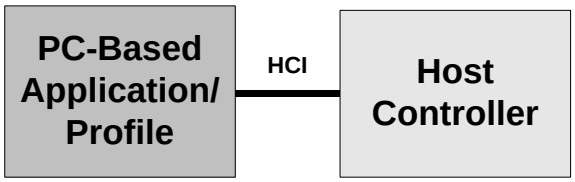


Figure 4: Network Processor Configuration with HCI

This configuration provides is a very convenient configuration for creating a test development environment where the “application” is actually a test tool that can execute scripts, generate logs, etc. Note however that the HCI as defined by Bluetooth only allows Controller commands and events. As such, a set of Vendor Specific commands and events will be used instead, and that is what this document intends to convey.

3. Numerical Notation Conventions

Multiple-octets may be specified in hexadecimal notation in one of two ways:

Standard Hexadecimal Notation

In this notation, a single hexadecimal radix indicator “0x” precedes the entire value. The octet order as read from left to right is from most significant octet to least significant octet. For example, for the value 0x123456ABCDEF, ’12’ is the most significant octet and ‘EF’ is the least significant octet.

Colon Separated Hexadecimal Notation

In this notation, the hexadecimal radix indicator “0x” is *not* used and octets are colon separated. The octet order as read from left to right is from least significant octet to most significant octet. For example, for the value 12:34:56:AB:CD:EF, ’12’ is the least significant octet and ‘EF’ is the most significant octet.

4. Definitions, Abbreviations, Acronyms

Term	Definition
ATT	Attribute Protocol
BC	Broadcast
BLE	Bluetooth Low Energy
BT	Bluetooth
CMD	Command
CSG	Command Subgroup
EC	Event Code
EOEF	Event Opcode Event Field
EOGF	Event Opcode Group Field
ESG	Event Subgroup
GAP	Generic Access Profile
GATT	Generic Attribute Profile
HCI	Host Controller Interface
IDE	Integrated Development Environment
L2CAP	Logical Link Control and Adaptation Protocol
LE	Low Energy
LL	Link Layer
OCF	Opcode Command Field
OGF	Opcode Group Field
OTA	Over The Air
PB	Packet Boundary
PER	Packet Error Rate
PHY	Physical Layer
PPM	Parts Per Million
SCA	Sleep Clock Accuracy
SM	Security Manager
NV	Non-Volatile

5. References

[1] Specification of the Bluetooth System, Core Version 4.0, June 30, 2010.
http://www.bluetooth.com/Specification%20Documents/Core_V40.zip

6. Revision History

Date (YMD)	Document version	Description of changes
2010-09-30	V1.0	Initial
2011-07-13	V1.1	BLE V1.1 RTM.
2011-12-02	V1.1b	BLE V1.1b RTM.
2012-03-16	V1.2.1	BLE V1.2.1 RTM
2012-05-18	V1.2.2	BLE V1.2.2 RTM
2012-12-13	V1.3	BLE V1.3 RTM
2013-04-18	V1.3.1	BLE V1.3.1 RTM
2013-06-14	V1.3.2	BLE V1.3.2 RTM
2013-12-??	V1.4	BLE V1.4 RTM

7. HCI Overview

The HCI is a standardized *Bluetooth* interface for sending commands, receiving events, and for sending and receiving data. It is typically realized as a serial interface, using either RS232 or USB communication devices. As the name implies, the HCI is used to bridge the Host and Controller devices. Commands and Events can either be specified, or can be vendor specific for extensibility. The following sections summarize the HCI protocol, the specification defined commands and events used by BLE, and a detailed description of the vendor specific commands and events defined by Texas Instruments Inc. For complete details on the HCI as specified by the Special Interest Group (SIG), please see the Core specification [1].

8. Specification Interface

8.1 HCI Interface Protocol

The HCI supports four types of packets: Command Packet, Asynchronous Data Packet, Synchronous Data Packet, and Event Packet. The packet type is a one byte value that precedes the HCI packet. The packet type has the following values:

Packet	Packet Type
Command	1
Asynchronous Data	2
Synchronous Data	3
Event	4

Table 1: HCI Packet Types

The contents of each packet are shown as follows (please see section 5.4 of [1], Vol. 2, Part E for additional details).

8.1.1 Command Packet

The command packet is comprised of the opcode, the number of parameters, and parameters themselves.

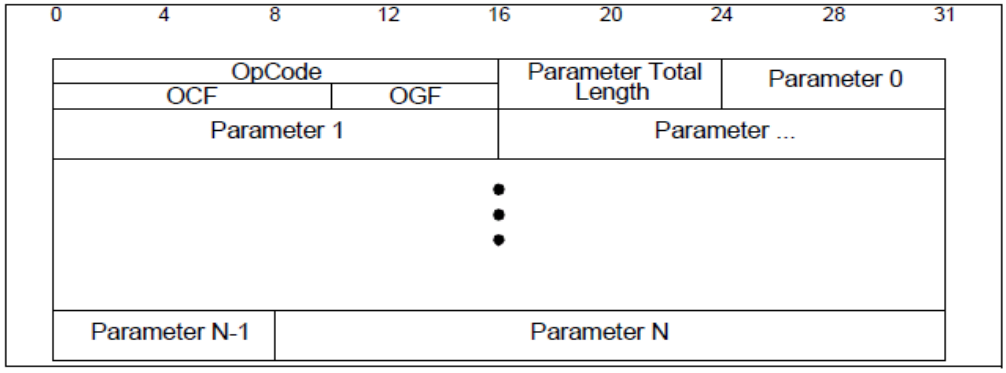


Figure 5: Command Packet

8.1.2 Asynchronous Data Packet

The asynchronous data packet is comprised of the connection handle, fragmentation bits, the number of data bytes, and the data bytes themselves.

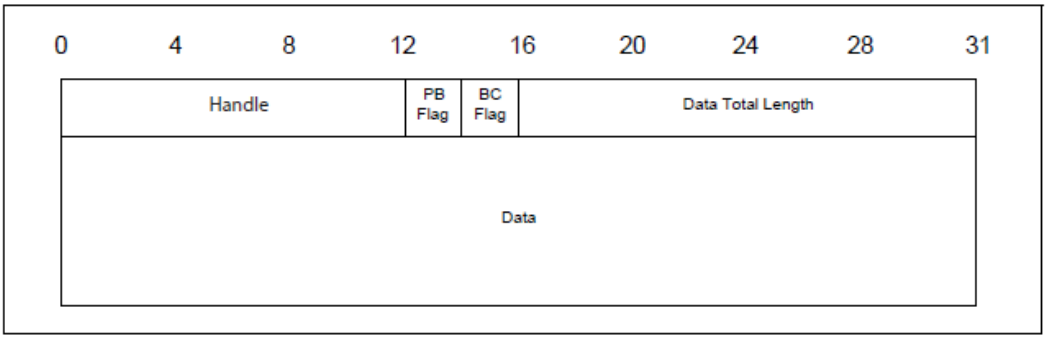


Figure 6: Asynchronous Data Packet

8.1.3 Synchronous Data Packet

This synchronous data packet is not used in BLE.

8.1.4 Event Packet

The event packet is comprised of the event code, the number of event parameters, and the event parameters themselves.

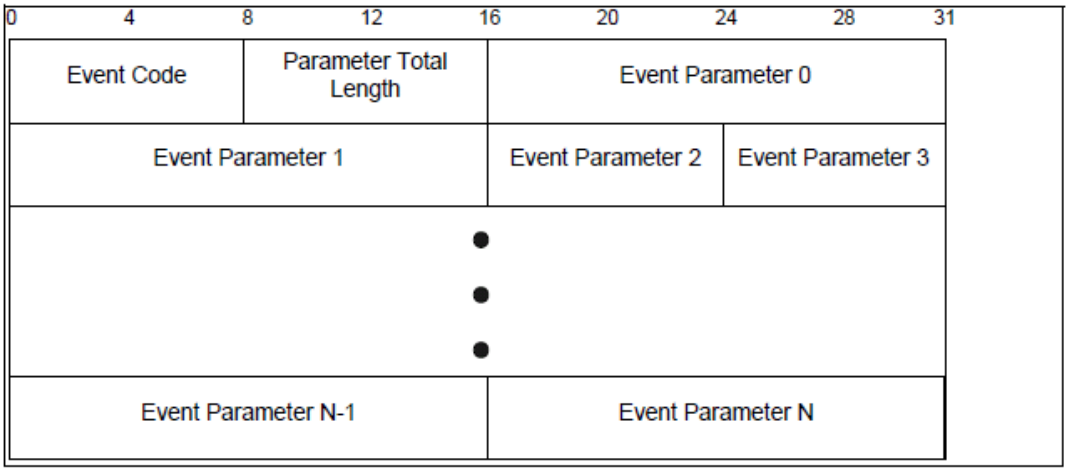


Figure 7: Event Packet

8.2 HCI Command

HCI commands use a 16-bit opcode for identification. The opcode is subdivided into two parts: a 10-bit Opcode Command Field (OCF) and a 6-bit Opcode Group Field (OGF).

HCI Command Opcode

The OGF values are defined by the Bluetooth (BT) Core specification. The LE specification has its own OGF value. Also, there is an escape OGF value so that vendor specific OCF codes can be used. The following OGF values are valid for BLE:

- Link Control Commands: 1
- Link Policy Commands: 2
- Controller and Baseband Commands: 3
- Informational Parameters: 4
- Status Parameters: 5
- Testing Commands: 6
- LE Only Commands: 8
- Vendor Specific Commands: 63

The following table lists all specification BLE commands and their opcodes. Note that while all commands can be used in a Network Processor Configuration with HCI, not all events will be returned as they will be trapped and possibly discarded by the BLE Stack.

Commands			
LE Commands	**OGF**	**OCF**	**Opcode**
LE Set Event Mask	8	1	0x2001
LE Read Buffer Size	8	2	0x2002
LE Read Local Supported Features	8	3	0x2003
LE Set Random Address	8	5	0x2005
LE Set Advertising Parameters	8	6	0x2006
LE Read Advertising Channel TX Power	8	7	0x2007
LE Set Advertising Data	8	8	0x2008
LE Set Scan Response Data	8	9	0x2009
LE Set Advertise Enable	8	10	0x200A
LE Set Scan Parameters	8	11	0x200B
LE Set Scan Enable	8	12	0x200C
LE Create Connection	8	13	0x200D
LE Create Connection Cancel	8	14	0x200E
LE Read White List Size	8	15	0x200F
LE Clear White List	8	16	0x2010
LE Add Device To White List	8	17	0x2011
LE Remove Device From White List	8	18	0x2012
LE Connection Update	8	19	0x2013
LE Set Host Channel Classification	8	20	0x2014
LE Read Channel Map	8	21	0x2015
LE Read Remote Used Features	8	22	0x2016
LE Encrypt	8	23	0x2017
LE Rand	8	24	0x2018
LE Start Encryption	8	25	0x2019
LE Long Term Key Requested Reply	8	26	0x201A
LE Long Term Key Requested Negative Reply	8	27	0x201B
LE Read Supported States	8	28	0x201C
LE Receiver Test	8	29	0x201D
LE Transmitter Test (max TX power for CC2541 is 0 dBm)	8	30	0x201E
LE Test End Command	8	31	0x201F

Commands			
BT Commands for LE	**OGF**	**OCF**	**Opcode**
Disconnect	1	6	0x0406
Read Remote Version Information	1	29	0x041D
Set Event Mask	3	1	0x0C01
Reset	3	3	0x0C03
Read Transmit Power Level	3	45	0x0C2D
Set Controller To Host Flow Control (optional)	3	49	0x0C31
Host Buffer Size (optional)	3	51	0x0C33
Host Number Of Completed Packets (optional)	3	53	0x0C35
Read Local Version Information	4	1	0x1001
Read Local Supported Commands (optional)	4	2	0x1002
Read Local Supported Features	4	3	0x1003
Read BD_ADDR	4	9	0x1009
Read RSSI	5	5	0x1405

Table 2: BLE Commands

8.3 HCI Events

HCI events use an 8-bit event code. All event codes are unique for BT and BLE. Only event code 255 is reserved for vendor specific events. There is only one event code for all LE events. The first event parameter is used as the subevent code to distinguish the LE event types.

The following table lists all the BLE events and their event codes, and subevent codes when applicable:

Events		
LE Events	**Event Code**	**Subevent Code**
LE Connection Complete	0x3E	0x01
LE Advertising Report	0x3E	0x02
LE Connection Update Complete	0x3E	0x03
LE Read Remote Used Features Complete	0x3E	0x04
LE Long Term Key Requested	0x3E	0x05
BT Events	**Event Code**	
Disconnection Complete	0x05	
Encryption Change	0x08	
Read Remote Version Information Complete	0x0C	

Command Complete	0x0E
Command Status	0x0F
Hardware Error (optional)	0x10
Number Of Completed Packets	0x13
Data Buffer Overflow	0x1A
Encryption Key Refresh Complete	0x30

Table 3: BLE Events

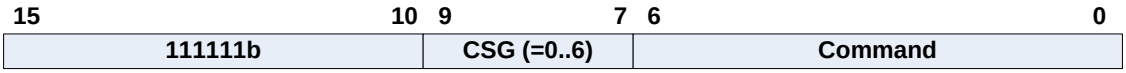
9. Vendor Specific Interface

As mentioned, vendors can specify their own HCI commands and events by using the pre-defined vendor specific opcode and vendor specific event code.

9.1 Vendor Specific Commands

A vendor specific opcode is indicated by an OGF value of 63. The vendor can use the remaining 10 bits (i.e. the OCF) as they like. TI defines its vendor specific OCF values by subdividing the 10 bits into a 3 MSB Command Subgroup (CSG) and a 7 LSB Command (CMD). The CSG is used by the HCI to route the commands to a designated subsystem within the BLE stack. In this way, vendor specific commands can be specified for any BLE stack layer.

HCI Vendor Specific Command Opcode, CSG=0..6



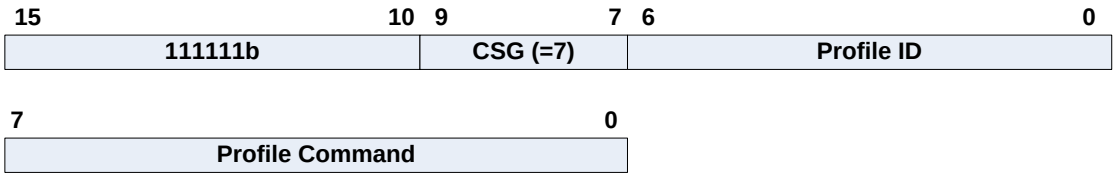
The Command Subgroups are defined as follows:

CSG	Subgroup
0	HCI
1	L2CAP
2	ATT
3	GATT
4	GAP
5	UTIL
6	Reserved
7	User Profile

Table 4: Command Opcode Subgroups

For Command Subgroups 0 to 6, the remaining 7 bits of Command provide up to 128 commands for each subgroup. For Subgroup 7, the remaining 7 bits specify one of 128 profiles and indicates that the subsequent byte is to be used as the command for that particular profile (i.e. up to 256 commands per profile).

HCI Vendor Specific Command Opcode, CSG=7



The following table lists all TI-specific HCI commands:

Vendor Specific Commands				
LE Commands	**OGF**	**CSG**	**CMD**	**Opcode**
HCI Extension Set Rx Gain	63	0	0	0xFC00
HCI Extension Set Tx Power	63	0	1	0xFC01
HCI Extension One Packet Per Event	63	0	2	0xFC02
HCI Extension Clock Divide On Halt	63	0	3	0xFC03
HCI Extension Declare NV Usage	63	0	4	0xFC04
HCI Extension Decrypt	63	0	5	0xFC05
HCI Extension Set Local Supported Features	63	0	6	0xFC06
HCI Extension Set Fast Tx Response Time	63	0	7	0xFC07
HCI Extension Modem Test Tx	63	0	8	0xFC08
HCI Extension Modem Hop Test Tx	63	0	9	0xFC09
HCI Extension Modem Test Rx	63	0	10	0xFC0A
HCI Extension End Modem Test	63	0	11	0xFC0B
HCI Extension Set BDADDR	63	0	12	0xFC0C
HCI Extension Set SCA	63	0	13	0xFC0D
HCI Extension Enable PTM[1]	63	0	14	0xFC0E
HCI Extension Set Frequency Tuning	63	0	15	0xFC0F
HCI Extension Save Frequency Tuning	63	0	16	0xFC10
HCI Extension Set Max DTM Tx Power	63	0	17	0xFC11
HCI Extension Map PM IO Port	63	0	18	0xFC12

[1] Not supported by HCI; only direct function call is allowed. No event is returned.

Vendor Specific Commands				
LE Commands	**OGF**	**CSG**	**CMD**	**Opcode**
HCI Extension Disconnect Immediate	63	0	19	0xFC13
HCI Extension Packet Error Rate	63	0	20	0xFC14
HCI Extension Packet Error Rate by Channel[2]	63	0	21	0xFC15
HCI Extension Extend RF Range	63	0	22	0xFC16
HCI Extension Advertiser Event Notice[2]	63	0	23	0xFC17
HCI Extension Connection Event Notice[2]	63	0	24	0xFC18
HCI Extension Halt During RF	63	0	25	0xFC19
HCI Extension Set Slave Latency Override	63	0	26	0xFC1A
HCI Extension Build Revision	63	0	27	0xFC1B
HCI Extension Delay Sleep	63	0	28	0xFC1C
HCI Extension Reset System	63	0	29	0xFC1D
HCI Overlapped Processing	63	0	30	0xFC1E
HCI Number Completed Packets Limit	63	0	31	0xFC1F
L2CAP Connection Parameter Update Request	63	1	18	0xFC92
ATT Error Response	63	2	1	0xFD01
ATT Exchange MTU Request	63	2	2	0xFD02
ATT Exchange MTU Response	63	2	3	0xFD03
ATT Find Information Request	63	2	4	0xFD04
ATT Find Information Response	63	2	5	0xFD05
ATT Find By Type Value Request	63	2	6	0xFD06
ATT Find By Type Value Response	63	2	7	0xFD07
ATT Read By Type Request	63	2	8	0xFD08
ATT Read By Type Response	63	2	9	0xFD09
ATT Read Request	63	2	10	0xFD0A
ATT Read Response	63	2	11	0xFD0B
ATT Read Blob Request	63	2	12	0xFD0C
ATT Read Blob Response	63	2	13	0xFD0D
ATT Read Multiple Request	63	2	14	0xFD0E
ATT Read Multiple Response	63	2	15	0xFD0F
ATT Read By Group Type Request	63	2	16	0xFD10
ATT Read By Group Type Response	63	2	17	0xFD11

[2] Not supported by HCI; only direct function call is allowed. No event is returned.

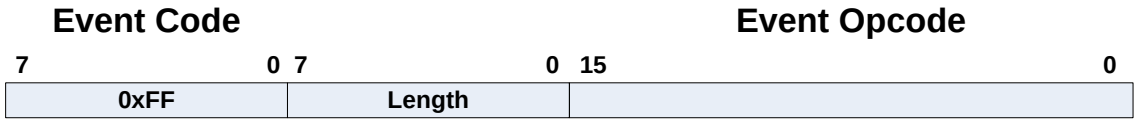
Vendor Specific Commands				
LE Commands	**OGF**	**CSG**	**CMD**	**Opcode**
ATT Write Request	63	2	18	0xFD12
ATT Write Response	63	2	19	0xFD13
ATT Prepare Write Request	63	2	22	0xFD16
ATT Prepare Write Response	63	2	23	0xFD17
ATT Execute Write Request	63	2	24	0xFD18
ATT Execute Write Response	63	2	25	0xFD19
ATT Handle Value Notification	63	2	27	0xFD1B
ATT Handle Value Indication	63	2	29	0xFD1D
ATT Handle Value Confirmation	63	2	30	0xFD1E
GATT Discover Characteristics By UUID	63	3	8	0xFD88
GATT Write Long	63	3	22	0xFD96
GAP Device Initialization	63	4	0	0xFE00
GAP Configure Device Address	63	4	3	0xFE03
GAP Device Discovery Request	63	4	4	0xFE04
GAP Device Discovery Cancel	63	4	5	0xFE05
GAP Make Discoverable	63	4	6	0xFE06
GAP Update Advertising Data	63	4	7	0xFE07
GAP End Discoverable	63	4	8	0xFE08
GAP Establish Link Request	63	4	9	0xFE09
GAP Terminate Link Request	63	4	10	0xFE0A
GAP Authenticate	63	4	11	0xFE0B
GAP Passkey Update	63	4	12	0xFE0C
GAP Slave Security Request	63	4	13	0xFE0D
GAP Signable	63	4	14	0xFE0E
GAP Bond	63	4	15	0xFE0F
GAP Terminate Auth	63	4	16	0xFE10
GAP Update Link Parameter Request	63	4	17	0xFE11
GAP Set Parameter	63	4	48	0xFE30
GAP Get Parameter	63	4	49	0xFE31
GAP Resolve Private Address	63	4	50	0xFE32
GAP Set Advertisement Token	63	4	51	0xFE33
GAP Remove Advertisement Token	63	4	52	0xFE34
GAP Update Advertisement Tokens	63	4	53	0xFE35

Vendor Specific Commands				
LE Commands	**OGF**	**CSG**	**CMD**	**Opcode**
GAP Bond Set Parameter	63	4	54	0xFE36
GAP Bond Get Parameter	63	4	55	0xFE37
UTIL Reserved	63	5	0	0xFE80
UTIL NV Read	63	5	1	0xFE81
UTIL NV Write	63	5	2	0xFE82
Reserved	63	6	0	0xFF00
User Profiles	63	7	0	0xFF80

Table 5: Vendor Specific Commands

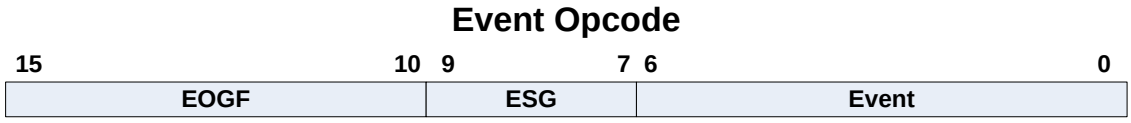
9.2 Vendor Specific Events

A vendor specific event code is indicated by a value of 255. The vendor must then use event parameters (following the length byte) to specify vendor specific events. TI defines the following two bytes as the Event Opcode.



The Event Opcode was chosen to mirror the Command Opcode by dividing it into two parts: a 6 bit Event Opcode Group Field (EOGF), and a 10 bit Event Opcode Event Field (EOEF).

The EOEF is again chosen to mirror the Command OCF by dividing it into two parts: the Event Subgroup (ESG) and the Event.



The EOGF is defined as follows:

EOGF	Group
0	Embedded Opcode
1	Core Opcode
2	Profile Request
3	Profile Response
4 .. 63	Reserved

Table 6: Event Opcode Group

The ESG is defined as in Table 4. The Events are as defined in the following table. Please note that the value of the Events cannot be less than 0x400 as the first 1024 values are reserved. The reason for this has to do with Client/Server Request/Response Tunneling, which is described in the following section. Tunneling requires embedding Command Opcodes in HCI Events. When this is done, the EOGF is zero, and the remaining 10 bits ***is*** the Command Opcode. In order to prevent Command and Event Opcode overlap, the first 1024 values are reserved in the Event Opcode space. Also note that the Event Code (EC) is always 0xFF since normally only Controller events are returned via the HCI.

Vendor Specific Events					
LE Events	**EC**	**EOGF**	**ESG**	**Event**	**Opcode**
HCI Extension Set Rx Gain	0xFF	1	0	0	0x0400
HCI Extension Set Tx Power	0xFF	1	0	1	0x0401
HCI Extension One Packet Per Event	0xFF	1	0	2	0x0402
HCI Extension Clock Divide On Halt	0xFF	1	0	3	0x0403
HCI Extension Declare NV Usage	0xFF	1	0	4	0x0404
HCI Extension Decrypt	0xFF	1	0	5	0x0405
HCI Extension Set Local Supported Features	0xFF	1	0	6	0x0406
HCI Extension Set Fast Tx Response Time	0xFF	1	0	7	0x0407
HCI Extension Modem Test Tx	0xFF	1	0	8	0x0408
HCI Extension Modem Hop Test Tx	0xFF	1	0	9	0x0409
HCI Extension Modem Test Rx	0xFF	1	0	10	0x040A
HCI Extension End Modem Test	0xFF	1	0	11	0x040B
HCI Extension Set BDADDR	0xFF	1	0	12	0x040C
HCI Extension Set SCA	0xFF	1	0	13	0x040D
HCI Extension Enable PTM[3]	0xFF	1	0	14	0x040E
HCI Extension Set Frequency Tuning	0xFF	1	0	15	0x040F
HCI Extension Save Frequency Tuning	0xFF	1	0	16	0x0410
HCI Extension Set Max DTM Tx Power	0xFF	1	0	17	0x0411
HCI Extension Map PM IO Port	0xFF	1	0	18	0x0412
HCI Extension Disconnect Immediate	0xFF	1	0	19	0x0413
HCI Extension Packet Error Rate	0xFF	1	0	20	0x0414
HCI Extension Packet Error Rate by Channel[3]	0xFF	1	0	21	0x0415
HCI Extension Extend RF Range	0xFF	1	0	22	0x0416
HCI Extension Advertiser Event Notice[3]	0xFF	1	0	23	0x0417
HCI Extension Connection Event Notice[3]	0xFF	1	0	24	0x0418
HCI Extension Halt During RF	0xFF	1	0	25	0x0419
HCI Extension Set Slave Latency Override	0xFF	1	0	26	0x041A
HCI Extension Build Revision	0xFF	1	0	27	0x041B
HCI Extension Delay Sleep	0xFF	1	0	28	0x041C
HCI Extension Reset System	0xFF	1	0	29	0x041D

[3] Not supported by HCI; only direct function call is allowed. No event is returned.

Vendor Specific Events					
LE Events	**EC**	**EOGF**	**ESG**	**Event**	**Opcode**
HCI Extension Overlapped Processing	0xFF	1	0	30	0x041E
HCI Extension Number Completed Packets Limit	0xFF	1	0	31	0x041F
L2CAP Command Reject	0xFF	1	1	1	0x0481
L2CAP Connection Parameter Update Response	0xFF	1	1	19	0x0493
ATT Error Response	0xFF	1	2	1	0x0501
ATT Exchange MTU Request	0xFF	1	2	2	0x0502
ATT Exchange MTU Response	0xFF	1	2	3	0x0503
ATT Find Information Request	0xFF	1	2	4	0x0504
ATT Find Information Request	0xFF	1	2	5	0x0505
ATT Find By Type Value Request	0xFF	1	2	6	0x0506
ATT Find By Type Value Response	0xFF	1	2	7	0x0507
ATT Read By Type Request	0xFF	1	2	8	0x0508
ATT Read By Type Response	0xFF	1	2	9	0x0509
ATT Read Request	0xFF	1	2	10	0x050A
ATT Read Response	0xFF	1	2	11	0x050B
ATT Read Blob Request	0xFF	1	2	12	0x050C
ATT Read Blob Response	0xFF	1	2	13	0x050D
ATT Read Multiple Request	0xFF	1	2	14	0x050E
ATT Read Multiple Response	0xFF	1	2	15	0x050F
ATT Read By Group Type Request	0xFF	1	2	16	0x0510
ATT Read By Group Type Response	0xFF	1	2	17	0x0511
ATT Write Request	0xFF	1	2	18	0x0512
ATT Write Response	0xFF	1	2	19	0x0513
ATT Prepare Write Request	0xFF	1	2	22	0x0516
ATT Prepare Write Response	0xFF	1	2	23	0x0517
ATT Execute Write Request	0xFF	1	2	24	0x0518
ATT Execute Write Response	0xFF	1	2	25	0x0519
ATT Handle Value Notification	0xFF	1	2	27	0x051B
ATT Handle Value Indication	0xFF	1	2	29	0x051D
ATT Handle Value Confirmation	0xFF	1	2	30	0x051E
GAP Device Init Done	0xFF	1	4	0	0x0600
GAP Device Discovery	0xFF	1	4	1	0x0601
GAP Advert Data Update Done	0xFF	1	4	2	0x0602

Vendor Specific Events					
LE Events	**EC**	**EOGF**	**ESG**	**Event**	**Opcode**
GAP Make Discoverable Done	0xFF	1	4	3	0x0603
GAP End Discoverable Done	0xFF	1	4	4	0x0604
GAP Link Established	0xFF	1	4	5	0x0605
GAP Link Terminated	0xFF	1	4	6	0x0606
GAP Link Parameter Update	0xFF	1	4	7	0x0607
GAP Random Address Changed	0xFF	1	4	8	0x0608
GAP Signature Updated	0xFF	1	4	9	0x0609
GAP Authentication Complete	0xFF	1	4	10	0x060A
GAP Passkey Needed	0xFF	1	4	11	0x060B
GAP Slave Requested Security	0xFF	1	4	12	0x060C
GAP Device Information	0xFF	1	4	13	0x060D
GAP Bond Complete	0xFF	1	4	14	0x060E
GAP Pairing Requested	0xFF	1	4	15	0x060F
Command Status	0xFF	1	4	127	0x067F

Table 7: Vendor Specific Events

You will note that there are two EOGF values for Profiles. At this time, no profiles are defined well enough to document here. These values are defined in anticipation of not only needing large numbers of profiles and their commands, but also of needing the direction the command is travelling when embedded in an HCI Command or Event. You can see that ATT does not have this issue as these commands are already defined using even values for commands and odd values for events, and thus, direction is distinguishable. For profiles, it is not yet known how the commands and events will be defined.

9.3 Request and Response Tunneling

In the Client/Server model defined and supported by the BLE stack, the Client sends Requests to the Server and the Server sends Responses back to the Client. The Requests sent by the Client may be handled by a Server on the same device, or they may travel OTA to the Server on another device. Similarly, the Response sent by the Server may be handled by a Client on the same device, or may be sent OTA to a Client on another device from which the request came. But in either case, as long as the Requests and Responses remain within the scope of the BLE stack software (i.e. the BLE Server database is on the device), the BLE stack remains unconcerned about whether the Requests and Responses are sent/received by the same device or are from another device. Please see Figure 8.

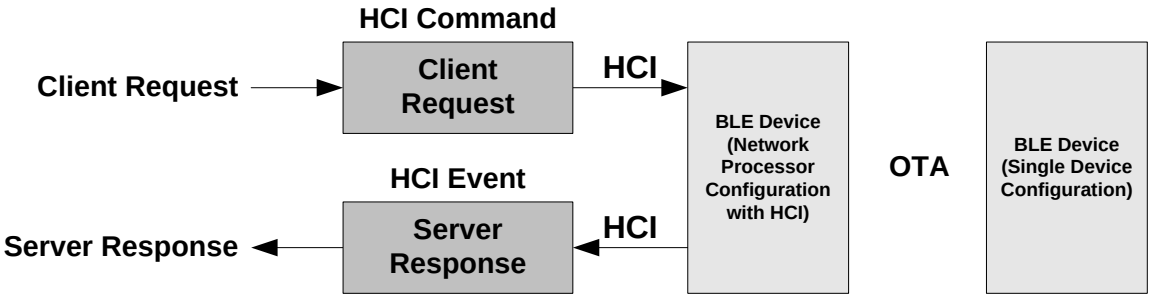


Figure 8: Request/Response with Server Database in BLE Stack

However, when using the Network Processor Configuration with HCI such that the Server database is not located on the device, then Requests and Reponses have to be mapped into HCI Commands and Events. The HCI is specified such that only Commands are sent from the Host to the Controller, and only Events are sent from the Controller to the Host. If the Server database is located on say a PC, then when an OTA Request is received by the Server device, it must be sent to the PC via the HCI. Even though the Request started out on one end as an HCI Command, it must be provided to the remote PC as an HCI event on the other. Similarly, when the PC sends the Response on one end, which will be an HCI Event to the remote PC on the other, it must be sent to the device as an HCI Command. Thus, the Request, which starts out as an HCI Command, must be embedded in an HCI Event when received by the remote PC, and the Response, which starts out as an HCI Command, must be embedded in an HCI Event when received by the remote PC. In this way, Requests and Responses are being tunneled in HCI Commands and Events. Please see Figure 9.

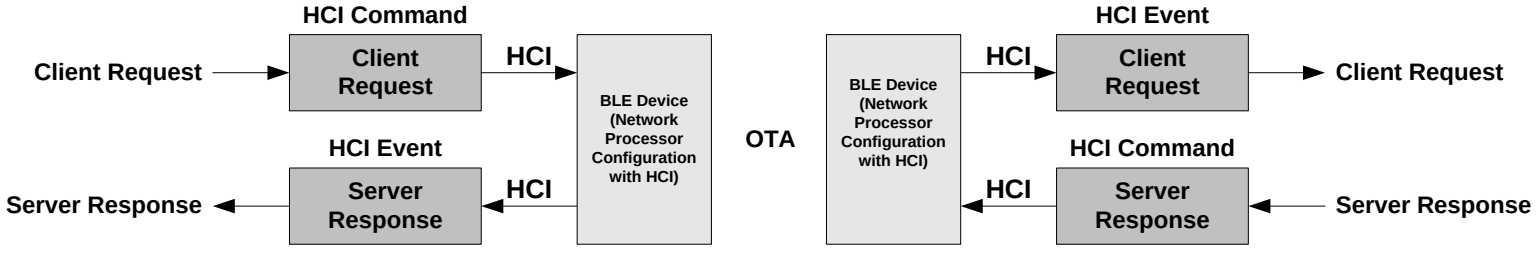


Figure 9: Request/Response with Server Database not in BLE Stack

10. HCI Extension Vendor Specific Commands

In addition to the BLE HCI commands, the following HCI Extension vendor specific commands are also available.

10.1 HCI Extension Set Receiver Gain

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_SetRxGainCmd	0xFC00	rxGain	Status

Description

This command is used to set the RF receiver gain. The default system value for this feature is *standard receiver gain*.

Command Parameters

rxGain: (1 byte)

Value	Parameter Description
0x00	HCI_EXT_RX_GAIN_STD
0x01	HCI_EXT_RX_GAIN_HIGH

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_SetRxGainCmd** has completed, a vendor specific Command Complete event shall be generated.

10.2 HCI Extension Set Transmitter Power

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_SetTxPowerCmd	0xFC01	txPower	Status

Description

This command is used to set the RF transmitter output power. The default system value for this feature is *0 dBm*. Note that a setting of 4dBm is only allowed for the CC2540.

Command Parameters

txPower: (1 byte)

Value	Parameter Description
0x00	HCI_EXT_TX_POWER_MINUS_23_DBM
0x01	HCI_EXT_TX_POWER_MINUS_6_DBM

Value	Parameter Description
0x02	HCI_EXT_TX_POWER_0_DBM
0x03	HCI_EXT_TX_POWER_4_DBM (CC2540 only)

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_SetTxPowerCmd** has completed, a vendor specific Command Complete event shall be generated.

10.3 HCI Extension One Packet Per Event

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_OnePacketPerEventCmd	0xFC02	control	Status

Description

This command is used to configure the Link Layer to only allow one packet per connection event. The default system value for this feature is *disabled*.

This command can be used to tradeoff throughput and power consumption during a connection. When enabled, power can be conserved during a connection by limiting the number of packets per connection event to one, at the expense of more limited throughput. When disabled, the number of packets transferred during a connection event is not limited, at the expense of higher power consumption.

Command Parameters

control: (1 byte)

Value	Parameter Description
0x00	HCI_EXT_DISABLE_ONE_PKT_PER_EVT
0x01	HCI_EXT_ENABLE_ONE_PKT_PER_EVT

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_OnePacketPerEventCmd** has completed, a vendor specific Command Complete event shall be generated.

10.4 HCI Extension Clock Divide On Halt

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_ClkDivOnHaltCmd	0xFC03	control	Status

Description

This command is used to configure the Link Layer to divide the system clock when the MCU is halted during a radio operation. The default system value for this feature is *disabled*.

Note: This command is only valid when the MCU is halted during RF operation (please see **HCI_EXT_HaltDuringRfCmd**).

Command Parameters

control: (1 byte)

Value	Parameter Description
0x00	HCI_EXT_DISABLE_CLK_DIVIDE_ON_HALT
0x01	HCI_EXT_ENABLE_CLK_DIVIDE_ON_HALT

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_ClkDivOnHaltCmd** has completed, a vendor specific Command Complete event shall be generated.

10.5 HCI Extension Declare NV Usage

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_DeclareNvUsageCmd	0xFC04	mode	Status

Description

This command is used to inform the Controller whether the Host is using NV memory during BLE operations. The default system value for this feature is *NV In Use*.

When the NV is not in use during BLE operations, the Controller is able to bypass internal checks that reduce overhead processing, thereby reducing average power consumption.

Note: This command is only allowed when the BLE Controller is idle.

Note: Using NV when declaring it is not in use may result in a hung BLE Connection.

Command Parameters

control: (1 byte)

Value	Parameter Description
0x00	HCI_EXT_NV_NOT_IN_USE
0x01	HCI_EXT_NV_IN_USE

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_DeclareNvUsageCmd** has completed, a vendor specific Command Complete event shall be generated.

10.6 HCI Extension Decrypt

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_DecryptCmd	0xFC05	key, encText	Status

Description

This command is used to decrypt encrypted text using AES128.

Command Parameters

key: (16 bytes)

Value	Parameter Description
0xXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX	128 bit key for the decryption of the data given in the command. The most significant octet of the data corresponds to key[0] using the notation specified in FIPS 197.

encText: (16 bytes)

Value	Parameter Description
0xXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX	128 bit encrypted data to be decrypted. The most significant octet of the key corresponds to key[0] using the notation specified in FIPS 197.

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_DecryptCmd** has completed, a vendor specific Command Complete event shall be generated.

10.7 HCI Extension Set Local Supported Features

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_SetLocalSupportedFeaturesCmd	0xFC06	localFeatures	Status

Description

This command is used to set the Controller's Local Supported Features. For a complete list of supported LE features, please see [1], Part B, Section 4.6.

Note: This command can be issued either before or after one or more connections are formed. However, the local features set in this manner are only effective if performed *before* a Feature Exchange Procedure has been initiated by the Master. Once this control procedure has been completed for a particular connection, only the exchanged feature set for that connection will be used.

Command Parameters

localFeatures: (8 bytes)

Value	Parameter Description
0x0000000000000001	Encryption Feature
0xFFFFFFFFFFFFFFFE	Reserved for future use

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_SetLocalSupportedFeaturesCmd** has completed, a vendor specific Command Complete event shall be generated.

10.8 HCI Extension Set Fast Transmit Response Time

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_SetFastTxResponseTimeCmd	0xFC07	control	Status

Description

This command is used to configure the Link Layer fast transmit response time feature. The default system value for this feature is *enabled*.

Note: This command is only valid for a Slave controller.

When the Host transmits data, the controller (by default) ensures the packet is sent over the LL connection with as little delay as possible, even when the connection is configured to use slave latency. That is, the transmit response time will tend to be no longer than the connection interval. This results in lower power savings since the LL may need to wake to transmit during connection events that would normally have been skipped. If saving power is more critical than fast transmit response time, then this feature can be disabled using this command. When disabled, the transmit response time will be no longer than slave latency + 1 times the connection interval.

Command Parameters

control: (1 byte)

Value	Parameter Description
0x00	HCI_EXT_DISABLE_FAST_TX_RESP_TIME
0x01	HCI_EXT_ENABLE_FAST_TX_RESP_TIME

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_SetFastTxResponseTimeCmd** has completed, a vendor specific Command Complete event shall be generated.

10.9 HCI Extension Modem Test Transmit

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_ModemTestTxCmd	0xFC08	cwMode, txFreq	Status

Description

This API is used to start a continuous transmitter modem test, using either a modulated or unmodulated carrier wave tone, at the frequency that corresponds to the specified RF channel. Use the HCI_EXT_EndModemTest command to end the test.

Note: The RF channel, not the BLE frequency, is specified! You can obtain the RF channel from the BLE frequency as follows: RF Channel = (BLE Frequency – 2402) / 2.

Note: When the HCI_EXT_EndModemTest is issued to stop this test, a Controller reset will take place.

Note: The device will transmit at the default output power (0 dBm) unless changed by HCI_EXT_SetTxPowerCmd.

Note: This modem test can be used to satisfy in part radio regulation requirements as specific in standards such as ARIB STD-T66.

Command Parameters

cwMode: (1 byte)

Value	Parameter Description
0x00	HCI_EXT_TX_MODULATED_CARRIER
0x01	HCI_EXT_TX_UNMODULATED_CARRIER

t
txFreq: (1 bytes)

Value	Parameter Description
0..39	RF channel of transmit frequency.

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_ModemTestTxCmd** has completed, a vendor specific Command Complete event shall be generated.

10.10 HCI Extension Modem Hop Test Transmit

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_ModemHopTestTxCmd	0xFC09		Status

Description

This API is used to start a continuous transmitter direct test mode test using a modulated carrier wave and transmitting a 37 byte packet of pseudo-random 9 bit data. A packet is transmitted on a different frequency (linearly stepping through all RF channels 0..39) every 625us. Use the HCI_EXT_EndModemTest command to end the test.

Note: When the HCI_EXT_EndModemTest is issued to stop this test, a Controller reset will take place.

Note: The device will transmit at the default output power (0 dBm) unless changed by HCI_EXT_SetTxPowerCmd.

Note: This modem test can be used to satisfy in part radio regulation requirements as specific in standards such as ARIB STD-T66.

Command Parameters:

None

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_ModemHopTestTxCmd** has completed, a vendor specific Command Complete event shall be generated.

10.11 HCI Extension Modem Test Receive

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_ModemTestRxCmd	0xFC0A	rxFreq	Status

Description

This API is used to start a continuous receiver modem test using a modulated carrier wave tone, at the frequency that corresponds to the specific RF channel. Any received data is discarded. Receiver gain may be adjusted using the HCI_EXT_SetRxGain command. RSSI may be read during this test by using the HCI_ReadRssi command. Use HCI_EXT_EndModemTest command to end the test.

Note: The RF channel, not the BLE frequency, is specified! You can obtain the RF channel from the BLE frequency as follows: RF Channel = (BLE Frequency – 2402) / 2.

Note: When the HCI_EXT_EndModemTest is issued to stop this test, a Controller reset will take place.

Note: This modem test can be used to satisfy in part radio regulation requirements as specific in standards such as ARIB STD-T66.

Command Parameters

rxFreq: (1 bytes)

Value	Parameter Description
0..39	RF channel of receive frequency.

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_ModemTestRxCmd** has completed, a vendor specific Command Complete event shall be generated.

10.12 HCI Extension End Modem Test

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_EndModemTestCmd	0xFC0B		Status

Description

This API is used to shutdown a modem test. A Controller reset will take place.

Command Parameters

None

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_EndModemTestCmd** has completed, a vendor specific Command Complete event shall be generated.

10.13 HCI Extension Set BDADDR

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_SetBDADDRCmd	0xFC0C	bdAddr	Status

Description

This command is used to set this device's BLE address (BDADDR). This address will override the device's address determined when the device is reset (i.e. a hardware reset, not an HCI Controller Reset). To restore the device's initialized address, issue this command with an invalid address.

Note: This command is only allowed when the Controller is in the Standby state.

Command Parameters

bdAddr: (6 bytes)

Value	Parameter Description
0x000000000000.. 0xFFFFFFFFFFFE	Valid BLE device address.
0xFFFFFFFFFFFF	Invalid BLE device address. Used to restore the device address to that which was determined at initialization.

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_SetBDADDRCmd** has completed, a vendor specific Command Complete event shall be generated.

10.14 HCI Extension Set SCA

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_SetSCACmd	0xFC0D	scaInPPM	Status

Description

This command is used to set this device's Sleep Clock Accuracy (SCA) value, in parts per million (PPM), from 0 to 500. For a Master device, the value is converted to one of eight ordinal values representing a SCA range (per [1], Volume 6, Part B, Section 2.3.3.1, Table 2.2), which will be used when a connection is created. For a Slave device, the value is directly used. The system default value for a Master and Slave device is 50ppm and 40ppm, respectively.

Note: This command is only allowed when the device is *not* in a connection.

Note: The device's SCA value remains unaffected by an HCI Reset.

Command Parameters

scaInPPM: (2 bytes)

Value	Parameter Description
0..0x1F4	Valid SCA value.
0x01F5..0xFFFF	Invalid SCA value.

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_SetSCACmd** has completed, a vendor specific Command Complete event shall be generated.

10.15 HCI Extension Enable PTM

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_EnablePTMCmd	0xFC0E		Status

Description

This command is used to enable Production Test Mode (PTM). This mode is used by the customer during assembly of their product to allow limited access to the BLE Controller for testing and configuration. This command is only available when the BLE Controller is built without external access to the Controller (i.e. when no transport interface such as RS232 is permitted). This mode will remain enabled until the device is reset. Please see the related application note for additional details.

Note: This command is only allowed as a direct function call, and is only intended to be used by an embedded application. **No vendor specific Command Complete event will be generated.**

Command Parameters

None

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x0C	HCI_ERROR_CODE_CMD_DISALLOWED

Event(s) Generated

When the **HCI_EXT_EnablePTMCmd** has completed, it will simply return. No vendor specific Command Complete event will be generated.

10.16 HCI Extension Set Frequency Tuning

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_SetFreqTuneCmd	0xFC0F	step	Status

Description

This PTM-only command is used to set this device's Frequency Tuning either up one step or down one step. When the current setting is already at its max value, then stepping up will have no effect. When the current setting is already at its min value, then stepping down will have no effect. This setting will only remain in effect until the device is reset unless **HCI_EXT_SaveFreqTuneCmd** is used to save it in non-volatile memory.

Command Parameters

mode: (1 bytes)

Value	Parameter Description
0	HCI_PTM_SET_FREQ_TUNE_DOWN
1	HCI_PTM_SET_FREQ_TUNE_UP

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_SetFreqTuneCmd** has completed, a vendor specific Command Complete event shall be generated.

10.17 HCI Extension Save Frequency Tuning

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_SaveFreqTuneCmd	0xFC10		Status

Description

This PTM-only command is used to save this device's Frequency Tuning setting in non-volatile memory. This setting will be used by the BLE Controller upon reset, and when waking from Sleep.

Command Parameters

None

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_SaveFreqTuneCmd** has completed, a vendor specific Command Complete event shall be generated.

10.18 HCI Extension Set Max DTM Transmitter Power

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_SetMaxDtmTxPowerCmd	0xFC11	txPower	Status

Description

This command is used to override the RF transmitter output power used by the Direct Test Mode (DTM). Normally, the maximum transmitter output power setting used by DTM is the maximum transmitter output power setting for the device (i.e. 4 dBm for the CC2540; 0 dBm for the CC2541). This command will change the value used by DTM.

Note: When DTM is ended by a call to HCI_LE_TestEndCmd, or a HCI_Reset is used, the transmitter output power setting is restored to the default value of 0 dBm.

Command Parameters

txPower: (1 byte)

Value	Parameter Description
0x00	HCI_EXT_TX_POWER_MINUS_23_DBM
0x01	HCI_EXT_TX_POWER_MINUS_6_DBM
0x02	HCI_EXT_TX_POWER_0_DBM
0x03	HCI_EXT_TX_POWER_4_DBM (CC2540 only)

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_SetMaxDtmTxPowerCmd** has completed, a vendor specific Command Complete event shall be generated.

10.19 HCI Extension Map PM IO Port

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_MapPmInOutPortCmd	0xFC12	ioPort, ioPin	Status

Description

This command is used to configure and map a CC254x I/O Port as a General-Purpose I/O (GPIO) output signal that reflects the Power Management (PM) state of the CC254x device. The GPIO output will be High on Wake, and Low upon entering Sleep. This feature can be disabled by specifying HCI_EXT_PM_IO_PORT_NONE for the ioPort (ioPin is then ignored). The system default value upon hardware reset is *disabled*.

This command can be used to control an external DC-DC Converter (its actual intent) such has the TI TPS62730 (or any similar converter that works the same way). **This command should be used with *extreme* care as it will override how the Port/Pin was previously configured!** This includes the mapping of Port 0 pins to 32kHz clock output, Analog I/O, UART, Timers; Port 1 pins to Observables, Digital Regulator status, UART, Timers; Port 2 pins to an external 32kHz XOSC. The selected Port/Pin will be configured as an output GPIO with interrupts masked. Careless use can result in a reconfiguration that could disrupt the system. For example, if the Port/Pin is being used as part of the serial interface for the device, the Port/Pin will be reconfigured from its original Peripheral function to a

GPIO, disrupting the serial port. **It is therefore the user's responsibility to ensure the selected Port/Pin does not cause any conflicts in the system.**

Note: Only Pins 0, 3 and 4 are valid for Port 2 since Pins 1 and 2 are mapped to debugger signals DD and DC.

Note: Port/Pin signal change will obviously only occur when Power Savings is enabled.

Note: The CC254xEM modules map the TI TPS62730 control signal to P1.2, which happens to map to the SmartRF05EB LCD Chip Select. Thus, the LCD can't be used when setup this way.

Command Parameters

ioPort: (1 byte)

Value	Parameter Description
0x00	HCI_EXT_PM_IO_PORT_P0
0x01	HCI_EXT_PM_IO_PORT_P1
0x02	HCI_EXT_PM_IO_PORT_P2
0xFF	HCI_EXT_PM_IO_PORT_NONE

ioPin: (1 byte)

Value	Parameter Description
0x00	HCI_EXT_PM_IO_PORT_PIN0
0x01	HCI_EXT_PM_IO_PORT_PIN1
0x02	HCI_EXT_PM_IO_PORT_PIN2
0x03	HCI_EXT_PM_IO_PORT_PIN3
0x04	HCI_EXT_PM_IO_PORT_PIN4
0x05	HCI_EXT_PM_IO_PORT_PIN5
0x06	HCI_EXT_PM_IO_PORT_PIN6
0x07	HCI_EXT_PM_IO_PORT_PIN7

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_MapPmIoPortCmd** has completed, a vendor specific Command Complete event shall be generated.

10.20 HCI Extension Disconnect Immediate

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_DisconnectImmedCmd	0xFC13	connHandle	Status

Description

This command is used to disconnect a connection immediately. This command can be useful for when a connection needs to be ended without the latency associated with the normal BLE Controller Terminate control procedure.

Note that the Host issuing the command will still receive the HCI Disconnection Complete event with a Reason status of 0x16 (i.e. Connection Terminated by Local Host), followed by an HCI Vendor Specific Event.

Command Parameters

connHandle: (2 bytes)

Value	Parameter Description
0x0000 .. 0x0EFF	Connection Handle to be used to identify a connection. Note: 0x0F00 – 0x0FFF are reserved for future use.

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_DisconnectImmedCmd** has completed, an HCI Disconnection Complete event followed by a vendor specific Command Complete event shall be generated.

10.21 HCI Extension Packet Error Rate

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_PacketErrorRateCmd	0xFC14	connHandle, command	Status

Description

This command is used to Reset or Read the Packet Error Rate counters for a connection. When Reset, the counters are cleared; when Read, the total number of packets received, the number of packets received with a CRC error, the number of events, and the number of missed events are returned. The system default value upon hardware reset is *Reset.*

Note: The counters are only 16 bits. At the shortest connection interval, this provides a little over 8 minutes of data.

Command Parameters

connHandle: (2 bytes)

Value	Parameter Description
0x0000 .. 0x0EFF	Connection Handle to be used to identify a connection. Note: 0x0F00 – 0x0FFF are reserved for future use.

***command*: (1 byte)**

Value	Parameter Description
0x00	HCI_EXT_PER_RESET

Value	Parameter Description
0x01	HCI_EXT_PER_READ

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_PacketErrorRateCmd** has completed, a vendor specific Command Complete event followed by a vendor specific Command Complete event shall be generated.

10.22 HCI Extension Packet Error Rate By Channel

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_PERbyChanCmd	0xFC15	connHandle, *perByChan	Status

Description

This command is used to start or end Packet Error Rate by Channel counter accumulation for a connection, and can be used by an application to make Coexistence assessments. Based on the results, an application can perform an Update Channel Classification command to limit channel interference from other wireless standards. If ***perByChan** is NULL, counter accumulation will be discontinued. If ***perByChan** is not NULL, then it is assumed that there is sufficient memory for the PER data, based on the following type definition **perByChan_t** located in **ll.h**:

```
#define LL_MAX_NUM_DATA_CHAN 37


// Packet Error Rate Information By Channel
typedef struct
{
  uint16 numPkts[ LL_MAX_NUM_DATA_CHAN ];
  uint16 numCrcErr[ LL_MAX_NUM_DATA_CHAN ];
} perByChan_t;
```

Note: This command is only allowed as a direct function call, and is only intended to be used by an embedded application.

Note: **It is the user's responsibility to ensure there is sufficient memory allocated!** The user is also responsible for maintaining the counters, clearing them if required before starting accumulation.

Note: As indicated, the counters are 16 bits. At the shortest connection interval, this provides a bit over 8 minutes of data.

Note: This command can be used in combination with **HCI_EXT_PacketErrorRateCmd**.

Command Parameters

connHandle: (2 bytes)

Value	Parameter Description
0x0000 .. 0x0EFF	Connection Handle to be used to identify a connection. Note: 0x0F00 – 0x0FFF are reserved for future use.

***perByChan: (1 byte)**

Value	Parameter Description
NULL	End counter accumulation.
Non-NULL	Start counter accumulation by channel.

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_PERbyChanCmd** has completed, a vendor specific Command Complete event shall be generated.

10.23 HCI Extension Extend RF Range

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_ExtendRfRangeCmd	0xFC16		Status

Description

This command is used to configure the CC254x to automatically control the TI CC2590 2.4GHz RF Front End device. Using the CC2590 allows a maximum Tx output power of 10dBm (the specified BLE maximum), and increases Rx sensitivity, thus extending the RF range of the CC254x. Once this command is used, the configuration will not change unless the CC254x is reset.

Automatic control of the CC2590 is achieved using the CC254x Observables, which take control of GPIO P1.2 and P1.3. The GPIO P1.1 is also taken to control RF gain. These GPIOs are therefore not available when using this feature.

This command can be used in combination with **HCI_EXT_SetTxPowerCmd**, resulting in a cumulative Tx output power. Therefore, for the CC2540 only, attempting to set Tx output power to 4dBm (i.e. using **HCI_EXT_TX_POWER_4_DBM**), will instead set the Tx output power to 0dBm.

The command **HCI_EXT_SetRxGainCmd** should be used to set the Rx gain per usual. That is, the CC254x Rx Standard/High gain setting is mirrored to the CC2590 High Gain Mode (HGM) Low/High setting.

When this command is used, the CC254x Tx output power and Rx gain will retain their previous values, unless the previous Tx output power value was set to 4dBm on the CC2540. In this case, as previously explained, the value will be set to 0dBm.

Command Parameters

None

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_ExtendRfRangeCmd** has completed, a vendor specific Command Complete event shall be generated.

10.24 HCI Extension Advertiser Event Notice

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_AdvEventNoticeCmd	0xFC17	taskID, taskEvent	Status

Description

This command is used to configure the CC254x to set a user task's event when an Advertisement event completes. Only a single task event value is allowed (i.e. must be a power of two). A non-zero taskEvent value is taken to be "enable", while a zero valued taskEvent is taken to be "disable". The default value is "disable".

Note: This command is only allowed as a direct function call, and is only intended to be used by an embedded application. **No vendor specific Command Complete event will be generated.**

Command Parameters

taskID: (1 byte)

Value	Parameter Description
0x00..0xFF	OSAL task ID.

taskEvent: (2 bytes)

Value	Parameter Description
$2^0..2^{14}$	OSAL task event. Note that 2^{15} is a reserved system task event.

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS

Event(s) Generated

When the **HCI_EXT_AdvEventNoticeCmd** has completed, it will simply return. No vendor specific Command Complete event will be generated.

10.25 HCI Extension Connection Event Notice

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_ConnEventNoticeCmd	0xFC18	taskID, taskEvent	Status

Description

This command is used to configure the CC254x to set a user task's event when a Connection event completes. Only a single task event value is allowed (i.e. must be a power of two). A non-zero taskEvent value is taken to be "enable", while a zero valued taskEvent is taken to be "disable". The default value is "disable".

Note: Only a Slave connection is supported.

Note: This command is only allowed as a direct function call, and is only intended to be used by an embedded application. **No vendor specific Command Complete event will be generated.**

Command Parameters

taskID: (1 byte)

Value	Parameter Description
0x00..0xFF	OSAL task ID.

taskEvent: (2 bytes)

Value	Parameter Description
$2^0..2^{14}$	OSAL task event. Note that 2^{15} is a reserved system task event.

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x02	HCI_ERROR_CODE_UNKNOWN_CONN_ID
0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS

Event(s) Generated

When the **HCI_EXT_ConnEventNoticeCmd** has completed, it will simply return. No vendor specific Command Complete event will be generated.

10.26 HCI Extension Halt During RF

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_HaltDuringRfCmd	0xFC19	mode	Status

Description

This command is used to enable or disable the halting of the MCU while the radio is operating. When the MCU is not halted, the peak current is higher, but the system is more responsive. When the MCU is halted, the peak current consumption is reduced, but the system is less responsive. The default value is *Enable*.

Note: This command will be disallowed if there are any active BLE connections.

Note: The **HCI_EXT_ClkDivOnHaltCmd** will be disallowed if the halt during RF is not enabled.

Command Parameters

mode: (1 byte)

Value	Parameter Description
0x00	HCI_EXT_HALT_DURING_RF_DISABLE
0x01	HCI_EXT_HALT_DURING_RF_ENABLE

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_HaltDuringRfCmd** has completed, a vendor specific Command Complete event shall be generated.

10.27 HCI Extension Set Slave Latency Override

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_SetSlaveLatencyOverrideCmd	0xFC1A	mode	Status

Description

This command is used to enable or disable the Slave Latency Override, allowing the user to ensure that Slave Latency is not applied even though it is active. The default value is *Disable.*

Note: This command will be disallowed for no connection, or the connection is not in the Slave role.

Command Parameters

mode: (1 byte)

Value	Parameter Description
0x00	HCI_EXT_DISABLE_SL_OVERRIDE

Value	Parameter Description
0x01	HCI_EXT_ENABLE_SL_OVERRIDE

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_SetSlaveLatencyOverrideCmd** has completed, a vendor specific Command Complete event shall be generated.

10.28 HCI Extension Build Revision

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_BuildRevisionCmd	0xFC1B	mode, userRevNum	Status

Description

This command is used to a) allow the embedded user code to set their own 16 bit revision number, and b) to read the build revision number of the BLE stack library software. The default value of the user revision number is *zero*.

When the user updates a BLE project by adding their own code, they may use this API to set their own revision number. When called with mode set to **HCI_EXT_SET_APP_REVISION**, the stack will save this value. No event will be returned from this API when used this way as it is intended to be called from within the target itself. Note however that this does not preclude this command from being received via the HCI. However, no event will be returned.

When this API is used from the HCI, then the second parameter is ignored, and a vendor specific event is returned with the user's revision number and the build revision number of the BLE stack.

Command Parameters

mode: (1 byte)

Value	Parameter Description
0x00	HCI_EXT_SET_APP_REVISION
0x01	HCI_EXT_READ_BUILD_REVISION

userRevNum: (2 bytes)

Value	Parameter Description
0xXXXX	Any 16 bit value the application wishes to use as their revision number.

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_BuildRevisionCmd** has completed, a vendor specific Command Complete event shall be generated, ***but only*** when the value of mode is **HCI_EXT_READ_BUILD_REVISION**.

10.29 HCI Extension Delay Sleep

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_DelaySleepCmd	0xFC1C	delay	Status

Description

This command is used to set the delay before sleep occurs after Reset or upon waking from PM3 (i.e. deep sleep) to allow the external 32kHz crystal to stabilize. If this command is never used, the default delay is 400ms.

If the customer's hardware requires a different delay or does not require this delay at all, it can be changed by calling this command during their OSAL task initialization. A non-zero delay value will change the delay after Reset and all subsequent (unless changed again) wakes from PM3; a zero delay value will eliminate the delay after Reset and all subsequent (unless changed again) wakes from PM3.

If this command is used any time after system initialization, then the new delay value will be applied the next time the delay is used.

Note: This delay only applies to Reset and Deep Sleep (i.e. PM3). If a periodic timer is used, or a BLE operation is active, then only PM2 is used, and this delay will only occur after Reset.

Note: There is no distinction made between a hard and soft reset. The delay (if non-zero) will be applied the same way in either case.

Command Parameters

delay: (2 bytes)

Value	Parameter Description
0x0000..0x03E8	In milliseconds.

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_DelaySleepCmd** has completed, a vendor specific Command Complete event shall be generated.

10.30 HCI Extension Reset System

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_ResetSystemCmd	0xFC1D	mode	Status

Description

This command is used to issue a hard or soft system reset. A hard reset is caused by a watchdog timer timeout, while a soft reset is caused by resetting the PC to zero.

Command Parameters

mode: (1 byte)

Value	Parameter Description
0x00	HCI_EXT_RESET_SYSTEM_HARD
0x01	HCI_EXT_RESET_SYSTEM_SOFT

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_ResetSystemCmd** has completed, a vendor specific Command Complete event shall be generated.

10.31 HCI Extension Overlapped Processing

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_OverlappedProcessingCmd	0xFC1E	mode	Status

Description

This command is used to enable or disable overlapped processing. The default is *disabled*.

Command Parameters

mode: (1 byte)

Value	Parameter Description
0x00	HCI_EXT_DISABLE_OVERLAPPED_PROCESSING
0x01	HCI_EXT_ENABLE_OVERLAPPED_PROCESSING

Return Parameters

Status: (1 byte)

Value	Parameter Description

0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_OverlappedProcessingCmd** has completed, a vendor specific Command Complete event shall be generated.

10.32 HCI Extension Number Completed Packets Limit

Command	Opcode	Command Parameters	Return Parameters
HCI_EXT_NumComplPktsLimitCmd	0xFC1F	limit, flushOnEvt	Status

Description

This command is used to set the limit on the minimum number of complete packets before a Number of Completed Packets event is returned by the Controller. If the limit is not reached by the end of a connection event, then the Number of Completed Packets event will be returned (if non-zero) based on the **flushOnEvt** flag. The limit can be set from one to the maximum number of HCI buffers (please see the LE Read Buffer Size command in the Bluetooth Core specification). The default limit is *one*; the default **flushOnEvt** flag is *FALSE*.

Command Parameters

limit: (1 byte)

Value	Parameter Description
0x01..<max buffers>	Where <max buffers> is returned by **HCI_LE_ReadBufSizeCmd**.

flushOnEvt: (1 byte)

Value	Parameter Description
0x00	Only return a Number of Completed Packets event when the number of completed packets is greater than or equal to the limit.
0x01	Return a Number of Complete Packets event if the number of completed packets is less than the limit.

Return Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

Event(s) Generated

When the **HCI_EXT_NumComplPktsLimitCmd** has completed, a vendor specific Command Complete event shall be generated.

11. HCI Extension Vendor Specific Events

The HCI Extension vendor specific commands generate the following vendor specific events.

11.1 HCI Extension Set Receiver Gain

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x0400	Status, cmdOpcode

Description

This event is sent to indicate the RF receiver gain has been set, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC00	HCI Extension Set Receiver Gain Command

11.2 HCI Extension Set Transmitter Power

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x0401	Status, cmdOpcode

Description

This event is sent to indicate the RF transmitter power has been set, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC01	HCI Extension Set Transmitter Power Command

11.3 HCI Extension One Packet Per Event

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x0402	Status, cmdOpcode

Description

This event is sent to indicate the One Packet Per Event feature has been enabled or disabled, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC02	HCI Extension One Packet Per Event Command

11.4 HCI Extension Clock Divide On Halt

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x0403	Status, cmdOpcode

Description

This event is sent to indicate the Clock Divide On Halt feature has been enabled or disabled, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x0C	HCI_ERROR_CODE_CMD_DISALLOWED
0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC03	HCI Extension Clock Divide On Halt Command

11.5 HCI Extension Declare NV Usage

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x0404	Status, cmdOpcode

Description

This event is sent to indicate the Declare NV Usage feature has been set, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x0C	HCI_ERROR_CODE_CMD_DISALLOWED
0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC04	HCI Extension Declare NV Usage Command

11.6 HCI Extension Decrypt

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x0405	Status, cmdOpcode, plainTextData

Description

This event is sent to indicate Decryption has completed.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC05	HCI Extension Decrypt Command

plainTextData: (16 bytes)

Value	Parameter Description
0xXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX	128 bit decrypted data block. The most significant octet of plainTextData corresponds to plainTextData [0] using the notation specified in FIPS 197.

11.7 HCI Extension Set Local Supported Features

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x0406	Status, cmdOpcode

Description

This event is sent to indicate the Set Local Supported Features command has completed.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC06	HCI Extension Set Local Supported Features Command

11.8 HCI Extension Set Fast Transmit Response Time

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x0407	Status, cmdOpcode

Description

This event is sent to indicate the Set Fast Transmit Response Time feature has been enabled or disabled, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x0C	HCI_ERROR_CODE_CMD_DISALLOWED
0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC07	HCI Extension Set Fast Transmit Response Time Command

11.9 HCI Extension Modem Test Transmit

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x0408	Status, cmdOpcode

Description

This event is sent to indicate the Modem Test Transmit test has started, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS
0x21	HCI_ERROR_CODE_ROLE_CHANGE_NOT_ALLOWED

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC08	HCI Extension Modem Test Transmit Command

11.10 HCI Extension Modem Hop Test Transmit

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x0409	Status, cmdOpcode

Description

This event is sent to indicate the Modem Hop Test Transmit test has started, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x21	HCI_ERROR_CODE_ROLE_CHANGE_NOT_ALLOWED

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC09	HCI Extension Modem Hop Test Transmit Command

11.11 HCI Extension Modem Test Receive

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x040A	Status, cmdOpcode

Description

This event is sent to indicate the Modem Test Receive test has started, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS
0x21	HCI_ERROR_CODE_ROLE_CHANGE_NOT_ALLOWED

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC0A	HCI Extension Modem Test Receive Command

11.12 HCI Extension End Modem Test

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x040B	Status, cmdOpcode

Description

This event is sent to indicate the modem test has been shutdown, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x21	HCI_ERROR_CODE_ROLE_CHANGE_NOT_ALLOWED

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC0B	HCI Extension End Modem Test Command

11.13 HCI Extension Set BDADDR

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x040C	Status, cmdOpcode

Description

This event is sent to indicate the device's BLE address has been set, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x0C	HCI_ERROR_CODE_CMD_DISALLOWED
0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC0C	HCI Extension Set BDADDR Command

11.14 HCI Extension Set SCA

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x040D	Status, cmdOpcode

Description

This event is sent to indicate the device's SCA has been set, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x0C	HCI_ERROR_CODE_CMD_DISALLOWED
0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC0D	HCI Extension Set SCA Command

11.15 HCI Extension Enable PTM

There is not a corresponding event opcode (0x040E) and parameters for this command as it is only allowed as a direct function call by the application software.

11.16 HCI Extension Set Frequency Tuning

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x040F	Status, cmdOpcode

Description

This event is sent to indicate the device's frequency tuning value has be adjusted one step up or down, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x0C	HCI_ERROR_CODE_CMD_DISALLOWED
0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC0F	HCI Extension Set Frequency Tuning Command

11.17 HCI Extension Save Frequency Tuning

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x0410	Status, cmdOpcode

Description

This event is sent to indicate the device's current frequency tuning value has been saved to non-volatile memory, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x0C	HCI_ERROR_CODE_CMD_DISALLOWED

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC10	HCI Extension Save Frequency Tuning Command

11.18 HCI Extension Set Max DTM Transmitter Power

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x0411	Status, cmdOpcode

Description

This event is sent to indicate the maximum Direct Test Mode (DTM) RF transmitter power has been set, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC11	HCI Extension Set Transmitter Power Command

11.19 HCI Extension Map PM IO Port

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x0412	Status, cmdOpcode

Description

This event is sent to indicate the PM IO Port has been configured and mapped, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x0C	HCI_ERROR_CODE_CMD_DISALLOWED
0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC12	HCI Extension Map PM IO Port Command

11.20 HCI Extension Disconnect Immediate

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x0413	Status, cmdOpcode

Description

This event is sent to indicate the Disconnect Immediate command has completed, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x02	HCI_ERROR_CODE_UNKNOWN_CONN_ID
0x0C	HCI_ERROR_CODE_CMD_DISALLOWED
0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC13	HCI Extension Disconnect Immediate Command

11.21 HCI Extension Packet Error Rate

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x0414	Status, cmdOpcode, cmdVal, numPkts, numCrcErr, numEvents, numMissedEvts

Description

This event is sent to indicate the Packet Error Rate Reset or Read command has completed, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x02	HCI_ERROR_CODE_UNKNOWN_CONN_ID
0x0C	HCI_ERROR_CODE_CMD_DISALLOWED

0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC14	HCI Extension Packet Error Rate Command

cmdVal: (2 bytes)

Value	Parameter Description
0x00	HCI_EXT_PER_RESET
0x01	HCI_EXT_PER_READ

Note: The following event parameters are for the Read command only.

numPkts: (2 bytes)

Value	Parameter Description
0x0000 .. 0xFFFF	Total number of received packets.

numCrcErr: (2 bytes)

Value	Parameter Description
0x0000 .. 0xFFFF	Number of received packets with CRC error.

numEvents: (2 bytes)

Value	Parameter Description
0x0000 .. 0xFFFF	Number of connection events.

numMissedEvents: (2 bytes)

Value	Parameter Description
0x0000 .. 0xFFFF	Number of missed connection events.

11.22 HCI Extension Packet Error Rate By Channel

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x0415	Status, cmdOpcode

Description

This event is sent to indicate the Packet Error Rate By Channel command has completed, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x02	HCI_ERROR_CODE_UNKNOWN_CONN_ID

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC15	HCI Extension Packet Error Rate By Channel Command

11.23 HCI Extension Extend RF Range

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x0416	Status, cmdOpcode

Description

This event is sent to indicate the Extend RF Range command has completed.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC16	HCI Extension Extend RF Range Command

11.24 HCI Extension Advertiser Event Notice

There is not a corresponding event opcode (0x0417) and parameters for this command as it is only allowed as a direct function call by the application software.

11.25 HCI Extension Connection Event Notice

There is not a corresponding event opcode (0x0418) and parameters for this command as it is only allowed as a direct function call by the application software.

11.26 HCI Extension Halt During RF

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x0419	Status, cmdOpcode

Description

This event is sent to indicate the Halt During RF feature has been enabled or disabled, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x0C	HCI_ERROR_CODE_CMD_DISALLOWED
0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC19	HCI Extension Halt During RF Command

11.27 HCI Extension Set Slave Latency Override

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x041A	Status, cmdOpcode

Description

This event is sent to indicate the Set Slave Latency Override feature has been enabled or disabled, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x0C	HCI_ERROR_CODE_CMD_DISALLOWED
0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC1A	HCI Extension Set Slave Latency Override Command

11.28 HCI Extension Build Revision

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x041B	Status, cmdOpcode, userRevNum, buildRevNum

Description

This event is sent to indicate the user revision number and the build revision of the stack, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC1B	HCI Extension Build Revision Command

userRevNum: (2 bytes)

Value	Parameter Description
0xXXXX	The user revision number set by the application software. If no value was ever set, than 0x0000.

buildRevNum: (2 bytes)

Value	Parameter Description
0xXXXX	The build revision number of the BLE stack.

11.29 HCI Extension Delay Sleep

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x041C	Status, cmdOpcode

Description

This event is sent to indicate the Delay Sleep command has completed, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description

0x00	HCI_SUCCESS
0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC1C	HCI Extension Delay Sleep Command

11.30 HCI Extension Reset System

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x041D	Status, cmdOpcode

Description

This event is sent to indicate the Reset System command has completed, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC1D	HCI Extension Reset System Command

11.31 HCI Extension Overlapped Processing

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x041E	Status, cmdOpcode

Description

This event is sent to indicate the Overlapped Processing command has completed, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC1E	HCI Extension Overlapped Processing Command

11.32 HCI Extension Number Completed Packets Limit

Event	Opcode	Event Parameters
HCI_Vendor_Specific_Event	0x041F	Status, cmdOpcode

Description

This event is sent to indicate the Number Completed Packets Limit command has completed, or that there was an error.

Event Parameters

Status: (1 byte)

Value	Parameter Description
0x00	HCI_SUCCESS
0x12	HCI_ERROR_CODE_INVALID_HCI_CMD_PARAMS

cmdOpcode: (2 bytes)

Value	Parameter Description
0xFC1F	HCI Extension Number Complete Packets Limit Command

12. GAP Vendor Specific Commands

12.1 GAP Device Initialization

Command	Opcode	Command Parameters	Return Parameters
GAP_DeviceInit	0xFE00	profileRole, maxScanResponses, IRK, CSRK, signCounter	Status

Description:

This command is used to setup the device in a GAP Role and should only be called once per reboot. To enable multiple combinations setup multiple GAP Roles (profileRole parameter).

Multiple Role settings examples:

- GAP_PROFILE_PERIPHERAL and GAP_PROFILE_BROADCASTER – allows a connection and advertising (non-connectable) at the same time.
- GAP_PROFILE_PERIPHERAL and GAP_PROFILE_OBSERVER – allows a connection (with master) and scanning at the same time.
- GAP_PROFILE_PERIPHERAL, GAP_PROFILE_OBSERVER and GAP_PROFILE_BROADCASTER – allows a connection (with master) and scanning or advertising at the same time.
- GAP_PROFILE_CENTRAL and GAP_PROFILE_BROADCASTER – allows connections and advertising (non-connectable) at the same time.

Command Parameters:

profileRole: Bit Mask (1 octet)

Value	Parameter Description
0x01	GAP_PROFILE_BROADCASTER
0x02	GAP_PROFILE_OBSERVER
0x04	GAP_PROFILE_PERIPHERAL
0x08	GAP_PROFILE_CENTRAL

maxScanResponses: (1 octet)

Range	Parameter Description
0 – 0xFF	Central or Observer only: The device will allocate buffer space for received advertisement packets. The default is 3. The larger the number, the more RAM that is needed and maintained.

IRK: (16 octets)

Range	Parameter Description

Range	Parameter Description
"XX:XX:XX:XX: XX:XX:XX:XX: XX:XX:XX:XX: XX:XX:XX:XX"	16 byte Identity Resolving Key (IRK). If this value is all 0's, the GAP will randomly generate all 16 bytes. This key is used to generate Resolvable Private Addresses.

CSRK: (16 octets)

Range	Parameter Description
"XX:XX:XX:XX: XX:XX:XX:XX: XX:XX:XX:XX: XX:XX:XX:XX"	16 byte Connection Signature Resolving Key (CSRK). If this value is all 0's, the GAP will randomly generate all 16 bytes. This key is used to generate data Signatures.

signCounter: (4 octets)

Range	Parameter Description
0x00000000 – 0xFFFFFFFF	32 bit Signature Counter. Initial signature counter.

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x02	INVALIDPARAMETER

Event(s) Generated:

When device initialization is received, the host will send the HCI Ext Command Status Event with the ***Status*** parameter. When initialization task is complete, the host will send the GAP Device Init Done Event.

12.2 GAP Configure Device Address

Command	Opcode	Command Parameters	Return Parameters
GAP_ConfigDeviceAddr	0xFE03	addrType, Addr	Status

Description:

Send this command to set the device's address type. If ADDRTYPE_PRIVATE_RESOLVE is selected, the address will change periodically.

Command Parameters:

addrType: (1 octet)

Value	Parameter Description
0	ADDRTYPE_PUBLIC
1	ADDRTYPE_STATIC
2	ADDRTYPE_PRIVATE_NONRESOLVE
3	ADDRTYPE_PRIVATE_RESOLVE

Addr: (6 octet)

Range	Parameter Description
"XX:XX:XX:XX:XX:XX"	Intended address. Only used with ADDRTYPE_STATIC or ADDRTYPE_PRIVATE_NONRESOLVE.

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x02	INVALIDPARAMETER
0x10	GAP_DeviceInit must be completed first.
0x12	Address type can't be change during an active connection.

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status*** parameter. If ADDRTYPE_PRIVATE_RESOLVE addrType is selected, the GAP Random Address Changed Event will be generated when the address is automatically updated.

12.3 GAP Device Discovery Request

Command	Opcode	Command Parameters	Return Parameters
GAP_DeviceDiscoveryRequest	0xFE04	mode, activeScan, whiteList	Status

Description:

Send this command to start a scan for advertisement packets. This command is valid for a central or a peripheral device.

Command Parameters:

mode: (1 octet)

Value	Parameter Description
0	Non-Discoverable Scan
1	General Mode Scan
2	Limited Mode Scan
3	Scan for all devices

activeScan: (1 octet)

Value	Parameter Description
0	Turn off active scanning (SCAN_REQ)
1	Turn on active scanning (SCAN_REQ)

whiteList: (1 octet)

Value	Parameter Description
0	Don't use the white list during a scan
1	Use the white list during a scan

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x11	Scan is not available.
0x12	Invalid profile role.

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status*** parameter. During the scan, the device will generate GAP Device Information Events for advertising devices, then issue a GAP Device Discovery Event when the scan is completed.

12.4 GAP Device Discovery Cancel

Command	Opcode	Command Parameters	Return Parameters
GAP_DeviceDiscoveryCancel	0xFE05		Status

Description:

Send this command to end a scan for advertisement packets. This command is valid for a central or a peripheral device.

Command Parameters:

None

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x11	Scan is not available.
0x12	Invalid profile role.

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status*** parameter, then issue a GAP Device Discovery Event to display the scan progress since the start of the scan.

12.5 GAP Make Discoverable

Command	Opcode	Command Parameters	Return Parameters
GAP_MakeDiscoverable	0xFE06	eventType, initiatorAddrType, initiatorAddr, channelMap, filterPolicy	Status

Description:

Send this command to start the device advertising.

Command Parameters:

eventType: (1 octet)

Value	Parameter Description
0	Connectable undirected advertisement
1	Connectable directed advertisement

Value	Parameter Description
2	Discoverable undirected advertisement
3	Non-connectable undirected advertisement

initiatorAddrType: (1 octet)

Value	Parameter Description
0	ADDRTYPE_PUBLIC
1	ADDRTYPE_STATIC
2	ADDRTYPE_PRIVATE_NONRESOLVE
3	ADDRTYPE_PRIVATE_RESOLVE

initiatorAddr: (6 octet)

Range	Parameter Description
"XX:XX:XX:XX:XX:XX"	Intended address. Only used for directed advertisments

channelMap: Bit Mask (1 octet)

Bit Definitions	Parameter Description
0	Channel 37
1	Channel 38
2	Channel 39
3 – 7	reserved

filterPolicy: (1 octet)

Value	Parameter Description
0	Allow scan requests from any, allow connect request from any.
1	Allow scan requests from white list only, allow connect request from any.
2	Allow scan requests from any, allow connect request from white list only.
3	Allow scan requests from white list only, allow connect requests from white list only.
4 – 0xFF	reserved

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x10	Advertising data isn't setup.
0x11	Not available at this time.
0x12	Invalid profile role.

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status*** parameter, then, when the device starts advertising the GAP Make Discoverable Done Event is generated. When advertising is completed (limited mode advertising has a time limit), the GAP End Discoverable Event is generated.

12.6 GAP Update Advertising Data

Command	Opcode	Command Parameters	Return Parameters
GAP_UpdateAdvertisingData	0xFE07	adType, dataLen, advertData	Status

Description:

Send this command to set the raw advertising or scan response data.

Command Parameters:

adType: (1 octet)

Value	Parameter Description
0	SCAN_RSP data
1	Advertisement data

dataLen: (1 octet)

Range	Parameter Description
0 – 31	Length of the advertData field (in octets)

advertData: (dataLen octets)

Value	Parameter Description
"XX:XX … XX"	Raw advertising data

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x12	Invalid profile role.

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status*** parameter, then, when the task is complete the GAP Advert Data Update Done Event is generated.

12.7 GAP End Discoverable

Command	Opcode	Command Parameters	Return Parameters
GAP_EndDiscoverable	0xFE08		Status

Description:

Send this command to end advertising.

Command Parameters:

None

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x12	Not advertising

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status*** parameter, then issue a GAP End Discoverable Done Event advertising has stopped.

12.8 GAP Establish Link Request

Command	Opcode	Command Parameters	Return Parameters

Command	Opcode	Command Parameters	Return Parameters
GAP_EstablishLinkRequest	0xFE09	highDutyCycle, whiteList, addrTypePeer, peerAddr	Status

Description:

Send this command to initiate a connection with a peripheral device. Only central devices can issue this command.

Command Parameters:

highDutyCycle: (1 octet)

Value	Parameter Description
0	disabled
1	enabled

A central device may use high duty cycle scan parameters in order to achieve low latency connection time with a peripheral device using directed link establishment.

whiteList: (1 octet)

Value	Parameter Description
0	Don't use the white list
1	Only connect to a device in the white list

addrTypePeer: (1 octet)

Value	Parameter Description
0	ADDRTYPE_PUBLIC
1	ADDRTYPE_STATIC
2	ADDRTYPE_PRIVATE_NONRESOLVE
3	ADDRTYPE_PRIVATE_RESOLVE

peerAddr: (6 octet)

Range	Parameter Description
"XX:XX:XX:XX:XX:XX"	Peripheral address to connect with.

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS

0x10	Not ready to perform this action. Performing a scan.
0x12	Invalid profile role.

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status*** parameter. When the connection has been made, the GAP Link Established Event will be generated.

12.9 GAP Terminate Link Request

Command	Opcode	Command Parameters	Return Parameters
GAP_TerminateLinkRequest	0xFE0A	connHandle	Status

Description:

Send this command to terminate a connection link, a connection request or all connected links.

Command Parameters:

connHandle: (2 octets)

Value	Parameter Description
0 – 0xFFFD	Existing connection handle to terminate
0xFFFE	Terminate the “Establish Link Request”
0xFFFF	Terminate all links

reason: (1 octet)

Value	Parameter Description
0x05	Authentication Failure
0x13	Remote User Terminated Connection
0x14	Remote Device Terminated Connection Due To Low Resources
0x15	Remote Device Terminated Connection due to Power Off
0x1A	Unsupported Remote Feature
0x29	Pairing With Unit Key Not Supported
0x3B	Unacceptable Connection Interval

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x12	No link to terminate

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status*** parameter. When the connection is terminated, the GAP Link Terminated Event will be generated.

12.10 GAP Authenticate

Command	Opcode	Command Parameters	Return Parameters
GAP_Authenticate	0xFE0B	connHandle, secReq.ioCaps, secReq.oobAvailable, secReq.oob, secReq.authReq, secReq.maxEncKeySize, secReq.keyDist, pairReq.Enable, pairReq.ioCaps, pairReq.oobDataFlag, pairReq.authReq, pairReq.maxEncKeySize, pairReq.keyDist	Status

Description:

Send this command to initiate the pairing process (if Central device), wait for the pairing process (if Peripheral device), or accept a pairing request (if Peripheral device).

Command Parameters:

connHandle: (2 octets)

Value	Parameter Description
0 – 0xFFFD	Connection handle

secReq.ioCaps: (1 octet)

Value	Parameter Description
0	Display Only
1	Display – Yes or No
2	Keyboard Only

Value	Parameter Description
3	No Input and No Output
4	Keyboard and Display
5 – 0xFF	reserved

secReq.oobAvailable: (1 octet)

Value	Parameter Description
0	Out-Of-Bounds (OOB) data is NOT available
1	Out-Of-Bounds (OOB) data is available

secReq.oob: (16 octets)

Value	Parameter Description
"XX:XX:XX:XX: XX:XX:XX:XX: XX:XX:XX:XX: XX:XX:XX:XX"	Out-Of-Bounds data - Initial TK value for the pairing process.

secReq.authReq: Bit Mask (1 octet)

Bit	Parameter Description
0	Bonding – exchange and save key information
1	Reserved
2	Man-In-The-Middle protection
3 – 7	Reserved

secReq.maxEncKeySize: (1 octet)

Range	Parameter Description
7 – 16	Maximum encryption key size to support

secReq.keyDist: Bit Mask (1 octet)

Bit	Parameter Description
0	Slave Encryption Key
1	Slave Identification Key
2	Slave Signing Key
3	Master Encryption Key
4	Master Identification Key
5	Master Signing Key

Bit	Parameter Description
6 – 7	Reserved

pairReq.Enable: (1 octet)

Value	Parameter Description
0	Pairing Request hasn't been received.
1	Pairing Request has already been received. Peripheral Role only.

The following fields should be exact same values received in the Pairing Request.

pairReq.ioCaps: (1 octet)

Value	Parameter Description
0	Display Only
1	Display – Yes or No
2	Keyboard Only
3	No Input and No Output
4	Keyboard and Display
5 – 0xFF	reserved

pairReq.oobDataFlag: (1 octet)

Value	Parameter Description
0	Out-Of-Bounds (OOB) data is NOT available
1	Out-Of-Bounds (OOB) data is available

pairReq.authReq: Bit Mask (1 octet)

Bit	Parameter Description
0	Bonding – exchange and save key information
1	Reserved
2	Man-In-The-Middle protection
3 – 7	Reserved

pairReq.maxEncKeySize: (1 octet)

Range	Parameter Description
7 – 16	Maximum encryption key size to support

pairReq.keyDist: Bit Mask (1 octet)

Bit	Parameter Description
0	Slave Encryption Key
1	Slave Identification Key
2	Slave Signing Key
3	Master Encryption Key
4	Master Identification Key
5	Master Signing Key
6 – 7	Reserved

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x02	Invalid Parameter
0x11	Already in this mode
0x12	Incorrect Profile Role
0x14	Invalid connection handle

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status*** parameter. When the pairing process is complete (either SUCCESS or Failure), a GAP Authentication Complete Event will be generated. If a passkey is needed, a GAP Passkey Needed Event will be generated.

12.11 GAP Update Link Parameter Request

Command	Opcode	Command Parameters	Return Parameters
GAP_UpdateLinkParamReq	0xFE11	connectionHandle, intervalMin, intervalMax, connLatency, connTimeout	Status

Description:

Send this command to change the Link Layer connection parameters of a connection. This command can only be used when the local device's role is Master.

Command Parameters:

connHandle: (2 octets)

Value	Parameter Description
0 – 0xFFFD	Connection handle

intervalMin: (2 octets)

Range	
6 - 3200	Minimum value for the connection event interval. This shall be less than or equal to *intervalMax*. Range: 0x0006 to 0x0C80 Time = *intervalMin* * 1.25 msec Time Range: 7.5 msec to 4 seconds.

intervalMax: (2 octets)

Range	Parameter Description
6 - 3200	Maximum value for the connection event interval. This shall be greater than or equal to *intervalMin*. Range: 0x0006 to 0x0C80 Time = *intervalMax* * 1.25 msec Time Range: 7.5 msec to 4 seconds.

connLatency: (2 octets)

Range	Parameter Description
0 - 499	Slave latency for the connection in number of connection events. Range: 0x0000 to 0x01F3

connTimeout: (2 octets)

Range	Parameter Description
10 - 3200	Supervision timeout for the LE Link. Range: 0x000A to 0x0C80 Time = *connTimeout* * 10 msec Time Range: 100 msec to 32 seconds

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x01	FAILURE
0x02	INVALIDPARAMETER
0x12	bleIncorrectMode
0x14	bleNotConnected

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status*** parameter. When the connection parameters have been applied by the Controller, the GAP Link Parameter Update Event will be generated.

12.12 GAP Passkey Update

Command	Opcode	Command Parameters	Return Parameters
GAP_PasskeyUpdate	0xFE0C	connHandle, passkey	Status

Description:

Send this command when the GAP Passkey Needed Event is received. This command sends a passkey needed during the Pairing Process.

Command Parameters:

connHandle: (2 octets)

Value	Parameter Description
0 – 0xFFFD	Connection handle to issue the passkey

passkey: (6 octets)

Value	Parameter Description
"…"	6 character ASCII string of numbers (ex. "019655")

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x03	Passkey is NULL, or isn't formatted properly

0x12	Link not found

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status*** parameter.

12.13 GAP Slave Security Request

Command	Opcode	Command Parameters	Return Parameters
GAP_SlaveSecurityRequest	0xFE0D	connHandle, authReq	Status

Description:

Send this command, Peripheral Role only, to initiate security from a slave device. This message is also sent, by the Peripheral, to upgrade security (Pairing) to "Authenticated", make sure to ask for Man-In-The-Middle (MITM) protection in the "authReq" field.

Command Parameters:

connHandle: (2 octets)

Value	Parameter Description
0 – 0xFFFD	Connection handle

authReq: Bit Mask (1 octet)

Bit	Parameter Description
0	Bonding – exchange and save key information
1	Reserved
2	Man-In-The-Middle protection
3 – 7	Reserved

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x11	wrong GAP role, must be a Peripheral Role
0x14	Link not found

Event(s) Generated:

When this command is received, the host will send the GAP HCI Ext Command Status Event with the ***Status*** parameter.

12.14 GAP Signable

Command	Opcode	Command Parameters	Return Parameters
GAP_Signable	0xFE0E	connHandle, authenticated, CSRK, signCounter	Status

Description:

Send this command for a connected and bound device to enable signed data.

Command Parameters:

connHandle: (2 octets)

Value	Parameter Description
0 – 0xFFFD	Connection handle

authenticated: (1 octet)

Value	Parameter Description
0	CSRK is not authenticated
1	CSRK is authenticated

CSRK: (16 octets)

Value	Parameter Description
"XX:XX:XX:XX: XX:XX:XX:XX: XX:XX:XX:XX: XX:XX:XX:XX"	CSRK of connected device.

signCounter: (4 octets)

Range	Parameter Description
0x00000000 – 0xFFFFFFFF	32 bit Signature Counter. The connected device's last saved sign counter.

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x12	wrong GAP role, must be a Peripheral Role
0x14	Link not found

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status*** parameter.

12.15 GAP Bond

Command	Opcode	Command Parameters	Return Parameters
GAP_Bond	0xFE0F	connHandle, authenticated, LTK, DIV, rand, LTKsize	Status

Description:

Send this command for a connected and bound device to load the encryption key.

Command Parameters:

connHandle: (2 octets)

Value	Parameter Description
0 – 0xFFFD	Connection handle

authenticated: (1 octet)

Value	Parameter Description
0	LTK is not authenticated
1	LTK is authenticated

LTK: (16 octets)

Value	Parameter Description
"XX:XX:XX:XX: XX:XX:XX:XX: XX:XX:XX:XX: XX:XX:XX:XX"	16 byte Long Term Key (LTK).

DIV: (2 octets)

Range	Parameter Description
0 – 0xFFFF	The DIV used with this LTK.

rand: (8 octets)

Value	Parameter Description
"XX:XX:XX:XX: XX:XX:XX:XX"	The 8 byte random number generated for this LTK.

LTKsize: (1 octet)

Range	Parameter Description
7 – 16	Encryption key size

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x12	wrong GAP role, must be a Peripheral Role
0x14	Link not found

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status*** parameter. When both connected devices have setup encryption, the GAP Bond Complete Event is generated.

12.16 GAP Terminate Auth

Command	Opcode	Command Parameters	Return Parameters
GAP_TerminateAuth	0xFE10	connHandle, reason	Status

Description:

Send this command to terminate a pairing process.

Command Parameters:

connHandle: (2 octets)

Value	Parameter Description

Value	Parameter Description
0 – 0xFFFD	Connection handle

reason: (1 octet)

Value	Parameter Description
0xXX	Pairing Fail reason code

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0xXX	Error code

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status*** parameter. When the existing pairing had ended, the GAP Authentication Complete Event with be generated.

12.17 GAP Set Parameter

Command	Opcode	Command Parameters	Return Parameters
GAP_SetParam	0xFE30	paramID, paramValue	Status

Description:

Send this command to write a GAP Parameter.

Command Parameters:

paramID: (1 octet)

Value	Parameter Description
0	TGAP_GEN_DISC_ADV_MIN - Minimum time to remain advertising, when in Discoverable mode (mSec). Setting this parameter to 0 turns off the timer (default).
1	TGAP_LIM_ADV_TIMEOUT - Maximum time to remain advertising, when in Limited Discoverable mode. In seconds (default 180 seconds).
2	TGAP_GEN_DISC_SCAN - Minimum time to perform scanning, when performing General Discovery proc (mSec).

Value	Parameter Description
3	TGAP_LIM_DISC_SCAN - Minimum time to perform scanning, when performing Limited Discovery proc (mSec).
4	TGAP_CONN_EST_ADV_TIMEOUT - Advertising timeout, when performing Connection Establishment proc (mSec).
5	TGAP_CONN_PARAM_TIMEOUT - Link Layer connection parameter update notification timer, connection parameter update proc (mSec).
6	TGAP_LIM_DISC_ADV_INT_MIN - Minimum advertising interval, when in limited discoverable mode (mSec).
7	TGAP_LIM_DISC_ADV_INT_MAX - Maximum advertising interval, when in limited discoverable mode (mSec).
8	TGAP_GEN_DISC_ADV_INT_MIN - Minimum advertising interval, when in General discoverable mode (mSec).
9	TGAP_GEN_DISC_ADV_INT_MAX - Maximum advertising interval, when in General discoverable mode (mSec).
10	TGAP_CONN_ADV_INT_MIN - Minimum advertising interval, when in Connectable mode (mSec).
11	TGAP_CONN_ADV_INT_MAX - Maximum advertising interval, when in Connectable mode (mSec).
12	TGAP_CONN_SCAN_INT - Scan interval used during Link Layer Initiating state, when in Connectable mode (mSec).
13	TGAP_CONN_SCAN_WIND - Scan window used during Link Layer Initiating state, when in Connectable mode (mSec).
14	TGAP_CONN_HIGH_SCAN_INT - Scan interval used during Link Layer Initiating state, when in Connectable mode, high duty scan cycle scan paramaters (mSec).
15	TGAP_CONN_HIGH_SCAN_WIND - Scan window used during Link Layer Initiating state, when in Connectable mode, high duty scan cycle scan paramaters (mSec).
16	TGAP_GEN_DISC_SCAN_INT - Scan interval used during Link Layer Scanning state, when in General Discovery proc (mSec).
17	TGAP_GEN_DISC_SCAN_WIND - Scan window used during Link Layer Scanning state, when in General Discovery proc (mSec).
18	TGAP_LIM_DISC_SCAN_INT - Scan interval used during Link Layer Scanning state, when in Limited Discovery proc (mSec).
19	TGAP_LIM_DISC_SCAN_WIND - Scan window used during Link Layer Scanning state, when in Limited Discovery proc (mSec).
20	TGAP_CONN_EST_ADV - Advertising interval, when using Connection Establishment proc (mSec).
21	TGAP_CONN_EST_INT_MIN - Minimum Link Layer connection interval, when using Connection Establishment proc (mSec).
22	TGAP_CONN_EST_INT_MAX - Maximum Link Layer connection interval, when using Connection Establishment proc (mSec).

Value	Parameter Description
23	TGAP_CONN_EST_SCAN_INT - Scan interval used during Link Layer Initiating state, when using Connection Establishment proc (mSec).
24	TGAP_CONN_EST_SCAN_WIND - Scan window used during Link Layer Initiating state, when using Connection Establishment proc (mSec).
25	TGAP_CONN_EST_SUPERV_TIMEOUT - Link Layer connection supervision timeout, when using Connection Establishment proc (mSec).
26	TGAP_CONN_EST_LATENCY - Link Layer connection slave latency, when using Connection Establishment proc (mSec)
27	TGAP_CONN_EST_MIN_CE_LEN - Local informational parameter about min len of connection needed, when using Connection Establishment proc (mSec).
28	TGAP_CONN_EST_MAX_CE_LEN - Local informational parameter about max len of connection needed, when using Connection Establishment proc (mSec).
29	TGAP_PRIVATE_ADDR_INT - Minimum Time Interval between private (resolvable) address changes. In minutes (default 15 minutes).
30	TGAP_CONN_PAUSE_CENTRAL – Central idle timer. In seconds (default 1 second).
31	TGAP_CONN_PAUSE_PERIPHERAL – Minimum time upon connection establishment before the peripheral starts a connection update procedure. In seconds (default 5 seconds).
32	TGAP_SM_TIMEOUT - SM Message Timeout (milliseconds). (default 30 seconds).
33	TGAP_SM_MIN_KEY_LEN - SM Minimum Key Length supported (default 7).
34	TGAP_SM_MAX_KEY_LEN - SM Maximum Key Length supported (default 16).
35	TGAP_FILTER_ADV_REPORTS - Filter duplicate advertising reports (Default TRUE).
36	TGAP_SCAN_RSP_RSSI_MIN - Minimum RSSI required for scan responses to be reported to the app (Default -127).
37	TGAP_REJECT_CONN_PARAMS- Whether or not to reject Connection Parameter Update Request received on Central device. Default FALSE.

The following parameters are use for testing only (DO NOT USE):

Value	Parameter Description
38	TGAP_GAP_TESTCODE - GAP Test Modes: 0 – Test Mode Off 1 – No Response
39	TGAP_SM_TESTCODE - SM Test Modes: 0 – Test Mode Off 1 – No Response 2 – Send Bad Confirm 3 – Bad Confirm Verify 4 – Send SMP Confirm Message
100	TGAP_GATT_TESTCODE - GATT Test Modes: 0 – Test Mode Off 1 – Ignore incoming request 2 – Forward Prepare Write Request right away 3 – Use Max ATT MTU size with Exchange MTU Response 4 – Corrupt incoming Prepare Write Request data
101	TGAP_ATT_TESTCODE - ATT Test Modes: 0 – Test Mode Off 1 – Do Not authenticate incoming signature
102	TGAP_GGS_TESTCODE - GGS Test Modes: 0 – Test Mode Off 1 – Make Device Name attribute writable 2 – Make Appearance attribute writable 3 – Make Peripheral Privacy Flag attribute writable with authentication

paramValue: (2 octets)

Value	Parameter Description
0xXXXX	Depends on the parameter

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x02	Invalid paramID

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status*** parameter.

12.18 GAP Get Parameter

Command	Opcode	Command Parameters	Return Parameters
GAP_GetParam	0xFE31	paramID,	Status, paramValue

Description:

Send this command to read a GAP Parameter.

Command Parameters:

paramID: (1 octet)

Value	Parameter Description
0xXX	See paramID list in *GAP Set Parameter*

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x02	Invalid paramID

paramValue: (2 octets)

Value	Parameter Description
0xXXXX	Depends on the paramID passed in. See paramID descriptions in *GAP Set Parameter* for size and values.

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status*** and ***paramValue*** parameters.

12.19 GAP Resolve Private Address

Command	Opcode	Command Parameters	Return Parameters
GAP_ResolvePrivateAddr	0xFE32	IRK, addr	Status

Description:

Send this command to resolve a Private Resolvable Address.

Command Parameters:

IRK: (16 octets)

Value	Parameter Description
"XX:XX:XX:XX: XX:XX:XX:XX: XX:XX:XX:XX: XX:XX:XX:XX"	IRK to resolve addr with

addr: (6 octet)

Range	Parameter Description
"XX:XX:XX:XX:XX:XX"	Private resolvable address to resolve (with IRK).

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS – addr resolves
0x01	FAILURE – addr doesn't resolve

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status*** parameter.

12.20 GAP Set Advertisement Token

Command	Opcode	Command Parameters	Return Parameters
GAP_SetAdvToken	0xFE33	adType, advDataLen, advData	Status

Description:

Send this command to add an Advertisement Data Token to the advertisement data field of an advertisement packet.

Command Parameters:

adType: (1 octet)

Value	Parameter Description
0x01	Flags: Discovery Mode

0x02	Service: More 16-bit UUIDs available
0x03	Service: Complete list of 16-bit UUIDs
0x04	Service: More 32-bit UUIDs available
0x05	Service: Complete list of 32-bit UUIDs
0x06	Service: More 128-bit UUIDs available
0x07	Service: Complete list of 128-bit UUIDs
0x08	Shortened local name
0x09	Complete local name
0x0A	TX Power Level: 0xXX: -127 to +127 dBm
0x0D	Simple Pairing OOB Tag: Class of device (3 octets)
0x0E	Simple Pairing OOB Tag: Simple Pairing Hash C (16 octets)
0x0F	Simple Pairing OOB Tag: Simple Pairing Randomizer R (16 octets)
0x10	Security Manager TK Value
0x11	Secutiry Manager OOB Flags
0x12	Min and Max values of the connection interval (2 octets Min, 2 octets Max) (0xFFFF indicates no conn interval min or max)
0x13	Signed Data field
0x14	Service Solicitation: list of 16-bit Service UUIDs
0x15	Service Solicitation: list of 128-bit Service UUIDs
0x16	Service Data
0xFF	Manufacturer Specific Data: first 2 octets contain the Company Identifier Code followed by the additional manufacturer specific data

advDataLen: (1 octet)

Value	Parameter Description
0xXX	Length (in octets) of advData

advData: (advDataLen octets)

Value	Parameter Description
“XX:XX…XX”	Advertisement token data (over-the-air format).

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x02	Invalid Advertisement Type
0x0B	Token takes up too much space and doesn't fit into Advertisement data and Scan response data.
0x12	Invalid GAP Profile Role
0x18	Advertisement Type already exists

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status*** parameter.

12.21 GAP Remove Advertisement Token

Command	Opcode	Command Parameters	Return Parameters
GAP_RemoveAdvToken	0xFE34	adType	Status

Description:

Send this command to remove an Advertisement Data Token from the advertisement data field of an advertisement packet.

Command Parameters:

adType: (1 octet)

Value	Parameter Description
0x01	Flags: Discovery Mode
0x02	Service: More 16-bit UUIDs available
0x03	Service: Complete list of 16-bit UUIDs
0x04	Service: More 32-bit UUIDs available
0x05	Service: Complete list of 32-bit UUIDs
0x06	Service: More 128-bit UUIDs available
0x07	Service: Complete list of 128-bit UUIDs
0x08	Shortened local name
0x09	Complete local name

0x0A	TX Power Level: 0xXX: -127 to +127 dBm
0x0D	Simple Pairing OOB Tag: Class of device (3 octets)
0x0E	Simple Pairing OOB Tag: Simple Pairing Hash C (16 octets)
0x0F	Simple Pairing OOB Tag: Simple Pairing Randomizer R (16 octets)
0x10	Security Manager TK Value
0x11	Secutiry Manager OOB Flags
0x12	Min and Max values of the connection interval (2 octets Min, 2 octets Max) (0xFFFF indicates no conn interval min or max)
0x13	Signed Data field
0x14	Service Solicitation: list of 16-bit Service UUIDs
0x15	Service Solicitation: list of 128-bit Service UUIDs
0x16	Service Data
0xFF	Manufacturer Specific Data: first 2 octets contain the Company Identifier Code followed by the additional manufacturer specific data

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x02	adType not found.

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status*** parameter.

12.22 GAP Update Advertisement Tokens

Command	Opcode	Command Parameters	Return Parameters
GAP_UpdateAdvToken	0xFE35		Status

Description:

After adding an removing advertisement tokens, they must be updated to actual advertisements by sending this command.

Command Parameters:

none

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status*** parameter.

12.22.1 GAP Bond Set Parameter

Command	Opcode	Command Parameters	Return Parameters
GAP_BondSetParam	0xFE36	paramID, paramDataLen, paramData	Status

Description:

Send this command to set a GAP Bond parameter.

Command Parameters:

paramID: (2 octets)

Value	Parameter Description
0x0400	Pairing Mode - Read/Write. Size is uint8. Values: 0x00 – Pairing Not allowed 0x01 – Wait for Request (default) 0x02 – Don't wait, initiate a Slave Requested Security command (not available yet).
0x0401	Pairing Mode Initiate wait timeout. This is the time it will wait for a Pairing Request before sending the Slave Initiate Request. Read/Write. Size is uint16. Default is 1000(in milliseconds).
0x0402	Man-In-The-Middle (MITM) basically turns on Passkey protection in the pairing algorithm. Read/Write. Size is uint8. Values:

	0x00 – Disabled (default). 0x01 – Enabled.
0x0403	I/O capabilities. Read/Write. Size is uint8. Values: 0x00 – Display Only Device (default) 0x01 – Display – Yes an No capable 0x02 – Keyboard only 0x03 – No Input, No Output 0x04 – Keyboard and Display
0x0404	OOB data available for pairing algorithm. Read/Write. Size is uint8. Values: 0x00 – Disabled (default). 0x01 – Enabled.
0x0405	OOB Data. Read/Write. size uint8[16]. Default is all 0's.
0x0406	Request Bonding during the pairing process if enabled. Read/Write. Size is uint8. Values: 0x00 – Disabled (default). 0x01 – Enabled.
0x0407	The key distribution list for bonding. size is uint8. Bit Values: Bit 0 – Slave LTK and key information (default) Bit 1 – Slave IRK and ID information (default) Bit 2 – Slave CSRK Bit 3 – Master LTK and key information Bit 4 – Master IRK and ID information (default). Bit 5 – Master CSRK (default)
0x0408	The default passcode for MITM protection. size is uint32. Range is 0 - 999,999. Default is 0.
0x0409	Erase all of the bonded devices. Write Only - command. No Size.
0x040A	Test mode to automatically send a Pairing Fail when a Pairing Request is received. Read/Write. size is uint8. Default is 0 (disabled). Set to 1 to enable.
0x040B	Test mode Pairing Fail reason when auto failing. Read/Write. size is uint8. Default is 0x05 (SMP_PAIRING_FAILED_NOT_SUPPORTED).
0x040C	Key Size used in pairing. Read/Write. Size is uint8. Default is 16.
0x040D	Clears the White List adds to it each unique address stored by bonds in NV. Read/Write. Size is uint8. Default is FALSE.
0x040E	Gets the total number of bonds stored in NV. Read Only. Size is uint8. Default is 0 (no bonds).
0x040F	Possible actions Central may take upon an unsuccessful bonding. Write Only. Size is uint8. Default is 1 (initiate pairing).

paramDataLen: (1 octet)

Value	Parameter Description
0xXX	Length (in octets) of paramData

paramData: (paramDataLen octets)

Value	Parameter Description
"XX:XX…XX"	Parameter data – depends on paramID.

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x02	Invalid paramID
0x18	Invalid paramDataLen

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status*** parameter.

12.22.2 GAP Bond Get Parameter

Command	Opcode	Command Parameters	Return Parameters
GAP_BondGetParam	0xFE37	paramID	Status, paramDataLen, paramData

Description:

Send this command to read a GAP Bond parameter.

Command Parameters:

paramID: (2 octets)

Value	Parameter Description
0xXX	See paramID in *GAP Bond Set Parameter*

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x02	Invalid paramID
0x18	Invalid paramDataLen

paramDataLen: (1 octet)

Value	Parameter Description
0xXX	Length (in octets) of paramData

paramData: (paramDataLen octets)

Value	Parameter Description
“XX:XX…XX”	Depends on the paramID.

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status***, ***paramDataLen***, ***paramData*** parameters.

13. GAP Vendor Specific Events

13.1 GAP Device Init Done

Event	Opcode	Event Parameters
GAP_DeviceInitDone	0x0600	Status, devAddr, dataPktLen, numDataPkts, IRK, CSRK,

Description:

This event is sent to indicate that the device is done initializing.

Event Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS

devAddr: (6 octets)

Value	Parameter Description
"XX:XX:XX:XX:XX:XX"	The device's public address (BD_ADDR).

dataPktLen: (2 octets)

Range	Parameter Description
0x0000 – 0xFFFF	HC_LE_Data_Packet_Length

numDataPkts: (1 octet)

Range	Parameter Description
0x00 – 0xFF	HC_Total_Num_LE_Data_Packets

IRK: (16 octets)

Value	Parameter Description
"XX:XX:XX:XX: XX:XX:XX:XX: XX:XX:XX:XX: XX:XX:XX:XX"	16 byte Identity Resolving Key (IRK). This is either a randomly generated key or the original key passed in the GAP_DeviceInit command.

CSRK: (16 octets)

Value	Parameter Description

Value	Parameter Description
"XX:XX:XX:XX: XX:XX:XX:XX: XX:XX:XX:XX: XX:XX:XX:XX"	16 byte Connection Signature Resolving Key (CSRK). This is either a randomly generated key or the original key passed in the GAP_DeviceInit command.

13.2 GAP Device Discovery

Event	Opcode	Event Parameters
GAP_DeviceDiscovery	0x0601	Status, numDevs, array of {eventType, addrType, addr}

Description:

This event is sent to indicate that the scan is complete.

Event Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS

numDevs: (1 octet)

Range	Parameter Description
0 – 0xFF	The number of advertising devices detected during the scan. The number reflects the type of filter used during the scan.

eventType: (1 octet)

Value	Parameter Description
0	Connectable undirected advertisement
1	Connectable directed advertisement
2	Discoverable undirected advertisement
3	Non-connectable undirected advertisement
4	Scan Response

addrType: (1 octet)

Value	Parameter Description

Value	Parameter Description
0	ADDRTYPE_PUBLIC
1	ADDRTYPE_STATIC
2	ADDRTYPE_PRIVATE_NONRESOLVE
3	ADDRTYPE_PRIVATE_RESOLVE

addr: (6 octets)

Range	Parameter Description
"XX:XX:XX:XX:XX:XX"	Address of the device scanned.

13.3 GAP Advert Data Update Done

Event	Opcode	Event Parameters
GAP_AdvertDataUpdateDone	0x0602	Status , adType

Description:

This event is sent when the device sets the advertising data because of the GAP Update Advertising Data Command.

Event Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS

adType: (1 octet)

Value	Parameter Description
0	SCAN_RSP data
1	Advertisement data

13.4 GAP Make Discoverable Done

Event	Opcode	Event Parameters
GAP_MakeDiscoverableDone	0x0603	Status

Description:

This event is sent when the device starts advertising.

Event Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS

interval: (2 octets)

Range	Parameter Description
0xXXXX	Actual advertising interval selected by the Controller

13.5 GAP End Discoverable Done

Event	Opcode	Event Parameters
GAP_EndDiscoverableDone	0x0604	Status

Description:

This event is sent when the device ends advertising.

Event Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS

13.6 GAP Link Established

Event	Opcode	Event Parameters
GAP_LinkEstablished	0x0605	Status, devAddrType, devAddr, connHandle, connInterval, connLatency, connTimeout, clockAccuracy

Description:

This message is sent when a connection is established with another device. On a Central device, this message is a result for a GAP Establish Link Request. On a Peripheral device, this message is received when a central device initiated a connection.

Event Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS

devAddrType: (1 octet)

Value	Parameter Description
0	ADDRTYPE_PUBLIC
1	ADDRTYPE_STATIC
2	ADDRTYPE_PRIVATE_NONRESOLVE
3	ADDRTYPE_PRIVATE_RESOLVE

devAddr: (6 octets)

Range	Parameter Description
"XX:XX:XX:XX:XX:XX"	Address of the connected device

connHandle: (2 octets)

Range	Parameter Description
0 – 0xFFFD	Handle of the connection. This will be used to reference the connection in other "connection based" commands.

connInterval: (2 octets)

Value	Parameter Description
N = 0xXXXX	Connection interval used on this connection. Range: 0x0006 to 0x0C80 Time = N * 1.25 msec Time Range: 7.5 msec to 4 seconds

connLatency: (2 octets)

Value	Parameter Description
N = 0xXXXX	Connection latency used on this connection.

Value	Parameter Description
	Range: 0x0006 to 0x0C80 Time = N * 1.25 msec Time Range: 7.5 msec to 4 seconds

connTimeout: (2 octets)

Value	Parameter Description
N = 0xXXXX	Connection supervision timeout. Range: 0x0006 to 0x0C80 Time = N * 1.25 msec Time Range: 7.5 msec to 4 seconds

clockAccuracy: (1 octet)

Value	Parameter Description
0	500 ppm
1	250 ppm
2	150 ppm
3	100 ppm
4	75 ppm
5	50 ppm
6	30 ppm
7	20 ppm
8 – 0xFF	reserved

13.7 GAP Link Terminated

Event	Opcode	Event Parameters
GAP_LinkTerminated	0x0606	Status, connHandle, reason

Description:

This message is sent whenever a link is terminated.

Event Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS

connHandle: (2 octets)

Value	Parameter Description
XX	Connection Handle of terminated link

reason: (1 octet)

Value	Parameter Description
0x08	Supervisor Timeout
0x13	Peer Requested
0x16	Host Requested
0x22	Control Packet Timeout
0x28	Control Packet Instant Passed
0x3B	LSTO Violation
0x3D	MIC Failure

13.8 GAP Link Parmeter Update

Event	Opcode	Event Parameters
GAP_LinkParamUpdate	0x0607	Status, connHandle, connInterval, connLatency, connTimeout

Description:

This message is sent whenever connection parameter update is completed.

Event Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS

connHandle: (2 octets)

Value	Parameter Description
XX	Connection Handle of link

connInterval: (2 octets)

Value	Parameter Description
N = 0xXXXX	Connection interval used on this connection. Range: 0x0006 to 0x0C80 Time = N * 1.25 msec Time Range: 7.5 msec to 4 seconds

connLatency: (2 octets)

Value	Parameter Description
N = 0xXXXX	Connection latency used on this connection. Range: 0x0000 to 0x01F3

connTimeout: (2 octets)

Value	Parameter Description
N = 0xXXXX	Connection supervision timeout. Range: 0x000A to 0x0C80 Time = N * 10 msec Time Range: 100 msec to 32 seconds

13.9 GAP Random Address Changed

Event	Opcode	Event Parameters
GAP_RandomAddrChanged	0x0608	Status, addrType, newRandomAddr

Description:

This message is sent whenever the device's Private Resolvable Address automatically changes.

Event Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS

addrType: (1 octet)

Value	Parameter Description

Value	Parameter Description
0	ADDRTYPE_PUBLIC
1	ADDRTYPE_STATIC
2	ADDRTYPE_PRIVATE_NONRESOLVE
3	ADDRTYPE_PRIVATE_RESOLVE

newRandomAddr: (6 octets)

Value	Parameter Description
"XX:XX:XX:XX:XX:XX"	New Private Resolvable Address was generated.

13.10 GAP Signature Updated

Event	Opcode	Event Parameters
GAP_SignatureUpdated	0x0609	Status, addrType, devAddr, signCounter

Description:

This message is sent whenever sign counter is updated (incremented). This message will be generated when a new sign counter is received from a connected device or when this device increments its own sign counter.

Event Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS

addrType: (1 octet)

Value	Parameter Description
0	ADDRTYPE_PUBLIC
1	ADDRTYPE_STATIC
2	ADDRTYPE_PRIVATE_NONRESOLVE
3	ADDRTYPE_PRIVATE_RESOLVE

devAddr: (6 octets)

Range	Parameter Description

Range	Parameter Description
"XX:XX:XX:XX:XX:XX"	The device address of the sign counter that changed. It may be this device or a connected device.

signCounter: (6 octets)

Range	Parameter Description
0 – 0xFFFFFFFF	The new sign counter value for the referenced device.

13.11 GAP Authentication Complete

Event	Opcode	Event Parameters
GAP_AuthenticationComplete	0x060A	Status, connHandle, authState, secInfo, secInfo.LTKsize, secInfo.LTK, secInfo.DIV, secInfo.rand, devSecInfo, devSecInfo.LTKsize, devSecInfo.LTK, devSecInfo.DIV, devSecInfo.rand, identityInfo, identityInfo.IRK, identityInfo.BD_ADDR, signingInfo, signingInfo.CSRK, signingInfo.signCounter

Description:

This event is generated whenever the pairing process is completed (pass or fail).

Event Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x01 – 0xFF	Pairing failures

connHandle: (2 octets)

Value	Parameter Description
XX	Connection Handle of link

authState: Bit Mask (1 octet)

Bit	Parameter Description
0	Bonding – exchange and save key information
1	Reserved
2	Man-In-The-Middle protection
3 – 7	Reserved

secInfo: (1 octet)

Value	Parameter Description
0x00	The following "secInfo" parameters are NOT enabled in this event.
0x01	The following "secInfo" parameters are enabled in this event.

The following security information is for the device itself:

secInfo.LTKsize: (1 octet)

Range	Parameter Description
7 – 16	Encryption key size

secInfo.LTK: (16 octets)

Value	Parameter Description
"XX:XX:XX:XX: XX:XX:XX:XX: XX:XX:XX:XX: XX:XX:XX:XX"	16 byte Long Term Key (LTK).

secInfo.DIV: (2 octets)

Range	Parameter Description
0 – 0xFFFF	The DIV used with this LTK.

secInfo.rand: (8 octets)

Value	Parameter Description
"XX:XX:XX:XX: XX:XX:XX:XX"	The 8 byte random number generated for this LTK.

devSecInfo: (1 octet)

Value	Parameter Description

Value	Parameter Description
0x00	The following “devSecInfo” parameters are NOT enabled in this event.
0x01	The following “devSecInfo” parameters are enabled in this event.

The following security information is for the connected peer device:

devSecInfo.LTKsize: (1 octet)

Range	Parameter Description
7 – 16	Encryption key size

devSecInfo.LTK: (16 octets)

Value	Parameter Description
“XX:XX:XX:XX: XX:XX:XX:XX: XX:XX:XX:XX: XX:XX:XX:XX”	16 byte Long Term Key (LTK).

devSecInfo.DIV: (2 octets)

Range	Parameter Description
0 – 0xFFFF	The DIV used with this LTK.

devSecInfo.rand: (8 octets)

Value	Parameter Description
“XX:XX:XX:XX: XX:XX:XX:XX”	The 8 byte random number generated for this LTK.

identityInfo: (1 octet)

Value	Parameter Description
0x00	The following “identityInfo” parameters are NOT enabled in this event.
0x01	The following “identityInfo” parameters are enabled in this event.

identityInfo.IRK: (16 octets)

Value	Parameter Description
“XX:XX:XX:XX:	16 byte Identity Root Key (IRK). Used to resolve Private

Value	Parameter Description
XX:XX:XX:XX: XX:XX:XX:XX: XX:XX:XX:XX”	Resolvable Addresses.

identityInfo.BD_ADDR: (6 octets)

Range	Parameter Description
“XX:XX:XX:XX:XX:XX”	The connected device’s Public Address.

signingInfo: (1 octet)

Value	Parameter Description
0x00	The following “signingInfo” parameters are NOT enabled in this event.
0x01	The following “signingInfo” parameters are enabled in this event.

signingInfo.IRK: (16 octets)

Value	Parameter Description
“XX:XX:XX:XX: XX:XX:XX:XX: XX:XX:XX:XX: XX:XX:XX:XX”	16 byte Connected Signature Resolving Key (CSRK).

signingInfo.signCounter: (2 octets)

Range	Parameter Description
0 – 0xFFFF	The connected device’s current sign counter

13.12 GAP Passkey Needed

Event	Opcode	Event Parameters
GAP_PasskeyNeeded	0x060B	Status, devAddr, connHandle, uiInputs, uiOutputs

Description:

This event is generated during the pairing process if a passkey is needed.

Event Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS

devAddr: (6 octets)

Range	Parameter Description
“XX:XX:XX:XX:XX:XX”	Address of the pairing device.

connHandle: (2 octets)

Value	Parameter Description
XX	Connection Handle of link

uiInput: (1 octet)

Value	Parameter Description
0x00	Don’t ask user to input a passcode
0x01	Ask user to input a passcode

uiOuput: (1 octet)

Value	Parameter Description
0x00	Don’t display passcode
0x01	Display a passcode

13.13 GAP Slave Requested Security

Event	Opcode	Event Parameters
GAP_SlaveRequestedSecurity	0x060C	Status, connHandle, devAddr, authReq

Description:

This message is generated when the master device receives an SM Slave Request from the connected slave device.

Event Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS

connHandle: (2 octets)

Value	Parameter Description
XX	Connection Handle of link

devAddr: (6 octets)

Range	Parameter Description
"XX:XX:XX:XX:XX:XX"	The connected device's address.

authReq: Bit Mask (1 octet)

Bit	Parameter Description
0	Bonding – exchange and save key information
1	Reserved
2	Man-In-The-Middle protection
3 – 7	Reserved

13.14 GAP Device Information

Event	Opcode	Event Parameters
GAP_DeviceInformation	0x060D	Status, eventTypes, addrType, addr, rssi, dataLen, dataField

Description:

This message is sent during a scan and represents another device's advertisement or SCAN_RSP packet.

Event Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS

eventType: (1 octet)

Value	Parameter Description
0	Connectable undirected advertisement
1	Connectable directed advertisement

Value	Parameter Description
2	Discoverable undirected advertisement
3	Non-connectable undirected advertisement
4	Scan Response

addrType: (1 octet)

Value	Parameter Description
0	ADDRTYPE_PUBLIC
1	ADDRTYPE_STATIC
2	ADDRTYPE_PRIVATE_NONRESOLVE
3	ADDRTYPE_PRIVATE_RESOLVE

addr: (6 octets)

Range	Parameter Description
"XX:XX:XX:XX:XX:XX"	Address of the device scanned.

rssi: (1 octet)

Range	Parameter Description
0x00 – 0xFF	

dataLen: (1 octet)

Range	Parameter Description
0x00 – 0xFF	Number of octets in the following dataField field.

dataField: (dataLen octets)

Range	Parameter Description
"XX:XX … XX"	Data field of the advertisement or SCAN_RSP packets.

13.15 GAP Bond Complete

Event	Opcode	Event Parameters
GAP_BondComplete	0x060E	Status, connHandle

Description:

This message is sent when a bond is complete and the connection is encrypted.

Event Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x01 – 0xFF	error

connHandle: (2 octets)

Value	Parameter Description
XX	Connection Handle of link

13.16 GAP Pairing Requested

Event	Opcode	Event Parameters
GAP_PairingRequested	0x060F	Status, connHandle, ioCap, oobDataFlag, authReq, maxEncKeySize, keyDist

Description:

This message is sent when a bond is complete and the connection is encrypted.

Event Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x01 – 0xFF	error

connHandle: (2 octets)

Value	Parameter Description
XX	Connection Handle of link

ioCap: (1 octet)

Value	Parameter Description
0	Display Only
1	Display – Yes or No

Value	Parameter Description
2	Keyboard Only
3	No Input and No Output
4	Keyboard and Display
5 – 0xFF	reserved

oobDataFlag: (1 octet)

Value	Parameter Description
0	Out-Of-Bounds (OOB) data is NOT available
1	Out-Of-Bounds (OOB) data is available

authReq: Bit Mask (1 octet)

Bit	Parameter Description
0	Bonding – exchange and save key information
1	Reserved
2	Man-In-The-Middle protection
3 – 7	Reserved

maxEncKeySize: (1 octet)

Range	Parameter Description
7 – 16	Maximum encryption key size to support

keyDist: Bit Mask (1 octet)

Bit	Parameter Description
0	Slave Encryption Key
1	Slave Identification Key
2	Slave Signing Key
3	Master Encryption Key
4	Master Identification Key
5	Master Signing Key
6 – 7	Reserved

13.17 **Command Status**

Event	Opcode	Event Parameters
CommandStatus	0x067F	Status, opCode, dataLen, payload

Description:

The Command Status event is used to indicate that the command given by opCode parameter has been received and is being processed. If successful, an HCI vendor specific event that corresponds to the command will follow. Otherwise, no event will follow since the command was not started.

Event Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x01 – 0xFF	See Host Error Codes [20]

opCode: (2 octets)

Value	Parameter Description
XX	Connection Handle of link

dataLen: (1 octet)

Value	Parameter Description
XX	Length of payload

payload: (dataLen octets)

Value	Parameter Description
“XX:XX…XX”	Command payload

14. UTIL Vendor Specific Commands

14.1 UTIL NV Read Command

Command	Opcode	Command Parameters	Return Parameters
UTIL_NVRead	0xFE81	nvID, nvDataLen	Status, nvData

Description:

Send this command to read an NV parameter.

Command Parameters:

nvID: (1 octet)

Value	Parameter Description
0x02	This device's IRK. Size is 16 bytes.
0x03	This device's CSRK. Size is 16 bytes.
0x04	This device's sign counter. Size is uint32.
0x20 – 0x5F	GAP Bond Manager NV Items.

GAP Bond Manager NV Items:

This range is taken with the following repeating ID offsets, used below:
0 – bondRecord
1 – localLTK
2 – deviceLTK
3 – deviceIRK
4 – deviceCSRK
5 – deviceSignCounter

To calculate an NV item for the GAP Bond Manager:

The NV definitions:

- NVID_GB_START (0x20) - starting GAP Bond Manager NV ID
- GAP_BONDINGS_MAX (default 10) - Maximum number of bonding allowed (10 is max for number of NV IDs allocated in bcomdef.h).

Definitions for the formulas:

- KEYLEN – 16 bytes
- B_ADDR_LEN – 6 bytes
- MAX_OFFSETS = 6
- B_RANDOM_NUM_SIZE = 8

Structure definitions:

```
typedef struct
{
```

```
  uint8   LTK[KEYLEN];
  uint16  div;
  uint8   rand[B_RANDOM_NUM_SIZE];
  uint8   keySize;
} gapBondLTK_t;

typedef struct
{
  uint8   publicAddr[B_ADDR_LEN];     // Master's address
  uint8   reconnectAddr[B_ADDR_LEN];
  uint16  stateFlags;
} gapBondRec_t;
```

A single bonding entry consists of 6 components (NV items):

- Bond Record - defined as gapBondRec_t and uses for an NV ID offset
- local LTK Info - defined as gapBondLTK_t and uses localLTK for an NV ID offset
- device LTK Info - defined as gapBondLTK_t and uses deviceLTK for an NV ID offset
- device IRK - defined as "uint8 [KEYLEN]" and uses deviceIRK for an NV ID offset
- device CSRK - defined as "uint8 [KEYLEN]" and uses deviceCSRK for an NV ID offset
- device Sign Counter - defined as a uint32 and uses deviceSignCounter for an NV ID offset

When the device is initialized for the first time, all (GAP_BONDINGS_MAX) NV items are created and initialized to all 0xFF's. A bonding record of all 0xFF's indicates that the bonding record is empty and free to use.

Example calculation for each bonding records NV IDs, bondIdx represents the bond record (0-9):

- mainRecordNvID = ((bondIdx * MAX_OFFSETS) + NVID_GB_START)
- localLTKNvID = (((bondIdx * MAX_OFFSETS) + localLTK) + NVID_GB_START)
- devlLTKNvID = (((bondIdx * MAX_OFFSETS) + devlLTK) + NVID_GB_START)
- devIRKNvID = (((bondIdx * MAX_OFFSETS) + devIRK) + NVID_GB_START)
- devCSRKNvID = (((bondIdx * MAX_OFFSETS) + devCSRK) + NVID_GB_START)
- devSignCounterNvID = (((bondIdx * MAX_OFFSETS) + devSignCounter) + NVID_GB_START)

nvDataLen: (1 octet)

Value	Parameter Description
0xXX	Length (in octets) to read from nvID

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0xXX	failure

nvData: (nvDataLen octets)

Value	Parameter Description

Value	Parameter Description
“XX:XX…XX”	NV Data – depends on the nvID passed in.

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status and nvData*** parameters.

14.2 UTIL NV Write Command

Command	Opcode	Command Parameters	Return Parameters
UTIL_NVWrite	0xFE82	nvID, nvDataLen, nvData	Status

Description:

Send this command to write an NV parameter.

Command Parameters:

nvID: (1 octet)

Value	Parameter Description
0xXX	See the nvID description in the *UTIL NV Read Command*

nvDataLen: (1 octet)

Value	Parameter Description
0xXX	Length (in octets) nvData

nvData: (nvDataLen octets)

Value	Parameter Description
“XX:XX…XX”	NV Data depends on the nvID

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0xXX	failure

Event(s) Generated:

When this command is received, the host will send the HCI Ext Command Status Event with the ***Status*** parameter.

14.3 UTIL Force Boot Command

Command	Opcode	Command Parameters	Return Parameters
UTIL_ForceBoot	0xFE83	None	Status

Description:

Force the boot loader to run.

Command Parameters:

None

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x02	INVALIDPARAMETER

Event(s) Generated:

When this command is received, the device resets if the boot loader is present. Otherwise, the host will send the HCI Ext Command Status Event with the ***Status*** parameter set to 0x02.

15. L2CAP Vendor Specific Commands

All L2CAP commands have the following format:

Name	Size (octets)	Description
Opcode	2	PDU operation code
connectionHandle	2	Connection Handle of link
Command PDU	Variable	Command parameters

Note: The connection handle of 0xFFFE is considered as the loopback connection. All message sent to this connection will be loop backed to the local host.

For the command parameters, please see the corresponding section below.

15.1 L2CAP_ConnParamUpdateReq (0xFC92)

The Connection Parameter Update Request is sent from the LE slave device to the LE master device. This request allows the LE slave Host to request a set of new connection parameters.

Command Parameters:

intervalMin: (2 octets)

Range	
6 - 3200	Defines minimum value for the connection event interval in the following manner: connIntervalMin = Interval Min * 1.25 ms. Interval Min range: 6 to 3200 frames where 1 frame is 1.25 ms and equivalent to 2 BR/EDR slots. Values outside the range are reserved. Interval Min shall be less than or equal to Interval Max.

intervalMax: (2 octets)

Range	Parameter Description
6 - 3200	Defines maximum value for the connection event interval in the following manner: connIntervalMax = Interval Max * 1.25 ms. Interval Max range: 6 to 3200 frames. Values outside the range are reserved. Interval Max shall be equal to or greater than the Interval Min.

slaveLatency: (2 octets)

Range	Parameter Description

Range	Parameter Description
0 - 500	Defines the slave latency parameter (as number of LL connection events) in the following manner: connSlaveLatency = Slave Latency. The Slave Latency field shall have a value in the range of 0 to ((connSupervisionTimeout / connIntervalMax) - 1). The Slave Latency field shall be less than 500.

timeoutMultiplier: (2 octets)

Range	Parameter Description
10 - 3200	Defines connection timeout parameter in the following manner: connSupervisionTimeout = Timeout Multiplier * 10 ms The Timeout Multiplier field shall have a value in the range of 10 to 3200.

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x01	FAILURE
0x02	INVALIDPARAMETER
0x04	MSG_BUFFER_NOT_AVAIL
0x13	bleMemAllocError
0x14	bleNotConnected
0x15	bleNoResources

Event(s) Generated:

When this request is received, the LE slave host will send the Command Status Event with the ***Status*** parameter after forwarding the request to the LE master host. The LE master host will send the Connection Parameter Update Response (L2CAP_ConnParamUpdateRsp) event back.

If the LE slave host receives this request, it will respond with a Command Reject (L2CAP_CmdReject) with reason 0x0000 (command not understood).

16. L2CAP Vendor Specific Events

All L2CAP events have the following format:

Name	Size (octets)	Description
Opcode	2	PDU operation code
status	1	Event status
connectionHandle	2	Connection Handle of link
Event PDU	Variable	Event parameters

Event Status:

Value	Parameter Description
0x00	SUCCESS
0x14	bleNotConnected
0x17	bleTimeout

For the event parameters, please see the corresponding section below.

16.1 L2CAP_CmdRejct (0x0481)

The Command Reject is sent in response to a command with an unknown command code or when sending the corresponding response is inappropriate.

Event Parameters:

reason: (2 octets)

Value	Parameter Description
0x0000	Command not understood
0x0001	Signaling MTU exceeded
0x0002	Invalid CID in request

16.2 L2CAP_ConnParamUpdateRsp (0x0493)

This Connection Parameter Update Response is sent from the LE master device to the LE slave device. This response is sent by the master Host when it receives a Connection Parameter Update Request packet.

Event Parameters:

result: (2 octets)

Value	Parameter Description
0x0000	Connection Parameters accepted
0x0001	Connection Parameters rejected

17. ATT Vendor Specific Commands and Events

Most of the ATT requests and responses have two associated opcodes, command and event, due to Request and Response Tunneling as per section 9.3.

17.1 ATT Vendor Specific Commands

All ATT commands have the following format:

Name	Size (octets)	Description
Opcode	2	PDU operation code
connectionHandle	2	Connection Handle of link
Command PDU	Variable	Command parameters

Note: The connection handle of 0xFFFE is considered as the loopback connection. All messages sent to this connection will be loop backed to the local host.

For the command parameters, please see the corresponding section below.

Event(s) Generated:

When an ATT command is received, the host will send the Command Status Event with the ***Status*** parameter.

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x02	INVALIDPARAMETER
0x04	MSG_BUFFER_NOT_AVAIL
0x13	bleMemAllocError
0x14	bleNotConnected
0x16	blePending
0x19	bleLinkEncrypted
0x40	bleInvalidPDU
0x41	bleInsufficientAuthen
0x42	bleInsufficientEncrypt
0x43	bleInsufficientKeySize

17.2 ATT Vendor Specific Events

All ATT events have the following format:

Name	Size (octets)	Description
Opcode	2	PDU operation code
status	1	Event status
connectionHandle	2	Connection Handle of link
pduLen	1	Length of event PDU
Event PDU	Variable	Event parameters

Event Status:

Value	Parameter Description
0x00	SUCCESS
0x14	bleNotConnected
0x17	bleTimeout
0x1A	bleProcedureComplete

For the event parameters, please see the corresponding section below.

Note: The connection handle of 0xFFFE is considered as the loopback connection. All messages sent to this connection will be loop backed to the local host.

17.3 ATT_ErrorRsp (Command = 0xFD01, Event = 0x0501)

The Error Response is used to state that a given request cannot be performed and to provide the reason.

Note: The Write Command does not generate an Error Response.

Response Parameters:

reqOpcode: (1 octet)

Value	Parameter Description
XX	The request that generated this error response

handle: (2 octets)

Range	
0x0001 – 0xFFFF	The attribute handle that generated this error response

errCode: (1 octet)

Value	Parameter Description
0x01	The attribute handle given was not valid on this server.
0x02	The attribute cannot be read.
0x03	The attribute cannot be written.
0x04	The attribute PDU was invalid.
0x05	The attribute requires authentication before it can be read or written.
0x06	Attribute server does not support the request received from the client.
0x07	Offset specified was past the end of the attribute.
0x08	The attribute requires authorization before it can be read or written.
0x09	Too many prepare writes have been queued.
0x0A	No attribute found within the given attribute handle range.
0x0B	The attribute cannot be read or written using the Read Blob Request.
0x0C	The Encryption Key Size used for encrypting this link is insufficient.
0x0D	The attribute value length is invalid for the operation.
0x0E	The attribute request that was requested has encountered an error that was unlikely, and therefore could not be completed as requested.
0x0F	The attribute requires encryption before it can be read or written.
0x10	The attribute type is not a supported grouping attribute as defined by a higher layer specification.
0x11	Insufficient Resources to complete the request.
0x80	The attribute value is invalid for the operation.

17.4 ATT_ExchangeMTUReq (Command = 0xFD02, Event = 0x0502)

The Exchange MTU Request is used by the client to inform the server of the client's maximum receive MTU size and request the server to respond with its maximum receive MTU size is used to state that a given request cannot be performed and to provide the reason.

Request Parameters:

clientRxMTU: (2 octets)

Value	Parameter Description
XX	Client receive MTU size

Event(s) Generated:

When this request is received, the server will send the Exchange MTU Response.

17.5 ATT_ExchangeMTURsp (Command = 0xFD03, Event = 0x0503)

The Exchange MTU Response is sent in reply to a received Exchange MTU Request.

Response Parameters:

serverRxMTU: (2 octets)

Value	Parameter Description
XX	Attribute server receive MTU size

17.6 ATT_FindInfoReq (Command = 0xFD04, Event = 0x0504)

The Find Information Request is used to obtain the mapping of attribute handles with their associated types. This allows a client to discover the list of attributes and their types on a server.

Request Parameters:

startHandle: (2 octets)

Value	Parameter Description
0xXXXX	First requested handle number

endHandle: (2 octets)

Value	Parameter Description
0xXXXX	Last requested handle number

Event(s) Generated:

When this request is received, the server will send the Find Information Response. The client will forward all the Find Information Responses to the calling application. The response with the status of bleProcedureComplete will indicate the end of the sub-procedure.

If no attributes will be returned or any of the requested parameters is invalid, the server will send an Error Response.

17.7 ATT_FindInfoRsp (Command = 0xFD05, Event = 0x0505)

The Find Information Response is sent in reply to a received Find Information Request and contains information about the server.

Response Parameters:

format: (1 octet)

Value	Parameter Description
0x01	A list of 1 or more handles with their 16-bit Bluetooth UUIDs
0x02	A list of 1 or more handles with their 128-bit UUIDs

info: (4 to (ATT_MTU - 2) octets)

Value	Parameter Description
"XX:XX:XX:XX…XX"	The information data whose format is determined by the format field

The information data field is comprised of a list of data defined in the tables below depending on the value chosen for the format.

format = 0x01 (handles and their 16-bit Bluetooth UUIDs)

Handle	16-bit Bluetooth UUID
2 octets	2 octets

format = 0x02 (handles and their 128-bit UUIDs)

Handle	128-bit UUID
2 octets	16 octets

17.8 ATT_FindByTypeValueReq (Command = 0xFD06, Event = 0x0506)

The Find By Type Value Request is used to obtain the handles of attributes that have a 16-bit UUID attribute type and attribute value. This allows the range of handles associated with a given attribute to be discovered when the attribute type determines the grouping of a set of attributes.

Request Parameters:

startHandle: (2 octets)

Value	Parameter Description
0xXXXX	First requested handle number

endHandle: (2 octets)

Value	Parameter Description
0xXXXX	Last requested handle number

type: (2 octets)

Value	Parameter Description
"XX:XX"	2 octet UUID to find

value: (0 to (ATT_MTU - 7) octets)

Value	Parameter Description
"XX:XX…XX"	Attribute value to find

Event(s) Generated:

When this request is received, the server will send the Find By Type Value Response. The client will forward all the Find By Type Value Responses to the calling application. The response with the status of bleProcedureComplete will indicate the end of the sub-procedure.

If no attributes will be returned or any of the requested parameters is invalid, the server will send an Error Response.

17.9 ATT_FindByTypeValueRsp (Command = 0xFD07, Event = 0x0507)

The Find By Type Value Response is sent in reply to a received Find By Type Value Request and contains information about this server.

Response Parameters:

handlesInfo: (4 to (ATT_MTU - 1) octets)

Value	Parameter Description
"XX:XX:XX:XX…XX"	A list of 1 or more Handle Information.

The Handles Information List field is a list of one or more Handle Information. The Handles Information field is an attribute handle range as defined in Format of the Handles Information table below:

Format of Handles Information

Found Attribute Handle	Handle Group End Handle
2 octets	2 octets

17.10 ATT_ReadByTypeReq (Command = 0xFD08, Event = 0x0508)

The Read By Type Request is used to obtain the values of attributes where the attribute type is known but the handle is not known.

Request Parameters:

startHandle: (2 octets)

Value	Parameter Description
0xXXXX	First requested handle number

endHandle: (2 octets)

Value	Parameter Description
0xXXXX	Last requested handle number

type: (2 or 16 octets)

Value	Parameter Description
"XX:XX" or "XX:XX…XX"	2 or 16 octet UUID

Event(s) Generated:

When this request is received, the server will send the Read By Type Response. The client will forward all the Read By Type Responses to the calling application. The response with the status of bleProcedureComplete will indicate the end of the sub-procedure.

If no attribute with the given type exists within the handle range or the attribute value cannot be read, the server will send an Error Response.

17.11 ATT_ReadByTypeRsp (Command = 0xFD09, Event = 0x0509)

The Read By Type Response is sent in reply to a received Read By Type Request and contains the handles and values of the attributes that have been read.

Response Parameters:

length: (1 octet)

Value	Parameter Description
0xXX	The size of each attribute handle-value pair

data: (2 to (ATT_MTU-2) octets)

Value	Parameter Description
"XX:XX…XX"	A list of Attribute Data.

The Attribute Data field is comprised of a list of attribute handle and value pairs as defined in Format of the Attribute Data table below:

Format of Attribute Data

Attribute Handle	Attribute Value

Attribute Handle	Attribute Value
2 octets	(Length - 2) octets

17.12 ATT_ReadReq (Command = 0xFD0A, Event = 0x050A)

The Read Request is used request the server to read the value of an attribute and return its value in a Read Response.

Request Parameters:

handle: (2 octets)

Value	Parameter Description
0xXXXX	The handle of the attribute to be read

Event(s) Generated:

When this request is received, the server will send the Read Response.

If the attribute handle is invalid or the attribute value cannot be read, the server will send an Error Response.

17.13 ATT_ReadRsp (Command = 0xFD0B, Event = 0x050B)

The Read Response is sent in reply to a received Read Request and contains the value of the attribute that has been read.

Response Parameters:

value: (0 to (ATT_MTU - 1) octets)

Value	Parameter Description
"XX:XX…XX"	The value of the attribute with the handle given

17.14 ATT_ReadBlobReq (Command = 0xFD0C, Event = 0x050C)

The Read Blob Request is used request the server to read part of the value of an attribute at a given offset and return a specific part of the value in a Read Blob Response.

Request Parameters:

handle: (2 octets)

Value	Parameter Description
0xXXXX	The handle of the attribute to be read

offset: (2 octets)

Value	Parameter Description
0xXXXX	The offset of the first octet to be read

Event(s) Generated:

When this request is received, the server will send the Read Blob Response. The client will forward all the Read Blob Responses to the calling application. The response with the status of bleProcedureComplete will indicate the end of the sub-procedure.

If the attribute handle or offset is invalid, or the attribute value cannot be read, the server will send an Error Response.

17.15 ATT_ReadBlobRsp (Command = 0xFD0D)

The Read Blob Response is sent in reply to a received Read Blob Request and contains part of the value of the attribute that has been read.

Response Parameters:

value: (0 to (ATT_MTU - 1) octets)

Value	Parameter Description
"XX:XX…XX"	Part of the value of the attribute with the handle given

17.16 ATT_ReadMultiReq (Command = 0xFD0E, Event = 0x050E)

The Read Multiple Request is used to request the server to read two or more values of a set of attributes and return their values in a Read Multiple Response. Only values that have a known fixed size can be read, with the exception of the last value that can have a variable length.

Request Parameters:

handles: (4 to (ATT_MTU-1) octets)

Value	Parameter Description
"XX:XX:XX:XX…XX"	A set of two or more attribute handles.

Event(s) Generated:

When this request is received, the server will send the Read Multiple Response.

If any of the attribute handles are invalid or any of the attribute values cannot be read, the server will send an Error Response.

17.17 ATT_ReadMultiRsp (Command = 0xFD0F, Event = 0x050F)

The Read Multiple Response is sent in reply to a received Read Multiple Request and contains the values of the attributes that have been read.

Response Parameters:

values: (0 to (ATT_MTU - 1) octets)

Value	Parameter Description
"XX…XX"	A set of two or more values.

17.18 ATT_ReadByGrpTypeReq (Command = 0xFD10, Event = 0x0510)

The Read By Group Type Request is used to obtain the values of attributes where the attribute type is known, the type of a grouping attribute as defined by a higher layer specification, but the handle is not known.

Request Parameters:

startHandle: (2 octets)

Value	Parameter Description
0xXXXX	First requested handle number

endHandle: (2 octets)

Value	Parameter Description
0xXXXX	Last requested handle number

groupType: (2 or 16 octets)

Value	Parameter Description
"XX:XX" or "XX:XX…XX"	2 or 16 octet UUID

Event(s) Generated:

When this request is received, the server will send the Read By Group Type Response. The client will forward all the Read By Group Type Responses to the calling application. The response with the status of bleProcedureComplete will indicate the end of the sub-procedure.

If no attributes with the given type exists within the handle ranges or the Attribute Group Type is not a supported grouping attribute, the server will send an Error Response.

17.19 ATT_ReadByGrpTypeRsp (Command = 0xFD11, Event = 0x0511)

The Read By Group Type Response is sent in reply to a received Read By Group Type Request and contains the handles and values of the attributes that have been read.

Response Parameters:

length: (1 octet)

Value	Parameter Description
0xXX	The size of each attribute handle-value pair

attrData: (2 to (ATT_MTU - 2) octets)

Value	Parameter Description
"XX:XX:…XX"	A list of Attribute Data.

The Attribute Data field is comprised of a list of attribute handle and value pairs as defined in Format of the Attribute Data table below:

Format of Attribute Data

Attribute Handle	End Group Handle	Attribute Value
2 octets	2 octets	(Length - 4) octets

17.20 ATT_WriteReq (Command = 0xFD12, Event = 0x0512)

The Write Request is used to request the server to write the value of an attribute and acknowledge that this has been achieved in a Write Response.

The *command* field is set for the Write Command. The *signature* and *command* fields are set for the Signed Write Command.

Request Parameters:

The signature field represents different data as defined in the tables below depending on the type of the message.

signature: (1 octet) – when the field is part of a command

Value	Parameter Description
0x00	Do not include the Authentication Signature with the Write PDU.
0x01	Include the Authentication Signature with the Write PDU.

signature: (1 octet) - when the field is part of an event

Value	Parameter Description
0x00	The Authentication Signature is not included with the Write PDU.
0x01	The included Authentication Signature is valid.
0x02	The included Authentication Signature is not valid.

command: (1 octet)

Value	Parameter Description
0x00 or 0x01	Whether this is a Write Command: • 0x00 - No • 0x01 - Yes

handle: (2 octets)

Value	Parameter Description
0xXXXX	The handle of the attribute to be Written.

value: (0 to (ATT_MTU - 3) octets)

Value	Parameter Description
"XX…XX"	The value to be written to the attribute.

Event(s) Generated:

When this request is received, the server will send the Write Response.

If the attribute handle is invalid or the attribute value cannot be written, the server will send an Error Response. The server will not send an Error Response for the Write Command.

17.21 ATT_WriteRsp (Command = 0xFD13, Event = 0x0513)

The Write Response is sent in reply to a valid Write Request and acknowledges that the attribute has been successfully written.

Response Parameters:

None

17.22 ATT_PrepareWriteReq (Command = 0xFD16, Event = 0x0516)

The Prepare Write Request is used to request the server to prepare to write the value of an attribute. The server will respond to this request with a Prepare Write Response, so that the client can verify that the value was received correctly.

A client may send more than one Prepare Write Request to a server, which will queue and send a response for each handle value pair.

Request Parameters:

handle: (2 octets)

Value	Parameter Description
0xXXXX	The handle of the attribute to be Written.

offset: (2 octets)

Value	Parameter Description
0xXXXX	The offset of the first octet to be Written.

value: (0 to (ATT_MTU - 5) octets)

Value	Parameter Description
"XX…XX"	Part of the value of the attribute to be written.

Event(s) Generated:

When this request is received, the server will send the Prepare Write Response. The client will forward the response to the calling application only when the compile option TESTMODES is used.

If the attribute handle is invalid or the attribute value cannot be written, the server will send an Error Response.

17.23 ATT_PrepareWriteRsp (Command = 0xFD17, Event = 0x0517)

The Prepare Write Response is sent in response to a received Prepare Write Request and acknowledges that the value has been successfully received and placed in the prepare write queue.

Response Parameters:

handle: (2 octets)

Value	Parameter Description
0xXXXX	The handle of the attribute to be Written.

offset: (2 octets)

Value	Parameter Description
0xXXXX	The offset of the first octet to be Written.

value: (0 to (ATT_MTU - 5) octets)

Value	Parameter Description
"XX…XX"	Part of the value of the attribute to be written.

17.24 ATT_ExecuteWriteReq (Command = 0xFD18, Event = 0x0518)

The Execute Write Request is used to request the server to write or cancel the write of all the prepared values currently held in the prepare queue from this client. This request shall be handled by the server as an atomic operation.

Request Parameters:

flags: (1 octet)

Value	Parameter Description
0x00	Cancel all prepared writes
0x01	Immediately write all pending prepared values

Event(s) Generated:

When this request is received, the server will send the Execute Write Response.

If the attribute value cannot be written, the server will send an Error Response.

17.25 ATT_ExecuteWriteRsp (Command = 0xFD19, Event = 0x0519)

The Execute Write Response is sent in response to a received Execute Write Request.

Response Parameters:

None

17.26 ATT_HandleValueNoti (Command = 0xFD1B, Event = 0x051B)

A server can send a notification of an attribute's value at any time.

Request Parameters:

authenticated: (1 octet)

Value	Parameter Description
0x00 or 0x01	Whether or not an authenticated link is required: • 0x00 - No • 0x01 - Yes

handle: (2 octets)

Value	Parameter Description
0xXXXX	The handle of the attribute.

value: (0 to (ATT_MTU - 3) octets)

Value	Parameter Description
"XX…XX"	The current value of the attribute.

Event(s) Generated:

None

17.27 ATT_HandleValueInd (Command = 0xFD1D, Event = 0x051D)

A server can send an indication of an attribute's value at any time.

Request Parameters:

authenticated: (1 octet)

Value	Parameter Description
0x00 or 0x01	Whether or not an authenticated link is required: • 0x00 - No • 0x01 - Yes

handle: (2 octets)

Value	Parameter Description
0xXXXX	The handle of the attribute.

value: (0 to (ATT_MTU - 3) octets)

Value	Parameter Description
"XX…XX"	The current value of the attribute.

Event(s) Generated:

The client shall send a Handle Value Confirmation in response to a Handle Value Indication. No further indications to this client shall occur until the confirmation has been received by the server.

17.28 ATT_HandleValueCfm (Command = 0xFD1E, Event = 0x051E)

The Handle Value Confirmation is sent in response to a received Handle Value Indication and confirms that the client has received an indication of the given attribute.

Request Parameters:

None

18. GATT Vendor Specific Commands

All GATT commands have the following format:

Name	Size (octets)	Description
Opcode	2	PDU operation code
connectionHandle	2	Connection Handle of link
Command PDU	Variable	Command parameters

Note: The connection handle of 0xFFFE is considered as the loopback connection. All messages sent to this connection will be loop backed to the local host.

For the command parameters, please see the corresponding section below.

Event(s) Generated:

When a GATT command is received, the host will send the Command Status Event with the ***Status*** parameter.

Return Parameters:

Status: (1 octet)

Value	Parameter Description
0x00	SUCCESS
0x02	INVALIDPARAMETER
0x04	MSG_BUFFER_NOT_AVAIL
0x13	bleMemAllocError
0x14	bleNotConnected
0x40	bleInvalidPDU

18.1 GATT_ExchangeMTU (0xFD82)

This sub-procedure is used by a client to set the ATT_MTU to the maximum possible value that can be supported by both devices when the client supports a value greater than the default ATT_MTU for the Attribute Protocol. This sub-procedure shall only be initiated once during a connection.

The ATT Exchange MTU Request is used by this sub-procedure.

Request Parameters:

Please refer to Section 17.4 for the format of the request parameters.

Event(s) Generated:

This sub-procedure is complete when either ATT_ExchangeMTURsp (with SUCCESS or bleTimeout status) or ATT_ErrorRsp (with SUCCESS status) is received by the calling application task.

18.2 GATT_DiscAllPrimaryServices (0xFD90)

This sub-procedure is used by a client to discover all the primary services on a server.

The ATT Read By Group Type Request is used with the Attribute Type parameter set to the UUID for "Primary Service". The Starting Handle is set to 0x0001 and the Ending Handle is set to 0xFFFF.

Request Parameters:

None.

Event(s) Generated:

This sub-procedure is complete when either ATT_ReadByGrpTypeRsp (with bleProcedureComplete or bleTimeout status) or ATT_ErrorRsp (with SUCCESS status) is received by the calling application task.

18.3 GATT_DiscPrimaryServiceByUUID (0xFD86)

This sub-procedure is used by a client to discover a specific primary service on a server when only the Service UUID is known. The specific primary service may exist multiple times on a server. The primary service being discovered is identified by the service UUID.

The ATT Find By Type Value Request is used with the Attribute Type parameter set to the UUID for "Primary Service" and the Attribute Value set to the 16-bit Bluetooth UUID or 128-bit UUID for the specific primary service. The Starting Handle shall be set to 0x0001 and the Ending Handle shall be set to 0xFFFF.

Request Parameters:

value: (0 to (ATT_MTU - 7) octets)

Value	Parameter Description
“XX:XX…XX”	Attribute value to find

Event(s) Generated:

This sub-procedure is complete when either ATT_FindByTypeValueRsp (with bleProcedureComplete or bleTimeout status) or ATT_ErrorRsp (with SUCCESS status) is received by the calling application task.

18.4 GATT_FindIncludedServices (0xFDB0)

This sub-procedure is used by a client to find include service declarations within a service definition on a server. The service specified is identified by the service handle range.

The ATT Read By Type Request is used with the Attribute Type parameter set to the UUID for "Included Service". The Starting Handle is set to starting handle of the specified service and the Ending Handle is set to the ending handle of the specified service.

Request Parameters:

startHandle: (2 octets)

Value	Parameter Description
0xXXXX	First requested handle number

endHandle: (2 octets)

Value	Parameter Description
0xXXXX	Last requested handle number

Event(s) Generated:

This sub-procedure is complete when either ATT_ReadByTypeRsp (with bleProcedureComplete or bleTimeout status) or ATT_ErrorRsp (with SUCCESS status) is received by the calling application task.

18.5 GATT_DiscAllChars (0xFDB2)

This sub-procedure is used by a client to find all the characteristic declarations within a service definition on a server when only the service handle range is known. The service specified is identified by the service handle range.

The ATT Read By Type Request is used with the Attribute Type parameter set to the UUID for "Characteristic". The Starting Handle is set to starting handle of the specified service and the Ending Handle is set to the ending handle of the specified service.

Request Parameters:

startHandle: (2 octets)

Value	Parameter Description
0xXXXX	First requested handle number

endHandle: (2 octets)

Value	Parameter Description
0xXXXX	Last requested handle number

Event(s) Generated:

This sub-procedure is complete when either ATT_ReadByTypeRsp (with bleProcedureComplete or bleTimeout status) or ATT_ErrorRsp (with SUCCESS status) is received by the calling application task.

18.6 GATT_DiscCharsByUUID (0xFD88)

This sub-procedure is used by a client to discover service characteristics on a server when only the service handle ranges are known and the characteristic UUID is known. The specific service may exist multiple times on a server. The characteristic being discovered is identified by the characteristic UUID.

The ATT Read By Type Request is used with the Attribute Type is set to the UUID for "Characteristic" and the Starting Handle and Ending Handle parameters is set to the service handle range.

Request Parameters:

startHandle: (2 octets)

Value	Parameter Description
0xXXXX	First requested handle number

endHandle: (2 octets)

Value	Parameter Description
0xXXXX	Last requested handle number

type: (2 or 16 octets)

Value	Parameter Description
“XX:XX” or “XX:XX…XX”	2 or 16 octet UUID

Event(s) Generated:

This sub-procedure is complete when either ATT_ReadByTypeRsp (with bleProcedureComplete or bleTimeout status) or ATT_ErrorRsp (with SUCCESS status) is received by the calling application task.

18.7 GATT_DiscAllCharDescs (0xFD84)

This sub-procedure is used by a client to find all the characteristic descriptor’s Attribute Handles and Attribute Types within a characteristic definition when only the characteristic handle range is known. The characteristic specified is identified by the characteristic handle range.

The ATT Find Information Request is used with the Starting Handle set to starting handle of the specified characteristic and the Ending Handle set to the ending handle of the specified characteristic. The UUID Filter parameter is NULL (zero length).

Request Parameters:

Please refer to Section 17.6 for the format of the request parameters.

Event(s) Generated:

This sub-procedure is complete when either ATT_FindInfoRsp (with bleProcedureComplete or bleTimeout status) or ATT_ErrorRsp (with SUCCESS status) is received by the calling application task.

18.8 GATT_ReadCharValue (0xFD8A)

This sub-procedure is used to read a Characteristic Value from a server when the client knows the Characteristic Value Handle. The ATT Read Request is used with the Attribute Handle parameter set to the Characteristic Value Handle. The Read Response returns the Characteristic Value in the Attribute Value parameter.

The Read Response only contains a Characteristic Value that is less than or equal to (ATT_MTU – 1) octets in length. If the Characteristic Value is greater than (ATT_MTU – 1) octets in length, the Read Long Characteristic Value procedure may be used if the rest of the Characteristic Value is required.

Request Parameters:

Please refer to Section 17.12 for the format of the request parameters.

Event(s) Generated:

This sub-procedure is complete when either ATT_ReadRsp (with bleProcedureComplete or bleTimeout status) or ATT_ErrorRsp (with SUCCESS status) is received by the calling application task.

18.9 GATT_ReadUsingCharUUID (0xFDB4)

This sub-procedure is used to read a Characteristic Value from a server when the client only knows the characteristic UUID and does not know the handle of the characteristic.

The ATT Read By Type Request is used to perform the sub-procedure. The Attribute Type is set to the known characteristic UUID and the Starting Handle and Ending Handle parameters shall be set to the range over which this read is to be performed. This is typically the handle range for the service in which the characteristic belongs.

Request Parameters:

Please refer to Section 17.10 for the format of the request parameters.

Event(s) Generated:

This sub-procedure is complete when either ATT_ReadByTypeRsp (with bleProcedureComplete or bleTimeout status) or ATT_ErrorRsp (with SUCCESS status) is received by the calling application task.

18.10 GATT_ReadLongCharValue (0xFD8C)

This sub-procedure is used to read a Characteristic Value from a server when the client knows the Characteristic Value Handle and the length of the Characteristic Value is longer than can be sent in a single Read Response Attribute Protocol message.

The ATT Read Blob Request is used in this sub-procedure.

Request Parameters:

Please refer to Section 17.14 for the format of the request parameters.

Event(s) Generated:

This sub-procedure is complete when either ATT_ReadBlobRsp (with bleProcedureComplete or bleTimeout status) or ATT_ErrorRsp (with SUCCESS status) is received by the calling application task.

18.11 GATT_ReadMultiCharValues (0xFD8E)

This sub-procedure is used to read multiple Characteristic Values from a server when the client knows the Characteristic Value Handles. The Attribute Protocol Read Multiple Requests is used with the Set Of Handles parameter set to the Characteristic Value Handles. The Read Multiple Response returns the Characteristic Values in the Set Of Values parameter.

The ATT Read Multiple Request is used in this sub-procedure.

Request Parameters:

Please refer to Section 17.16 for the format of the request parameters.

Event(s) Generated:

This sub-procedure is complete when either ATT_ReadMultiRsp (with SUCCESS or bleTimeout status) or ATT_ErrorRsp (with SUCCESS status) is received by the calling application task.

18.12 GATT_WriteNoRsp (0xFDB6)

This sub-procedure is used to write a Characteristic Value to a server when the client knows the Characteristic Value Handle and the client does not need an acknowledgement that the write was successfully performed. This sub-procedure only writes the first (ATT_MTU – 3) octets of a Characteristic Value. This sub-procedure can not be used to write a long characteristic; instead the Write Long Characteristic Values sub-procedure should be used.

The ATT Write Command is used for this sub-procedure. The Attribute Handle parameter shall be set to the Characteristic Value Handle. The Attribute Value parameter shall be set to the new Characteristic Value.

Request Parameters:

handle: (2 octets)

Value	Parameter Description
0xXXXX	The handle of the attribute to be Written.

value: (0 to (ATT_MTU - 3) octets)

Value	Parameter Description

Value	Parameter Description
“XX…XX”	The value to be written to the attribute.

Event(s) Generated:

No response will be sent to the calling application task for this sub-procedure. If the Characteristic Value write request is the wrong size, or has an invalid value as defined by the profile, then the write will not succeed and no error will be generated by the server.

18.13 GATT_SignedWriteNoRsp (0xFDB8)

This sub-procedure is used to write a Characteristic Value to a server when the client knows the Characteristic Value Handle and the ATT Bearer is not encrypted. This sub-procedure shall only be used if the Characteristic Properties authenticated bit is enabled and the client and server device share a bond as defined in the GAP.

This sub-procedure only writes the first (ATT_MTU – 15) octets of an Attribute Value. This sub-procedure cannot be used to write a long Attribute.

The ATT Write Command is used for this sub-procedure. The Attribute Handle parameter shall be set to the Characteristic Value Handle. The Attribute Value parameter shall be set to the new Characteristic Value authenticated by signing the value, as defined in the Security Manager.

Request Parameters:

handle: (2 octets)

Value	Parameter Description
0xXXXX	The handle of the attribute to be Written.

value: (0 to (ATT_MTU - 3) octets)

Value	Parameter Description
“XX…XX”	The value to be written to the attribute.

Event(s) Generated:

No response will be sent to the calling application task for this sub-procedure. If the authenticated Characteristic Value that is written is the wrong size, or has an invalid value as defined by the profile, or the signed value does not authenticate the client, then the write will not succeed and no error will be generated by the server.

18.14 GATT_WriteCharValue (0xFD92)

This sub-procedure is used write a characteristic value to a server when the client knows the characteristic value handle. This sub-procedure only writes the first (ATT_MTU-3) octets of a characteristic value. This sub-procedure can not be used to write a long attribute; instead the Write Long Characteristic Values sub-procedure should be used.

The ATT Write Request is used in this sub-procedure. The Attribute Handle parameter shall be set to the Characteristic Value Handle. The Attribute Value parameter shall be set to the new characteristic.

Request Parameters:

Please refer to Section 17.20 for the format of the request parameters.

Event(s) Generated:

This sub-procedure is complete when either ATT_WriteRsp (with SUCCESS or bleTimeout status) or ATT_ErrorRsp (with SUCCESS status) is received by the calling application task.

18.15 GATT_WriteLongCharValue (0xFD96)

This sub-procedure is used to write a Characteristic Value to a server when the client knows the Characteristic Value Handle but the length of the Characteristic Value is longer than can be sent in a single Write Request Attribute Protocol message.

The ATT Prepare Write Request and Execute Write Request are used to perform this sub-procedure.

Request Parameters:

handle: (2 octets)

Value	Parameter Description
0xXXXX	The handle of the attribute to be Written.

offset: (2 octets)

Value	Parameter Description
0xXXXX	The offset of the first octet to be Written.

value: (0 to 512 octets)

Value	Parameter Description
“XX…XX”	The value of the attribute to be written. Note: the stack implementation supports the maximum length of 512 octets but this is always bound by the physical interface used to communicate with the device.

Event(s) Generated:

This sub-procedure is complete when either ATT_PrepareWriteRsp (with bleTimeout status), ATT_ExecuteWriteRsp (with SUCCESS or bleTimeout status), or ATT_ErrorRsp (with SUCCESS status) is received by the calling application task.

18.16 GATT_ReliableWrites (0xFDBA)

This sub-procedure is used to write a Characteristic Value to a server when the client knows the Characteristic Value Handle, and assurance is required that the correct Characteristic Value is going to be written by transferring the Characteristic Value to be written in both directions before the write is performed. This sub-procedure can also be used when multiple values must be written, in order, in a single operation.

The sub-procedure has two phases; the first phase prepares the characteristic values to be written. Once this is complete, the second phase performs the execution of all of the prepared characteristic value writes on the server from this client.

In the first phase, the ATT Prepare Write Request is used. In the second phase, the attribute protocol Execute Write Request is used.

Request Parameters:

numberRequests: (1 octet)

Value	Parameter Description
0xXX	The number of Prepare Write Request messages.

requests: (0 to 512 octets)

Value	Parameter Description
"XX:XX:…XX"	A list of Prepare Write Request messages. Note: the stack implementation supports the maximum length of 512 octets but this is always bound by the physical interface used to communicate with the device.

The Requests field is comprised of a list of Attribute Value Length and Prepare Write Request as defined in Format of the Requests table below:

Format of Requests

Attribute Value Length	Prepare Write Request
1 octet	Please see Section 17.22 for the format of Prepare Write Request

Event(s) Generated:

This sub-procedure is complete when either ATT_PrepareWriteRsp (with bleTimeout status), ATT_ExecuteWriteRsp (with SUCCESS or bleTimeout status), or ATT_ErrorRsp (with SUCCESS status) is received by the calling application task.

18.17 GATT_ReadCharDesc (0xFDBC)

This sub-procedure is used to read a Characteristic Descriptor from a server when the client knows the Characteristic Descriptor's Handle.

The ATT Read Request is used for this sub-procedure. The Read Request is used with the Attribute Handle parameter set to the characteristic descriptor handle. The Read Response returns the characteristic descriptor value in the Attribute Value parameter.

Request Parameters:

Please refer to Section 17.12 for the format of the request parameters.

Event(s) Generated:

This sub-procedure is complete when either ATT_ReadRsp (with bleProcedureComplete or bleTimeout status) or ATT_ErrorRsp (with SUCCESS status) is received by the calling application task.

18.18 GATT_ReadLongCharDesc (0xFDBE)

This sub-procedure is used to read a Characteristic Descriptor from a server when the client knows the Characteristic Descriptor Declaration's Attribute Handle and the length of the Characteristic Descriptor Declaration is longer than can be sent in a single Read Response Attribute Protocol message.

The ATT Read Blob Request is used to perform this sub-procedure. The Attribute Handle parameter shall be set to the characteristic descriptor handle. The Value Offset parameter shall be the offset within the characteristic descriptor to be read.

Request Parameters:

Please refer to Section 17.14 for the format of the request parameters.

Event(s) Generated:

This sub-procedure is complete when either ATT_ReadBlobRsp (with bleProcedureComplete or bleTimeout status) or ATT_ErrorRsp (with SUCCESS status) is received by the calling application task.

18.19 GATT_WriteCharDesc (0xFDC0)

This sub-procedure is used write a characteristic descriptor to a server when the client knows the characteristic descriptor handle.

The ATT Write Request is used for this sub-procedure. The Attribute Handle parameter shall be set to the characteristic descriptor handle. The Attribute Value parameter shall be set to the new characteristic descriptor value.

Request Parameters:

Please refer to Section 17.20 for the format of the request parameters.

Event(s) Generated:

This sub-procedure is complete when either ATT_WriteRsp (with SUCCESS or bleTimeout status) or ATT_ErrorRsp (with SUCCESS status) is received by the calling application task.

18.20 GATT_WriteLongCharDesc (0xFDC2)

This sub-procedure is used to write a Characteristic Value to a server when the client knows the Characteristic Value Handle but the length of the Characteristic Value is longer than can be sent in a single Write Request Attribute Protocol message.

The ATT Prepare Write Request and Execute Write Request are used to perform this sub-procedure.

Request Parameters:

handle: (2 octets)

Value	Parameter Description
0xXXXX	The handle of the attribute to be Written.

offset: (2 octets)

Value	Parameter Description
0xXXXX	The offset of the first octet to be Written.

value: (0 to 512 octets)

Value	Parameter Description
"XX…XX"	The value of the attribute to be written. Note: the stack implementation supports the maximum length of 512 octets but this is always bound by the physical interface used to communicate with the device.

Event(s) Generated:

This sub-procedure is complete when either ATT_PrepareWriteRsp (with bleTimeout status), ATT_ExecuteWriteRsp (with SUCCESS or bleTimeout status), or ATT_ErrorRsp (with SUCCESS status) is received by the calling application task.

18.21 GATT_Notification (0xFD9B)

This sub-procedure is used when a server is configured to notify a characteristic value to a client without expecting any attribute protocol layer acknowledgement that the notification was successfully received.

The ATT Handle Value Notification is used in this sub-procedure.

Note: A notification may be sent at any time and does not invoke a confirmation.

Request Parameters:

Please refer to Section 17.26 for the format of the request parameters.

Event(s) Generated:

None.

18.22 GATT_Indication (0xFD9D)

This sub-procedure is used when a server is configured to indicate a characteristic value to a client and expects an attribute protocol layer acknowledgement that the indication was successfully received.

The ATT Handle Value Indication is used in this sub-procedure.

Request Parameters:

Please refer to Section 17.27 for the format of the request parameters.

Event(s) Generated:

This sub-procedure is complete when ATT_HandleValueCfm (with SUCCESS or bleTimeout status) is received by the calling application task.

18.23 GATT_AddService (0xFDFC)

This command is used to add a new service to the GATT Server on the Network Processor when the GATT Database is implemented on the Application Processor. The GATT_AddAttribute command described in Section 18.25 must be used to add additional attributes to the service. The new service will be automatically registered with the GATT Server if it has no additional attribute to be added.

Note: The Command Status Event will have the Start Handle and End Handle for the service registered with the GATT Server.

No ATT request is used to perform this command.

Request Parameters:

UUID: (2 octets)

Value	Parameter Description
“00:28” or “01:28”	The type of the service to be added: • 0x2800 – Primary Service • 0x2801 – Secondary Service

numAttrs: (2 octets)

Value	Parameter Description
“XX:XX”	The number of the attributes in the service (including the service attribute).

Event(s) Generated:

None.

18.24 GATT_DelService (0xFDFD)

This command is used to delete a service from the GATT Server on the Network Processor when the GATT Database is implemented on the Application Processor.

No ATT request is used to perform this command.

Request Parameters:

handle: (2 octets)

Value	Parameter Description
"XX:XX"	The handle of the service to be deleted (0x0000 if the service hasn't been registered with the GATT Server yet).

Event(s) Generated:

None.

18.25 GATT_AddAttribute (0xFDFE)

This command is used to add a new attribute to the service being added to the GATT Server on the Network Processor when the GATT Database is implemented on the Application Processor. The service will be automatically registered with the GATT Server when its last attribute is added.

Note: The Command Status Event will have the Start Handle and End Handle for the service registered with the GATT Server.

No ATT request is used to perform this command.

Request Parameters:

UUID: (2 or 16 octets)

Value	Parameter Description
"XX:XX" or "XX:…:XX"	The type of the attribute to be added to a service.

permissions: Bit Mask (1 octet)

Value	Parameter Description
0x01	GATT_PERMIT_READ
0x02	GATT_PERMIT_WRITE
0x04	GATT_PERMIT_AUTHEN_READ
0x08	GATT_PERMIT_AUTHEN_WRITE
0x10	GATT_PERMIT_AUTHOR_READ
0x20	GATT_PERMIT_AUTHOR_WRITE

Event(s) Generated:

None.

19. GATT Vendor Specific Events

All GATT events have the following format:

Name	Size (octets)	Description
Opcode	2	PDU operation code
status	1	Event status
connectionHandle	2	Connection Handle of link
pduLen	1	Length of event PDU
Event PDU	Variable	Event parameters

Event Status:

Value	Parameter Description
0x00	SUCCESS
0x14	bleNotConnected
0x17	bleTimeout
0x1A	bleProcedureComplete

For the event parameters, please see the corresponding section below.

Note: The connection handle of 0xFFFE is considered as the loopback connection. All messages sent to this connection will be loop backed to the local host.

19.1 GATT_ClientCharCfgUpdated (0x0580)

The Client Characteristic Configuration Updated event is generated whenever the Client Characteristic Configuration attribute value is updated for a connection (i.e., GATT client).

Response Parameters:

attributeHandle: (2 octets)

Value	Parameter Description
0xXXXX	The handle of the Client Characteristic Configuration attribute

value: Bit Mask (2 octets)

Value	Parameter Description
0x0000	No operation
0x0001	The Characteristic Value is configured to be notified

Value	Parameter Description
0x0002	The Characteristic Value is configured to be indicated
0xFFF4	Reserved for future use

20. Host Error Codes

This section lists the various possible error codes generated by the Host. If an HCI extension command that sent a Command Status with the error code 'SUCCESS' before processing may find an error during execution then the error is reported in the normal completion command for the original command.

The error code 0x00 means SUCCESS. The possible range of failure error codes is 0x01-0xFF. The table below provides an error code description for each failure error code.

Value	Parameter Description
0x00	SUCCESS
0x00	FAILURE
0x02	INVALIDPARAMETER
0x03	INVALID_TASK
0x04	MSG_BUFFER_NOT_AVAIL
0x05	INVALID_MSG_POINTER
0x06	INVALID_EVENT_ID
0x07	INVALID_INTERRUPT_ID
0x08	NO_TIMER_AVAIL
0x09	NV_ITEM_UNINIT
0x0A	NV_OPER_FAILED
0x0B	INVALID_MEM_SIZE
0x0C	NV_BAD_ITEM_LEN
0x10	bleNotReady
0x11	bleAlreadyInRequestedMode
0x12	bleIncorrectMode
0x13	bleMemAllocError
0x14	bleNotConnected
0x15	bleNoResources
0x16	blePending
0x17	bleTimeout
0x18	bleInvalidRange
0x19	bleLinkEncrypted
0x1A	bleProcedureComplete
0x30	bleGAPUserCanceled
0x31	bleGAPConnNotAcceptable
0x32	bleGAPBondRejected
0x40	bleInvalidPDU

0x41	bleInsufficientAuthen
0x42	bleInsufficientEncrypt
0x43	bleInsufficientKeySize
0xFF	INVALID_TASK_ID

Table 8: List of Possible Host Error Codes