BlueMod+S42
Software User Guide

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APPLICABILITY TABLE

PRODUCT
BlueMod+S42

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Contents

1. Introduction

1.1. Scope

This document describes the usage of the development kit for the Bluetooth module BlueMod+S42.

1.2. Audience

This document is intended for Telit customers, especially system integrators, about to implement Bluetooth modules in their application.

1.3. Contact Information, Support

For general contact, technical support, to report documentation errors and to order manuals, contact Telit Technical Support Center (TTSC) at:

TS-SRD@telit.com

Alternatively, use:

http://www.telit.com/support

For detailed information about where you can buy the Telit modules or for recommendations on accessories and components visit:

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Our aim is to make this guide as helpful as possible. Keep us informed of your comments and suggestions for improvements.

Telit appreciates feedback from the users of our information.

1.4. Text Conventions

Danger – This information MUST be followed or catastrophic equipment failure or bodily injury may occur.

Caution or Warning – Alerts the user to important points about integrating the module, if these points are not followed, the module and end user equipment may fail or malfunction.

Tip or Information – Provides advice and suggestions that may be useful when integrating the module.

All dates are in ISO 8601 format, i.e. YYYY-MM-DD.

1.5. Related Documents

[1] BlueMod+S42 Hardware User Guide, 1VV0301303

[2] BlueMod+S42 AT Command Reference, 80512ST10771A

[3] Bluetooth 4.0 Core Specification

[4] UICP+ UART Interface Control Protocol, 30507ST10756A

2. Introduction

2.1. Overview

This document describes the usage of the BlueMod+S42 Bluetooth module featuring firmware version V3.001 or later.

For a detailed description of the commands refer to the *BlueMod+S42 AT Command Reference*.

All referenced documents can be downloaded from:
http://www.telit.com/bluetooth/bluemod-s42/.

2.2. Feature Set

The combined central and peripheral BlueMod+S42 firmware includes the following feature set:

- Handling for 4 parallel links (3 in central role and 1 in peripheral role)
- Generic GATT client support in central role
- Terminal I/O server role in peripheral role
- Up to 60 characteristics shared by all GATT clients
- 10 configurable 128 bit UUIDs
- Fix pin for easy security
- AT command mode and multiplexing mode
- Easy control over all connection parameters
- Advanced power saving features like UICP and SYSTEMOFF
- Firmware over the air update

This document shows the practical use of some commands listed in the AT command reference. For command details it is referred to the *BlueMod+S42 AT Command Reference*.

3. Modes and Connections

In AT command mode the BlueMod+S42 supports 3 parallel central connections or one peripheral Terminal I/O server connection. This means that the BlueMod+S42 stops advertising (being connectable) as peripheral as soon a central connection is established.

When a peripheral Terminal I/O server connection is active, it is not possible to establish a central connection to be used as GATT client.

The reason for this behavior is that a Terminal I/O connection in AT mode puts the serial interface in data mode, where it is not possible to handle AT commands or events for an additional central connection. Therefore it is not possible to use the ATD command for connection establishment during a Terminal I/O connection.

To use peripheral and central connections in parallel the BlueMod+S42 supports the multiplexing (MUX) mode. In this mode there is an always accessible AT command channel. This makes it possible to handle all 4 links in parallel (3 central connections and one peripheral Terminal I/O server connection). The host has to implement the simple to use multiplexing protocol.

3.1. AT Command Mode

This chapter describes connection examples for different roles:

- Central role: GATT client connections to BLE peripheral devices in AT command mode
- Peripheral role as Terminal I/O server

3.1.1. Central Role as GATT Client

In central role the BlueMod+S42 supports the possibility to connect to any Bluetooth low energy peripheral devices.

The following example lists the GATT connection in multiple steps include an explanation of the different result messages.

3.1.1.1. Searching for Available Peripheral Devices

If the Bluetooth address of the peripheral device is unknown the BlueMod+S42 needs to scan for available peripheral devices first.

AT+LESCAN=GATT	D0A4E9658F65,t3 RSSI:-60 TYPE:CONN NAME:BM+S 8F65 MNF:8F0009B0011000 UUID:FEFB DE338F0D1A22,t3 RSSI:-68 TYPE:CONN NAME:BM+S 1A22 MNF:8F0009B0011000 UUID:FEFB 0080254978B3,t2 RSSI:-62 TYPE:CONN NAME:BM+SR 7 MNF:8F0009B0011000 UUID:53544D544552494F5345525631303030 UUID:FEFB F1B9EB41D81E,t3 RSSI:-57 TYPE:CONN NAME:TESTDEVICE UUID:FF00 008025001162,t2 RSSI:-68 TYPE:CONN NAME:BM+SR 1 MNF:8F0009B0011000 UUID:53544D544552494F5345525631303030 UUID:FEFB OK

This output lists 5 different peripheral devices with different services.

To list peripheral devices with a specific UUID it is possible to add this UUID value in the AT+LESCAN command.

AT+LESCAN=uFF00	F1B9EB41D81E,t3 RSSI:-57 TYPE:CONN NAME:TESTDEVICE UUID:FF00 OK

The found peripheral device includes the following information:

Bluetooth address and type:	F1B9EB41D81E,t3
Signal strength in dbm:	RSSI:-57
Advertisement type:	TYPE:CONN
Device name:	NAME:TESTDEVICE
Service UUID:	UUID:FF00

3.1.1.2. Create GATT Connection

To establish a GATT connection to a peripheral device it is required to initiate a call request to the unique Bluetooth address.

ATDF1B9EB41D81E,t3,GATT	CONNECT GATT 0x10

The BlueMod+S42 reports the created GATT connection with the result message „CONNECT“ include the connection type „GATT“ and a connection handle “0x10”.

This connection handle is not set to a fixed value and will be different for each connection.

The given connection handle is required for further activities onto this peripheral device.

3.1.1.3. Discovering Services and Characteristics

After the GATT connection was established the BlueMod+S42 should search for available services and their characteristics using the AT+LESRVD command.

AT+LESRVD=0x10	UUID:1800 UUID:1801 UUID:180A UUID:FF00 OK

The BlueMod+S42 reports a list of GATT services from the peripheral device. This list of available services also includes the UUID: “FF00”. This UUID was listed during the LESCAN result of this peripheral device as well. If the required service UUID is already known, the service search function could be skipped.

In addition to the service UUID value it is required to get the characteristic values of the required service UUID.

AT+LESRVD=0x10,uFF00	UUID:FF00 0x0011 PROP:0x3E UUID:FF01 0x0014 PROP:0x3E UUID:FF02 0x0017 PROP:0x3E UUID:FF03 0x001A PROP:0x08 UUID:FF04 0x001C PROP:0x04 UUID:FF05 0x001E PROP:0x02 UUID:FF06 0x0020 PROP:0x10 UUID:FF07 0x0023 PROP:0x20 UUID:FF08 0x0026 PROP:0x30 UUID:FF09 0x0029 PROP:0x3E UUID:FF0A 0x002C PROP:0x3E UUID:FF0B 0x002F PROP:0x3E UUID:FF0C 0x0032 PROP:0x3E UUID:FF0D 0x0035 PROP:0x3E UUID:0000FF0A000010008000008025000000 0x0038 PROP:0x3E UUID:0000FF0B000010008000008025000000 0x003B PROP:0x3E UUID:0000FF0C000010008000008025000000 0x003E PROP:0x3E UUID:0000FF0D000010008000008025000000 OK

The BlueMod+S42 reports a list of GATT characteristics of the requested GATT service UUID: “FF00” from the peripheral device. This list of characteristics includes all characteristic specific values like, characteristic handle, characteristic properties, characteristic UUID.

The following example lists the information of the first characteristic in details:

characteristic handle: 0x0011
characteristic properties: PROP:0x3E
characteristic UUID: UUID:FF01

The characteristic handle is required for all access functions to use with this characteristic.

The characteristic properties inform about the possible access functions available on this characteristic, like**:** read, write, write without response, notify, indicate. In this example the properties PROP: 0x3E with the characteristic handle 0x0011 are set to all possible properties.

The characteristic UUID identifies the characteristic ID within this service.

3.1.1.4. Writing Data to a Characteristic

To write data to a characteristic it is required that the properties of this characteristic support "write" or "write without response".

There are two different options to write data to the characteristic:

- AT+LEWRITE: Initiate a write with response access to the characteristic
- AT+LEWRITECMD: Initiate a write without response access (write command) to the characteristic

In addition it is important to know the data size of the GATT characteristic.

This information is listed in the service specification of the addressed service.

In the example the data size is defined to two bytes.

To write two data bytes (0xaa and 0xbb) to the GATT server on the peripheral side the host controller needs to use the connection handle and characteristic handle from the ATD and AT+LESRVD commands. Additionally the data content has to be added to the command line.

AT+LEWRITE=0x10,0x0011,aabb	OK

The command "AT+LEWRITE" uses a "write request" command which is confirmed by the peripheral side with a "write response" message.

The result "OK" means that the value was written to the peripherals GATT server successfully.

AT+LEWRITECMD=0x10,0x0011,aabb	OK

The command "AT+LEWRITECMD" uses a "write command" which is not confirmed by the peripheral side. The result "OK" means that the data was sent over the air.

3.1.1.5. Reading Data from a Characteristic

To read data from a characteristic it is required that the properties of this characteristic supports "read", "notify" or "indicate".

To read data bytes from a characteristic of the GATT server on the peripheral side the host controller needs to use the connection handle and characteristic handle from the ATD and AT+LESRVD commands.

AT+LEREAD=0x10,0x0011	LEREAD:0x10,0x0011,AABB OK

The answer is separated into two parts:

The result message "OK" reports that reading to the required connection handle and characteristic handle was successful.

The "LEREAD:0x10,0x0011,AABB" message reports the read data of the requested connection handle "0x10" and characteristic handle "0x0011".

The data is formatted as a hexadecimal stream "AABB" that includes two bytes 0xAA and 0xBB.

3.1.1.6. Reading Data with Indications or Notifications

Indications and notifications are messages that inform the GATT client when a characteristic on the GATT server changes its value.

- INDICATIONS: The GATT client generated a response to the GATT server when receiving data
- NOTIFICATIONS: The GATT client generated no response to the GATT server when receiving data

This feature has to be enabled by the client for a specific characteristic.

It is not possible to enable indications and notifications at the same time.

To use this feature, it is required that the properties of the characteristic supports "notify" or "indicate". This information is given in the service discovery for the characteristic in the "PROP" value.

3.1.1.6.1. Enable Notifications:

AT+LECCCD=0x10,0x0011,1	OK

The result message “OK” reports that activating notifications to the required connection handle and characteristic handle was successful.

When the data of this characteristic on the GATT server changed to “0x36, 0x37” the BlueMod+S42 generates an event (“LENOTI”) that reports these changes:

	LENOTI:0x10,0x0011,3637

The reported “LENOTI” event of the BlueMod+S42 contains the new data of the characteristic with handle “0x0011” and connection handle “0x10”.

The data is formatted as a hexadecimal stream “3637” that includes two bytes 0x36 and 0x37.

Every data change on the remote GATT server characteristic generates a new “LENOTI” event until the notifications to this characteristic are switched off.

3.1.1.6.2. Disable Notifications:

AT+LECCCD=0x10,0x0011,0	OK

The result message “OK” reports that deactivating the notifications to the required connection handle and characteristic handle was successful.

3.1.1.6.3. Enable Indications:

AT+LECCCD=0x10,0x0011,2	OK

The result message “OK” reports that activating indications to the required connection handle and characteristic handle was successful.

When the data of this characteristic on the GATT server changed to “0x36, 0x38” the BlueMod+S42 generates an event (“LEIND”) that reports these changes:

	LEIND:0x10,0x0011,3638

The reported “LEIND” event of the BlueMod+S42 contains the new data of the characteristic with handle “0x0011” and connection handle “0x10”.

The data is formatted as a hexadecimal stream “3638” that includes two bytes 0x36 and 0x38.

Every data change on the remote GATT server characteristic generates a new “LEIND” event until the indications to this characteristic are switched off.

3.1.1.6.4. Disable Indications:

AT+LECCCD=0x10,0x0011,0	OK

The result message "OK" reports that deactivating the indications to the required connection handle and characteristic handle was successful.

3.1.1.6.5. Close Connection:

When the connection is not needed anymore, it could be disconnected. To close a GATT connection to a peripheral device the host controller needs to use the connection handle.

ATH=0x10	NO CARRIER 0x10

The response of the disconnect request "ATH" is the event "NO CARRIER" followed by disconnected connection handle.

The same event is reported when the remote peripheral disconnects the connection.
It is also possible to disconnect all existing GATT connection to different peripheral devices by using the GPIO "HANGUP".

3.1.2. Peripheral Role as Terminal I/O Server

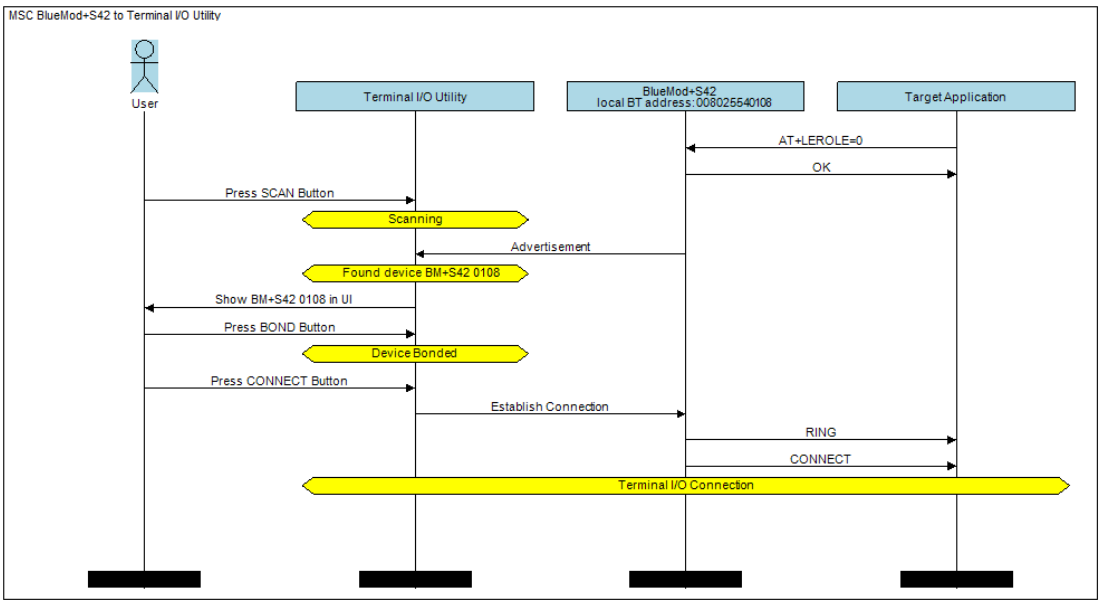
A Terminal I/O connection to the BlueMod+S42 can be created from each Bluetooth Low Energy device that supports the Terminal I/O client role.

Telit provide the Terminal I/O client implementation for iOS and Android.

To establish a Bluetooth Low Energy connection from the iPhone to the BlueMod+S42 the "Terminal IO Utility" app from Telit needs to be installed on the iPhone.

The following QR-Code provides the link to download the "Terminal IO Utility" app.

The Terminal IO Utility app allows the user to connect to Terminal I/O peripheral devices (BlueMod+S42) and exchange data providing a simple terminal emulation.



As soon as the connection is established data can be sent from iPhone to BlueMod+S42 and vice versa.

3.1.2.1. Incoming Terminal I/O Connection

For a Terminal I/O connection it is necessary that the Terminal I/O service and the advertising mode are enabled. This is the default behavior of the BlueMod+S42.

The BlueMod+S42 signals an incoming Terminal I/O connection with the following event:

	RING CONNECT TIO 0x01

The BlueMod+S42 report the incoming Terminal I/O connection with the result message "RING". The established Terminal I/O connection is reported with the message „CONNECT" including the connection type „TIO" and a connection handle "0x01".

The given connection handle is required for detailed activities onto this Terminal I/O connection.

After reporting the "CONNECT" result message the BlueMod+S42 changed from the AT based "command mode" to the "online data mode".

3.1.2.2. Exchange Terminal I/O Data

All data send on the serial interface is transparently sent to the Terminal I/O client side.

All data send by the remote Terminal I/O client is binary output on the serial interface of the BlueMod+S42.

When a peripheral Terminal I/O server connection is active, it is not possible to create a GATT connection to a peripheral device.

3.1.2.3. Close Terminal I/O Connection

The Terminal I/O connection can be closed in the following two different options:

- By using the GPIO "HANGUP"
  (only available if this GPIO is controlled by the host controller)
- Send the "ATH" command.

Using the GPIO "HANGUP"

set GPIO "HANGUP" to high level set GPIO "HANGUP" to low level	 NO CARRIER 0x01

Using the "ATH" command

<wait 1 sec after data exchange> +++ ATH=0x01	 OK NO CARRIER 0x01

The response of the disconnect request reports the event "NO CARRIER" followed by disconnected connection handle.

The same event is reported when the remote Terminal I/O client side disconnects the connection.

3.1.3. Multiple GATT Connections

This chapter describes the possibility to connect to different GATT peripheral devices at the same time.

In complement to chapter 3.1.1 the following example demonstrates GATT connections to 3 different peripheral devices.

3.1.3.1. Searching for Available Peripheral Devices

Scan for available devices:

AT+LESCAN=GATT	D0A4E9658F65,t3 RSSI:-60 TYPE:CONN NAME:BM+S 8F65 MNF:8F0009B0011000 UUID:FEFB DE338F0D1A22,t3 RSSI:-68 TYPE:CONN NAME:BM+S 1A22 MNF:8F0009B0011000 UUID:FEFB 0080254978B3,t2 RSSI:-62 TYPE:CONN NAME:BM+SR 7 MNF:8F0009B0011000 UUID:53544D544552494F5345525631303030 UUID:FEFB F1B9EB41D81E,t3 RSSI:-57 TYPE:CONN NAME:TESTDEVICE UUID:FF00 008025001162,t2 RSSI:-68 TYPE:CONN NAME:BM+SR 1 MNF:8F0009B0011000 UUID:53544D544552494F5345525631303030 UUID:FEFB OK

This output lists 5 different peripheral devices with different services.

3.1.3.2. Create Multiple GATT Connections

Initiate first GATT connection to a peripheral device.

ATDF1B9EB41D81E,t3,GATT	CONNECT GATT 0x10

The BlueMod+S42 reports the created GATT connection with the result message „CONNECT“ include the connection type „GATT“ and a connection handle “0x10”.

Initiate second GATT connection to a peripheral device.

ATDDE338F0D1A22,t3,GATT	CONNECT GATT 0x11

The BlueMod+S42 reports the created GATT connection with the result message „CONNECT“ include the connection type „GATT“ and a connection handle “0x11”.

Initiate third GATT connection to a peripheral device.

ATD0080254978B3,t2,GATT	CONNECT GATT 0x12

The BlueMod+S42 reports the created GATT connection with the result message „CONNECT“ include the connection type „GATT“ and a connection handle “0x12”.

For all further activities to each established GATT connections (read or write data), it is required to set the specific connection handle value.

This is already described here: 3.1.1 Central Role as GATT Client

3.2. MUX Mode

To handle connections to peripheral devices and the Terminal I/O connection in parallel the BlueMod+S42 supports the multiplexing (MUX) mode.

In this mode there is an always accessible AT command channel available. This command channel (channel ID= "FF") enables the possibility to handle all four links in parallel (three GATT connections to peripheral devices and one Terminal I/O connection).

The host has to implement the simple to use multiplexing protocol.

Data has to be sent and are received in the following framing (all values in hexadecimal format):

Name	Description	Length	Value
Start	Start of frame	8 bit	CC
Data Channel ID	Channel identifier	8 bit	00 – FE
Command Channel ID	Channel identifier	8 bit	FF
Length	Length of data	8 bit	-
Data	Max. 255 bytes data	Min. 0 byte Max. 255 bytes	-

Start of frame, channel ID, length and data are always transmitted in direct, binary form.

A detailed description of the multiplexing mode is listed in the *AT Command Reference*.

3.2.1. Central Role as GATT Client

In the multiplexing mode the BlueMod+S42 supports the possibility to connect to any Bluetooth low energy peripheral device and the Terminal I/O connection in parallel.

The following example lists one GATT connection and one Terminal I/O connection in multiple steps.

3.2.1.1. Enable the Multiplexing Mode

As default the BlueMod+S42 communicates to the serial interface in the AT command mode. This is the default behavior of the BlueMod+S42.

To enable the multiplexing mode during the run time it is required to send the following command:

AT+BMUX=1	OK

After this initial command the BlueMod+S42 reports the response "OK" in the AT command mode and then changes to the multiplexing mode. All exchanged data requires to be sent in the defined MUX packet framing.

The multiplexing response message of the BlueMod+S42 may be sent in several MUX frames.

The MUX mode can be left with the AT command "AT+BMUX=0" or a reset of the BlueMod+S42 device.

Note: The following example in the MUX mode is listing the serial data in hexadecimal coded form to identify the MUX framing. For a better understanding the corresponding text message (human readable) is added in italic letters.

3.2.1.2. Create GATT Connection

To establish a GATT connection to a peripheral device it is required to initiate a call request to the unique Bluetooth address.

cc ff 18 41 54 44 30 30 38 30 32 35 30 30 31 32 34 31 2c 74 32 2c 47 41 54 54 0d *ATD008025001241,t2,GATT*	
	cc ff 0e 0d 0a 43 4f 4e 4e 45 43 54 20 47 41 54 54 cc ff 05 20 30 78 31 30 cc ff 02 20 3c cc ff 0c 30 30 38 30 32 35 30 30 31 32 34 31 cc ff 05 20 30 78 30 32 cc ff 01 3e cc ff 02 0d 0a *CONNECT GATT 0x10 <008025001241 0x02>*

The BlueMod+S42 reports the created GATT connection with the result message „CONNECT" include the connection type „GATT" and a connection handle "0x10".

This connection handle is not set to a fixed value and will be different for each connection.

The given connection handle is required for further activities onto this peripheral device.

3.2.1.3. Discovering Services and Characteristics

After the GATT connection gets established the BlueMod+S42 is searching for available services.

cc ff 0f 41 54 2b 4c 45 53 52 56 44 3d 30 78 31 30 0d *AT+LESRVD=0x10*	cc ff 02 0d 0a cc ff 05 55 55 49 44 3a cc ff 04 31 38 30 30 cc ff 02 0d 0a cc ff 05 55 55 49 44 3a cc ff 04 31 38 30 31 cc ff 02 0d 0a cc ff 05 55 55 49 44 3a cc ff 04 31 38 30 41 cc ff 02 0d 0a cc ff 05 55 55 49 44 3a cc ff 04 46 45 46 42 cc ff 02 0d 0a cc ff 06 0d 0a 4f 4b 0d 0a *UUID:1800* *UUID:1801* *UUID:180A* *UUID:FEFB* *OK*

The BlueMod+S42 reports a list of GATT services from the peripheral device. This list of available services also includes the UUID: “FEFB” which is used for further activities.

In addition to the service UUID value it is required to get the characteristic values of the required service UUID “FEFB”.

cc ff 15 41 54 2b 4c 45 53 52 56 44 3d 30 78 31 30 2c 75 46 45 46 42 0d *AT+LESRVD=0x10,uFEFB*	cc ff 02 0d 0a cc ff 05 55 55 49 44 3a cc ff 04 46 45 46 42 cc ff 02 0d 0a cc ff 08 20 20 30 78 30 30 31 31 cc ff 0b 20 50 52 4f 50 3a 30 78 30 34 20 cc ff 05 55 55 49 44 3a cc ff 20 30 30 30 30 30 30 30 31 30 30 30 30 31 30 30 30 38 30 30 30 30 30 38 30 32 35 30 30 30 30 30 30 cc ff 02 0d 0a cc ff 08 20 20 30 78 30 30 31 33 cc ff 0b 20 50 52 4f 50 3a 30 78 31 30 20 cc ff 05 55 55 49 44 3a cc ff 20 30 30 30 30 30 30 30 32 30 30 30 30 31 30 30 30 38 30 30 30 30 30 38 30 32 35 30 30 30 30 30 30 cc ff 02 0d 0a cc ff 08 20 20 30 78 30 30 31 36 cc ff 0b 20 50 52 4f 50 3a 30 78 30 38 20 cc ff 05 55 55 49 44 3a cc ff 20 30 30 30 30 30 30 30 33 30 30 30 30 31 30 30 30 38 30 30 30 30 30 38 30 32 35 30 30 30 30 30 30 cc ff 02 0d 0a cc ff 08 20 20 30 78 30 30 31 38 cc ff 0b 20 50 52 4f 50 3a 30 78 32 30 20 cc ff 05 55 55 49 44 3a cc ff 20 30 30 30 30 30 30 30 34 30 30 30 30 31 30 30 30 38 30 30 30 30 30 38 30 32 35 30 30 30 30 30 30 cc ff 02 0d 0a cc ff 06 0d 0a 4f 4b 0d 0a *UUID:FEFB* *0x0011 PROP:0x04* *UUID:00000001000010008000008025000000* *0x0013 PROP:0x10* *UUID:00000002000010008000008025000000* *0x0016 PROP:0x08* *UUID:00000003000010008000008025000000* *0x0018 PROP:0x20* *UUID:00000004000010008000008025000000* *OK*

The BlueMod+S42 reports a list of characteristics of the required GATT service UUID: “FEFB” from the peripheral device. This list of characteristics includes all characteristic specific values like, characteristic handle, characteristic properties, characteristic UUID.

The list reports all characteristic information of the service UUID: “FEFB” in details:

characteristic handle:	0x0011
characteristic properties:	PROP:0x04
characteristic UUID:	UUID: 00000001000010008000008025000000
characteristic handle:	0x0013
characteristic properties:	PROP:0x10
characteristic UUID:	UUID: 00000002000010008000008025000000
characteristic handle:	0x0016
characteristic properties:	PROP:0x08
characteristic UUID:	UUID: 00000003000010008000008025000000
characteristic handle:	0x0018
characteristic properties:	PROP:0x20
characteristic UUID:	UUID: 00000004000010008000008025000000

The characteristic handle is required for all access functions to use with this characteristic.

The characteristic properties gives information about the possible access functions available on this characteristic, like: read, write, write without response, notify, and indicate. Detailed information is available in the AT Command Reference.

The characteristic UUID identifies the characteristic within this service.

3.2.1.4. Add MUX Channel from a Characteristic of the Connected GATT Peripheral Device

In the normal AT command mode data bytes needs to be written into the GATT server by using the connection handle and characteristic handle. Compare: 3.1.1.4 Writing Data to a Characteristic

In the MUX mode it is possible to create an own data channel to transfer the data bytes for this characteristic.

The example will add data channels for two characteristics of the service UUID: “FEFB”.

cc ff 1b 41 54 2b 4c 45 41 44 44 43 48 41 4e 3d 30 78 31 30 2c 30 78 31 33 2c 43 4d 44 0d *AT+LEADDCHAN=0x10,0x13,CMD*	cc ff 02 0d 0a cc ff 04 30 78 30 38 cc ff 02 0d 0a cc ff 06 0d 0a 4f 4b 0d 0a *0x08* *OK*
cc ff 1b 41 54 2b 4c 45 41 44 44 43 48 41 4e 3d30 78 31 30 2c 30 78 31 31 2c 43 4d 44 0d *AT+LEADDCHAN=0x10,0x11,CMD*	cc ff 02 0d 0a cc ff 04 30 78 30 37 cc ff 02 0d 0a cc ff 06 0d 0a 4f 4b 0d 0a *0x07* *OK*

To add a MUX data channel it is required to set the connection handle and characteristic handle of this peripheral device in addition to the “write type”.

As result of the “AT+LEADDCHAN” command the BlueMod+S42 returns the MUX channel ID include the response message “OK”. The reported MUX channel ID value will be different to each AT+LEADDCHAN command during the connection.

The list reports all information of the service UUID: “FEFB” in details:

characteristic handle: 0x0011
characteristic properties: PROP:0x04
characteristic UUID: UUID: 00000001000010008000008025000000
MUX channel: 0x08

characteristic handle: 0x0013
characteristic properties: PROP:0x10
characteristic UUID: UUID: 00000002000010008000008025000000
MUX channel: 0x07

3.2.1.5. Enable Indications or Notifications for MUX Channel

If the GATT server characteristic uses the properties “indication” or “notification”, it is possible to enable this feature by the client side in the MUX mode as well.

The MUX based command structure is identical to the AT based command.
See also: 3.1.1.6 Reading Data with Indications or Notifications

The following example demonstrates activating “notifications” for the characteristic handle “0x13” in MUX mode:

cc ff 16 41 54 2b 4c 45 43 43 43 44 3d 30 78 31 30 2c 30 78 31 33 2c 31 0d *AT+LECCCD=0x10,0x13,1*	cc ff 06 0d 0a 4f 4b 0d 0a *OK*

The result message “OK” reports that activating notifications to the required connection handle and characteristic handle was successful.

3.2.1.6. Exchange Data on MUX Channel

After creating MUX data channels with the AT+LEADDCHAN command the BlueMod+S42 uses these channels to exchange data between the local host and the GATT server characteristic during this active connection.

The following example demonstrates the data exchange between both given MUX channels of the service UUID: “FEFB”.

(GATT Server: reading data)
characteristic handle: 0x0011
characteristic properties: PROP:0x04
characteristic UUID: UUID: 00000001000010008000008025000000
MUX channel: 0x08

(GATT Server: writing data)
characteristic handle: 0x0013
characteristic properties: PROP:0x10
characteristic UUID: UUID: 00000002000010008000008025000000
MUX channel: 0x07

cc 08 08 41 42 43 44 45 46 47 0d *ABCDEFG*	cc 07 0b 31 32 33 34 35 36 37 38 39 20 30 *123456789 0*

The BlueMod+S42 received serial data on the MUX channel “0x08” and transfer these data bytes to the characteristic handle “0x13” of the GATT server.

The BlueMod+S42 received Bluetooth data from the GATT server from the characteristic handle “0x11” and send them on the MUX channel “0x07” to the serial interface.

3.2.1.7. Accept Incoming Terminal I/O Connection

During the active GATT server connection to maximum three peripheral devices it is possible to handle one Terminal I/O connection in parallel.

The following example lists the serial communication of an incoming Terminal I/O connection (i.e. from a mobile phone).

	cc ff 06 0d 0a 52 49 4e 47 cc ff 02 0d 0a *RING* cc ff 0d 0d 0a 43 4f 4e 4e 45 43 54 20 54 49 4f cc ff 05 20 30 78 30 31 cc ff 02 0d 0a *CONNECT TIO 0x01*

The BlueMod+S42 reports an incoming Terminal I/O connection with the result message „CONNECT“ include the connection type „TIO“ and a connection handle “0x01”.

The given connection handle is required for further activities onto this Terminal I/O connection.

3.2.1.8. Exchange Data on the Terminal I/O Connection

During the active Terminal I/O connection in the multiplexing mode the data needs to be exchanged on the given connection handle which is also used as MUX channel ID.

The following example demonstrates the serial data exchange between the BlueMod+S42 and the connected Bluetooth device using the Terminal I/O profile.

cc 01 0b 31 32 33 34 35 36 37 38 39 30 *1234567890*	 cc 01 14 30 30 30 30 30 30 30 31 20 61 62 63 64 *00000001 abcd*

The BlueMod+S42 received the serial MUX data content “1234567890” from the host controller and send it to the Terminal I/O client (i.e. mobile phone) with connection handle and MUX channel “0x01”.

The mobile phone sends back the response message “00000001 abcd” over the air to the BlueMod+S42 which is transferred onto the MUX channel “0x01” to the serial interface.

3.2.1.9. Close Terminal I/O Connection

To disconnect the Terminal I/O connection (i.e. from a mobile phone) the BlueMod+S42 close the connection with the use of the connection handle.

cc ff 09 41 54 48 3d 30 78 30 31 0d *ATH=0x01*	cc ff 0c 0d 0a 4e 4f 20 43 41 52 52 49 45 52 cc ff 05 20 30 78 30 31 *NO CARRIER 0x01*

The response of the disconnect request "ATH" is the event "NO CARRIER" followed by disconnected connection handle.

The same event is reported when the remote peripheral disconnects the connection.

4. Startup Timing

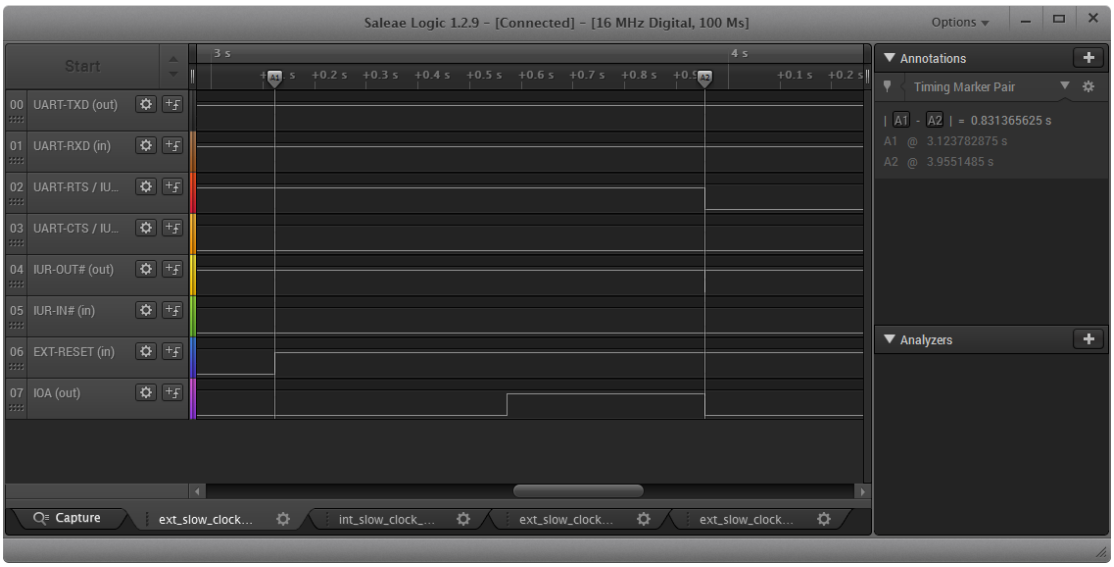
The start-up time until the BlueMod+S42 is able to accept link requests or serial data depends on:

- the firmware version
- the source for the slow clock
- the usage of the UART Interface Control Protocol (UICP)

For more details about the UICP protocol please refer to the document *UICP+ UART Interface Control Protocol*.

4.1. Firmware Version 3.002

The following diagram shows the startup timing of the BlueMod+S42 based on firmware version 3.002 with external 32,768 kHz crystal signal and UICP deactivated.



(*) The firmware is command ready ~840ms after the reset has been released and when GPIO8 (IOA) is low.

After GPIO8 gets low the state of the /RTS and /IUR-OUT lines depends on the UICP parameter. When UICP is disabled (AT+UICP=0) both output lines get low, otherwise the UICP function will be started.

For more details about the UICP protocol please refer to the document *UICP+ UART Interface Control Protocol*.

5. Security

This chapter describes the security mechanisms of the BlueMod+S42 to control the access to the local Bluetooth devices characteristics. The pairing process is triggered automatically when an access to a characteristic is requested that requires security.

5.1. Pairable and Bondable Mode

In general we distinguish between pairing and bond. Pairing is the active process to generate a set of encryption keys. The paring can be done with or without user interaction depending of the I/O capabilities. The pairing will result in a bond if the generated data is stored in the bonded device list (AT+BNDLIST).

AT+BPAIRMODE controls if a pairing is performed or not.

Value	Description
0	No pairing (pairing request will be refused)
1	Pairing

AT+BNDS controls the storing of the pairing information as bond.

Value	Description
0	No storing (no bond)
1	Storing (entry in the bonded device list)

The bonded device list is affected by the following commands:

- AT+BNDLIST shows the devices stored in the bonded device list
- AT+BNDSIZE determines the size of the bonded device list and deletes the whole list when modifying the size
- AT+BNDDEL deletes single entries or the whole list
- AT&F1 deletes the bonded device list

If the bonded device list is full and another device is bonded, the least recently used device will be overwritten by the new one. If bonds are not required please set AT+BNDS=0.

5.2. LE Secure Connections

Bluetooth 4.2 supports a new security mechanism called “Secure Connections”.

LE Secure Connection introduces a new method to generate a shared secret (key) in a way that ensures the data integrity and privacy of a connection even in cases where the pairing/ponding procedure was completely tapped with a Bluetooth sniffer if that shared secret is used for authentication and encryption.

Secure connection key generation is applicable for all authentication methods (e.g. just works or passkey entry) while all authentication trigged I/O activity remain the same as for legacy LE security but one new method (display yes/no) is introduced.

Bluetooth 4.2 mandates that LE Secure Connection key generation is used while pairing/bonding if both devices of a given connection support this feature. If one device of a

given connection only supports LE legacy security key generation procedures this legacy procedures will be used instead.

From user point of view this negotiation is mostly transparent and backward compatible. The only exceptions are if LE Secure Connection is mandated (AT+LETIO=4) or the new display yes/no (AT+BIOCAP=1) configuration is used.

By configuring AT+LETIO=4 for incoming Terminal I/O connections LE Secure Connection usage is mandated for incoming Terminal I/O connections. In such case Terminal I/O connections from devices that only support LE legacy security are rejected.

By configuring AT+BIOCAP=1 for I/O capabilities "display yes/no", the "yes/no" functionality is only used for LE Secure Connection procedures.

For LE legacy security only the "display" functionality is used so the results are the same as for a "display only" configuration.

5.3. Security Levels for Terminal I/O

The behavior of LE Security is configurable using the parameters for I/O capabilities (AT+BIOCAP) and a man in the middle protection (AT+BMITM).

The security level of Terminal I/O is configurable using the parameter AT+LETIO.

Value	Description
0	Terminal I/O service disabled (no advertising, no characteristics)
1	Terminal I/O service enabled, security is required
2	Terminal I/O service enabled, no security required
3	Terminal I/O service enabled, authenticated pairing with encryption (MITM required)
4	Terminal I/O service enabled, authenticated LE Secure connections pairing with encryption (MITM required, LE secure connections required)

AT+BIOCAP sets the input and output capabilities of the device used for LE Security.

Value	Description
0	Display only
1	Display Yes/No
2	Keyboard only
3	No input no output (default)
4	Display and keyboard

AT+BMITM controls the man in the middle (MITM) protection of the device during LE Security.

Value	**Description**
0	Man in the middle protection disabled (default)
1	Man in the middle protection enabled

LE Security defines the following association models based on the Input/Output (I/O) capabilities of the two devices:

- **Just Works:**

This method is used when at least one of the devices does not have display capability of six digits and also is not capable of entering six decimal digits using a keyboard or any other means (no I/O).

This method does not provide MITM protection (see 5.4 Connection Example Terminal I/O "Just Works").

- **Passkey Entry:**

This method may be used between a device with a display and a device with numeric keypad entry (such as a keyboard), or two devices with numeric keypad entry (see 5.5 Connection Example Terminal I/O "Passkey Entry").

In the first case, the display is used to show a six digit numeric code to the user, who then enters the code on the keypad.

In the second case, the user of each device enters the same six digit numeric code. Both cases provide MITM protection.

Possible combinations of I/O capabilities and the possibility of MITM protection are listed in the table below. For each case of the "MITM protection" an example of the serial messages between the BlueMod+S42 and the DTE are listed.
In case the user choose a scenario where MITM protection is not allowed but one of the communication devices is configured to MITM protection, the pairing is refused.

- **Display Yes/No:**

This method may be used between two devices with a display and keys that allow the user to accept or reject a connection.

If the Display Yes/No capability is supported by both devices the displays show a 6 digit numerical code. The user is then requested to compare the codes of both displays. If the codes on both displays are equal the user can accept the connection by pressing the "yes" input of both devices. In case the user presses the "no" input on at least one of the devices the pairing becomes rejected.

In cases where only one device of a connection supports Display Yes/No capabilities, the I/O capabilities of that device will be handled as a "Display only" configuration for passkey entry.

BM+S42 \ Remote device	Display only	Display Yes/No	Keyboard only	No input no output	Display and keyboard
Display only AT+BIOCAP=0	Just Works (both automatic confirmation) *No MITM protection*	Just Works (both automatic confirmation) *No MITM protection*	Passkey entry (one display, one input) *MITM protection* SSPPIN <BT addr> <passkey>	Just Works (both automatic confirmation) *No MITM protection*	Passkey entry (one display, one input) *MITM protection* SSPPIN <BT addr> <passkey>
Display Yes/No AT+BIOCAP=1	Just Works (both automatic confirmation) *No MITM protection*	Just Works (both automatic confirmation) No MITM protection	Passkey entry (one display, one input) *MITM protection* SSPPIN <BT addr> <passkey>	Just Works (both automatic confirmation) *No MITM protection*	Passkey entry (one display, one input) *MITM protection* SSPPIN <BT addr> <passkey>
Keyboard only AT+BIOCAP=2	Passkey entry (one display, one input) *MITM protection* SSPPIN <BT addr> ? AT+BSSPPIN <BT addr>,<passkey>	Passkey entry (one display, one input) *MITM protection* SSPPIN <BT addr> ? AT+BSSPPIN <BT addr>,<passkey>	Passkey entry (both input) *MITM protection* SSPPIN <BT addr> ? AT+BSSPPIN <BT addr>,<passkey>	Just Works (both automatic confirmation) *No MITM protection*	Passkey entry (one display, one input) *MITM protection* SSPPIN <BT addr> ? AT+BSSPPIN <BT addr>,<passkey>
No input no output AT+BIOCAP=3	Just Works (both automatic confirmation) *No MITM protection*	Just Works (both automatic confirmation) *No MITM protection*	Just Works (both automatic confirmation) *No MITM protection*	Just Works (both automatic confirmation) *No MITM protection*	Just Works (both automatic confirmation) *No MITM protection*
Display and keyboard AT+BIOCAP=4	Passkey entry (one display, one input) *MITM protection* SSPPIN <BT addr> ? AT+BSSPPIN <BT addr>,<passkey>	Passkey entry (one display, one input) *MITM protection* SSPPIN <BT addr> ? AT+BSSPPIN <BT addr>,<passkey>	Passkey entry (one display, one input) *MITM protection* SSPPIN <BT addr> <passkey>	Just Works (both automatic confirmation) *No MITM protection*	Passkey entry (one display, one input) *MITM protection* incoming connection: SSPPIN <BT addr> ? AT+BSSPPIN <BT addr>,<passkey> outgoing connection: SSPPIN <BT addr> <passkey>

Green color: BM+S42 output message SSPPIN <BT addr> ? (example)
Blue color: BM+S42 input request AT+BSSPPIN <BT addr> <passkey> (example)

The following flow charts will give an example for the different SSP authentication methods "just works" and "passkey entry" within an incoming call request from an iPhone (or other compatible iOS device) using Telit's Terminal I/O Utility app to the BlueMod+S42 (see also the connection example in chapter 3.1.2).

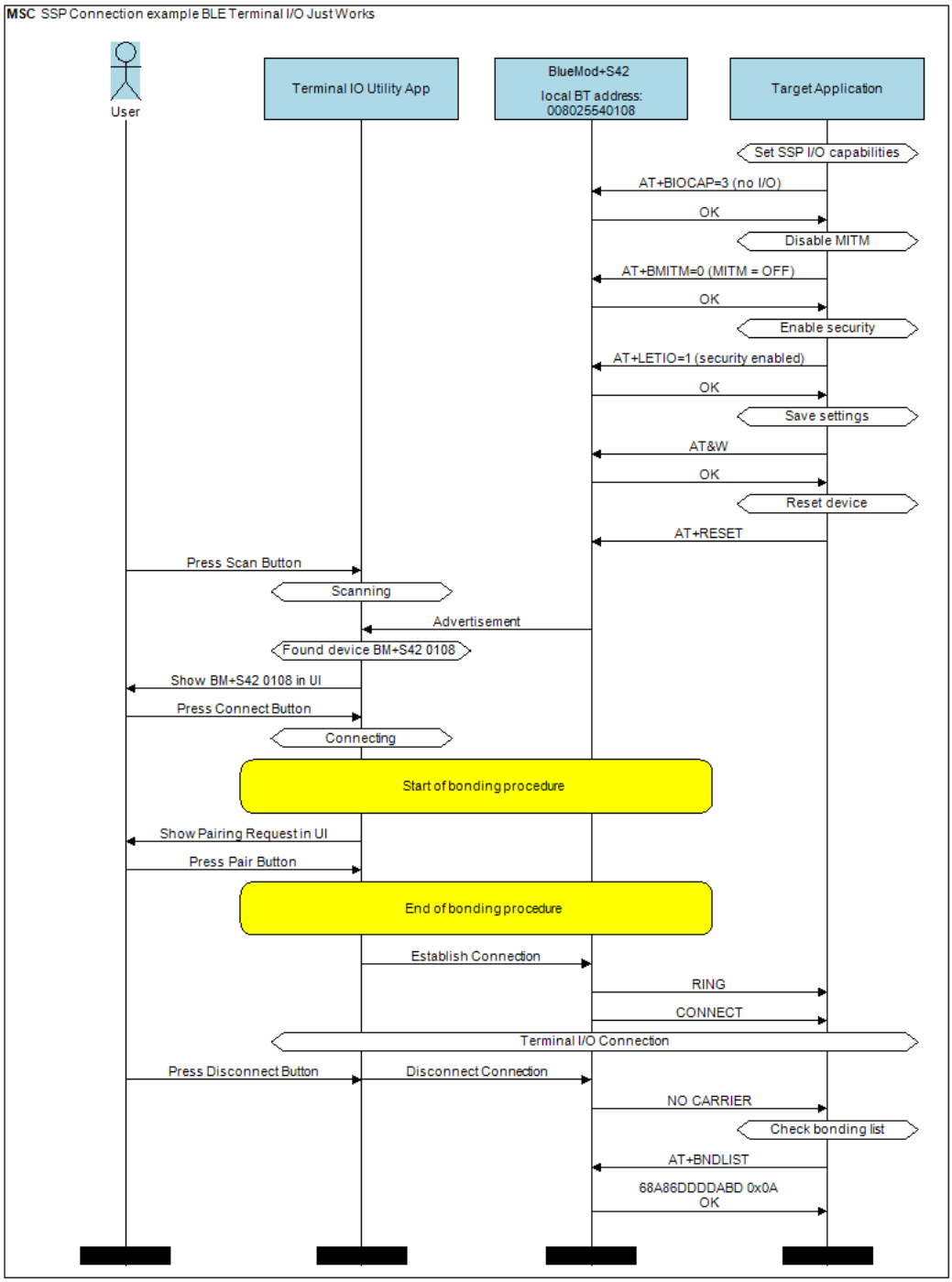
The "*Target Application*" part will simulate the device at the end (DTE) which communicates to the BlueMod+S42 with configuration commands.

The interesting part of the bonding procedure is placed between the yellow boxes "*Start of bonding procedure*" and "*End of bonding procedure*".

All serial commands between the "*Target Application*" and the "*BlueMod+S42*" out of the bonding procedure are used for further configuration of LE Security.

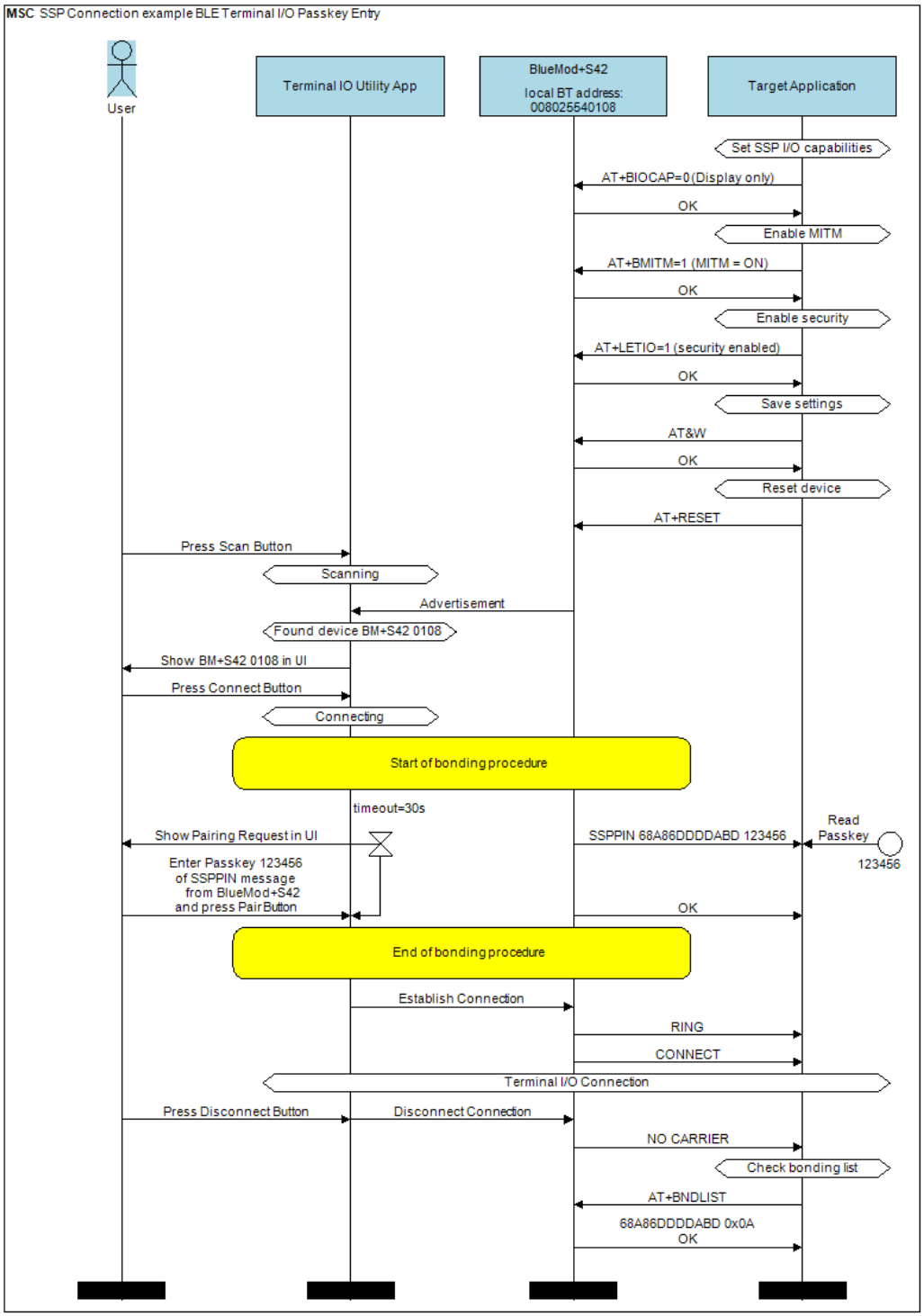
The configuration commands and responses within the flow charts are described in the *BlueMod+S42 AT Command Reference*.

5.4. Connection Example Terminal I/O “Just Works”



5.5. Connection Example Terminal I/O “Passkey Entry”

with I/O capabilities “display only”



6. UART Interface Control Protocol (UICP)

6.1. General Protocol Description

Telit UART Interface Control Protocol (UICP) defines a protocol to control the logical state of an UART based interface, thereby peers to switch off local UART devices for power saving (or other) reasons.

The UICP+ is a bi-directional, symmetrical protocol that allows to negotiate UART interface states with a communication partner connected via UART by the use of standard UART signal lines.

The UICP+ mechanisms defined here enable the involved peers to negotiate UART interface states by signaling the remote peer that it is allowed to enter or exit an UART interface up state.

The UICP+ does not enforce any power saving support of the involved peers but implements mechanisms to allow the save usage of MCU power saving features like UART peripheral switched off.

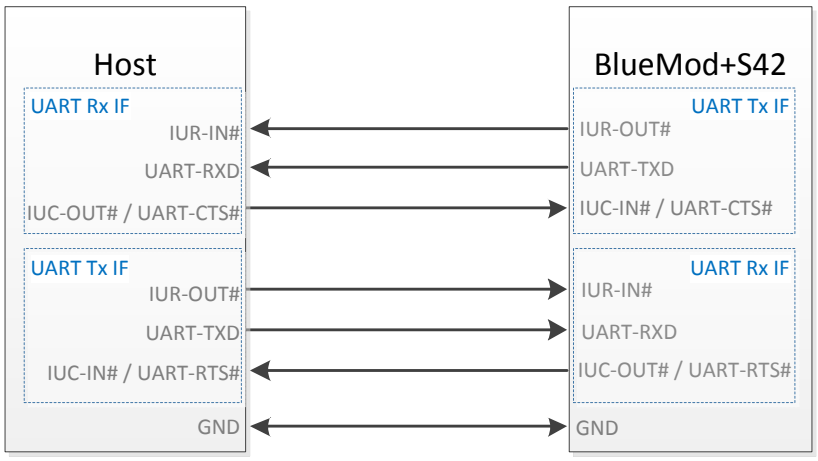
6.2. Requirements of Using UICP on BlueMod+S42

To make use of UICP, the lines UART-TXD, UART-RXD, UART-RTS# (IUC-OUT#), UART-CTS# (IUC-IN#), IUR-OUT# and IUR-IN# should be connected between BlueMod+S42 and the host and additionally the UICP protocol should be implemented on host site.

A detailed description of implementing UICP is described in the document *UICP+ UART Interface Control Protocol*.

To activate UICP on the BlueMod+S42 the configuration parameter AT+UICP=1 needs to be set (followed by AT&W and AT+RESET).

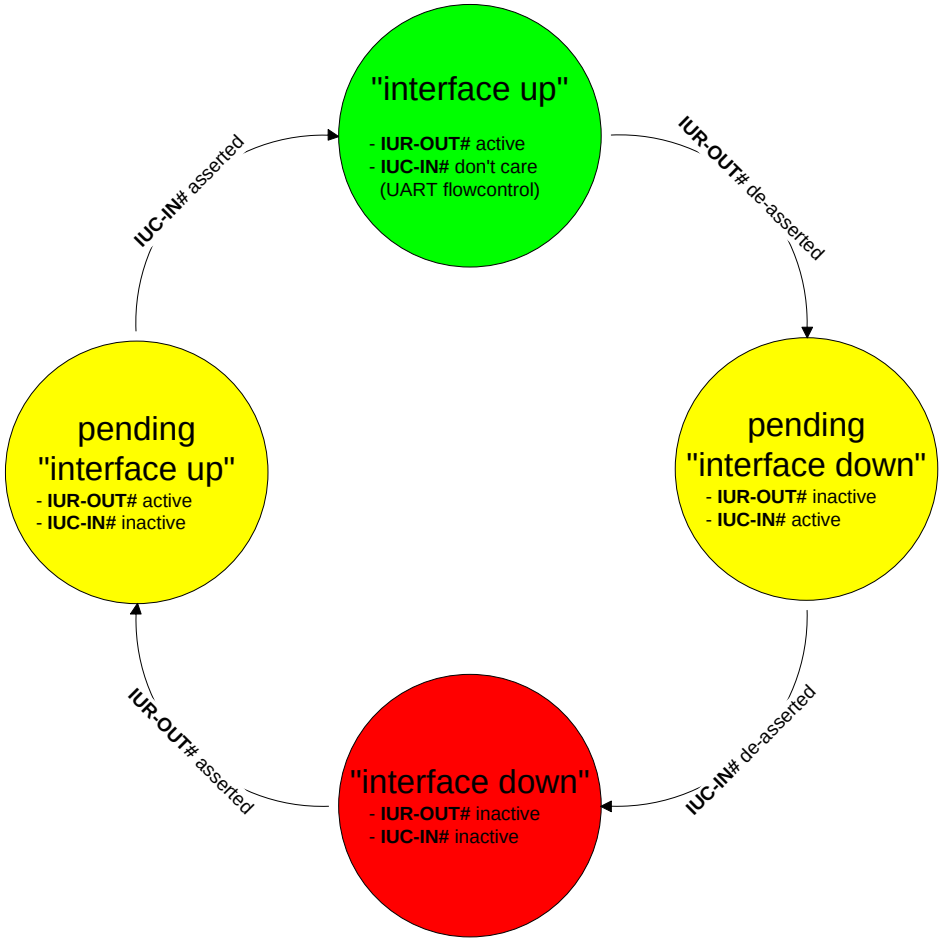
6.3. Connection Example between BlueMod+S42 and Host Controller



Further information about the BlueMod+S42 UART interface is described in the document *BlueMod+S42 Hardware User Guide*.

6.4. UICP Protocol States

The UICP protocol defines four states:



- **interface up**
  normal operation, RTS/CTS hardware flow control is active
- **pending interface down**
  IUR-OUT# is requested to go to "interface down" state
  IUC-IN# is not confirmed
- **interface down**
  IUR-OUT# and IUC-IN# are de-asserted in "interface down" state
  and can enable MCU power saving
- **pending interface up**
  IUR-OUT# is requested to go to "interface up" state,
  IUC-IN# is not confirmed

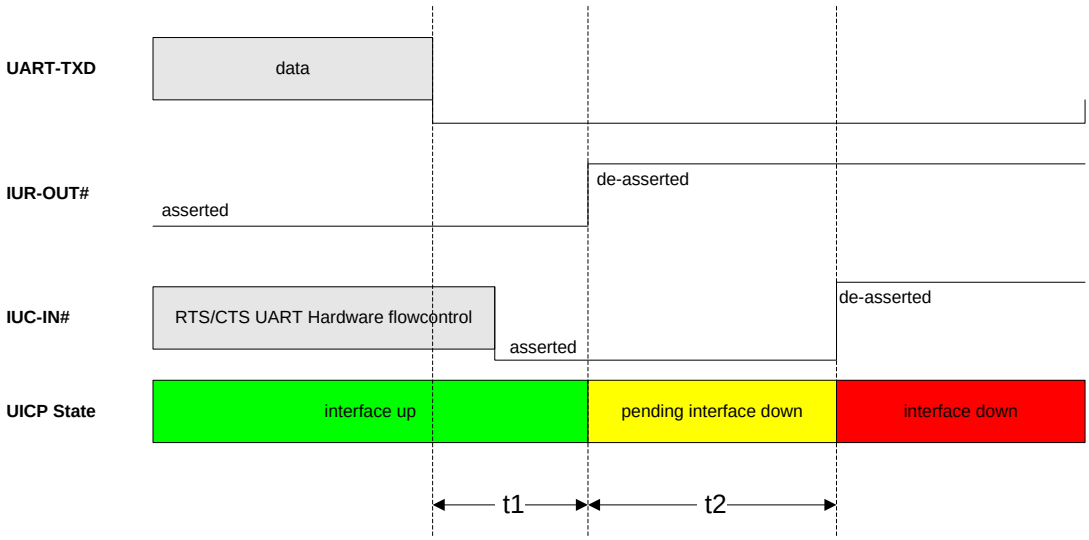
Note: All data received before the interface up state has been achieved shall be seen as invalid data and shall be discarded.

6.4.1. Drive from "interface up" to "interface down" State

Once a de-asserted IUR-OUT# signal of the initiator is detected by the acceptor, the acceptor shall confirm that signal by de-asserting its IUC-OUT# signal which is connected to the IUC-IN# signal of the initiator.

After the initiator detects a de-asserted IUC-IN# signal both devices go into "interface down" state and can enable MCU power saving mechanisms.

During MCU power saving, the MCU can switch off the UART but shall be able to detect an IUR# assert.



t1 >= 100ms (see this chapter)

t2 < 1s

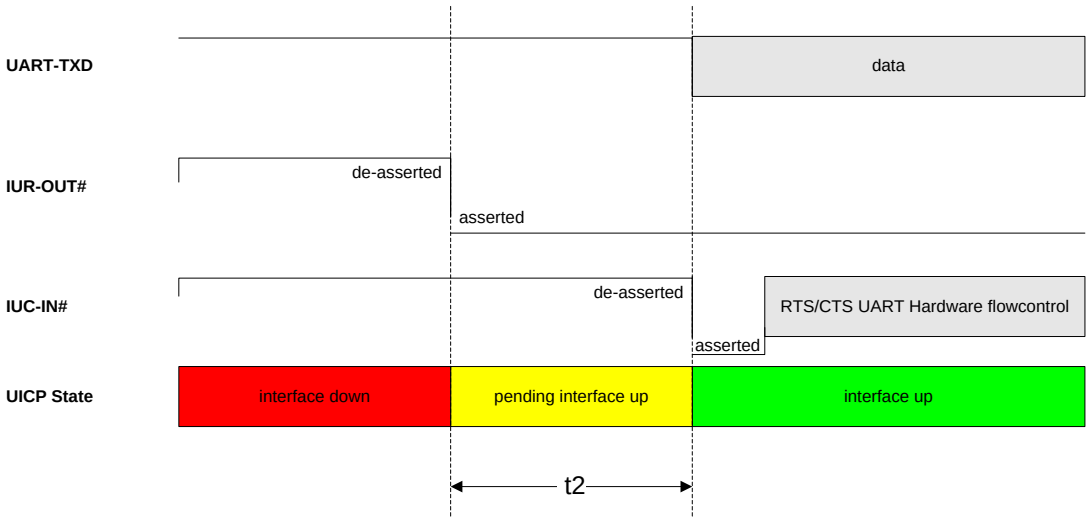
6.4.2. Drive from "interface down" to "interface up" State

To initiate the state change from "interface down" state to "interface up" state the initiator shall assert the IUR-OUT# signal.

The acceptor confirms the IUR-IN# signal with asserting its IUC-OUT# signal which is connected to the IUC-IN# signal of the initiator.

Once the acceptor detects the assert of the IUR-OUT# signal from the initiator, it can disable MCU power saving mechanisms but shall ensure the UART is ready to receive data before it confirms asserting its IUC-OUT# signal which is connected to the IUC-IN# signal of the initiator.

Once the initiator detects the assert of the IUC-IN# signal of the acceptor, the in initiator can send data to the acceptor.



6.5. Example of UICP Usage

The following examples show the state change between the BlueMod+S42 and the host.

The scenario here might be that both devices use the "interface down" state to drive the MCU into some kind of power saving mode that allows to "wake up" the MCU with external GPIO signals.

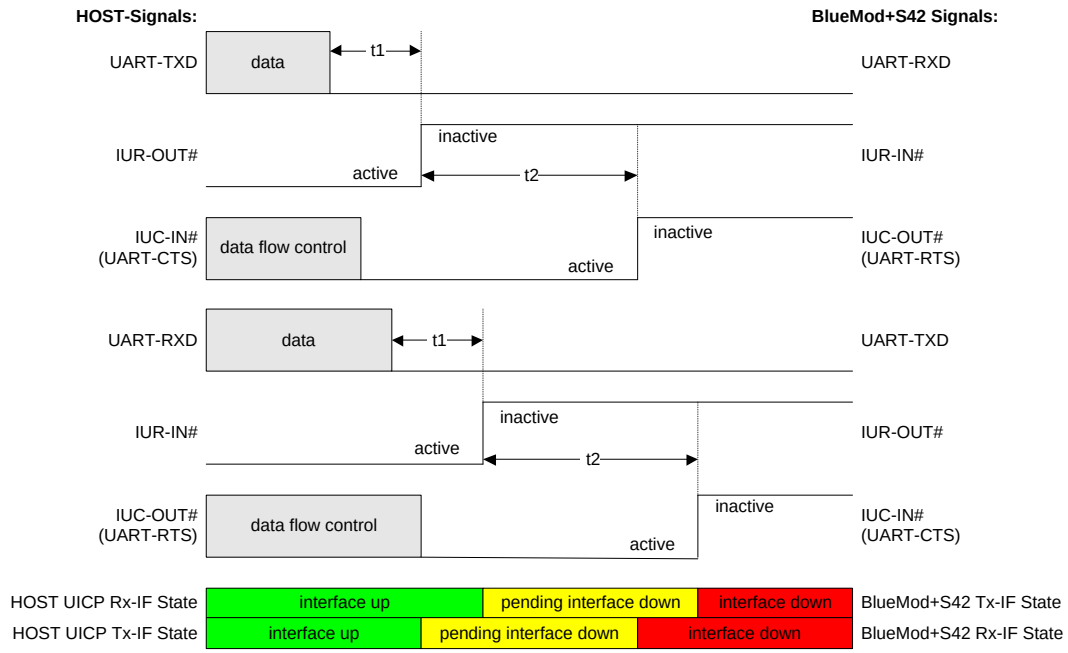
6.5.1. State Change from "interface up" to "interface down"

Host and BlueMod+S42 are in the state “interface up” and exchange bidirectional data. After the host has send all data and is idle for **t1** in its Tx direction it signals the BlueMod+S42 that it is allowed to go to “interface down” state by de-asserting IUR-OUT# signal.

Parallel to that UICP signaling from host to BlueMod+S42 the BlueMod+S42 has send all data as well and is idle for **t1** in its Tx direction, so it signals the host that it is allowed to go to “interface down” state by de-asserting IUR-OUT# signal.

The host and the BlueMod+S42 each wait for a maximum time **t2** to detect the de-asserted IUC-IN# signal. After receiving this input change via the IUC-IN# signal both devices may change from state “pending interface down” to state “interface down”.

Both UICP signaling sequences proceed in parallel until host and BlueMod+S42 interfaces are in “interface down” state.



6.5.2. State Change from "interface down" to "interface up"

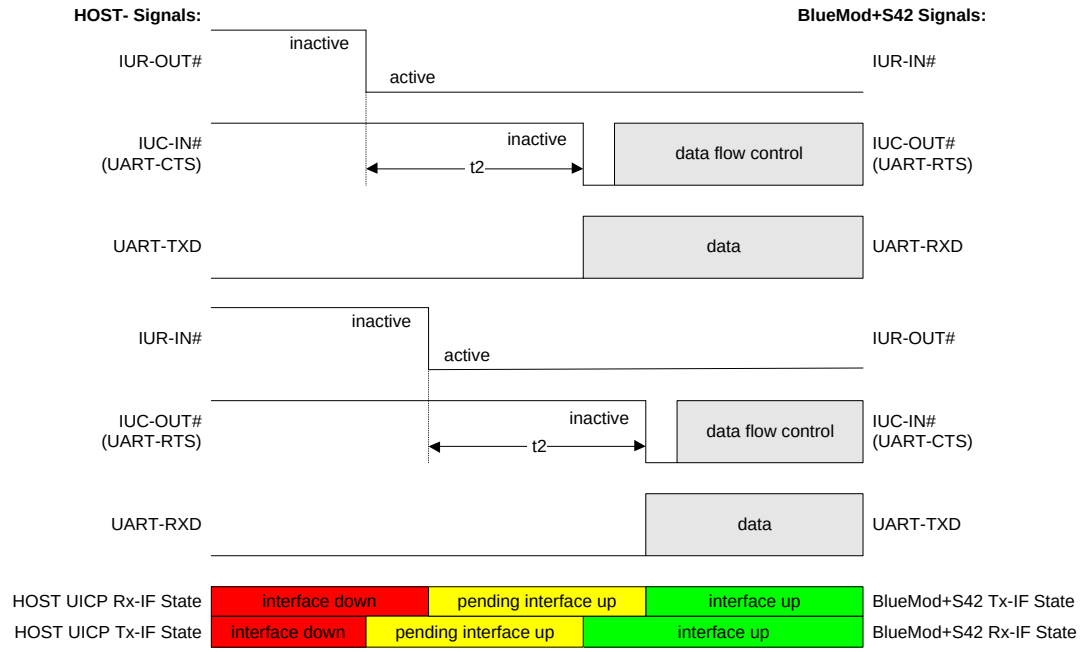
Host and BlueMod+S42 are in the state “Interface down” and may have the MCU into some kind of power saving state.

The host wants to send data to the BlueMod+S42 and asserts its IUR-OUT# signal.

Parallel to that UICP signaling from host to BlueMod+S42 the BlueMod+S42 wants to send data to the host and asserts its IUR-OUT# signal as well.

The host and the BlueMod+S42 each wait for a maximum time **t2** to detect the assertion via the IUC-IN# signal. After receiving this input change of IUC-IN# both devices may assume that the interface of the remote device changed from state “pending interface up” to state “interface up”.

Both UICP signaling sequences proceed in parallel until host and BlueMod+S42 interfaces are in “interface up” state and data can be exchanged bidirectional.



7. NFC Handover

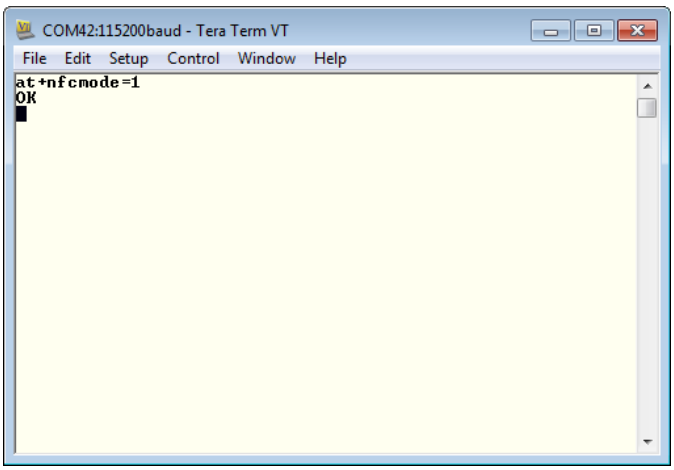
7.1. NFC Mode

The NFC mode can be activated or deactivated by using the following AT command:

AT+NFCMODE=<value>

Value	Description
0	NFC interface OFF
1	NFC interface ON

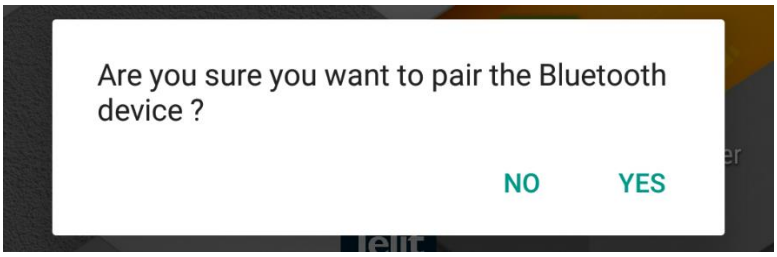
Enable the NFC Handover functionality by using the following AT command:



7.2. NFC Handover Example

Make sure NFC is available and enabled in the smartphone and move it over the NFC antenna.

The Bluetooth address will be read out and the smartphone initiates a Bluetooth pairing request to the device of the given Bluetooth address and a Bluetooth pairing request message will appear. Now continue with “Pair” or “Yes” to accept the Bluetooth pairing request scenario.



After the pairing request ended successfully you will find the new paired device within the Bluetooth settings of your smartphone.

For further information regarding NFC Handover please refer to the *BlueEva+S42 User Guide*.

8. Firmware Upgrade

The firmware upgrade will be done locally by either

- A Telit provided firmware update tool. This is a Windows™ program that contains the firmware and uses a PC with a serial port for the update
- Implementing the firmware update protocol on the host system or over the air.

8.1. Serial Firmware Upgrade

8.1.1. Prerequisites for Serial Firmware Upgrade

You need to have access to the UART interface of the BlueMod+S42.

Serial firmware update requires at least the serial lines UART-RXD, UART-TXD, UART-CTS#, UART-RTS# and GND.

Serial firmware update requires a UART speed of 38400 bps.

Pin BOOT0 (E-1) shall be pulled high to access the bootloader at start-up.

8.1.2. Telit BlueMod+S Updater

The firmware upgrade will be done by a Telit provided firmware update tool. This is a Windows™ program that contains the firmware and uses a PC with a serial port for the update.

For example a firmware version V3.002 will result in the executable file "BM+S42_v3_002_FWupdate.exe".

The software used for the upgrade is able to run on the following Win32/Win64 platforms:

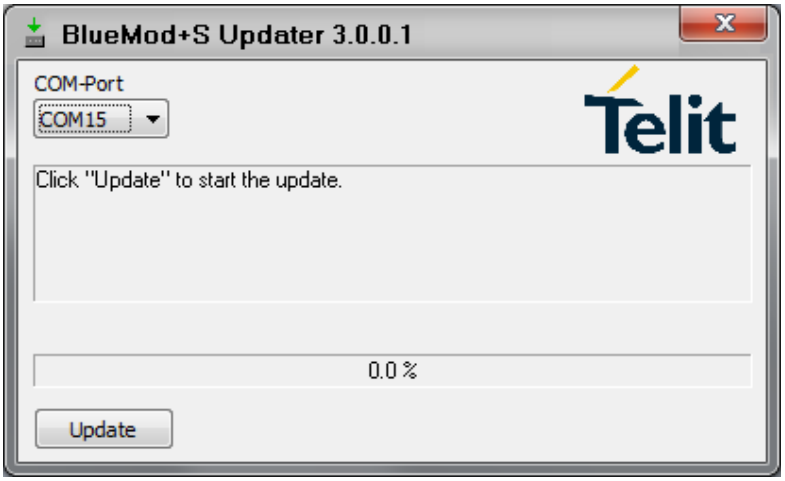
- Windows XP
- Windows Vista
- Windows 7
- Windows 8

Note: Testing was carried out on Windows 8 Pro, Windows 7 Ultimate and XP Professional platforms; however experience suggests that the described software runs on all XP platforms and all Windows 8 / 7 / Vista 32 and 64-bit platforms.

The program requires a PC with at least one free COM port.

The upload is processed via the serial port the device is attached to.

Before starting the update by pressing the “Update” button the device shall be reset.



- COM-Port
  The COM-Port the device is attached to
- Update
  Starts the update procedure

After the successful update close the software, remove the high level on pin BOOT0 and reset the BlueMod+S42.

Note: ***Do not disconnect the device while the update is in progress, otherwise the update will fail and has to be repeated. In case it is not possible to update the BlueMod+S42 please contact the Telit support (e-mail: ts-srd@telit.com).***

8.1.3. Firmware Update Protocol on the Host System

This chapter describes the protocol layer used for firmware update over serial on the BlueMod+S42.

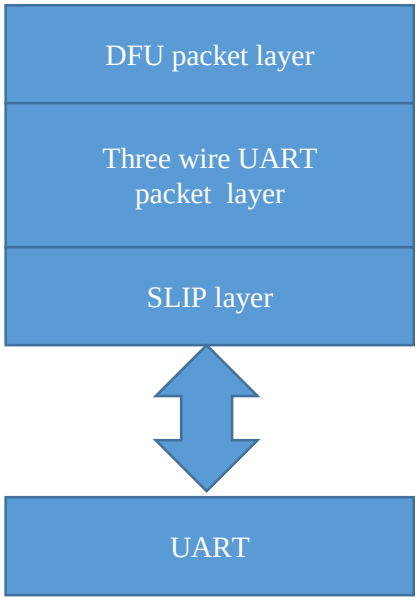
The table below contains the maximum possible binary firmware sizes:

Firmware variant	Maximum possible binary firmware size
V3.002	332 kBytes

Note: The actual size of each firmware binary file can be found in the firmware release notes.

8.1.3.1. Layer Structure

The device firmware update uses the HCI Three-Wire UART Transport Layer specified in *Bluetooth 4.0 Core Specification*. Instead of HCI frames, four different DFU packets are sent to the BlueMod+S42 over the UART serial interface using this transport.



8.1.3.2. DFU Packet Layer

There are four different packet types in this layer. The packet type is an unsigned 32 bit integer in LSB first order.

1. Start packet 0x00000003
2. Init packet 0x00000001
3. Application data packet 0x00000004
4. Stop packet 0x00000005

Start packet

With the "Start packet" the DFU bootloader is informed about the kind of update and the length of the binary image. The length of the image is an unsigned 32 bit integer in LSB first order. It is length of the file with the ".bin" extension in the Telit delivery package (zip file). For a binary application with image size of 17,336 bytes (0x000043B8), the packet is coded as:

Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7	Byte8
0x03	0x00	0x00	0x00	0x04	0x00	0x00	0x00

1.

Byte9	Byte10	Byte11	Byte12	Byte13	Byte14	Byte15	Byte16
0x00	0x00	0x00	0x00	0x00	0x00	0x00	0x00

2.

Byte17	Byte18	Byte19	Byte20
0xB8	0x43	0x00	0x00

Init packet

The init packet contains information about the application that is transferred. The DFU bootloader checks this information to determine if the image is valid for the device. Please use as contents only the init packet provided by Telit. The data starting with "Device type" and ending with "CRC of the image that will be transferred" (see the Nordic documentation) is provided by Telit in the Telit delivery package (zip file). It is the contents of the file with the extension ".dat". The binary application to load with the data packets is the file with the ".bin" extension.

The init packet is coded as:

Byte1	Byte2	Byte3	Byte4	Byte5 up to Byte n	Byte n+1	Byte n+2
0x01	0x00	0x00	0x00	Contents of the ".dat" file. The length is variable.	0x00	0x00

Required waiting

After accepting the init packet the bootloader prepares (erases) the internal flash memory to accommodate the new image. The bootloader accepts no data packets during this time. Please wait 10 seconds before sending the first data packet.

Application data packet

With the Application data packet the binary application image is transferred to the BlueMod+S42. The binary application to load with the data packets is the file with the ".bin" extension in the Telit delivery package (zip file). The maximum packet size is 512 bytes of data + header per packet. Each packet is coded:

Byte1	Byte2	Byte3	Byte4	Byte 5 … up to Byte 516
0x04	0x00	0x00	0x00	Max 512 bytes of binary application data

Stop packet

When the Application image has been transferred to the BlueMod+S42 boot loader the image must be activated. The stop packet will inform the boot loader that transferring of the image has completed and the application can be started. The packet is coded as:

Byte1	Byte2	Byte3	Byte4
0x05	0x00	0x00	0x00

8.1.3.3. Three Wire UART Packet Layer

Every packet that is sent over the Three-Wire UART Transport Layer has a packet header. It also has 16 bit CCITT-CRC at the end of the payload.

Each transport packet will contain one higher layer packet. A transport packet consists of a Packet Header of 4 octets, a payload of 4 to 516 octets, and a 16 bit CCITT-CRC.

The Packet header consists of a Sequence Number of 3 bits, an Acknowledge Number of 3 bits, a Data Integrity Check Present bit, a Reliable Packet bit, a Packet Type of 4 bits, a Payload Length of 12 bits and a 8 bit Header Checksum.

The used Packet Type is vendor specific (0xe).

LSB MSB

4 Octets	1.. 156 Octets	2 Octets
Packet Header	DFU packet layer	16 bit CCITT-CRC

The detailed format description of the used packet header can be found in *Bluetooth 4.0 Core Specification*.

For a detailed description of the procedural requirements of this protocol have a look in the *Bluetooth 4.0 Core Specification*, chapter “Three-Wire UART Transport Layer”.

8.1.3.4. SLIP Layer

The SLIP layer performs octet stuffing on the octets entering the layer so that specific octet codes which may occur in the original data do not occur in the resultant stream.

The SLIP layer places octet 0xC0 at the start and end of every packet it transmits.

Any occurrence of 0xC0 in the original packet is changed to the sequence 0xDB 0xDC before being transmitted. Any occurrence of 0xDB in the original packet is changed to the sequence 0xDB 0xDD before being transmitted. These sequences, 0xDB 0xDC and 0xDB 0xDD are SLIP escape sequences.

For a detailed description of this protocol have a look in the *Bluetooth 4.0 Core Specification*, chapter “Three-Wire UART Transport Layer”.

8.2. Firmware Update over The Air (OTA)

The BlueMod+S42 supports firmware over the air update. The firmware update over the air can be performed by using the Nordic nRF ToolBox app available for iOS and Android or by using the Nordic Master Control Panel and the corresponding Nordic Bluetooth hardware.

The firmware over the air update in the BlueMod+S42 will be enabled with the commands below:

1. AT+DFUMODE=2
2. AT+DFUSTART

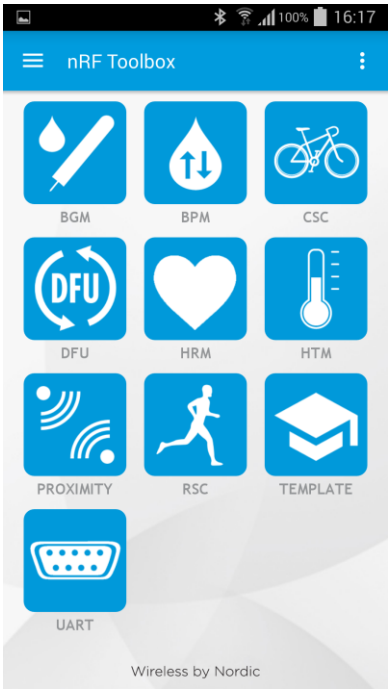
After sending the AT+DFUSTART command the BlueMod+S42 is visible in the air as "BM+S_DFU" (name configured with command AT+DFUNAME) for a time period of 2 minutes. If no firmware update is performed during this time the BlueMod+S42 will continue with normal operation.

The following chapter describes the firmware over the air update by using the Nordic nRF Toolbox app on Android.

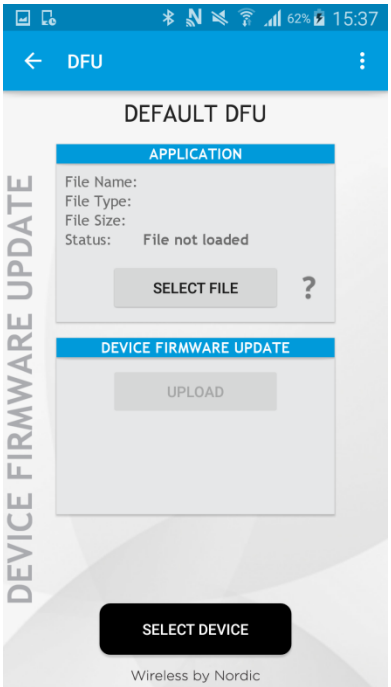
8.2.1. Firmware Update Over The Air using Nordic nRF Toolbox on Android

Make sure the BlueMod+S42 has already activated the firmware over the air update.

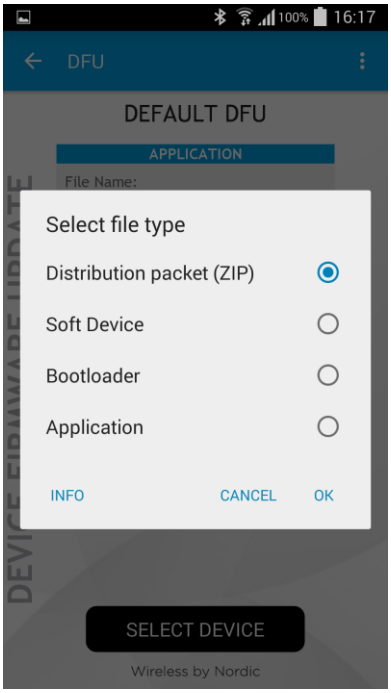
Open the nRF ToolBox app on the smartphone and choose “DFU“.



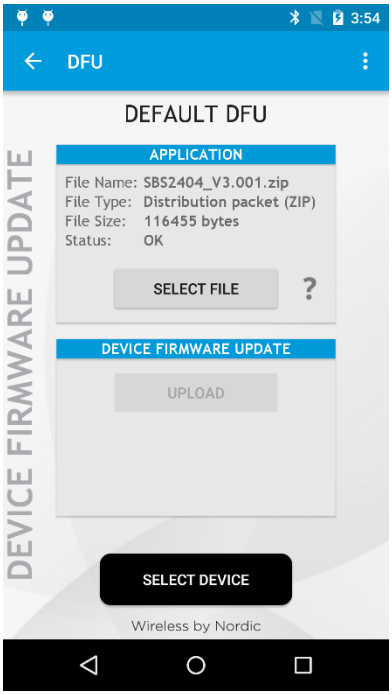
Press the button “SELECT FILE”.



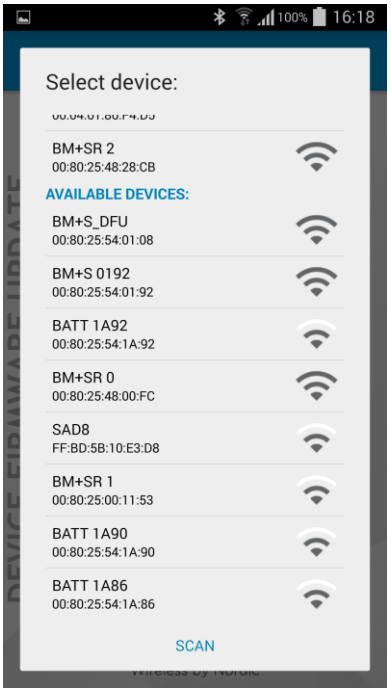
Select file type “Distribution packet (ZIP)”.



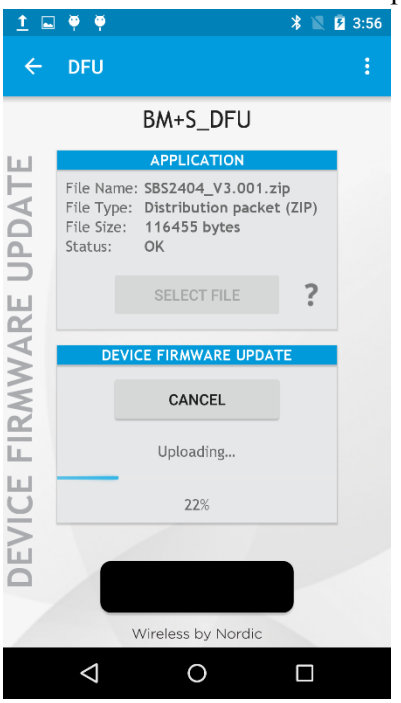
Search via file manager for the firmware package which was previously copied to the smartphone (e.g “SBS2404_V3.001.zip” in the example below).



Press the button “SELECT DEVICE” and select the “BM+S_DFU” from the list of available devices.



Press the “UPLOAD” button to upload the firmware package over the air to the BlueMod+S42.



After the file was uploaded successfully the BlueMod+S42 will start with the new firmware.

9. System OFF Mode

The BlueMod+S42 supports the possibility to set the module into low power mode during the time the module is not used with the AT+SYSTEMOFF command.

The BlueMod+S42 will restart on activity at the GPIO input lines UART-RTS#, IUR-IN# or GPIO[4].

The host controller can use the IOA pin (GPIO[8]) to monitor the system status. Please also verify the configuration of the AT+IOACFG parameter.

It is also possible to monitor the UART flow control line UART-RTS#.

9.1. Using System OFF Mode for Terminal I/O

The following example will list the communication between the host controller and the BlueMod+S42 using the integrated Terminal I/O profile.

To set the BlueMod+S42 into the low power mode the host controller needs to send the AT+SYSTEMOFF command.

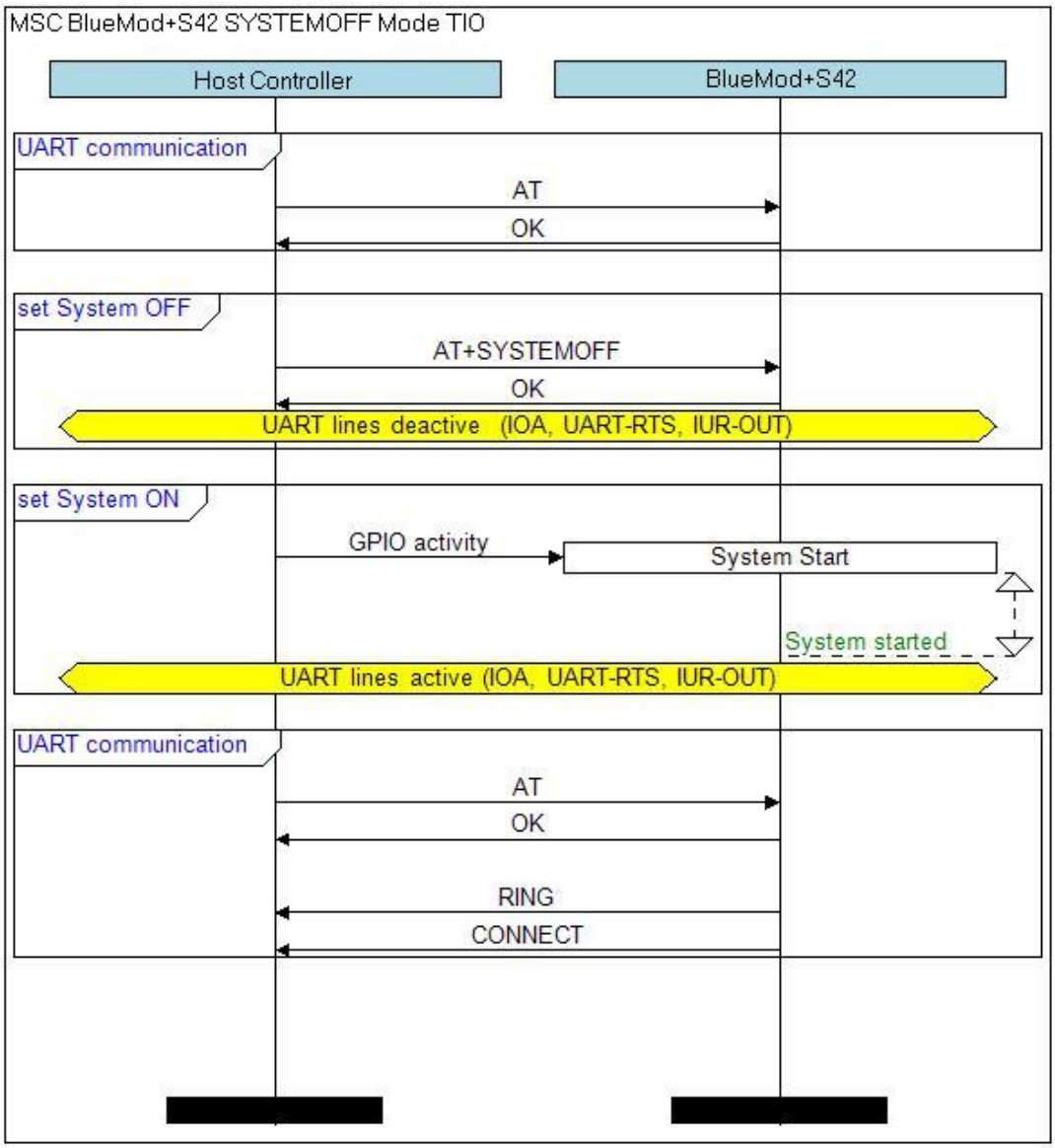
The BlueMod+S42 will respond “OK” before changing into low power mode.

To activate the BlueMod+S42 from low power mode the host controller needs to activate one of the following GPIO lines: UART-RTS#, IUR-IN#, GPIO[4]

The module detects the GPIO change and starts the firmware.

After the firmware is started the host can continue the UART communication.

An incoming call is reported with RING and CONNECT.


MSC BlueMod+S42 SYSTEMOFF Mode TIO
Host Controller
BlueMod+S42
UART communication
AT
OK
set System OFF
AT+SYSTEMOFF
OK
UART lines deactive (IOA, UART-RTS, IUR-OUT)
set System ON
GPIO activity
System Start
System started
UART lines active (IOA, UART-RTS, IUR-OUT)
UART communication
AT
OK
RING
CONNECT

10. LE Connection Parameters

This chapter describes the kind of creating a BLE connection from the central device to the peripheral device include the usage of the LE connection parameters.

10.1. Create a Bluetooth Low Energy Connection

In a typical Bluetooth Low Energy system, the peripheral device advertises with specific data letting any central device know that it is a connectable device. This advertisement contains the device address, and can contain some additional data as well, such as the device name. The central device, upon receiving the advertisement, sends a "scan request" to the peripheral. The peripheral responds with a "scan response". This is the process of device discovery, in that the central device is now aware of the peripheral device, and knows that it can form a connection with it. The central device can then send out a request to establish a link with the peripheral device. A connection request contains a few connection parameters:

- **Connection Interval**

  In a BLE connection between two devices, a frequency-hopping scheme is used, in that the two devices each send and receive data from one another on a specific channel, then "meet" at a new channel (the link layer of the BLE stack handles the channel switching) at a specific amount of time later. This "meeting" where the two devices send and receive data is known as a "connection event". Even if there is no application data to be sent or received, the two devices will still exchange link layer data to maintain the connection. The connection interval is the amount of time between two connection events, in units of 1.25ms. The connection interval can range from a minimum value of 6 (7.5ms) to a maximum of 3200 (4.0s).

  The BlueMod+S42 uses the configuration command AT+LECONINTMIN and AT+LECONINTMAX to set these predefined values of the connection interval.

- **Slave Latency**

  This parameter gives the slave (peripheral) device the option of skipping a number of connection events. This gives the peripheral device some flexibility, in that if it does not have any data to send it can choose to skip connection events and stay asleep, thus providing some power savings. The decision is up to the peripheral device.

  The slave latency value represents the maximum number of events that can be skipped. It can range from a minimum value of 0 (meaning that no connection events can be skipped) to a maximum of 499; however the maximum value must not make the effective connection interval (see below) greater than 32.0s.

  The BlueMod+S42 uses the configuration command AT+LESLAVELAT to set the predefined slave latency timeout value.

- **Supervision Timeout**

  This is the maximum amount of time between two successful connection events. If this amount of time passes without a successful connection event, the device is to consider the connection lost, and return to an unconnected state. This parameter value is represented in units of 10ms. The supervision timeout value can range from a minimum of 10 (100ms) to 3200 (32.0s). In addition, the timeout must be larger than the effective connection interval (explained below).

  The BlueMod+S42 calculates this timeout value as followed:
  (Slave latency value + 1) x 2 x Connection interval time x 2

  Limitations of calculated "Connection supervision timeout":

calculated value:	+/- 10ms
minimum value:	>= 100ms
maximum value:	<= 32s

10.2. Optimize the Connection Interval from Slave by using the Slave Latency

The "effective connection interval" is equal to the amount of time between two connection events, assuming that the slave skips the maximum number of possible events if slave latency is allowed (the effective connection interval is equal to the actual connection interval if slave latency is set to zero). It can be calculated using the formula:

Effective Connection Interval = (Connection Interval) * (1 + (Slave Latency))

Take the following example:

Connection Interval:	80	(80 * 1.25ms =100ms)
Slave Latency:	4	
Effective Connection Interval:		(100ms) * (1 + 4) = 500ms

This tells us that in a situation in which no data is being sent from the slave to the master, the slave will only transmit during a connection event once every 500ms.

10.3. Identify the Required Connection Interval

Different applications may require different connection intervals. The advantage of having a very long connection interval is that significant power is saved, since the device can sleep most of the time between connection events. The disadvantage is that if a device has data that it needs to send, it must wait until the next connection event.

The advantage of having a very short connection interval is that there is more opportunity for data to be sent or received, as the two devices will connect more frequently. The disadvantage is that more power will be consumed, since the device is frequently waking up for connection events.

In many applications, the slave will skip the maximum number of connection events. Therefore it is useful to consider the effective connection interval when selecting the connection parameters. Selecting the correct group of connection parameters plays an important role in power optimization of the BLE device. The following list gives a general summary of the trade-offs in connection parameter settings:

Reducing the connection interval will:

- Increase the power consumption for both devices
- Increase the throughput in both directions
- Reduce the amount of time that it takes for data to be sent in either direction

Increasing the connection interval will:

- Reduce the power consumption for both devices
- Reduce the throughput in both directions
- Increase the amount of time that it takes for data to be sent in either direction

Reducing the slave latency (or setting it to zero) will:

- Increase the power consumption for the peripheral device
- Reduce the amount of time that it takes for data sent from the central device to be received by the peripheral device

Increasing the slave latency will:

- Reduce power consumption for the peripheral during periods when the peripheral has no data to send to the central device
- Increase the amount of time that it takes for data sent from the central device to be received by the peripheral device

10.4. Update the Connection Parameters

In some cases, the central device will request a connection with a peripheral device containing connection parameters that are unfavorable to the peripheral device. In other cases, a peripheral device might have the desire to change parameters in the middle of a connection, based on the peripheral application. The peripheral device can request the central device to change the connection settings by sending a "Connection Parameter Update Request".

This request contains four parameters:

- minimum connection interval
- maximum connection interval
- slave latency
- timeout

These values represent the parameters that the peripheral device desires for the connection (the connection interval is given as a range). When the central device receives this request, it has the option of accepting or rejecting the new parameters.

The BlueMod+S42 uses the configuration command AT+LECONPARAM to initiate the "Connection Parameter Update Request" message or report the current connection parameter set.

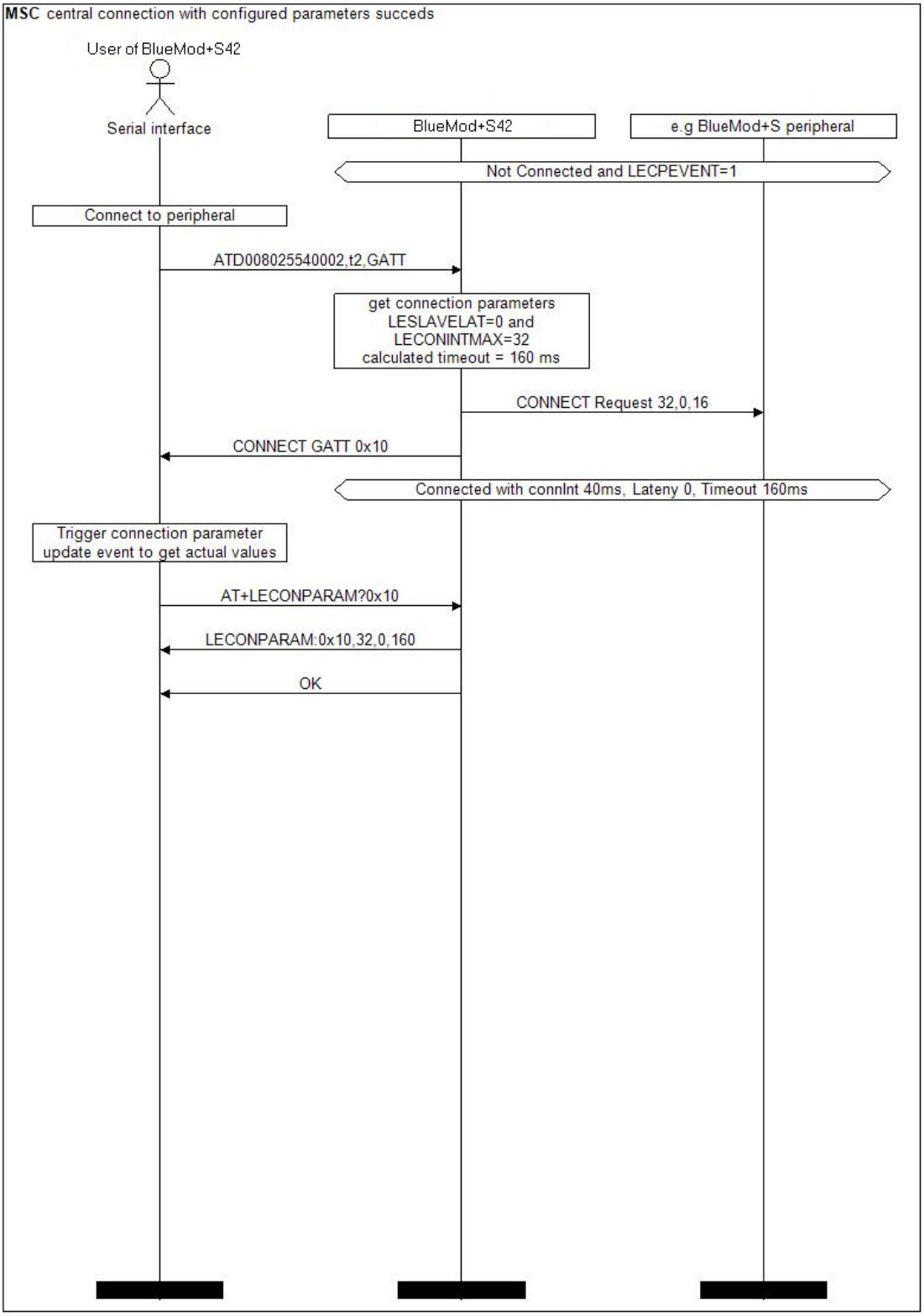
Changing the connection parameter set using the AT+LECONPARAM command effects in the current connection only. After disconnecting the GATT connection the BlueMod+S42 uses the configured connection parameters (AT+LECONINTMIN, AT+LECONINTMAX, AT+SLAVELAT, and the calculated connection timeout) for further connections.

To automatically signal a "Connection Parameter Update Request" the BlueMod+S42 uses the command "AT+LECPEVENT=1" that enables the reporting of connection parameter set changes to the local serial interface.
The BlueMod+S42 accepts all valid "Connection Parameter Update Requests" values of a peripheral device in order to save power consumption for the peripheral device.

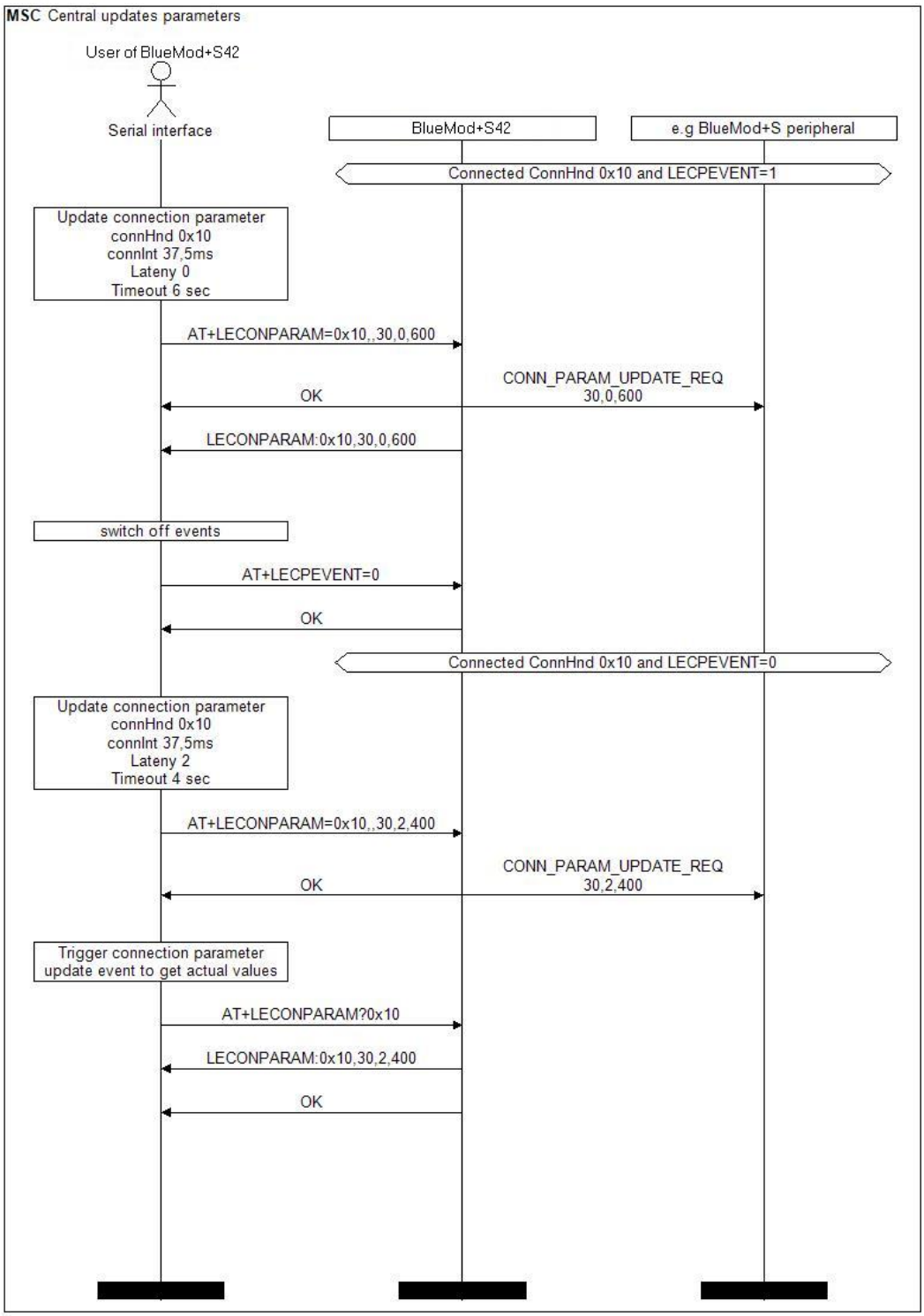
10.5. Connection Examples of Different Use Cases

The following examples will demonstrate Bluetooth LE GATT connections between different devices to demonstrate the initial connection parameter set and the possibility to monitor or change these connection parameter set.

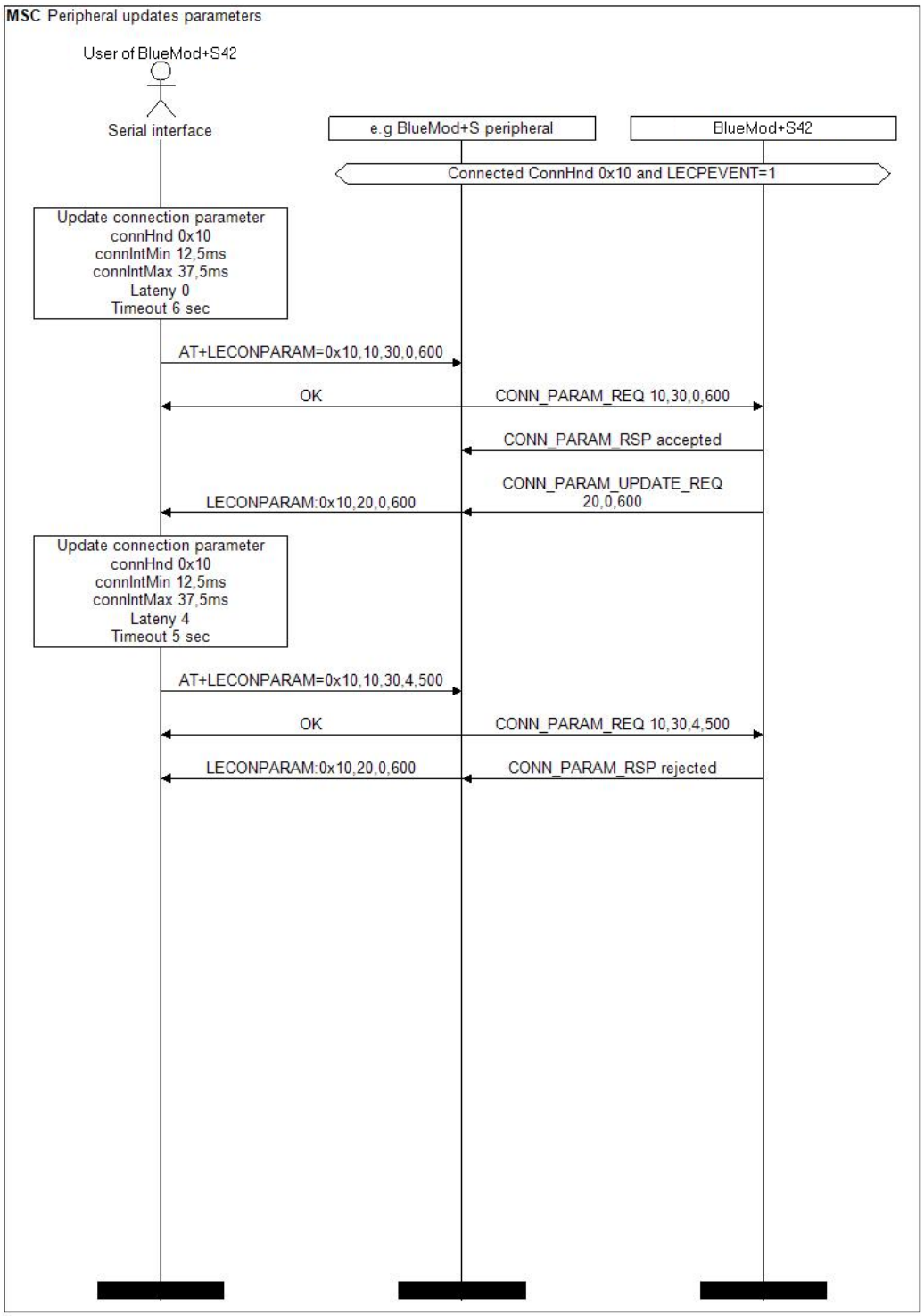
10.5.1. Central Side Initiates a GATT Connection



10.5.2. Central Side Changed Initial Connection Parameter



10.5.3. Peripheral Side Create a Connection Parameter Update Request



11. Document History

Revision	Date	Changes
r0	2016-08-19	First issue
r1	2016-10-05	Added new values 3,4 of AT+LETIO command, Added new chapter LE Secure Connections, Corrected value of AT+BIOCAP in connection example Terminal I/O "Passkey entry"