



life.augmented

# BlueNRG-LP를 이용한 Bluetooth LE 5.0 개발

STMicroelectronics Korea

Jun 11, 2020

성성유 차장



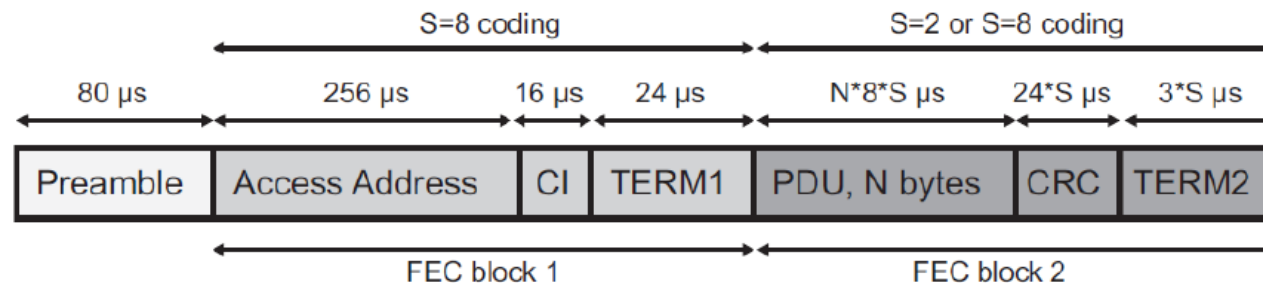
# Bluetooth LE 5.0(PHYs and LE Advertising Extensions)

# New PHY variants

- Bluetooth LE v5.0 adds two new PHY variants.
  - LE 2M PHY
    - 2Ms/s, GFSK.
    - It allows the physical layer to work at 2 Mbps and, as consequence, the application can achieve higher data rates than LE 1M. Since packets are shorter, power consumption is improved.
  - LE Coded PHY
    - LE Coded PHY uses the Forward Error Correction (FEC) to correct errors on received packets.
    - This allows the received packet to be correctly decoded and increases the transmitter distance.
  - LE 1M PHY(Bluetooth LE v4.x)
    - 1Ms/s, GFSK.

# New PHY variants

- LE 2M PHY
  - 2 Msym/s modulation
  - Uncoded data packet.
  - Same packet format for all uncoded PHYs (LE 1M and LE 2M)
    - Only preamble is different (twice the bits for LE 2M in order to have same duration)
- LE Coded PHY
  - 1 Msym/s modulation
    - Same as LE 1M
  - Payload can be coded with two different rates:
    - 500 kb/s ( $S = 2$ )
    - 125 kb/s ( $S = 8$ )



# New PHY variants

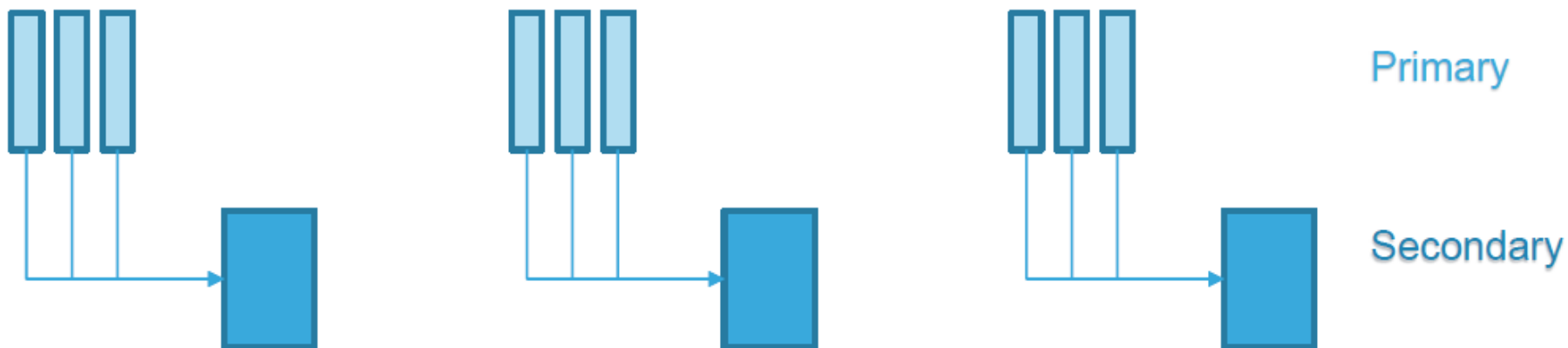
	LE 1M	LE Coded S=2	LE Coded S=8	LE 2M
Symbol Rate	1Ms/s	1Ms/s	1Ms/s	2Ms/s
Data Rate	1Mbit/s	500 Kbit/s	125 Kbit/s	2 Mbit/s
Error detection	CRC	CRC	CRC	CRC
Error Correction	NONE	FEC	FEC	NONE
Range Multiplier (approx.)	1	2	4	0.8
Bluetooth 5 Requirement	Mandatory	Optional	Optional	Optional

# Extended Advertising

- Bluetooth low energy v5.0 advertising extension capability allows
  - to extend the data length in connectionless scenarios (i.e. beacon)
  - to have multiple sets of advertising data to be sent
  - Bluetooth low energy v4.x : payload size for advertising (31 Bytes)
- New extended advertising packets can use the BLE 4.x connection channels (0-36) for extending advertising payload up to 255 octets.
- Initial advertising and legacy PDUs are transmitted on 3 RF channels (37,38, 39), known as “primary advertising physical channel”.
- Most of the communication is made on 37 RF channels, the “secondary advertising physical channel”.

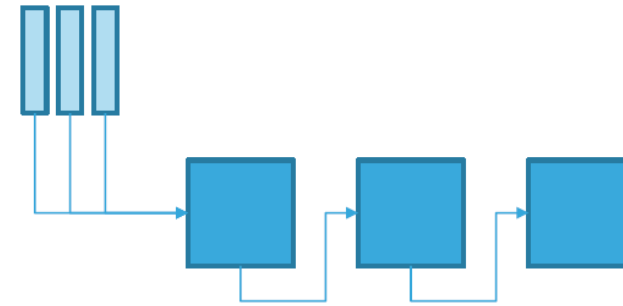
# Extended Advertising

- ADV\_EXT\_IND: new packet that can be sent on the Primary AdvPhyChannel
- If needed, it contains the pointer to an auxiliary packet on the Secondary AdvPhychannel
- Most of the info is on the Auxiliary packet



# Extended Advertising

- It is also possible to create a chain of advertising packets on Secondary channels in order to transmit more advertising payload data
  - Each advertising packet on Secondary Channel includes on its AuxPtr the number of the next Secondary Channel for the next advertising packet on the chain.
  - Each packet in the chain can be sent on a different RF channel.
  - AuxPtr : 6 bits channel index.(not physical channel)



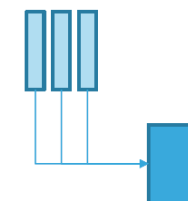
- **Reduced Contention and Duty Cycle**

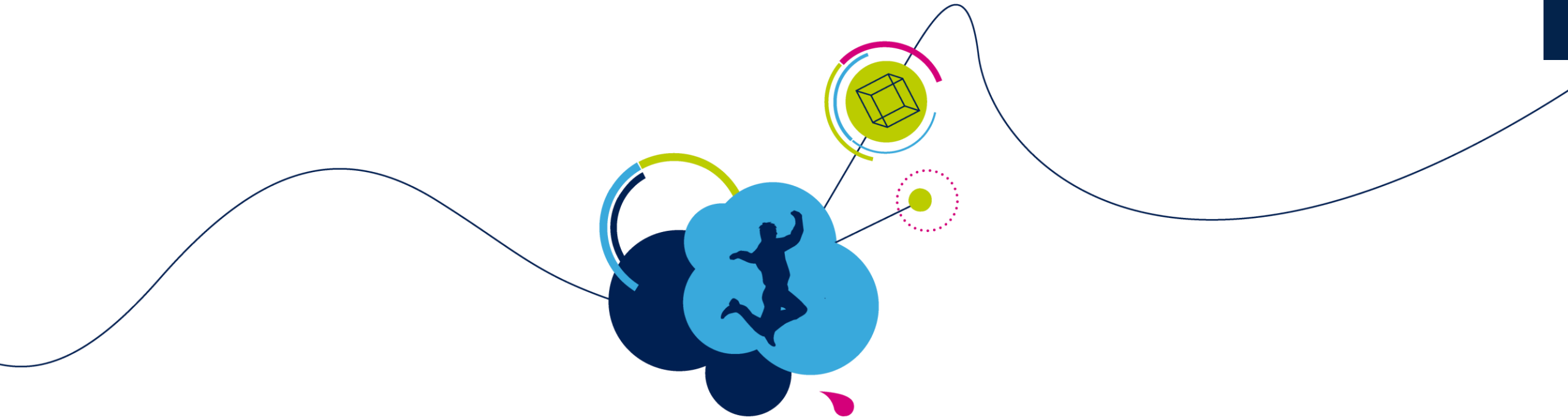
- A direct advantage of new extended advertising packets is the capability to send less data on Primary Channel (37,38,39) reducing the contention.
- Advertising data is sent only once, on the Secondary Channel, instead of 3 times on channel 37, 38 and 39: overall duty cycle is reduced.

Legacy Advertising



Extended Advertising





# BlueNRG-LP introduction



# Introducing BlueNRG-LP

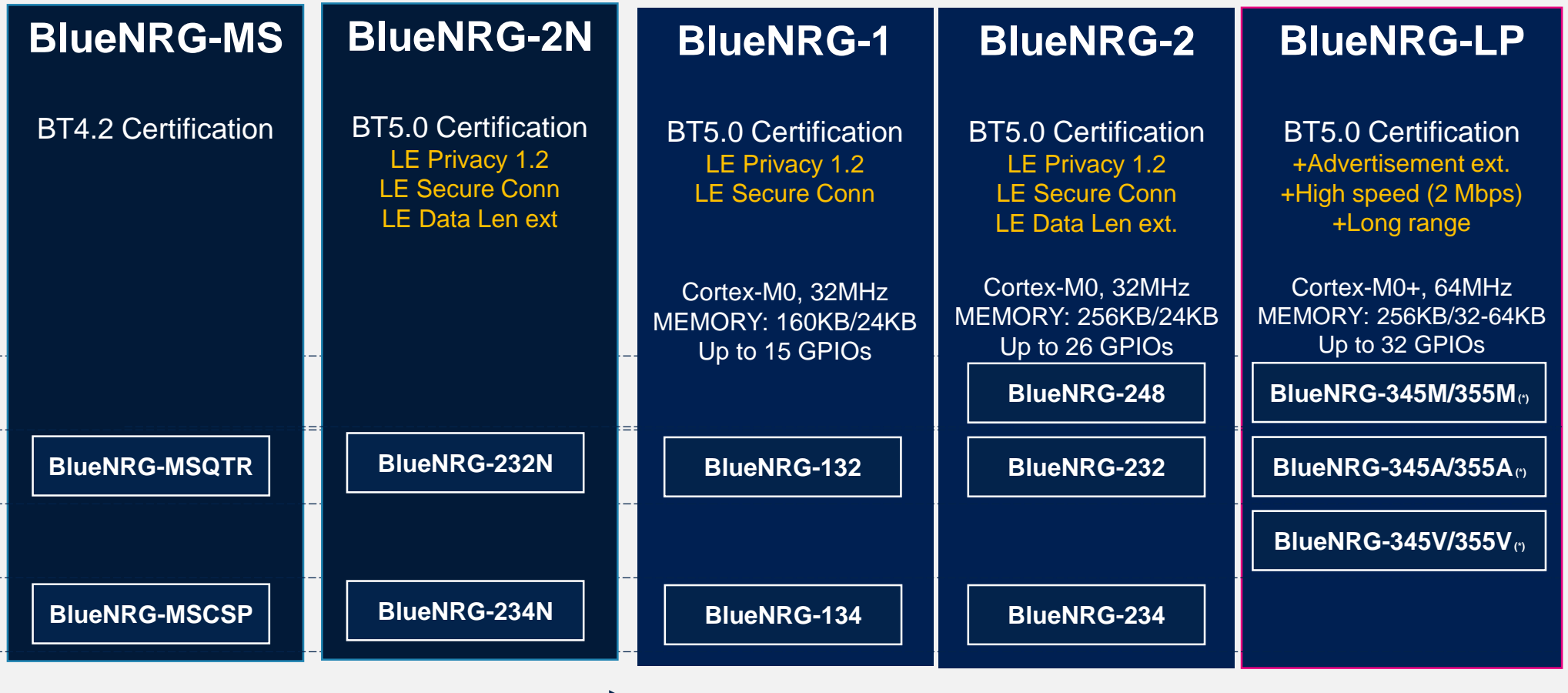
## BlueNRG 3<sup>rd</sup> Generation



Network CoProcessor

Wireless SoC

Scalability ↑



Value →

Value →



life.augmented

10-year longevity commitment on BlueNRG and Spirit, chips and modules



# BlueNRG-2N

## BLE 5.0 Network CoProcessor (fully compliant with BLE Core v4.2)

### Key Highlights

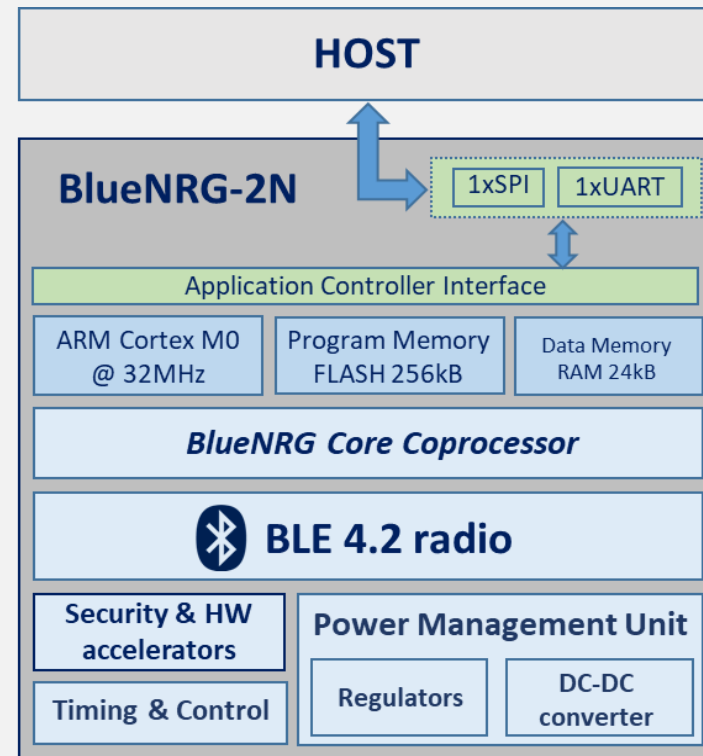
#### Bluetooth LE 5.0 certified

#### Radio performances

- Sleep current consumption down to 900 nA
- TX current consumption 6.8 mA (@ -2 dBm, 3.0 V)
- RX current consumption 6.2 mA (@ sensitivity level, 3.0 V)
- Up to +8 dBm programmable output power level (@ antenna connector).
- Excellent RF link budget (up to 96 dB)
- Integrated DC/DC Step Down Converter and LDO regulators.

The device comes pre-programmed with a production-ready and certified stack image.

### Block Diagram



### Availability

BlueNRG-232N QFN32  
BlueNRG-234N WLCSP

### Device information

- Selectable **SPI** or **UART** interface (via 1 GPIO)
- **FOTA** supported ( 256kB Flash embedded )
- **LE Data Length Extension** (up to 700kbps at application level)
  - Over-the-air firmware update is 2.5 times faster
- **LE Privacy 1.2**
  - Reduces the ability to be tracked over a period of time by changing address on a frequent basis without involving the HOST and saving battery life.
- **LE Secure Connections**
  - The pairing mechanism is established with the Elliptic Curve Diffie-Hellman (ECDH) key agreement protocol enabling a secure Key Exchange mechanism preventing eavesdropping.
- **Multi master to multi slave communication guaranteed.**
  - 2 Masters to 6 slaves simultaneously
  - Up to 8 simultaneous connections handled.
- Operating supply voltage: from 1.7 to 3.6 V
- Operating temperature: from -40 up to **105 °C**
- **Ordering codes**
  - **BlueNRG-232N** QFN32
  - **BlueNRG-234N** WLCSP



# BlueNRG-LP SoC

## More than BLE 5.0 fully compliant

### Key Highlights

#### Bluetooth LE 5.0 certified

#### Radio performances

- RX Sensitivity level
  - -97dBm @ 1Mbps
  - -104 dBm @ 125kbps
- Up to +8 dBm output power level. (1dBm step)
- 4.3 mA TX current (@ -2 dBm, 3.3 V)
- 3.4 mA RX current (@ sensitivity level, 3.3 V)

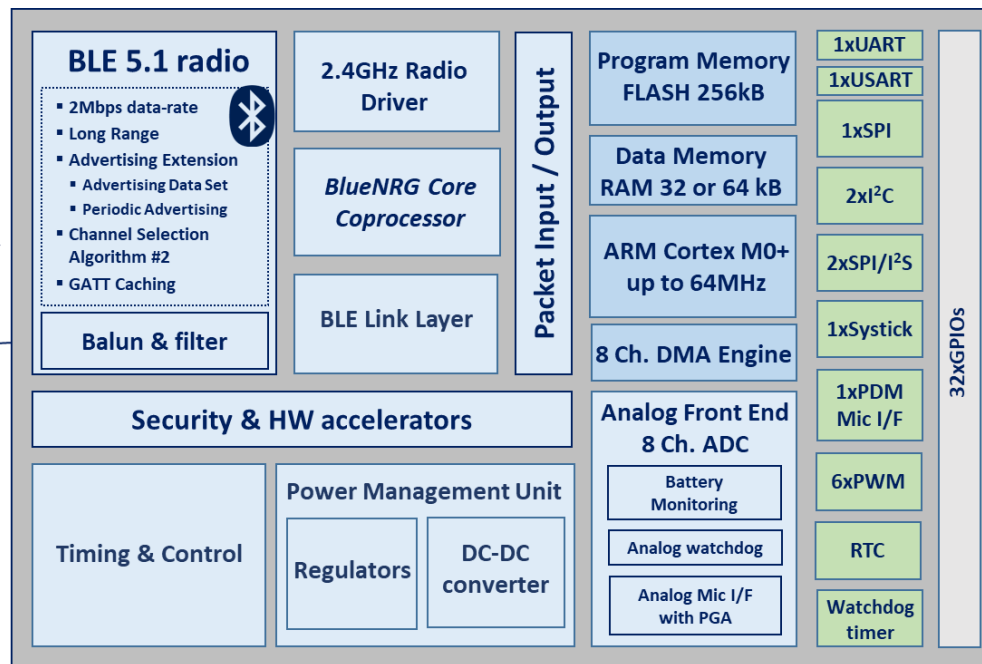
#### Reduced BOM cost

- Integrated Balun & Filter.
- Capacitor-less 32MHz crystal.

#### Advanced security set

- Flash read/write protection.
- Secure bootloader
- SWD access can be disabled

### Block Diagram



### ORDERING CODES

- **BlueNRG-345AC / BlueNRG-355AC** - Package QFN32
- **BlueNRG-345MC / BlueNRG-355MC** - Package QFN48
- **BlueNRG-345VC / BlueNRG-355VC** - Package WLCSP

### Device information

- High Throughput: 2Mbps Data Rate
- Distance Robustness: Long-range 125kbps or 500kbps
- Advertisement Extension: 255 bytes Advertising data, Advertising Data Set and Periodic Advertising Sync Transfer
- Robust Frequency Hopping: Channel Selection Algorithm #2
- GATT caching
- ARM Cortex-M0+, 64 MHz
- 256-Kbyte Flash, **32 / 64-KByte** SRAM, MPU
- Extensive peripheral set: 2 x SPI / I2S, 1x SPI, 2 x I<sup>2</sup>C, 1 x USART, 1 x UART, 6 x PWM, 1 x PDM, 1 x 12-bit ADC SAR
- Analog microphone i/f with PGA
- True Random Number Generator (RNG)
- Hardware encryption AES 128-bit security co-processor
- HW public key accelerator (PKA)
- CRC calculation unit
- 48-bit unique ID
- Operating supply voltage: from 1.7 to 3.6 V
- Operating temperature: from -40 up to 105 'C
- Package available: QFN32 (20 GPIOs), QFN48 (32 GPIOs), WLCSP49 (26 GPIOs)





# BlueNRG-LP ~ BlueNRG-305

## More than BLE 5.0 fully compliant

### Key Highlights

#### Bluetooth LE 5.0 certified

#### Radio performances

- RX Sensitivity level
  - -97dBm @ 1Mbps
  - -104 dBm @ 125bps
- Up to +8 dBm output power level.
- 4.3 mA TX current
- 3.4 mA RX current

#### Reduced BOM cost

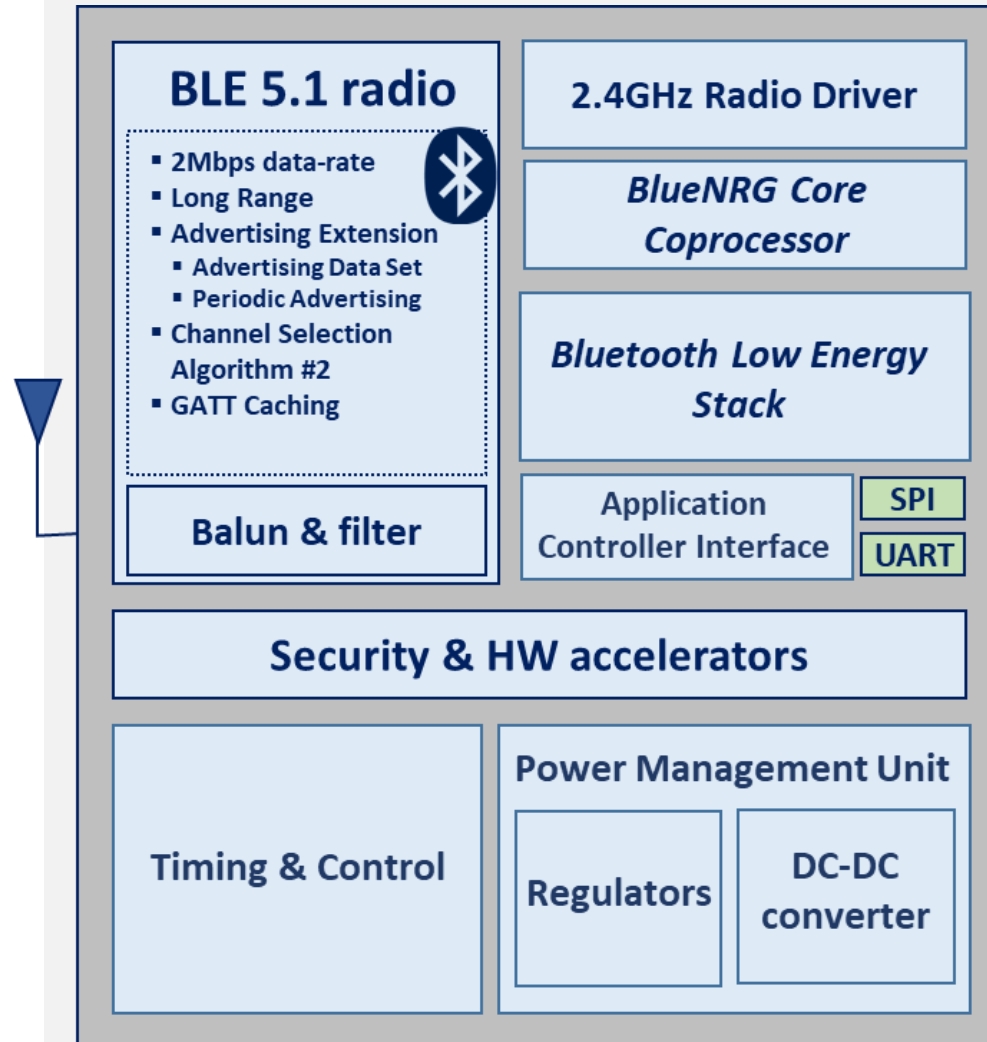
- Integrated Balun & Filter.
- Capacitor-less 32MHz crystal.

#### Advanced security set

- Flash read/write protection.
- Secure bootloader

#### Preloaded certified stack

### Block Diagram



### Device information

- High Throughput: 2Mbps Data Rate
- Distance Robustness: Long-range 125kbps or 500kbps
- Advertisement Extension: 255 bytes Advertising data, Advertising Data Set and Periodic Advertising Sync Transfer
- Frequency Hopping Robustness: Channel Selection Algorithm #2
- GATT caching
- True Random Number Generator (RNG)
- Hardware encryption AES maximum 128-bit security co-processor
- HW public key accelerator (PKA)
- CRC calculation unit
- 48-bit unique ID
- Operating supply voltage: from 1.7 to 3.6 V
- Operating temperature: from -40 up to 105 °C
- **Ordering codes**
  - **BlueNRG-305AC** QFN32
  - **BlueNRG-305VC** WLCSP49





# BLUENRG-LP Portfolio





# BlueNRG-LP: features for every need

## Wearable



Ultra-low power consumptions

## Lighting



Up to 32 GPIOs and 6 channels PWM

## Beacon / Retail / Tracking



Long Range

## Healthcare



Secure boot and OTA FW Upgrade

## Audio Electronics



Dual I2S interface for Complex Algorithms computation

## Personal Electronics



PGA interface to un-expensive Analog Microphones

## Toys / Gaming / Controllers



2 Mbps

## Home Appliance



CSA#2 for usage in high interference environments





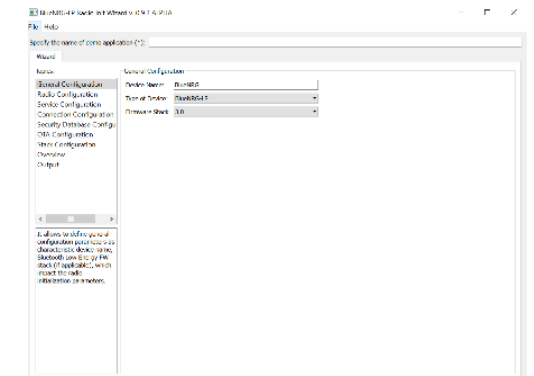
# PC Tools & Utilities

# PC tools & utilities

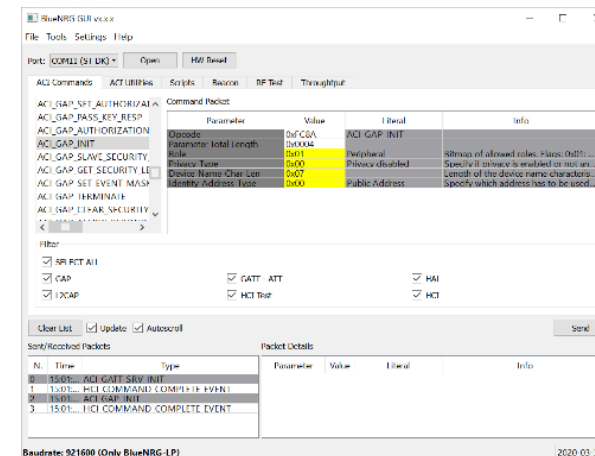
- Support DK for IAR and Keil
  - IAR and Keil patches for BlueNRG-LP
    - C:\Users\{username}\ST\BlueNRG-LP DK {version}\Utility
    - New Keil service pack v1.1.1
- BlueNRG-LP Navigator
- BlueNRG-LP Radio Init Wizard
- BlueNRG-GUI
  - BlueNRG-LP and BLE stack v3.x support
- BlueNRG-X Flasher utility
  - BlueNRG-LP (UART, SWD through CMSIS-DAP)



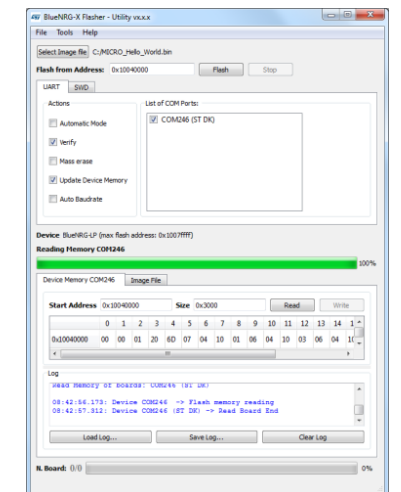
BlueNRG-LP Navigator



BlueNRG-LP Radio Init Wizard



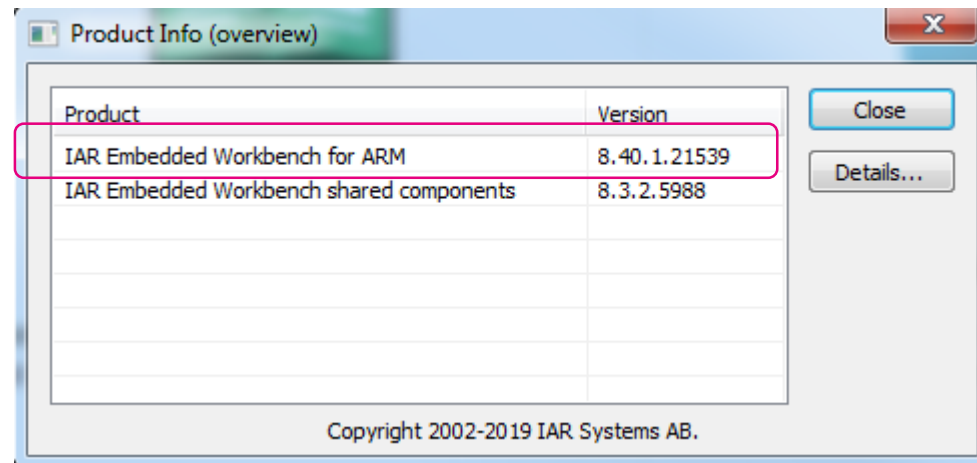
BlueNRG GUI



BlueNRG-X Flasher

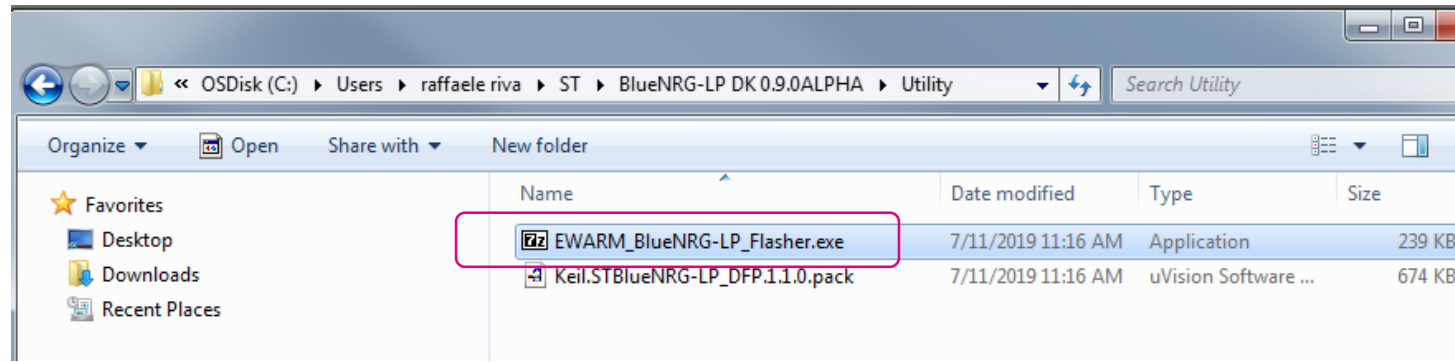
# IAR EW flash loader installation 1/4

- Install IAR Embedded Workbench for Arm **Version 8.40**
- You can download the version 8.40 from “My Pages” at [www.iar.com](http://www.iar.com)

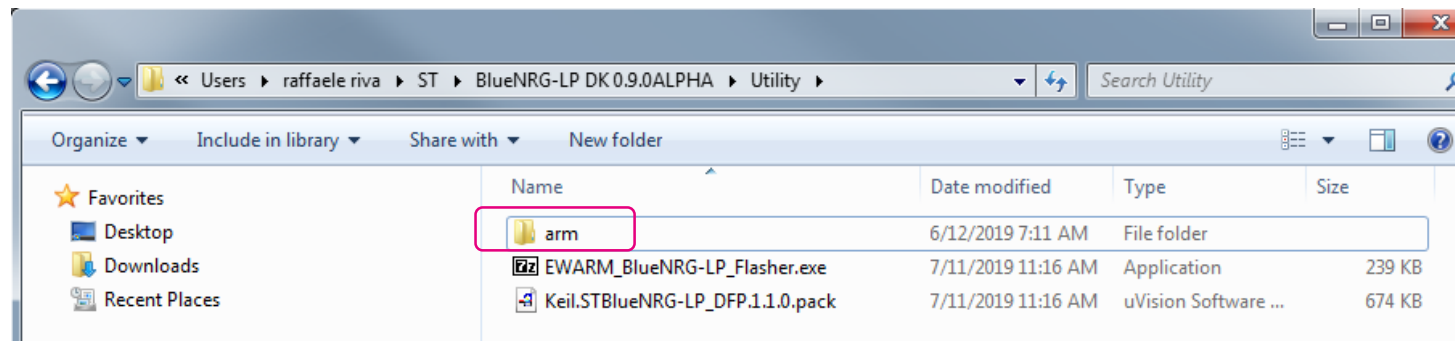


# IAR EW flash loader installation 2/4

1. Go to the PC folder “**C:\Users\{user name}\ST\BlueNRG-LP DK {version}\Utility**”
2. Select **EWARM\_BlueNRG-LP\_Flasher.exe** and double click on the file

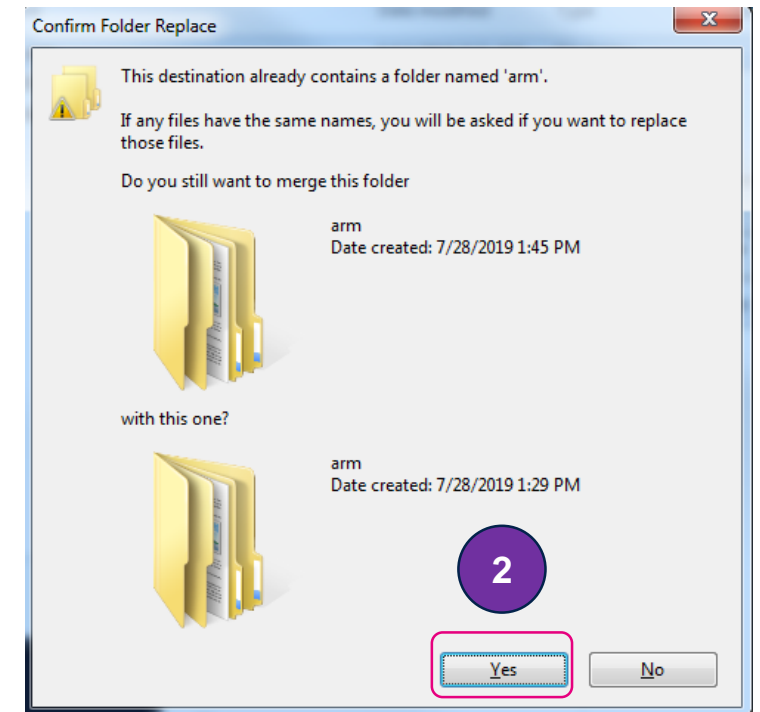
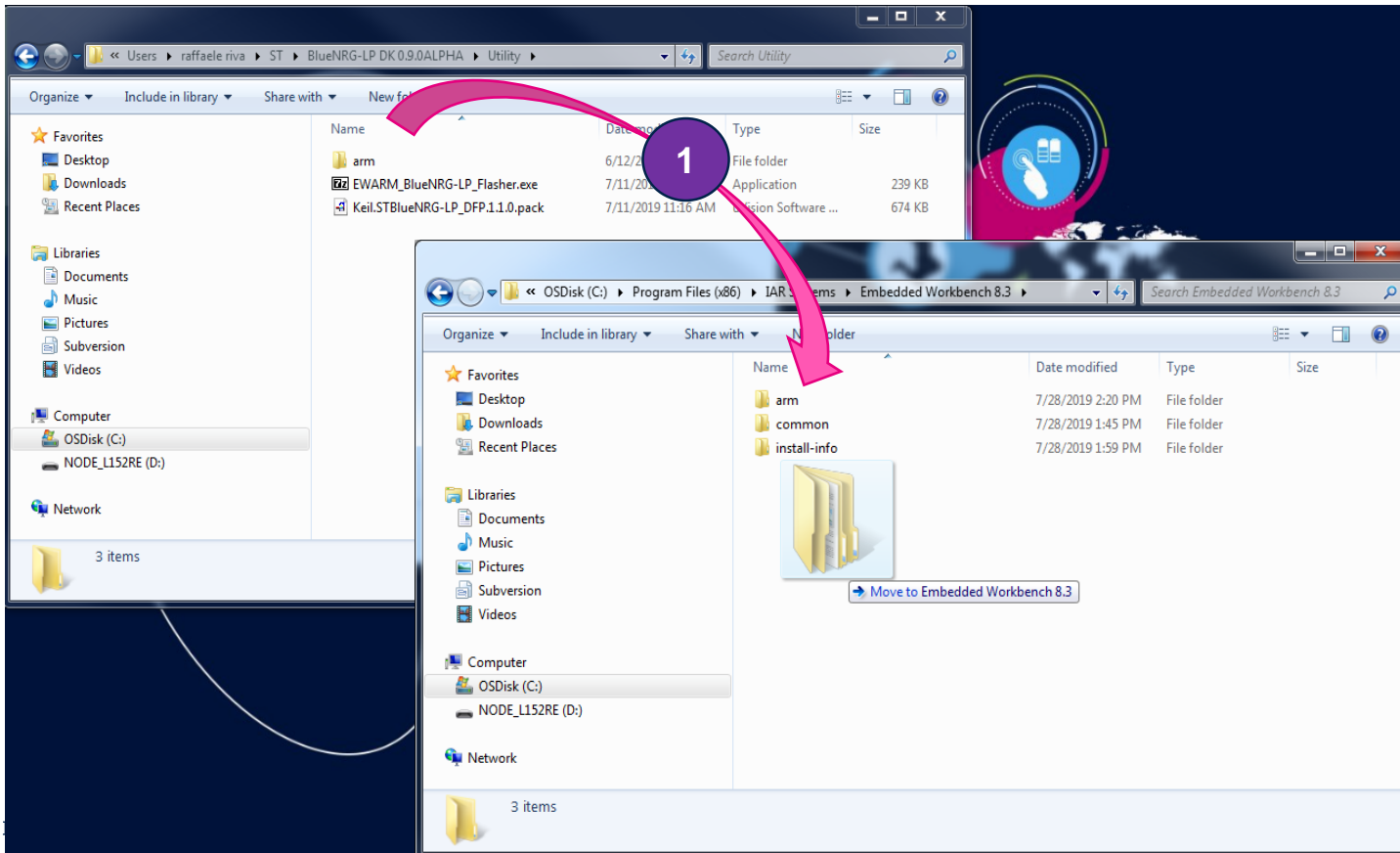


3. Extract the files in the same folder: a new **arm** folder will appear



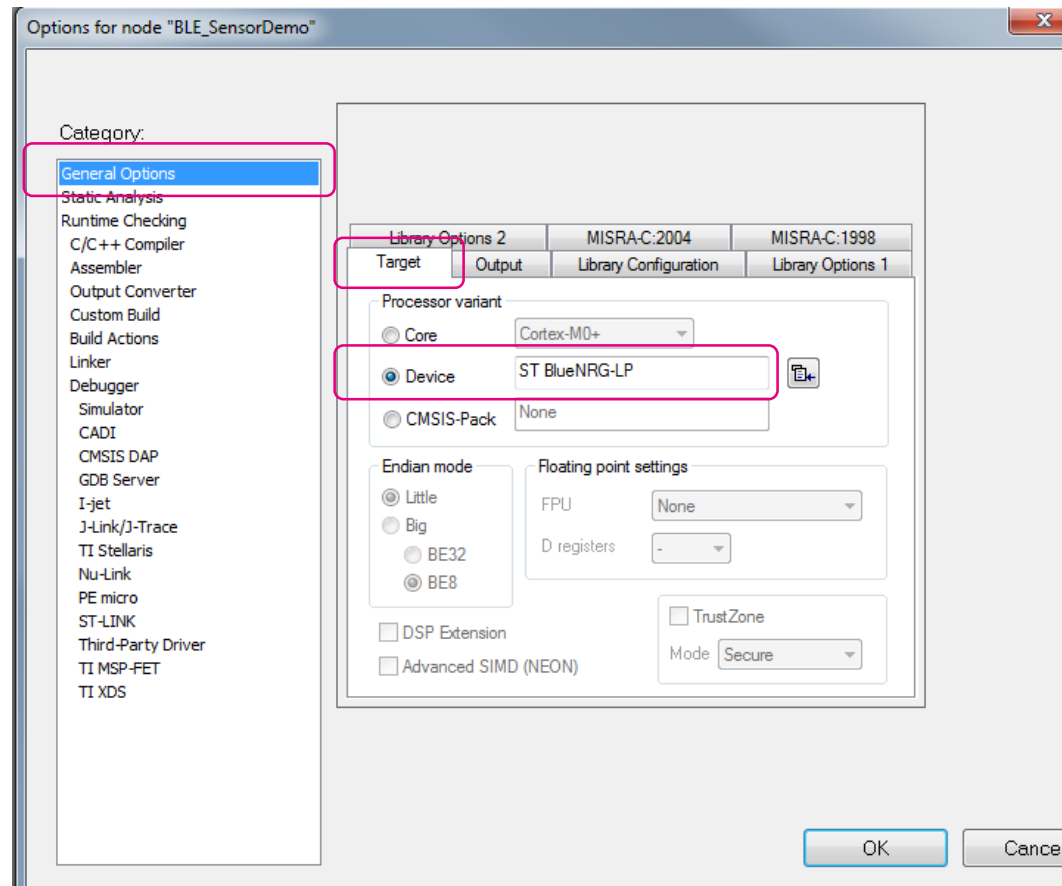
# IAR EW flash loader installation 3/4

1. Move the folder “arm” to the IAR EW installation path “C:\Program Files (x86)\IAR Systems\Embedded Workbench 8.3”.
2. A pop-up window will appear “Confirm Folder Replace”. Select Yes, this will merge the two folders bringing in the IAR installation folder the necessary files for building a project with the BlueNRG-LP as the target device.



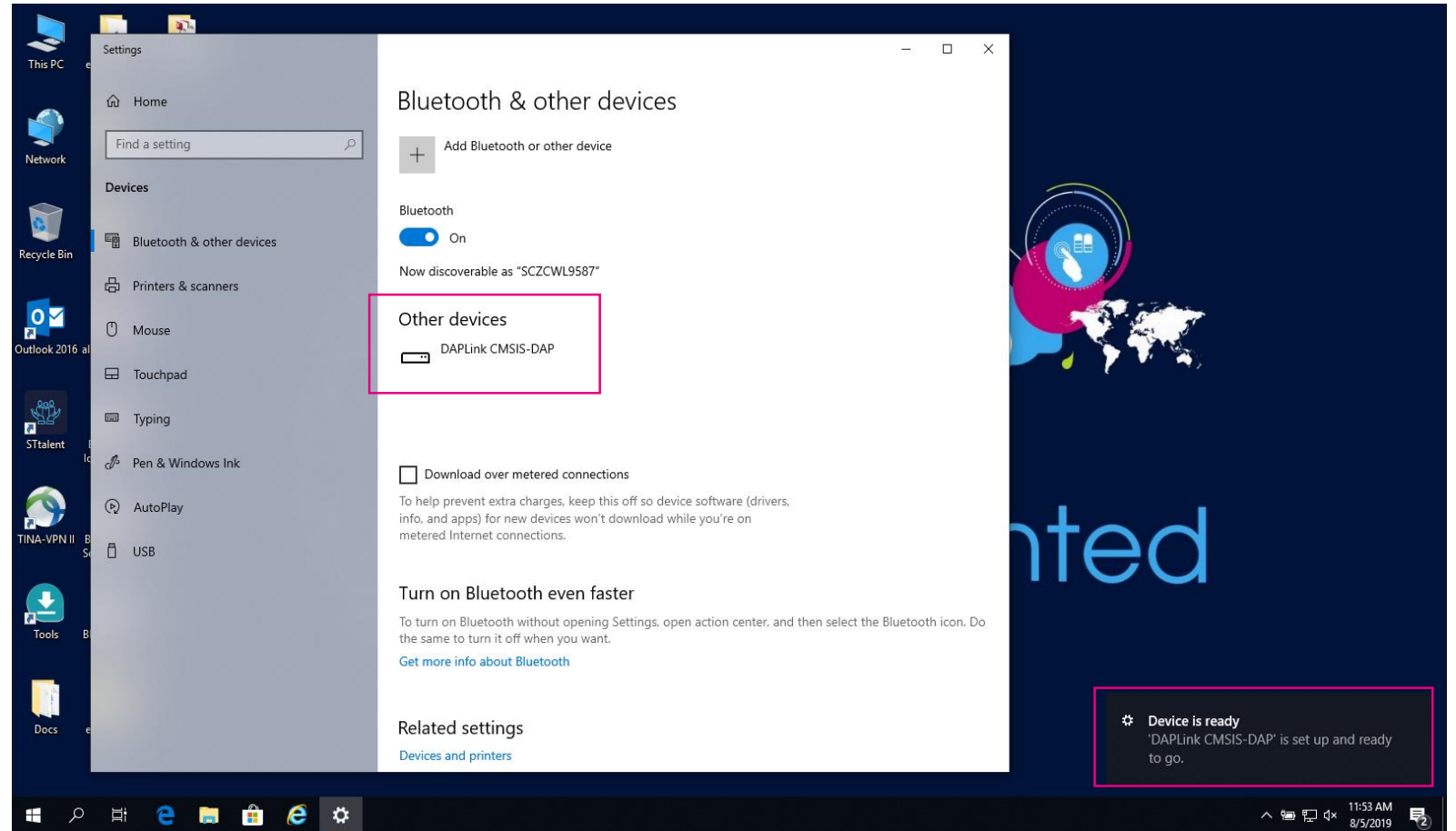
# IAR EW flash loader installation 4/4

- **Final check**, open a project and build it. As an example open the project:
  - **BLE\_SensorDemo.eww** in the folder C:\Users\your username\DK {version}\Projects\BLE\_Examples\BLE\_SensorDemo\EWARM\STEVAL-IDB011V1
  - Go to the project Options (tab "Project->Options"). In the tab "**General Options->Target**" you should see the ST BlueNRG-LP as the target device (see screenshot)
  - As you build the code (F7) the binary files will be created in the SDK folder "\Projects\BLE\_Examples\BLE\_SensorDemo\EWARM\STEVAL-IDB011V1\Release\Exe"



# CMSISDAP FW (Windows 10 users)

- BlueNRG-LP is installed and recognized by the Operating System as DAPLink CMSIS-DAP device natively
- No need to install any additional drivers



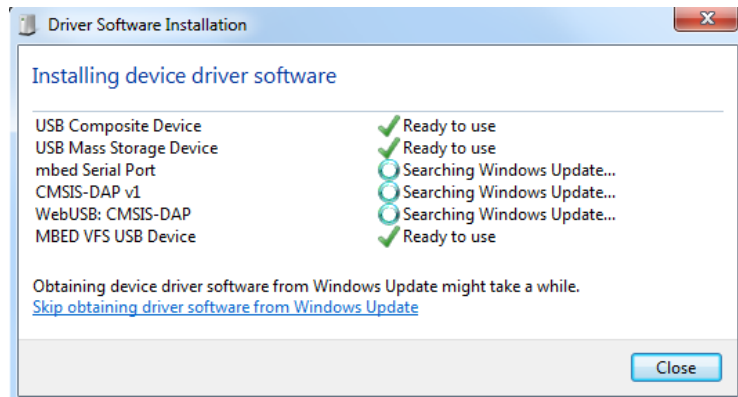
# USB CMSISDAP FW (Windows 7 ONLY users)

- In Windows 7 (not in Windows 10), install the Virtual COM port driver files available in the following web site:
  - <https://os.mbed.com/docs/mbed-os/v5.7/tutorials/windows-serial-driver.html>
  - Follow the installation instructions included in the web page.
- Before using the STEVAL-IDB011V1 align the USB\_CMSISDAP to the latest available version:
  - Follow the instructions here: C:\Program Files (x86)\STMicroelectronics\BlueNRG-LP DK {version}\Docs\USB\_CMSISDAP\_FW\_upgrade\_procedure\USB\_CMSISDAP\_FW\_upgrade\_procedure.html
- After upgrading the USB\_CMSISDAP FW, please unplug and re-plug again the STEVAL-IDB011V1 to the PC USB port, and wait for complete board recognition with associated PC drivers.
- See next slides for driver installation

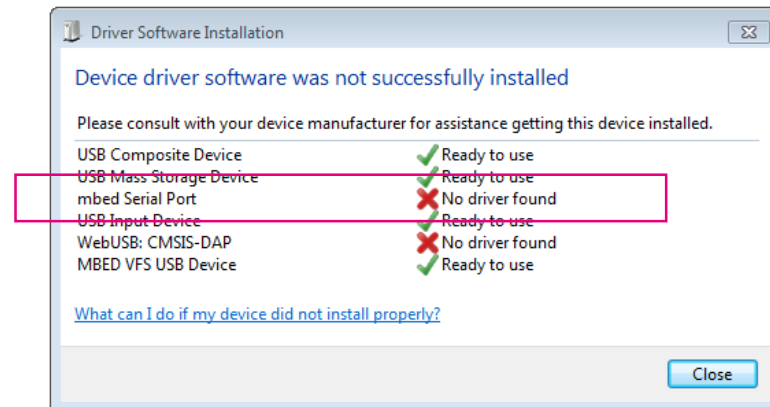
# USB CMSISDAP FW (Windows 7 ONLY users)

1. As you'll plug the board in the PC the Driver Software installation will start automatically using Windows Update
2. mbed Serial Port driver will NOT be installed automatically

1

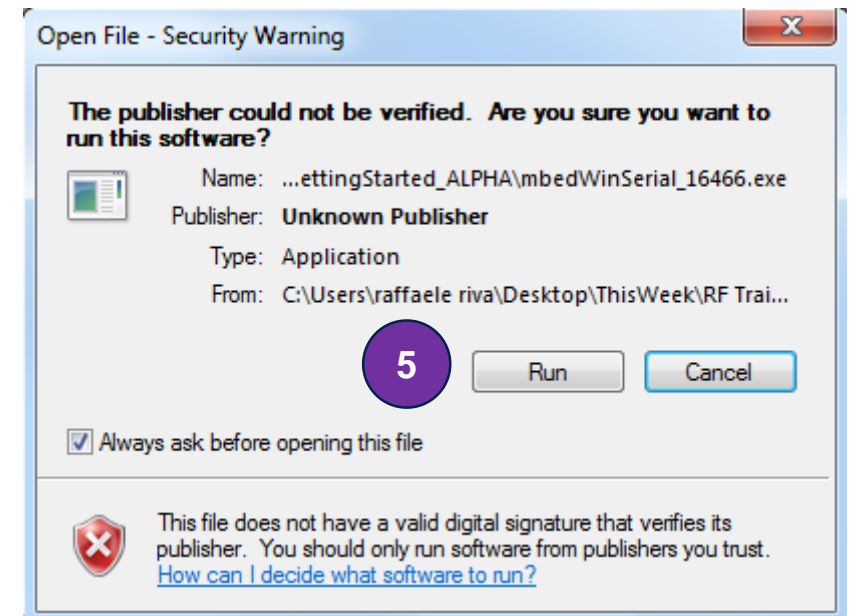
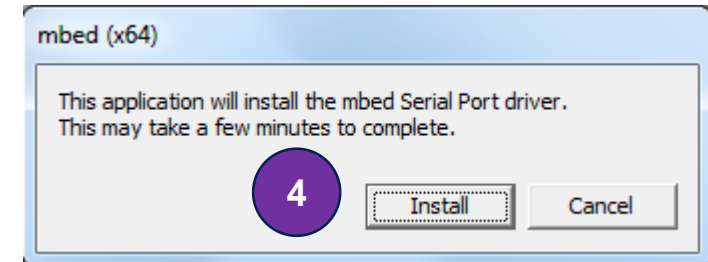
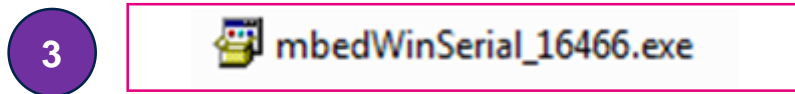


2



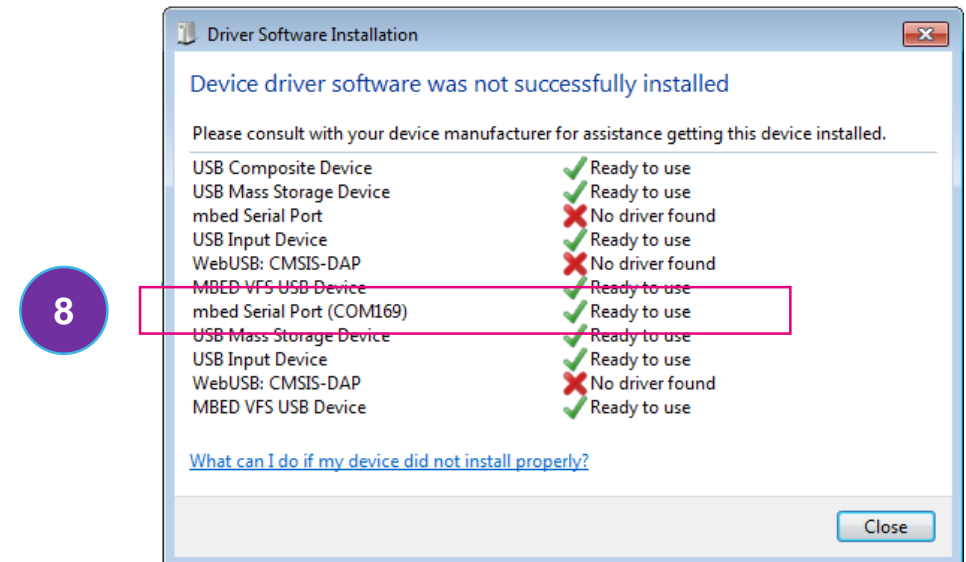
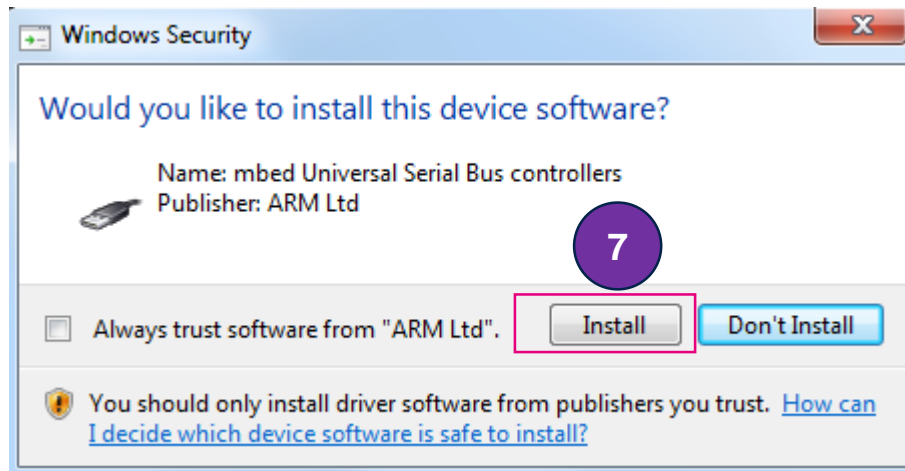
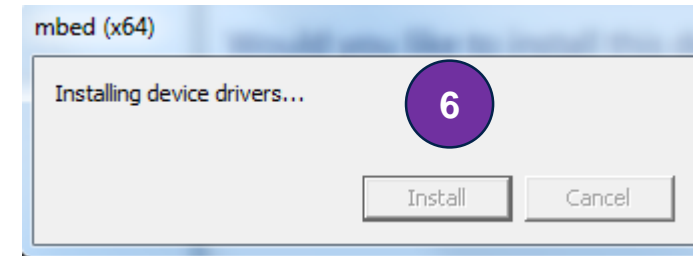
# USB CMSISDAP FW (Windows 7 ONLY users)

3. Launch the mbedWinSerial\_16466.exe
4. Click on “Install” on the pop-up window
5. Click on “Run” on the Security Warning pop-up



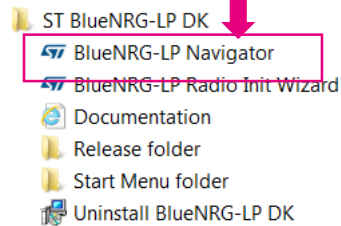
# USB CMSISDAP FW (Windows 7 ONLY users)

6. The Driver installation will start
7. Click on "Install" on the mbed Universal Serial Bus pop-up window
8. Once the driver is installed, a COM port will be associated to the mbed Serial Port



# BlueNRG-LP Navigator

- Direct access to all available demo applications in order to
  - Load and run prebuilt binary images
  - Get access to application documentation
  - Get access to application project folder (IDE toolchain + header, source files)
- BlueNRG-LP Navigator must be launched from the tab available on BlueNRG-LP DK Start Menu



- Alternatively, user can launch the BlueNRG-LP\_Navigator\_RUN.bat available on Application folder

**BlueNRG-LP Navigator v.0.9.2 ALPHA**

**Demonstration Applications**

- Demonstration Applications
- Development Kits
- Release Notes
- License File
- Documentation Index

**BlueNRG-LP**

BlueNRG-LP is a very low power Bluetooth low energy on Chip, compliant with Bluetooth specification.

The BlueNRG-LP extends the features of award-winning BlueNRG-1, BlueNRG-2 System on Chips, enabling a range of M0+ for running the user application code.

**BlueNRG-LP Navigator v.0.9.2 ALPHA**

**STEVAl-IDB011V1**

Hover the mouse pointer to highlight the item on the board

JUMPERS	PINS		
JP1	A1	A7	B7
JP2	A11	A8	B8
JP3	A12	A9	B9
JP4	A13	B0	GND
JP5	A14	B14	RST
	A15	B2	VBAT
	A4	B3	
	A5	B4	
	A6	B5	

**LEDs**

- DL1
- DL2
- DL3
- DL4
- US

**Buttons**

- PUSH1
- PUSH2
- RESET

**COMPONENTS**

- 32KHz crystal (Low Speed)
- 32MHz crystal (RF)
- 8MHz crystal (uC)
- BlueNRG-LP (QFN48)
- PS223H1
- LSM6DSOX
- Micro USB
- SMA connector
- USB to UART/CMSIS-DAP micro

The battery holder is on the back

**Bluetooth**

**BlueNRG-LP Navigator v.0.9.2 ALPHA**

**ExtendedAdv**

Hover the mouse pointer to highlight the item on the board

**RESET** - Reset BlueNRG-LP

**BLE Beacon**

This is a BLE beacon demo that shows how to configure a BlueNRG-LP device in order to advertise specific manufacturing data and allow another BLE device to know if it is in the range of the BlueNRG-LP beacon device. It provides a reference example about how using the BLE Over-The-Air (OTA) Service Manager firmware upgrade capability. This example also allows to use the extended advertising feature in order to configure beacon also on a secondary advertising channel.

**Usage**

The Beacon demo configures a BlueNRG-LP device in advertising mode (non-connectable mode) with specific manufacturing data. It transmits advertisement packets at regular intervals which contain the following manufacturing data:

Board selected: COM55

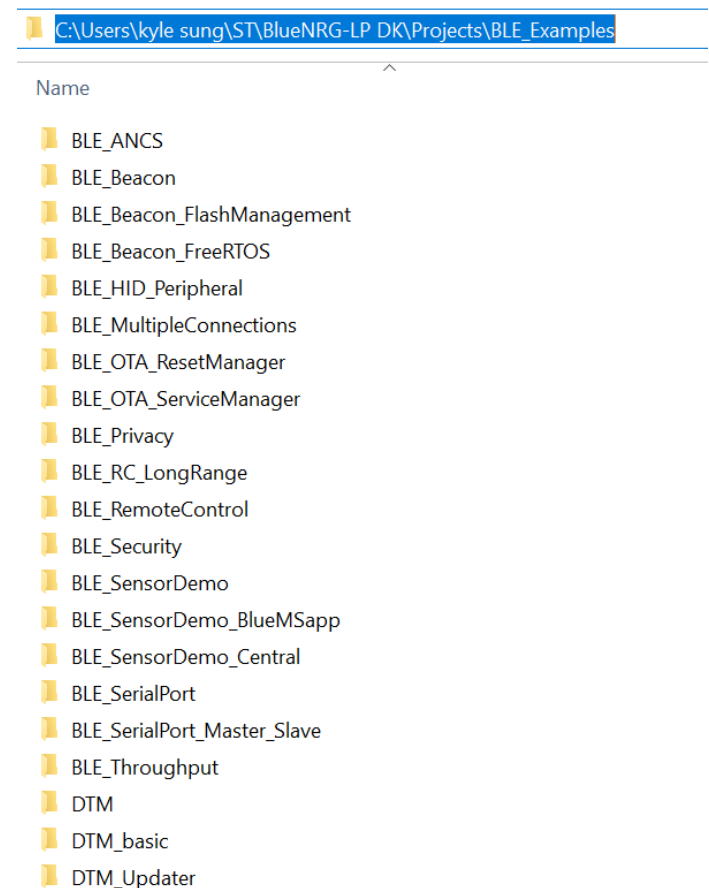
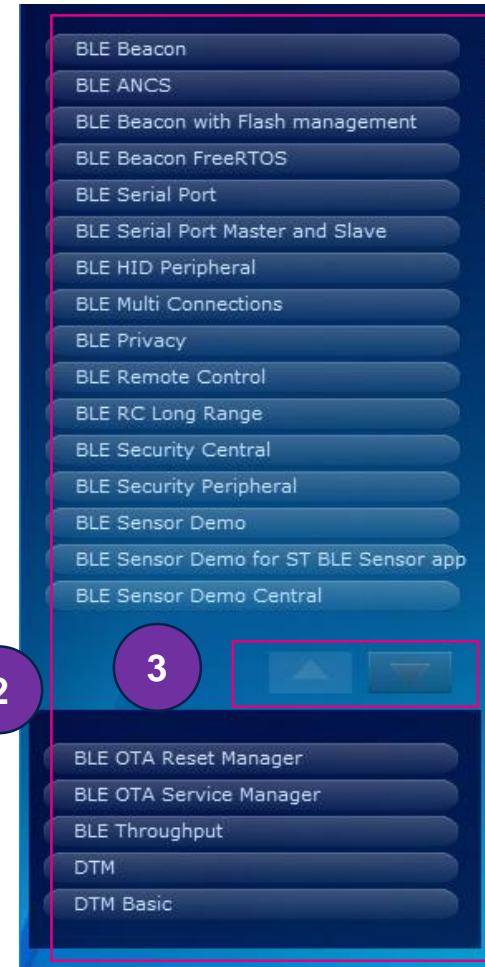
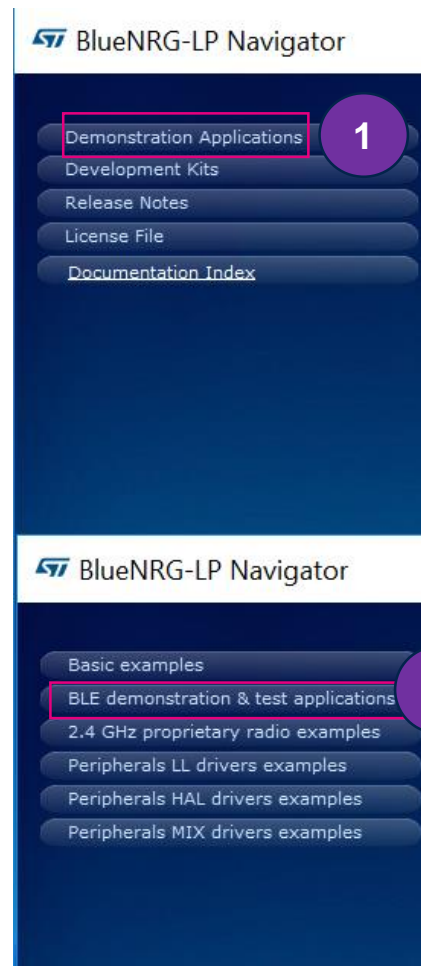
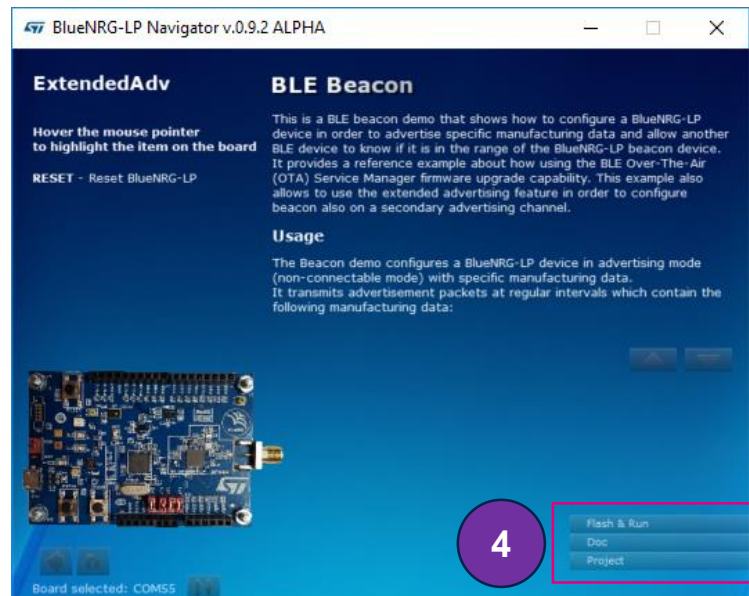
**1**

- Flash & Run
- Doc
- Project

1. Flash & Run / Doc / Project

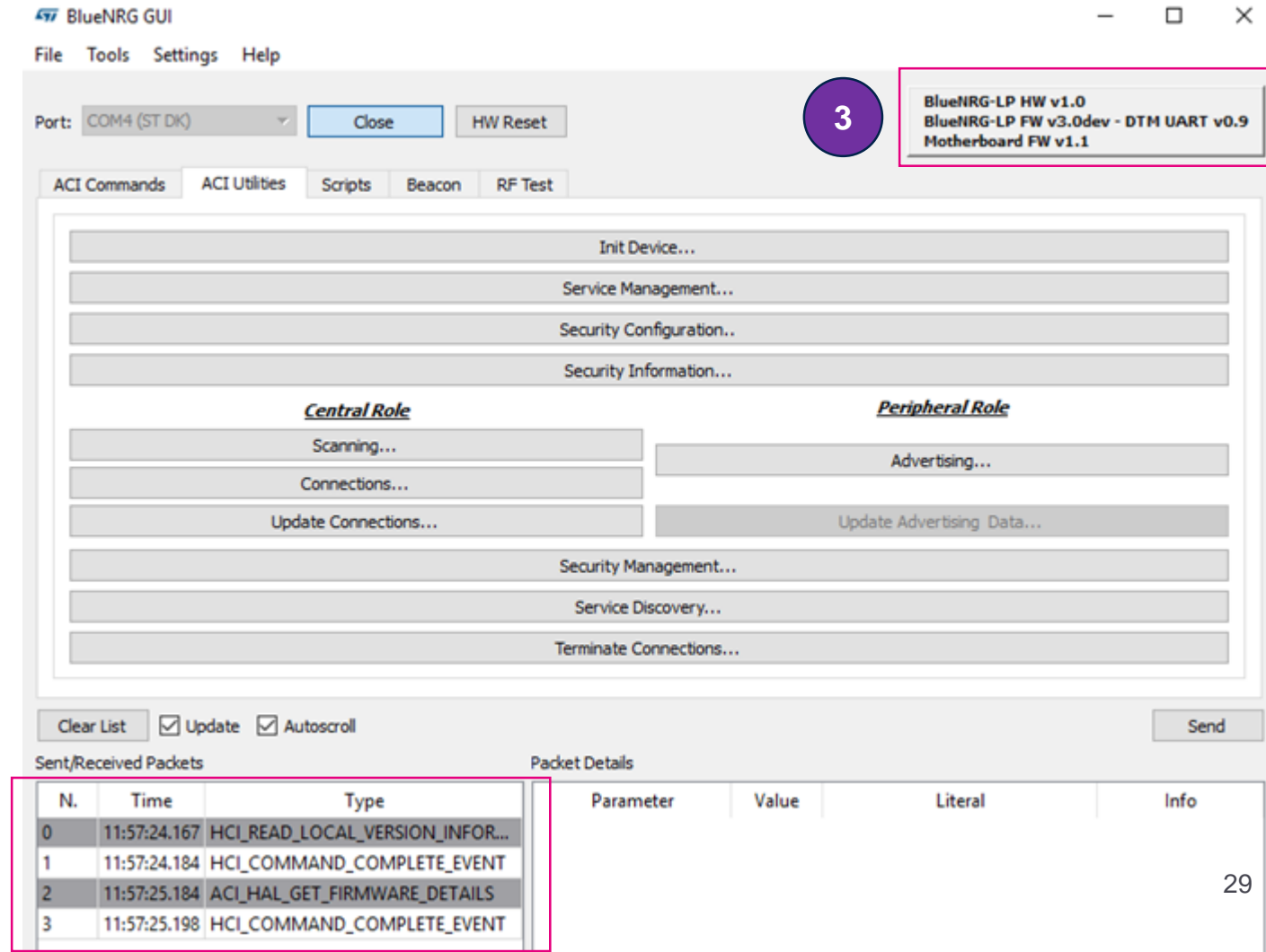
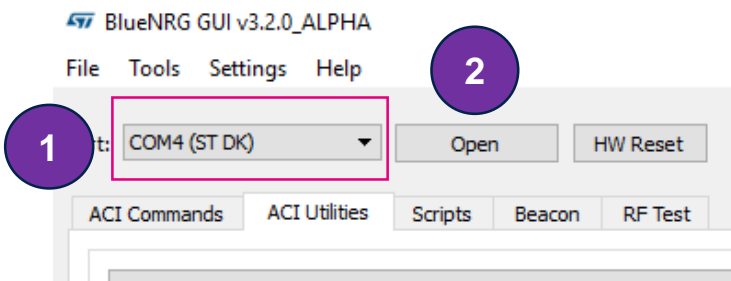
# BlueNRG-LP Navigator

- BlueNRG-DK Bluetooth LE examples
  1. Click Demonstration...
  2. Click BLE Demonstration...
  3. Click to move above or below
  4. Flash & Run / Doc / Project



# BlueNRG-LP GUI

1. Select the COM port labeled (ST DK)
2. Click on Open button
3. The versions appear in the top right corner



# BlueNRG GUI

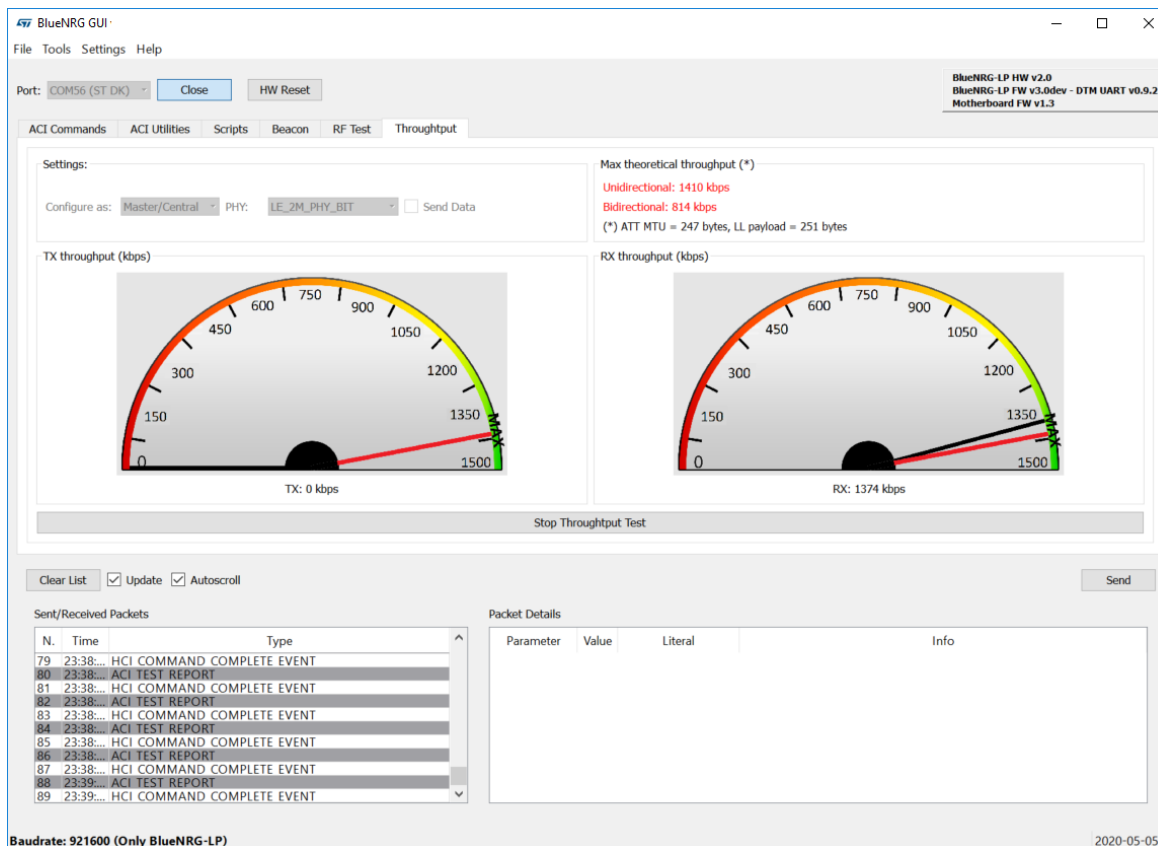
- DTM supporting BlueNRG-LP device and BLE stack v3.x :
  - DTM UART mode: default baud rates 921600.
- Added throughput tab on BlueNRG GUI for performing RF throughput tests with different PHY settings.

The screenshot displays the BlueNRG GUI v3.x.x interface. At the top, there are menu options (File, Tools, Settings, Help) and a port selection dropdown set to 'COM242 (ST DK)' with 'Open' and 'HW Reset' buttons. Below this is a tabbed interface with 'ACI Commands', 'ACI Utilities', 'Scripts', 'Beacon', 'RF Test', and 'Throughput' tabs. The 'ACI Commands' list includes various commands like 'ACI\_GAP\_SET\_JO\_CAPABILITY' and 'ACI\_GAP\_INIT'. A 'Filter' section contains checkboxes for 'SELECT ALL', 'GAP', 'L2CAP', 'GATT - ATT', 'HCI Test', 'HAL', and 'HCI'. The 'Command Packet' table shows parameters for an 'ACI\_GAP\_INIT' command, such as 'Opcode' (0xFC8A), 'Role' (0x01), and 'Privacy\_Type' (0x00). Below this is a 'Sent/Received Packets' table with columns for N., Time, and Type. The 'Packet Details' table mirrors the 'Command Packet' table. At the bottom, the baud rate is set to 921600 and the date is 2019-10-04.

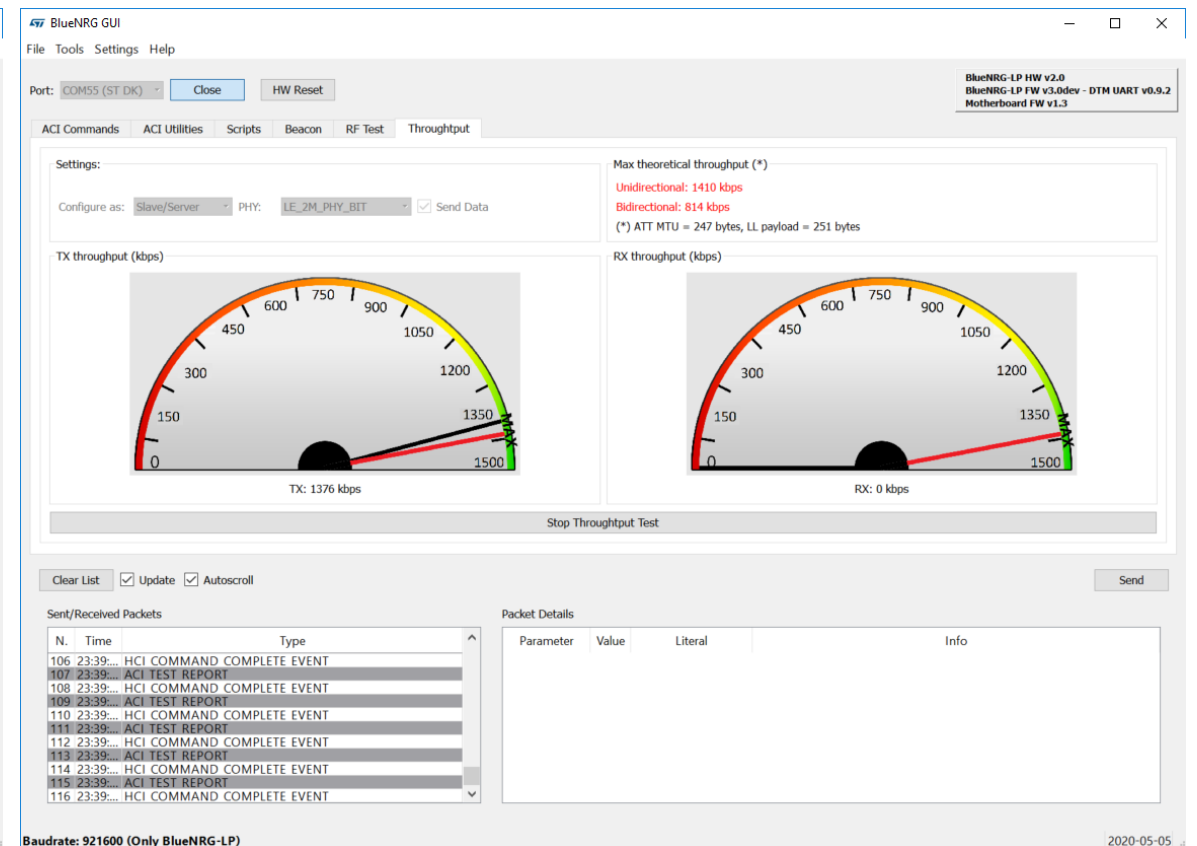
Parameter	Value	Literal	Info
Opcode	0xFC8A	ACI_GAP_INIT	
Parameter Total Length	0x04		
Role	0x01	Peripheral	Bitmap of allowed t...
Privacy_Type	0x00	Privacy disabled	Specify if privacy ...
Device_Name_Char_L...	0x07		Length of the devic...
Identity_Address_Type	0x00	Public Address	Specify which adre...

N.	Time	Type
0	15:03:55.190	ACI_GATT_INIT
1	15:03:55.190	HCI_COMMAND_COMPLETE_EVENT
2	15:04:02.164	ACI_GAP_INIT
3	15:04:02.164	HCI_COMMAND_COMPLETE_EVENT

# BlueNRG GUI: RF throughput unidirectional



Slave sends notifications



Master receives notifications

## NOTES :

- **RED line:** the theoretical throughput is calculated taking in account the ATT MTU = 247 bytes and LL payload = 251 bytes.
- **Black line** is the actual measured throughput value

# BlueNRG GUI: RF throughput unidirectional

Configure as: **Slave/Server** PHY: **LE\_2M\_PHY\_BIT**  Send Data

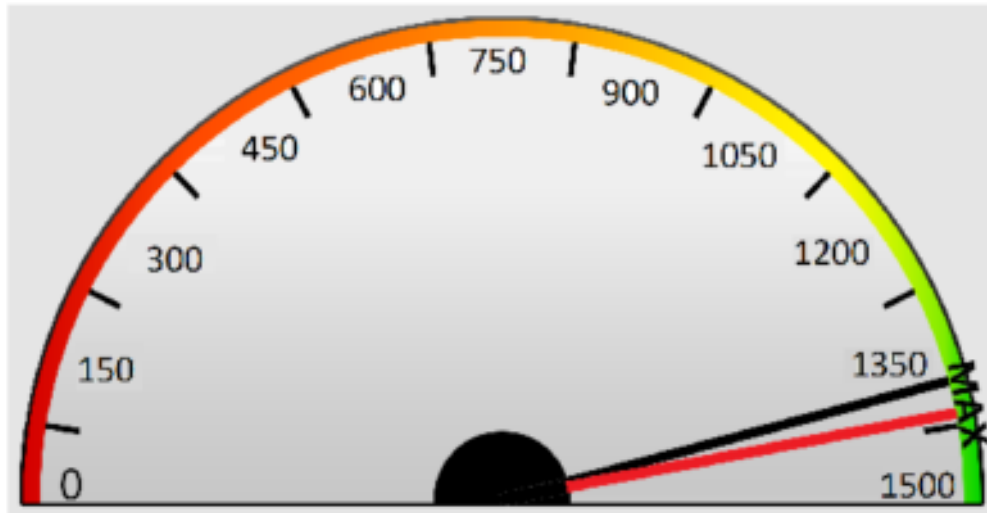
Max theoretical throughput (\*)

Unidirectional: 1410 kbps

Bidirectional: 814 kbps

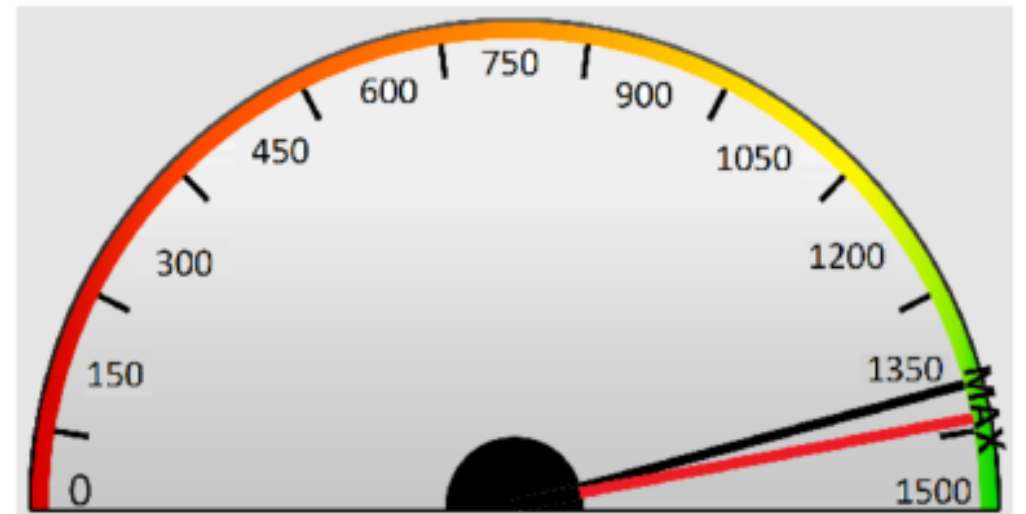
(\*) ATT MTU = 247 bytes, LL payload = 251 bytes

TX throughput (kbps)



TX: 1376 kbps

RX throughput (kbps)



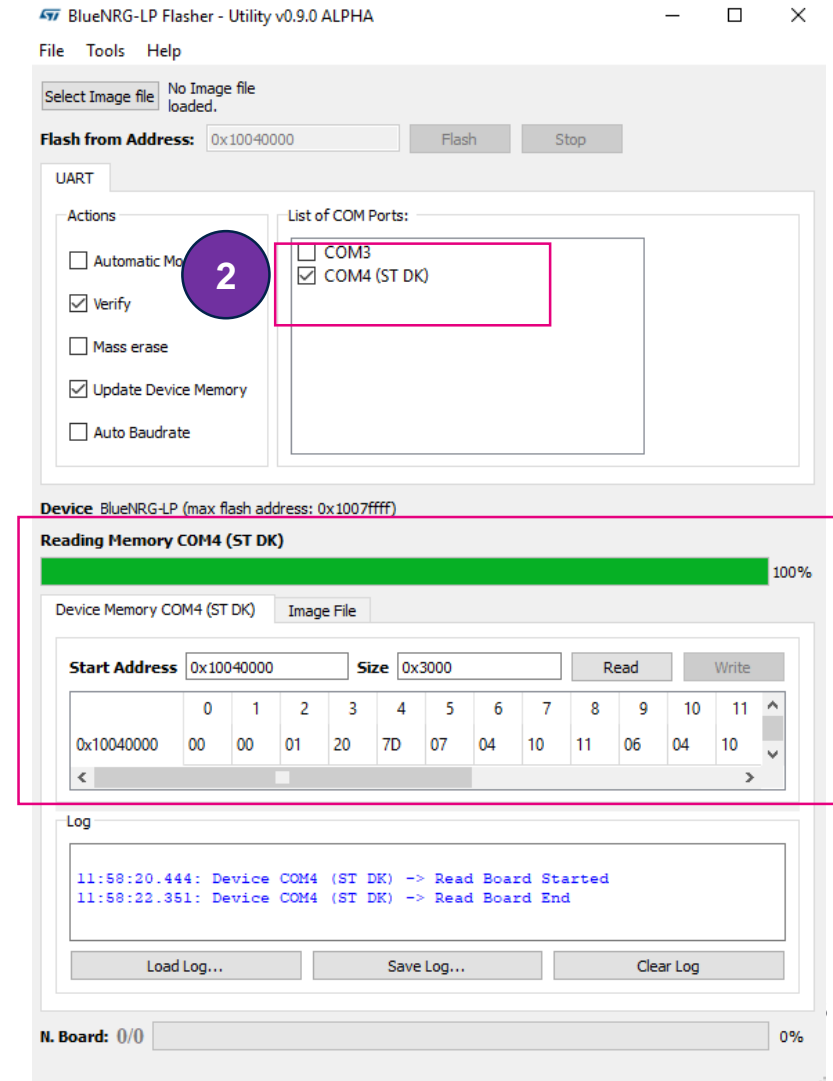
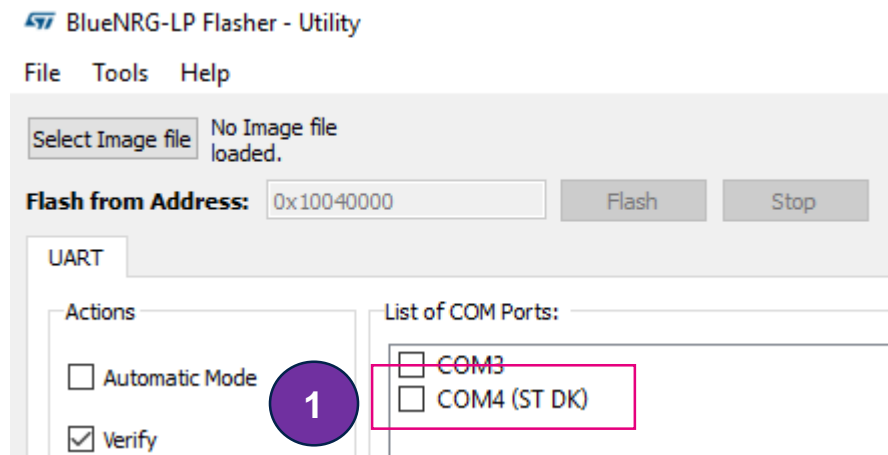
RX: 1374 kbps

Slave sends notifications

Master receives notifications

# BlueNRG-LP Flasher Utility

1. Open the BlueNRG-LP Flasher Utility (and close the GUI if previously open)
2. Select the COM port labeled (ST DK)
3. The Reading Memory panel will populate with the embedded Flash data



# BlueNRG-LP Flasher Utility (UART)

1. Select the binary at project (\*.bin or \*.hex)
2. Select Actions and COM port
3. Press 'Flash' button
4. Pop-up message after finished download

BlueNRG-X Flasher Utility v0.9.2ALPHA

File Tools Help

Select Image file

Flash from Address: 0x10040000

Flash Stop

UART SWD

Actions

- Automatic Mode
- Verify
- Mass erase
- Update Device Memory
- Auto Baudrate

List of COM Ports:

- COM56 (ST DK)

Device: BlueNRG-LP (max flash address: 0x1007ffff)

Reading Memory COM56 (ST DK)

Device Memory COM56 (ST DK) Image File

Start Address 0x10040000

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	ASCII	
0x10040000	00	00	01	20	CD	8A	06	10	A9	6D	06	10	B5	6D	06	10	í @m µm	
0x10040010	AA	55	55	AA	45	55	4C	42	00	00	00	00	00	00	00	00	ªUU*EULB	
0x10040020	00	00	00	00	00	00	00	00	00	00	00	00	00	C1	6D	06	10	Âm
0x10040030	00	00	00	00	00	00	00	00	07	50	04	10	C3	6D	06	10	P Âm	
0x10040040	D3	51	04	10	D7	53	04	10	3B	55	04	10	E3	62	04	10	ÓQ xS ;U äb	
0x10040050	1B	6B	04	10	6B	6B	04	10	C3	6B	04	10	2F	6D	04	10	k kk Äk /m	

Show Log

```
*****START FLASH OPERATION*****  
Flash Boards: COM56 (ST DK)  
16:49:04.278: Device COM56 (ST DK) -> Flash Programming  
16:49:43.091: Device COM56 (ST DK) -> Read Board Started  
16:49:50.255: Device COM56 (ST DK) -> Read Board End  
16:49:52.177: Device COM56 (ST DK) -> Flashed and Verified.
```

Load Log... Save Log... Clear Log

N. Board: 1/1

# BlueNRG-LP Flasher Utility (CMSIS DAP)

1. Select the binary at project (\*.bin or \*.hex)
2. Select Actions and COM port
3. Press 'Flash' button
4. Pop-up message after finished download

BlueNRG-X Flasher Utility v0.9.2ALPHA

File Tools Help

Select Image file: C:\Users\... (x86)\STMicroelectronics\BlueNRG-LP DK 0.9.2ALPHA\Firmware\BLE\_Examples\BLE\_Beacon\STEVAL-IDB011V1\BLE\_Beacon\_ExtendedAdv.hex

Flash from Address: 0x10040000 Flash Stop

UART SWD

Actions

CMSIS DAP

Automatic Mode

Verify

Readout Protection

Mass erase

Update Device Memory

MAC Address

MAC Address: Start: 0x000000000000 - End: 0x000000000000

MAC Flash Location

Save MAC Address Log File Name timestamp

Set Mac Address...

Device: BlueNRG-LP (max flash address: 0x1007ffff)

Read flash memory of connected device

100%

Device Memory Image File

Start Address 0x10040000 Size 0x1C310 Read Write

0	1	2	3	4	5	6	7	8	9	10	11	12	13
---	---	---	---	---	---	---	---	---	---	----	----	----	----

Show Log

```
16:56:16.937: Flash Programmed in 3.755000 sec.
16:56:16.937: Flash Verify Operation -> SUCCESS
16:56:18.278: Device Disconnection ->SUCCESS
16:56:18.915: Flash operation finished!
*****END FLASH OPERATION*****
*****FLASH READ OPERATION*****
16:56:19.056: Waiting device to read ->
```

Load Log... Save Log... Clear Log

N. Board: 1/1 0%



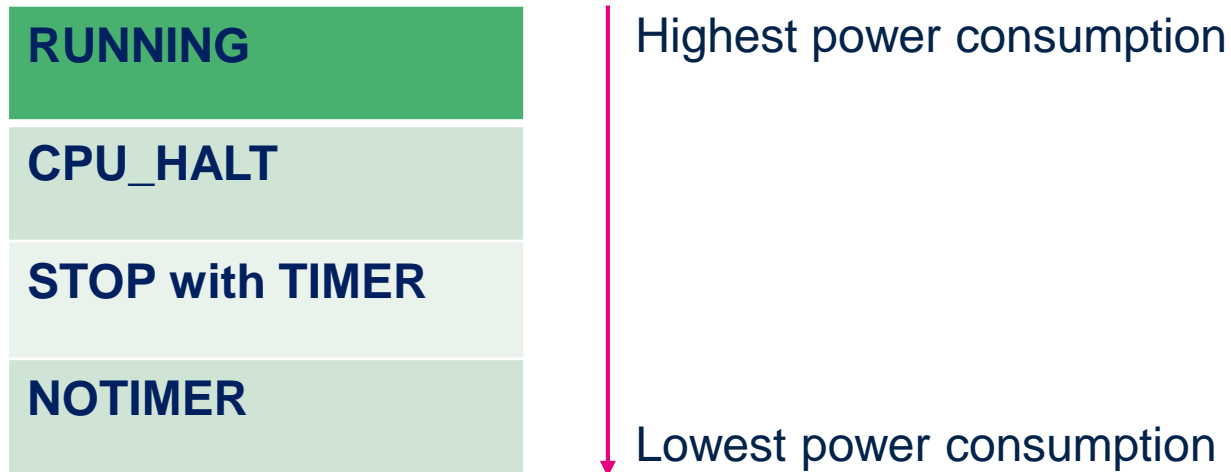
# BlueNRG-LP Low Power Mode

# Low Power Mode

- **POWER\_SAVE\_LEVEL\_RUNNING**
  - In this power save mode, everything is active and running. In practice this mode is not used, but it is defined for completeness of information: it is not a real power save mode.
- **POWER\_SAVE\_LEVEL\_CPU\_HALT**
  - This power save mode implements the HW CPU-Halt power save mode (only the CPU is halted).
- **POWER\_SAVE\_LEVEL\_STOP\_WITH\_TIMER**
  - This power save mode implements the HW Deep stop mode with the low speed clock ON.
  - The device is in deep sleep and the timer clock sources (LSI or LSE) remain running.
  - Wakeup is possible from GPIOs (PA0 to PA11 and PB0 to PB7), RTC, IWDG, Radio and the Hal Virtual Timers.
- **POWER\_SAVE\_LEVEL\_NOTIMER**
  - This power save mode implements the HW Deep stop mode with the low speed clock OFF.
  - The device is in deep sleep. All the peripherals and clock sources are turned off.
  - Wakeup is possible only from GPIOs (PA8 to PA11 and PB0 to PB11).

# Low Power Mode

- Refer to application note : BlueNRG-LP power save modes
- Low power mode project
  - C:\Users\{user}\ST\{DK version}\Projects\Peripheral\_Examples\Examples\_MIX\MICRO\Micro\_PowerManager



# Low Power Mode

- Application note : BlueNRG-LP power save modes
- Low power mode test
  - C:\Users\{user}\ST\{DK version}\Projects\Peripheral\_Examples\Examples\_MIX\MICRO\Micro\_PowerManager

Projects\Peripheral\_Examples\Examples\_MIX\MICRO\MICRO\_PowerManager\EWARM\STEVAL-IDB011V1

Name

- BlueNRG\_LP.icf
- Micro\_PowerManager.ewd
- Micro\_PowerManager.ewp
- Micro\_PowerManager.eww

VT COM55 - Tera Term VT

File Edit Setup Control Window Help

Power Manager FH demo!

Digit ? for help command

POWER MANAGER help commands:

- s: SHUTDOWN LEVEL : the only wakeup source is a low pulse on the RSTN pad
- t: POWER\_SAVE\_LEVEL\_STOP\_WITH\_TIMER : wake on uart (PA8)/timeout 5 sec (VTIMER)/button PUSH1 (PA10)
- z: POWER\_SAVE\_LEVEL\_STOP\_WITH\_TIMER : wake on uart (PA8)/timeout 5 sec (RTC)/button PUSH1 (PA10)
- n: POWER\_SAVE\_LEVEL\_NOTIMER : wake on uart (PA8)/button PUSH1 (PA10)
- c: POWER\_SAVE\_LEVEL\_CPU\_HALT : wake on button PUSH1 (PA10)
- l: Toggle led LED1
- p: Print Hello World message
- r: Reset the BlueNRG-LP
- ?: Display this help menu



# BlueNRG-LP Over The Air FW upgrade



- Download

- 1. UART Download (Built-in bootloader)

- PA8(Rx), PA9(Tx), PA10(boot pin), Vcc, GND.
    - 8bit / No parity / 1 stop bit / no flow control / Baud rate range [500 – 460800].
    - Application note : BlueNRG-LP UART bootloader protocol.
    - PA10 during power-up : Low (Normal), High(Bootloader)

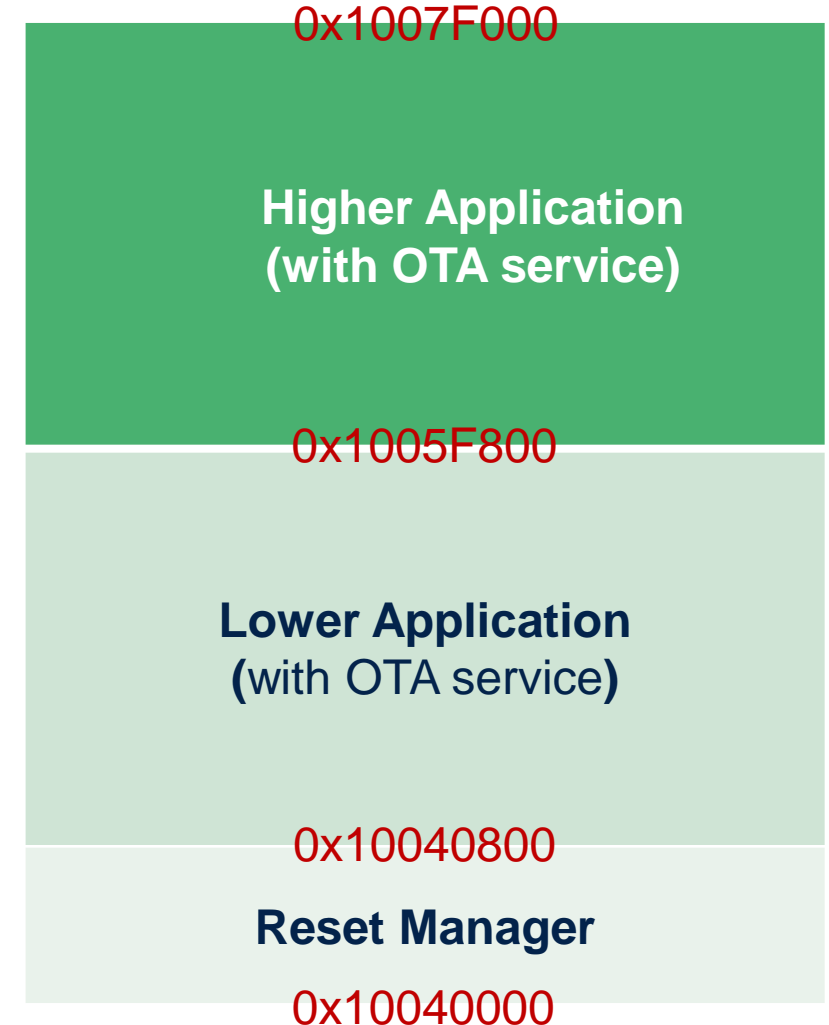
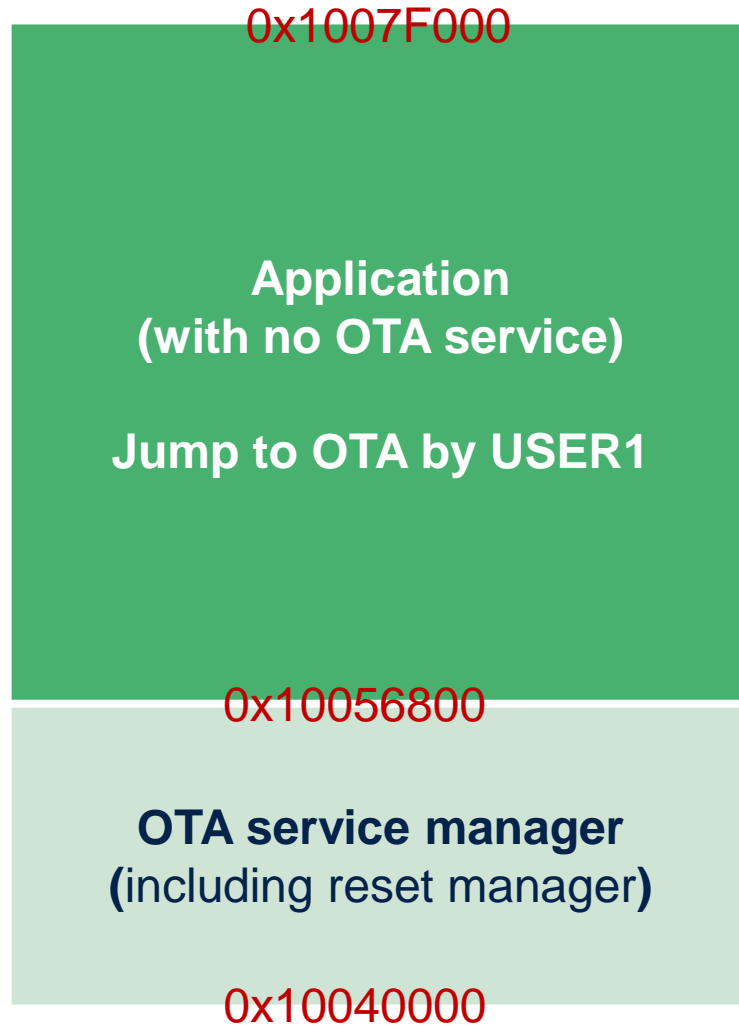
- 2. ST-Link Download (SWD)

- SWDIO, SWCLK, Reset, Vcc, GND.

- 3. OTA (Over the air firmware upgrade)

- Device was already downloaded by UART or ST-Link.

- OTA structure



- Preparing Two BlueNRG-LP EVBs

- Download DTM project to one board.
  - C:\Users\{user}\ST\{DK version}\Projects\BLE\_Examples\DTM
- Download Reset manager, OTA Service manager or Sensor Demo MS.

- Reset Manager

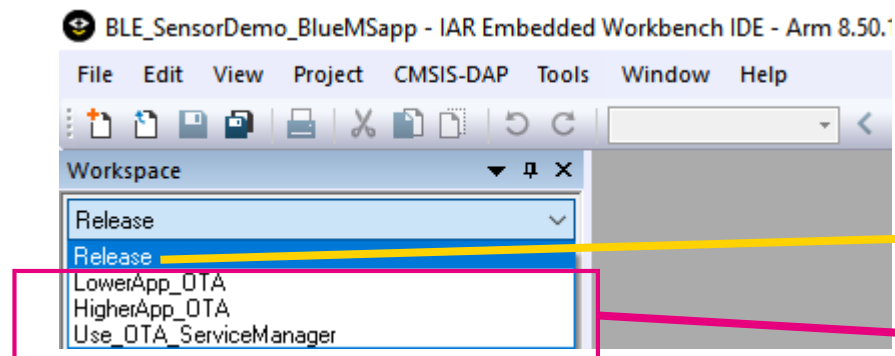
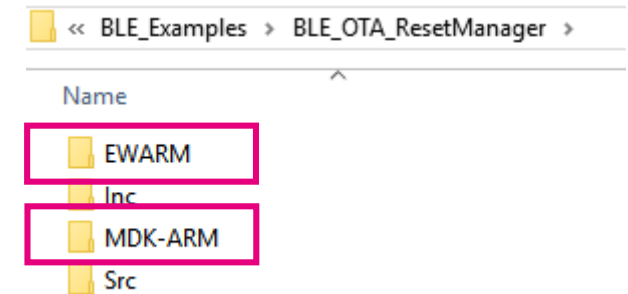
- C:\Users\{user}\ST\{DK version}\Projects\BLE\_Examples\BLE\_OTA\_ResetManager

- OTA Service Manager

- C:\Users\{user}\ST\{DK version}\Projects\BLE\_Examples\BLE\_OTA\_ServiceManager

- Application

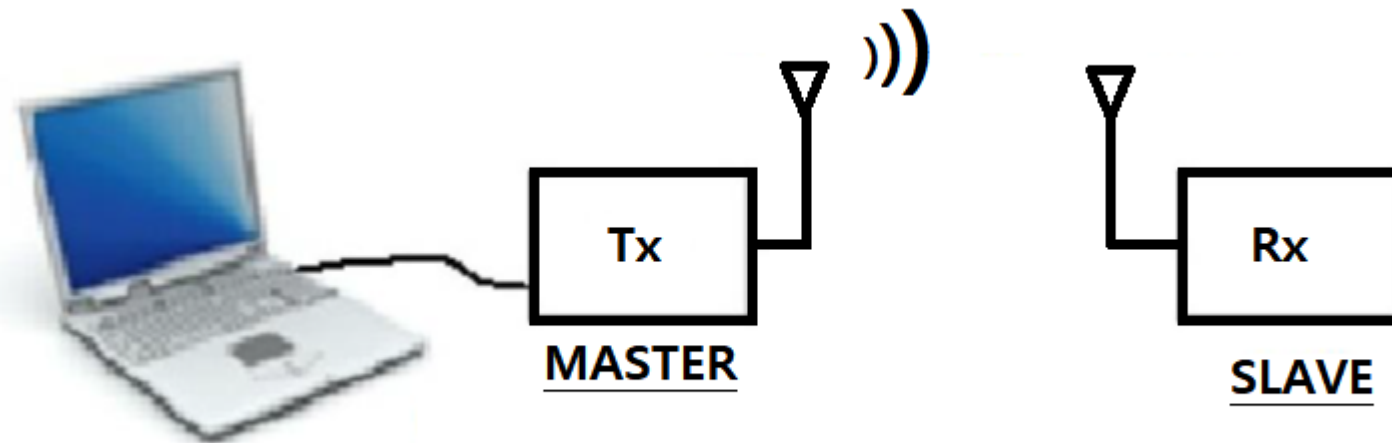
- C:\Users\{user}\ST\{DK version}\Projects\BLE\_Examples\BLE\_SensorDemo\_BlueMSapp



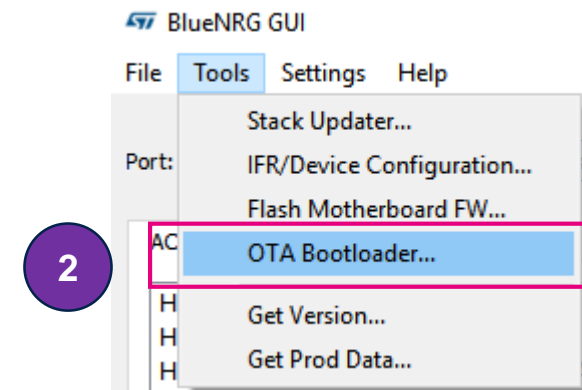
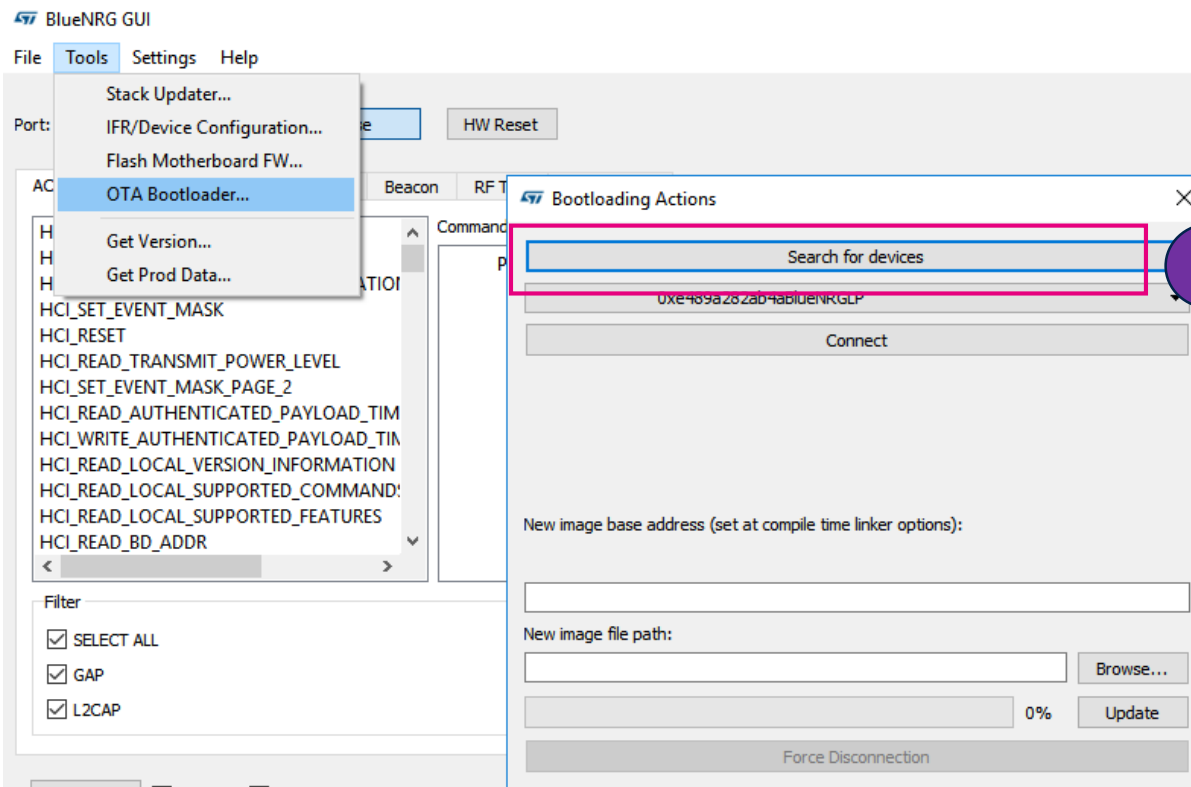
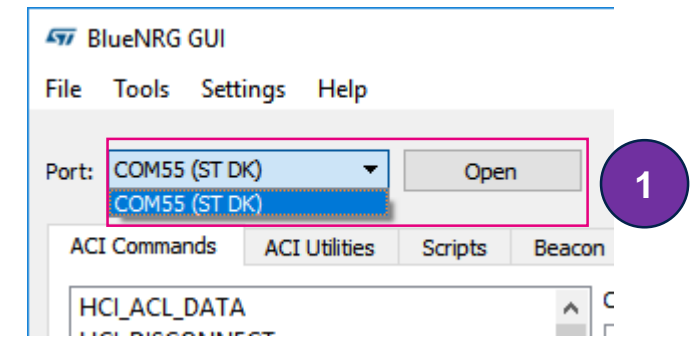
Normal application project

OTA application project

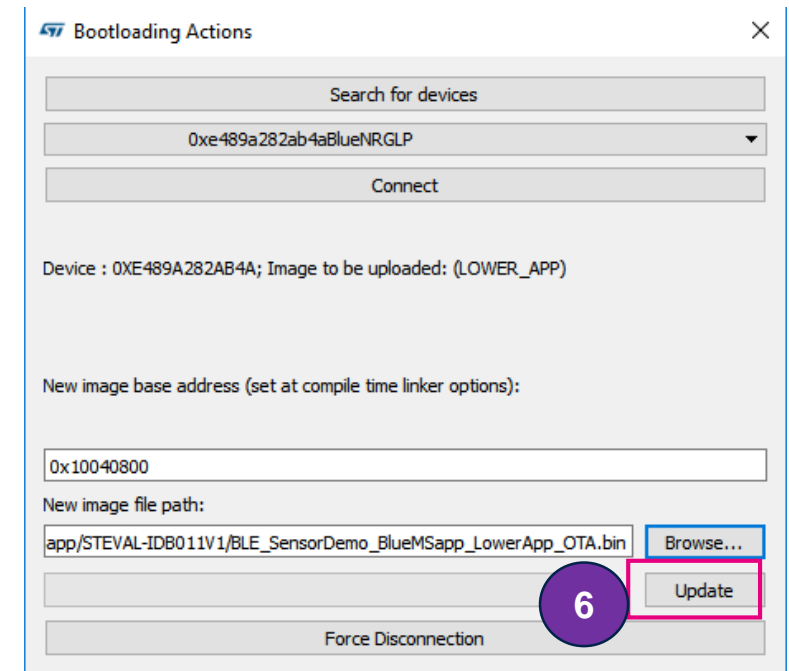
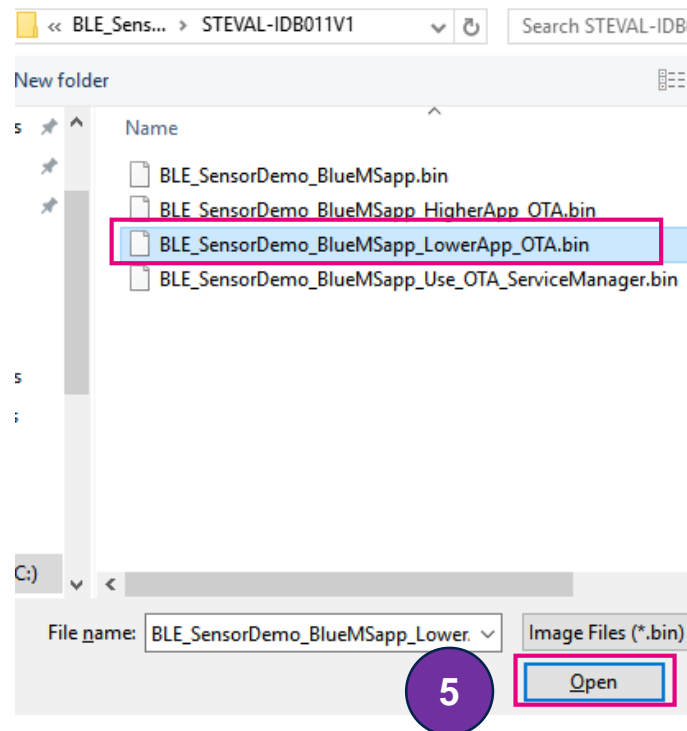
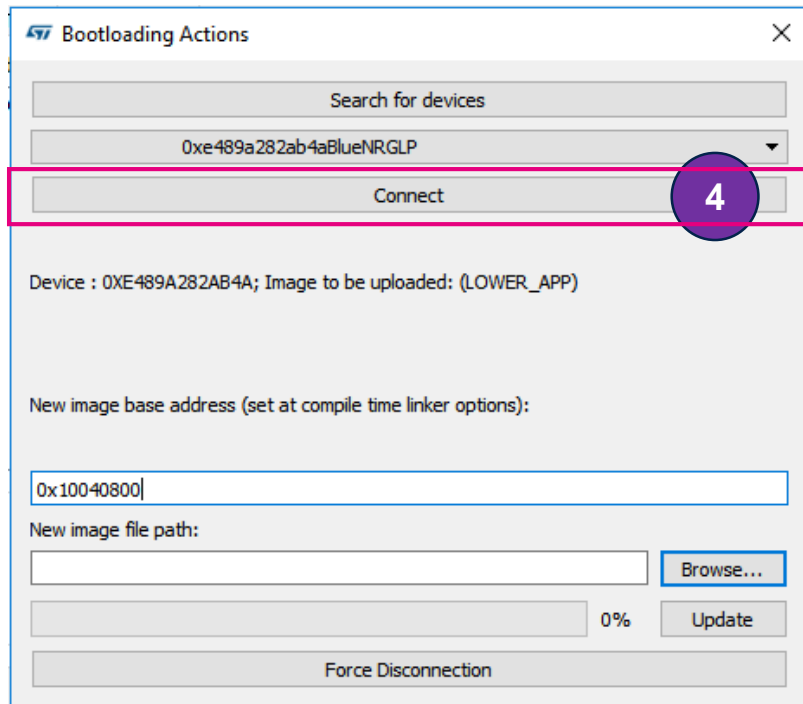
- Application note : BlueNRG-LP BLE OTA firmware upgrade
- Preparing Target(Rx) board.
  1. Download Reset Manager
  2. Download SensorDemo Higher APP
- Preparing Tx board
  1. Download DTM UART



- GUI OTA test sequence (Tx Board.)
0. Download DTM UART binary to EVB
  1. Select the COM port labeled (ST DK)
  2. Select on OTA Bootloader
  3. Click on “Search for device”



4. Click on “connect”
5. Select “BLE\_SensorDemo\_LowerApp\_OTA.bin” and Click on “open”
6. Click on “update”

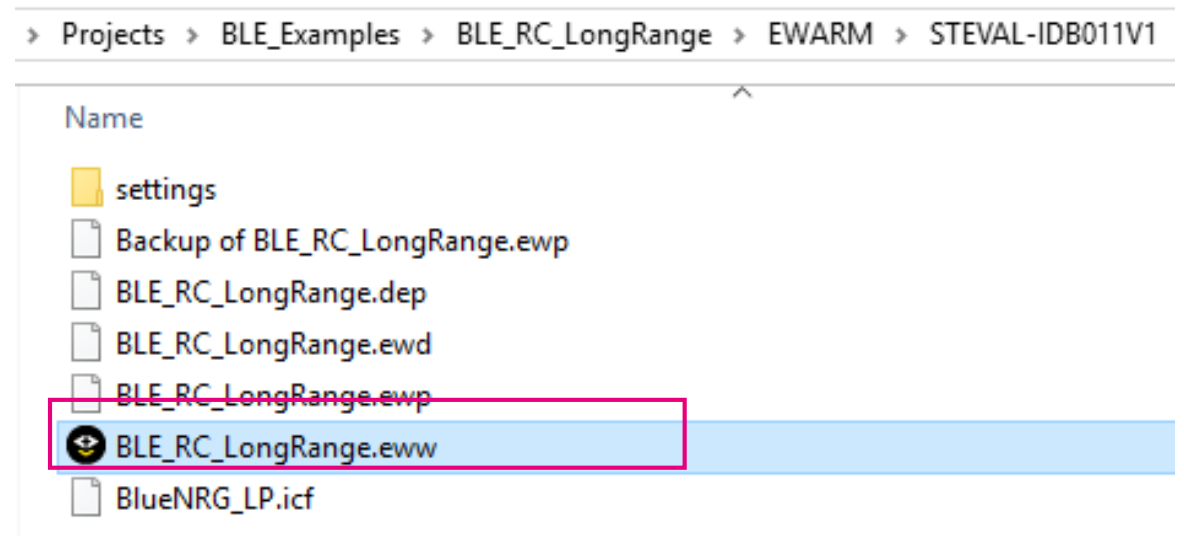
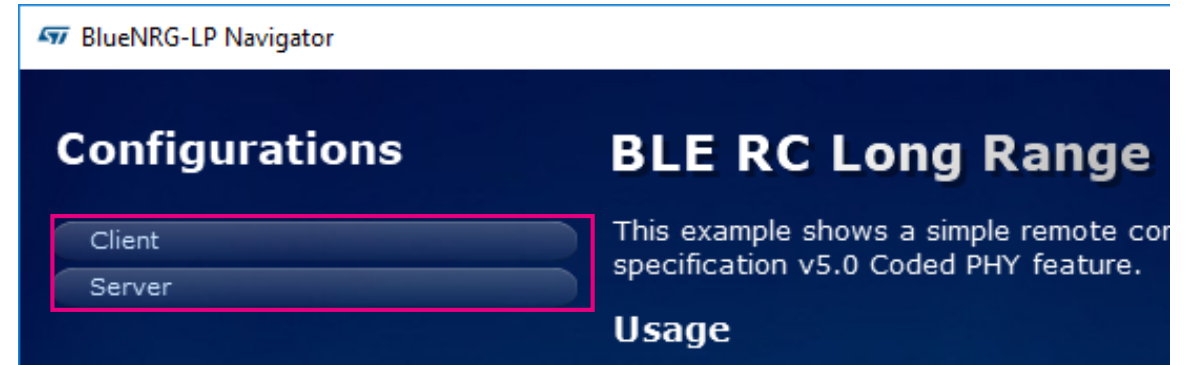




# BlueNRG-LP Project in SDK

# Project in SDK

- BLE\_RC\_LongRange
  - Client / Server : Scan and Connect each Public Address
  - Switch PHY by USER\_BUTTON1
  - 1M PHY <==> Coded PHY (S=8)
- DL2 LED
  - Blinking ( searching )
  - ON ( connected )
- DL3 LED
  - Blinking ( T : 300ms )
  - Blinking T > 300 ms → Retransmission
- U5 Blue LED
  - ON : Coded PHY
  - OFF : 1M PHY



# Project in SDK

- BLE\_RC\_LongRange

- Client

```
Write 0x00 to handle 0x0012, 0x00
Write 0x04 to handle 0x0012, 0x00
Write 0x00 to handle 0x0012, 0x00
Write 0x04 to handle 0x0012, 0x00
PHY changed: 3 3
Write 0x00 to handle 0x0012, 0x00
Write 0x04 to handle 0x0012, 0x00
Write 0x00 to handle 0x0012, 0x00
Write 0x04 to handle 0x0012, 0x00
Write 0x00 to handle 0x0012, 0x00
Write 0x04 to handle 0x0012, 0x00
Write 0x00 to handle 0x0012, 0x00
Write 0x04 to handle 0x0012, 0x00
Write 0x00 to handle 0x0012, 0x00
PHY changed: 1 1
Write 0x04 to handle 0x0012, 0x00
Write 0x00 to handle 0x0012, 0x00
Write 0x04 to handle 0x0012, 0x00
```

- Server

```
Advertising configuration 00
Updated temperature: 28.68 C deg
aci_gap_set_advertising_enable() --> SUCCESS

Start Advertising phy 1

Connected
Switch to LE CODED PHY
PHY changed: 3 3
Switch to LE 1M PHY
PHY changed: 1 1
```

# Project in SDK

- BLE\_SensorDemo
  - Test with BlueNRG Application at Phone.
  - Update All ST sensors.
- BLE\_SensorDemo\_Central
  - Test with BLE\_SensorDemo.

Projects > BLE\_Examples > BLE\_SensorDemo > EWARM > STEVAL-IDB011V1

Name

- settings
- BLE\_SensorDemo.dep
- BLE\_SensorDemo.ewd
- BLE\_SensorDemo.ewp
- BLE\_SensorDemo.eww**
- BlueNRG\_LP.icf

BLE\_SensorDemo\_Central > EWARM > STEVAL-IDB011V1 >

Name

- settings
- BLE\_SensorDemo\_Central.dep
- BLE\_SensorDemo\_Central.ewd
- BLE\_SensorDemo\_Central.ewp
- BLE\_SensorDemo\_Central.eww**
- BlueNRG\_LP.icf

# Project in SDK

- BLE\_SensorDemo\_Central

```
BlueNRG-LP BLE Sensor Demo Application (version: 1.0.0)
Advertising configuration 0x00
Set advertising data 0x00
```

## BLE\_SensorDemo\_Central

```
ADDR Type = 1
ADDR = 0x46a448fd71e0
AD DATA (Length=12):
02 01 06 08 09 42 6c 75 65 4e 52 47
RSSI = 0xfffffd5
BlueNRG device found
```

```
ACC-> X:-41, Y:128, Z:-42. Temperature->35.0
```

```
ACC-> X:-12, Y:94, Z:-391. Temperature->35.0
```

```
ACC-> X:-42, Y:17, Z:-641. Temperature->35.0
```

```
ACC-> X:-22, Y:22, Z:-27. Temperature->35.0
```

```
ACC-> X:-23, Y:61, Z:-16. Temperature->35.0
```



# BlueNRG-LP Reference

# BlueNRG-LP reference document

- BlueNRG-LP DK install path

- C:\Program Files (x86)\STMicroelectronics\BlueNRG-LP DK {version}
- C:\Users\{username}\ST\BlueNRG-LP DK {version} → Project code path

C:\Users\kyle sung\ST\BlueNRG-LP DK

Name

- Drivers
- Middlewares
- Projects
- Utility

C:\Program Files (x86)\STMicroelectronics\BlueNRG-LP DK

Name

- Application
- Docs
- Firmware
- unins000.dat
- unins000.exe

## 1. Double click 'index.html'

C:\Program Files (x86)\STMicroelectronics\BlueNRG-LP DK\Docs

Name

- license.txt
- index.html
- BLE\_Examples

1

# BlueNRG-LP reference document

## Release Notes

- [BlueNRG-LP Development Kits Release Notes](#)

## Key Resources

- [BlueNRG-LP Key Resources](#)

## Device & Kits Documentation

- [Bringing up the BlueNRG-LP device Application Note](#)
- [PCB design guidelines for the BlueNRG-LP device Application Note](#)
- [BlueNRG-LP Power Save Modes Application Note](#)
- [BlueNRG-LP UART Bootloader Protocol Application Note](#)
- [BlueNRG-LP Development Kit User Manual](#)
- [STEVAL-IDB011V1 \(QFN48\) Schematic](#)
- [STEVAL-IDB011V1 \(QFN48\) BOM file](#)
- [STEVAL-IDB011V1 \(QFN48\) gerber files](#)
- [STEVAL-IDB010V1 \(CSP49\) Schematic](#)
- [STEVAL-IDB010V1 \(CSP49\) BOM file](#)
- [STEVAL-IDB010V1 \(CSP49\) gerber files](#)
- [USB CMSIS-DAP FW upgrade procedure](#)

## Datasheet, Limitations and Reference Manual

- [BlueNRG-LP Datasheet preliminary version](#)
- [BlueNRG-LP Limitations preliminary version](#)
- [BlueNRG-LP Reference manual preliminary version](#)
- [BlueNRG-LP Radio Controller Reference Manual](#)

## BlueNRG-BLE Stack Library documentation

- [BlueNRG-BLE Stack Library Release Notes](#)
- [BlueNRG-BLE Stack Library documentation \(APIs, events, modular\)](#)
- [Bluetooth LE Stack v2.x to v3.x migration guideline documentation](#)
- [BLE Over The Air Firmware Upgrade](#)
- [BLE Stack v3.x Library programming guidelines](#)
- [BLE Stack v3.x GATT User Reference Guidelines](#)
- [GATT database size](#)
- [BLE stack v3.x Stack Memory Manager](#)
- [SPI protocol for network coprocessor](#)
- [BLE application debugging tips](#)



# BlueNRG-LP reference document

## 2.4 GHz Proprietary Radio APIs documentation

- [BlueNRG-LP 2.4 GHz proprietary radio low level driver LL APIs documentation](#)
- [BlueNRG-LP 2.4 GHz proprietary radio low level driver HAL APIs documentation](#)
- [BlueNRG-LP 2.4 GHz proprietary radio low level driver User Manual](#)

## Virtual Timers Module APIs documentation

- [Virtual Timers module LL APIs documentation](#)
- [Virtual Timers module LL HAL APIs documentation](#)
- [Timer module Application Note](#)

## Peripheral (LL & HAL) drivers documentation

- [BlueNRG-LP Peripheral LL Drivers documentation](#)
- [BlueNRG-LP Peripheral HAL Drivers documentation](#)

## SDK & Middlewares drivers documentation

- [BlueNRG-LP SDK drivers](#)
- [BlueNRG-LP Middlewares, hal drivers](#)

## BLE Demonstrations, 2.4 GHz Proprietary Radio Applications &

- [BlueNRG-LP BLE Demonstrations Applications](#)
- [BlueNRG-LP 2.4 GHz Proprietary Radio Applications](#)
- [BlueNRG-LP Peripheral LL Drivers Applications](#)
- [BlueNRG-LP Peripheral HAL Drivers Applications](#)
- [BlueNRG-LP Peripheral MIX Drivers Applications](#)

## Central/Master Library

- [BlueNRG-LP Central/Master Library APIs & events callbacks](#)

## PC applications

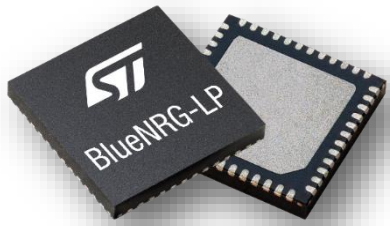
- [BlueNRG-LP BLE Radio Parameters Initialization Wizard](#)

## BlueNRG-LP Network Coprocessor (UART, SPI mode)

- [BlueNRG-LP Network coprocessor framework](#)
- [BlueNRG-LP Network coprocessor setup & framework \(UART mode\)](#)
- [BlueNRG-LP Network coprocessor setup & framework \(SPI mode\)](#)
- [BlueNRG-LP Network coprocessor APIs, Events & Constants](#)



# BlueNRG MESH



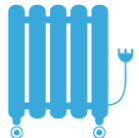
# BlueNRG-MESH

## Brings Smart-home to Your Fingertip

Easily connecting appliances to iOS/Android, out-of-the-box



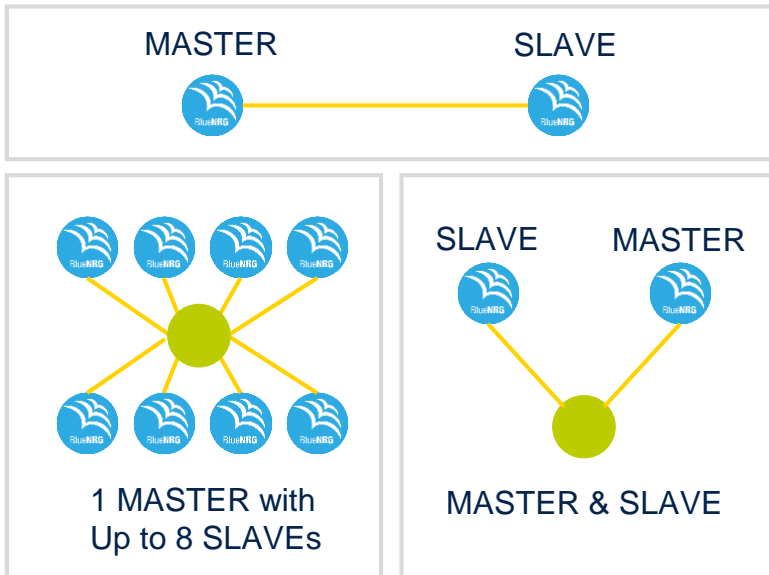
- Bluetooth **Mesh 1.0 certified Profile Library** and **Bluetooth LE stack**
- **Two-layer security** (128-bit AES-CCM and 256-bit ECDH protocol)
- **Low-power** and **Friendship** supported
- Provisioned node **database transfer** among smartphones via Email and Cloud application
- **Embedded** and **Mobile SDK** to build both your Android and iOS Apps
- Reduces development costs and accelerates time-to-market



Available across full BlueNRG portfolio  
iOS and Android SDK

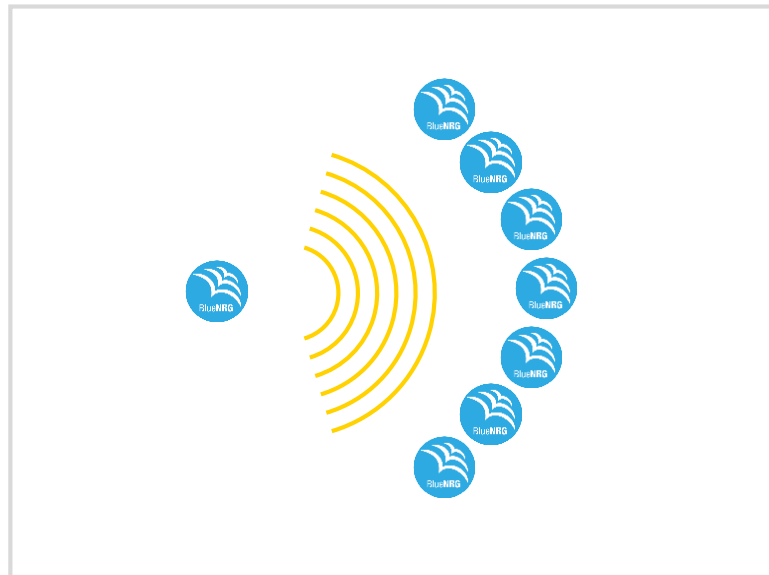
# Bluetooth Low Energy Networking

## PAIRING one-to-one



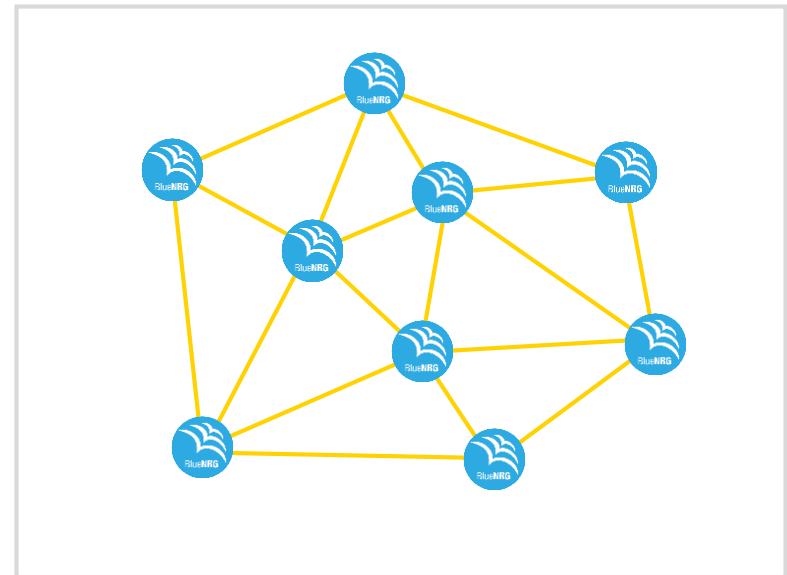
- DATA TRANSFER**
- Sports & fitness devices
  - Health and wellness devices
  - Peripherals and accessories

## BROADCASTING one-to-many



- LOCALIZED INFORMATION**
- Point of interest beacons
  - Item finding beacons
  - Way finding beacons

## MESH Many-to-many



- LARGE DEVICE NETWORKS**
- Building automation
  - Wireless sensor networks
  - Asset tracking



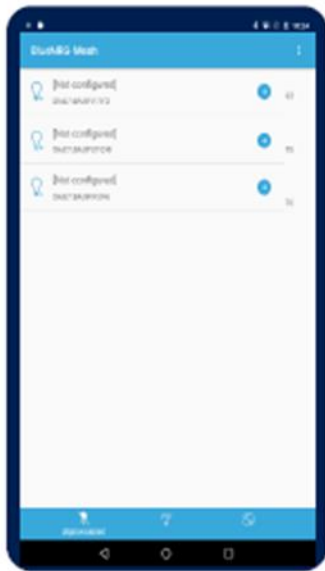
# BlueNRG-Mesh SDK

## Software Platform support

### BlueNRG-Mesh App



ST BLE Mesh app  
for Android and iOS



<https://itunes.apple.com/us/app/bluenrg-mesh/id1348645067>



<https://play.google.com/store/apps/details?id=com.st.bluenrgmesh>

### BlueNRG Platform SW

- **STSW-BNRG-Mesh**
  - Mesh over Bluetooth low energy for **BlueNRG** family products  
[https://www.st.com/content/st\\_com/en/products/embedded-software/wireless-connectivity-software/stsw-bnrg-mesh.html](https://www.st.com/content/st_com/en/products/embedded-software/wireless-connectivity-software/stsw-bnrg-mesh.html)
- **X-CUBE-BLEMESH1**
  - Mesh over Bluetooth low energy software expansion for **STM32Cube**
  - <https://www.st.com/en/embedded-software/x-cube-blemesh1.html>
- **Application Example: FP-SNS-BLEMESH1**
  - **STM32Cube** function pack for IoT node with BLE Mesh connectivity and **Sensor model example**
  - <https://www.st.com/en/embedded-software/fp-sns-blemesh1.html>



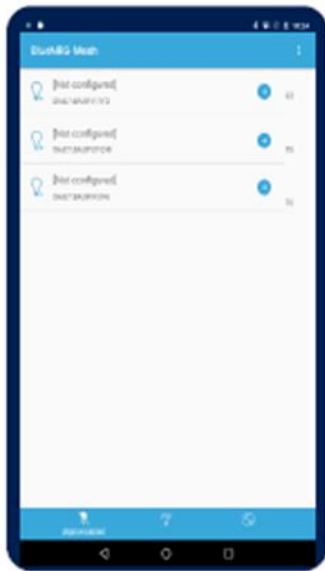
# BlueNRG-Mesh SDK

## Software Platform support

### BlueNRG-Mesh App



ST BLE Mesh app  
for Android and iOS



<https://itunes.apple.com/us/app/bluenrg-mesh/id1348645067>



<https://play.google.com/store/apps/details?id=com.st.bluenrgmesh>

### BlueNRG Platform SW

- **STSW-BNRG-Mesh**
  - Mesh over Bluetooth low energy for **BlueNRG** family products  
[https://www.st.com/content/st\\_com/en/products/embedded-software/wireless-connectivity-software/stsw-bnrg-mesh.html](https://www.st.com/content/st_com/en/products/embedded-software/wireless-connectivity-software/stsw-bnrg-mesh.html)
- **X-CUBE-BLEMESH1**
  - Mesh over Bluetooth low energy software expansion for **STM32Cube**
  - <https://www.st.com/en/embedded-software/x-cube-blemesh1.html>
- **Application Example: FP-SNS-BLEMESH1**
  - **STM32Cube** function pack for IoT node with BLE Mesh connectivity and **Sensor model example**
  - <https://www.st.com/en/embedded-software/fp-sns-blemesh1.html>

# BlueNRG-Mesh Ecosystem



## DEVICES

## EVALUATION KITS

## DEVELOPMENT KITS

## HIGHLIGHTS



BLE SoC Ecosystem

Chip:  
**BlueNRG-1**  
**BlueNRG-2**  
**BlueNRG-LP(\*)**

Modules:  
 BlueNRG-M2SA  
 BlueNRG-M2SP

STEVAL-IDB007V2  
 STEVAL-IDB008V2  
 STEVAL-IDB009V1  
 STEVAL-BCN002V1B

STEVAL-IDB007V1M  
**STEVAL-IDB008V1M**  
 STEVAL-BLUEPLUG1  
**STEVAL-BLUEPLUG2**

## STSW-BNRG-Mesh

v1.09.000

Core Lib

v1.12.000

Android Lib

v1.11.000

iOS Lib

v1.06.002

- Multiple Network Keys
- Embedded Provisioner
- Concurrent Beaconing (Alpha)
- AT-layer (Alpha)



STM32 Open Development Environment

SPI to BLE Ecosystem

Chip:  
**BlueNRG-2N**  
**BlueNRG-MS**

Modules:  
 BlueNRG-M0A  
 BlueNRG-M0L

X-NUCLEO-IDB05A1  
**X-NUCLEO-IDB05A2**  
 X-NUCLEO-BNRG2A1

STEVAL-MKSBOX1V1

## X-CUBE-BLEMESH1

v1.4.0 (\*)

## FP-SNS-BLEMESH1

v1.2.0 (\*)

- Support BlueNRG Soc as Network Processor
- Support SensorTile.box

(\*) Coming soon

Legacy Products

New Products (e/o Q1 '20)

# Thank you

© STMicroelectronics - All rights reserved.

The STMicroelectronics corporate logo is a registered trademark of the STMicroelectronics group of companies. All other names are the property of their respective owners.



life.augmented