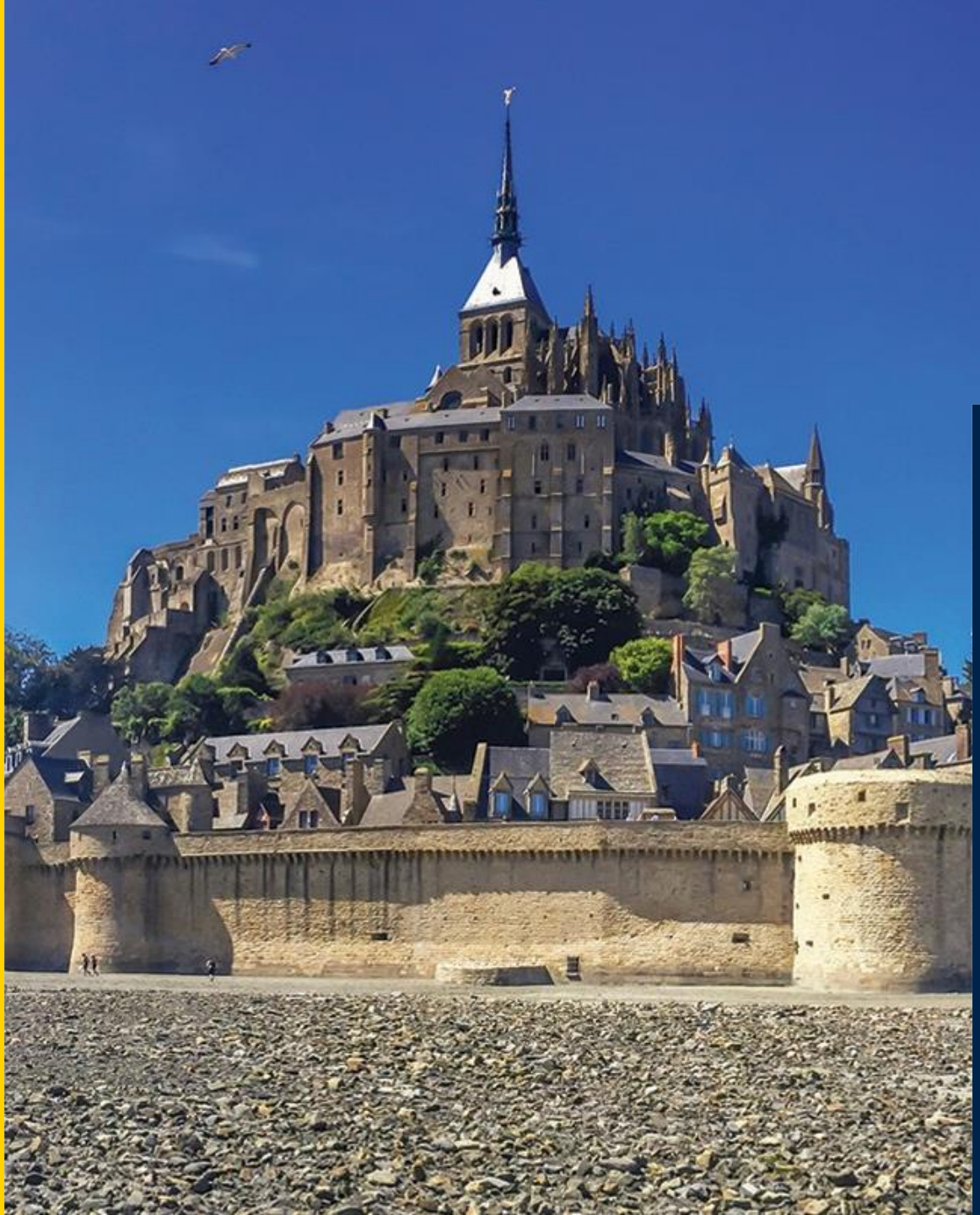

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최신 BlueNRG 제품군과 Bluetooth® Low Energy 애플리케이션 개발

STMicroelectronics

성성유 차장 (Kyle Sung)

BlueNRG

Agenda

1. BlueNRG family
2. BlueNRG-LP introduction
3. BlueNRG-LP key benefits and enhancements
4. BlueNRG-2N Bluetooth LE 5.2 Network Processor
5. WiSE Studio for BlueNRG family

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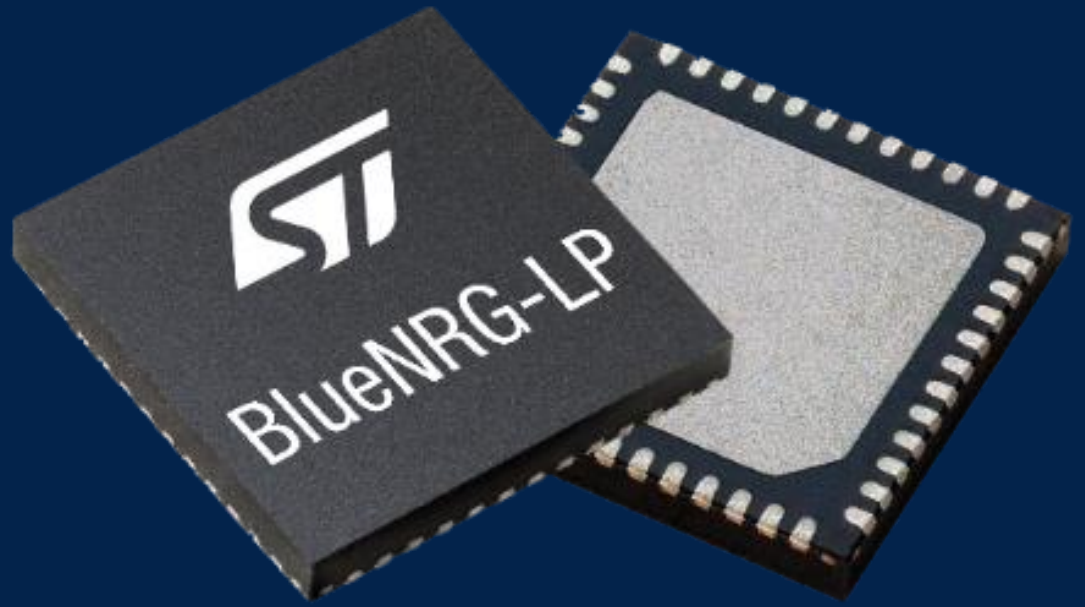
BlueNRG family



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BlueNRG SoC simplifies IoT

Low-Power Bluetooth® Low Energy Application Processor (ARM Cortex-M0/-M0+ programmable core with up to 256 kB eFLASH)

- Simplified HMI
- Easy customization
- Remote reading
- Service and maintenance
- Firmware upgrade
- Added-value services

Bluetooth® 5 Certified

LONGEVITY 10 YEARS COMMITMENT

QFN48
6 x 6 mm

QFN32
5 x 5 mm

WLCSP49
3.14 x 3.14 mm

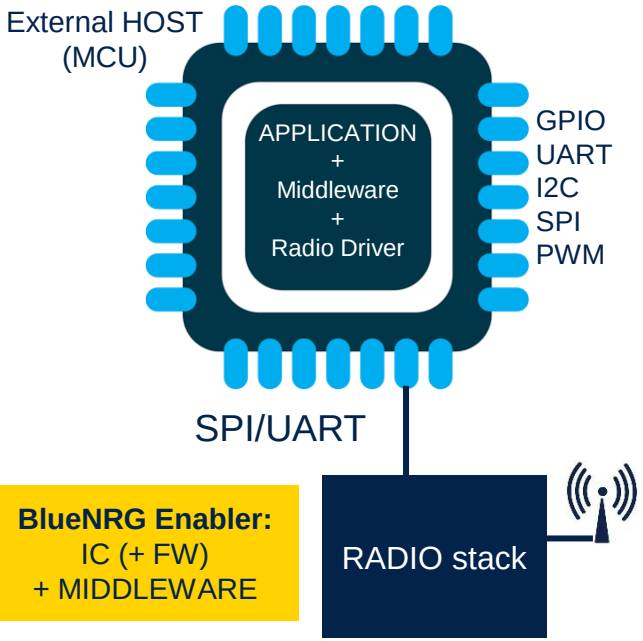
WLCSP34
2.66 x 2.56 mm

Scalable packages

BlueNRG's design flexibility

NETWORK PROCESSOR

Application is running over a dedicated MCU along with **BLE middleware**

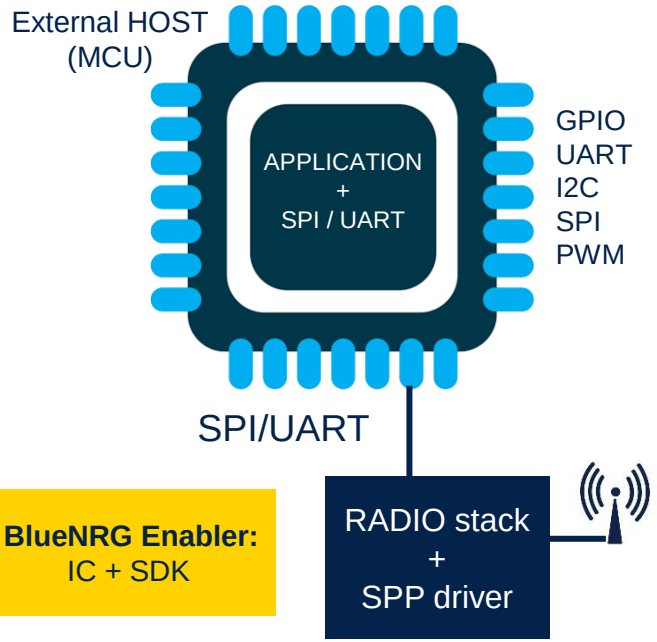


BlueNRG Enabler:
IC (+ FW)
+ MIDDLEWARE

Specific integration of radio middleware/driver required

DATA-PUMP

Radio link added through a simple and standard **serial interface**

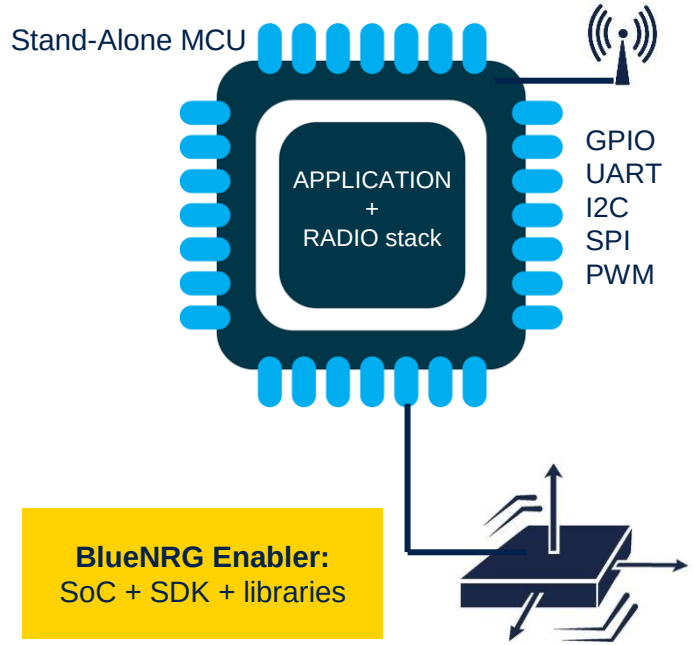


BlueNRG Enabler:
IC + SDK

Radio as a simple plug-in on a standard serial interface

APPLICATION PROCESSOR

Data acquisition, **processing** and **radio connectivity** in a single-chip



BlueNRG Enabler:
SoC + SDK + libraries

Full code ownership in all-in-one image (data, processing, radio)

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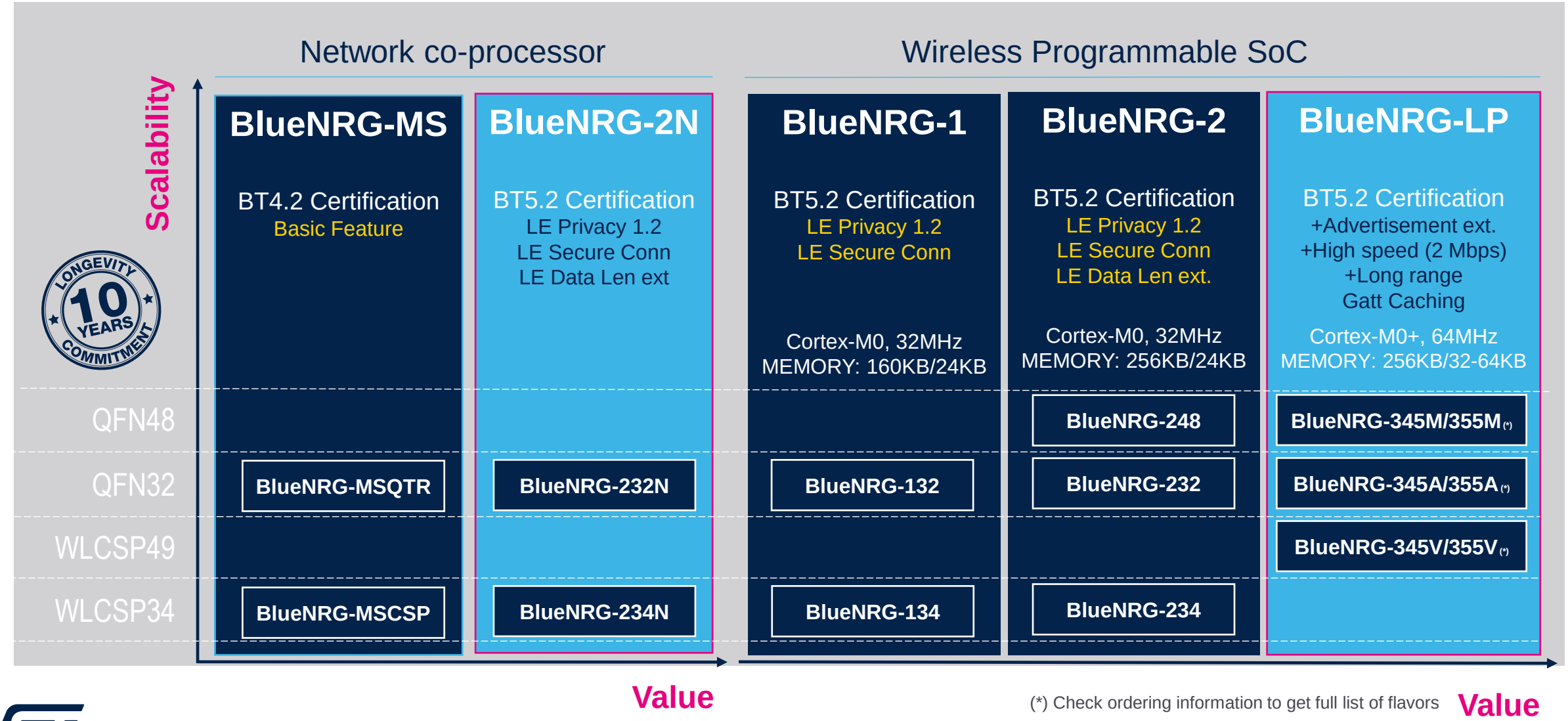
BlueNRG family value

STMicroelectronics Low Power RF

Flexibility	Various topology capabilities from add on BLE to SoC Portfolio to fit application and associated technical requirements
Simplicity	Evaluation and demonstration kits Powerful SDK with SW examples and smart phone app
Customer support	Hardware and software design checks and guidance Training, recommendations, bring up, pre-cert, on-line/site support

BlueNRG portfolio



(*) Check ordering information to get full list of flavors

Bluetooth® LE SoC vs network processor

Dual-chip architecture

Network Processor

Radio with external host

- Monolithic radio link
- Software de-coupling
- Flexible architecture
- Design scalability
- Device model diversity

BLUENRG-MS
BLUENRG-2N

Single-chip architecture

Application Processor

Single-chip solution

- Space optimized
- Anticipated requirements
- Limited model variations
- Predictable deign complexity
- Cost effectiveness

BLUENRG-1
BLUENRG-2
BLUENRG-LP

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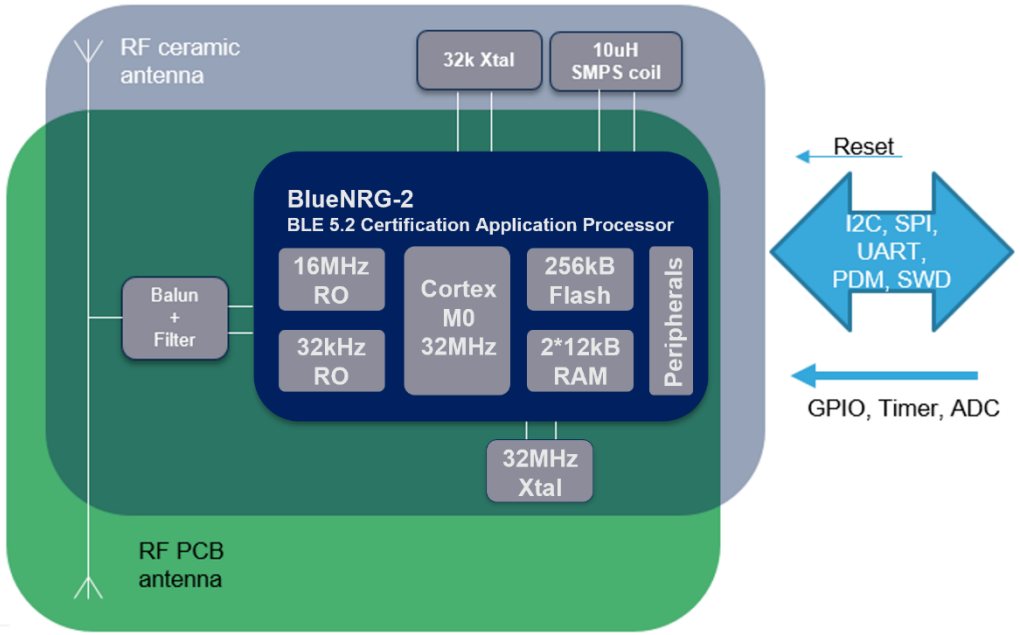
BlueNRG-M2SA–BlueNRG-M2SP

BlueNRG-M2SA

BlueNRG-M2SP



KEY APPLICATIONS

- Smart-home appliances
- Industrial automation
- Remote control and monitoring

EVALUATION BOARDS

- **X-NUCLEO-BNRG2A1**, BlueNRG-M2SP
- **STEVAL-IDB008V1M**, BlueNRG-M2SA

KEY BENEFITS AND FEATURES

READY-TO-GO BLE CONNECTIVITY:

- BlueNRG-232 Bluetooth Low Energy wireless processor
- Up to +7 dBm output power (-M2SP), -85 dBm Rx sensitivity
- Cortex-M0 @ 32MHz, 2x 12KB RAM and 256KB Flash memory
- Included AES-128 security co-processor
- KC, CE/RED, FCC, IC, TELEC, WPC (-M2SP) and SRRC (-M2SA) modular approval certified

PRE-CERTIFIED SOLUTION:

- BT SIG 5.2 certification for module
- Supports master and slave modes
- Multiple roles supported simultaneously
- Embedded GAP, ATT/GATT, SM and L2CAP layers
- Bluetooth low energy profiles supported

ALL-IN-ONE SOLUTION:

- Small form factor: 13.5 x 11.5 x 2 mm
- Industrial temperature range: -40 °C to +85 °C
- Power supply voltage from 1.7V to 3.6V

BlueNRG-M2SA is power consumption optimized.
BlueNRG-M2SP is cost optimized.

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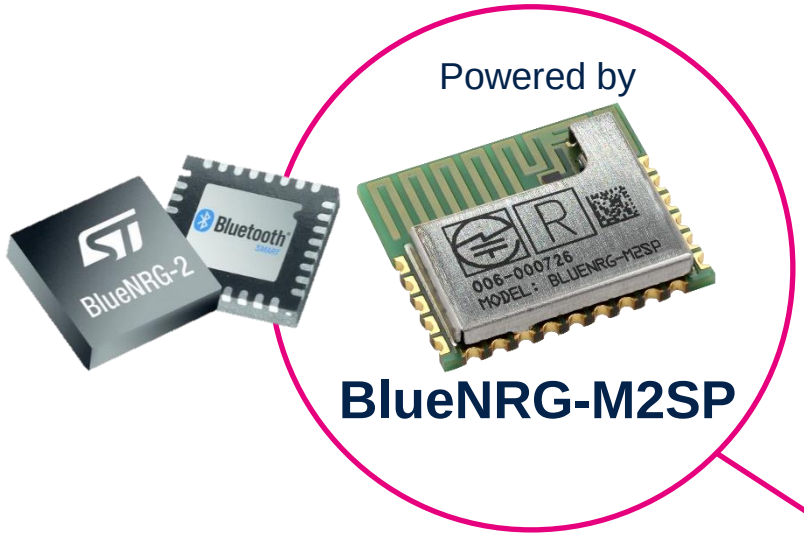
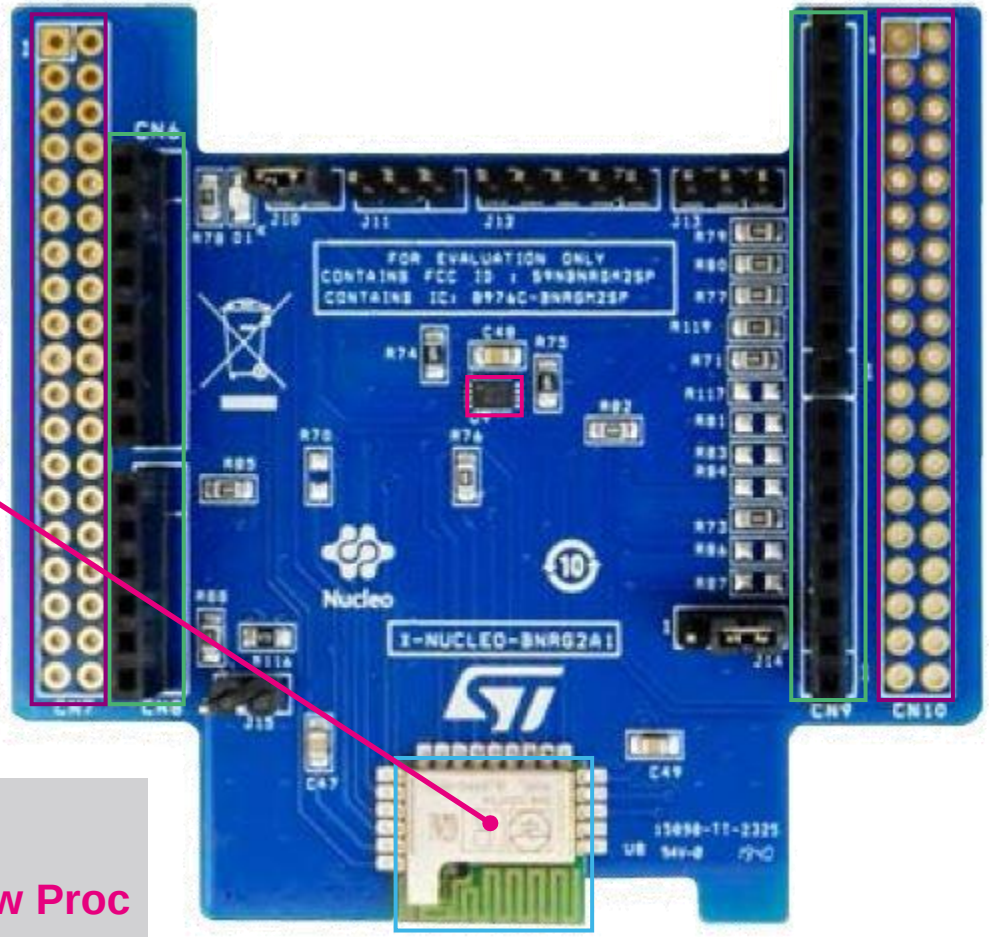
X-NUCLEO-BNRG2A1
BlueNRG-M2SP and BlueNRG-2N evaluation board





BlueNRG Module Family
Suitable for

2.4GHz Proprietary

Bluetooth 5

Bluetooth SIG Mesh

EXPANSION FW PACKAGES
- X-CUBE-BLE2
- X-CUBE-BLEMESH1
- FP-SNS-BLEMESH1

STM32 Open Development Environment

BlueNRG-M2 Wireless SoC **emulating BlueNRG-2N Ntw Proc**

- BlueNRG-232, BALF-NRG-02D2, 32MHz Oscillator
- M95640
- Arduino UNO R3 connector
- ST Morpho connector (opt)

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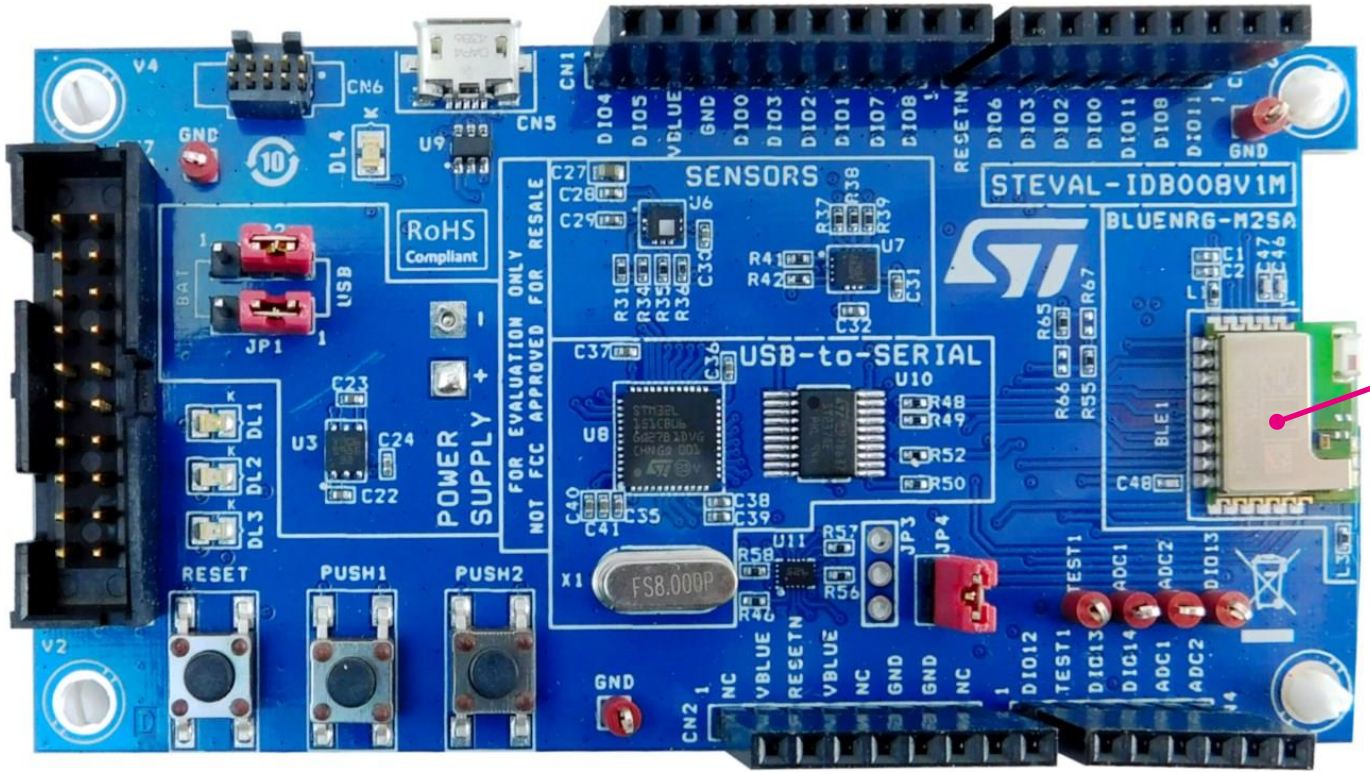
STEVAL-IDB008V1M
BlueNRG-M2SA evaluation board

BlueNRG Module Family
Suitable for

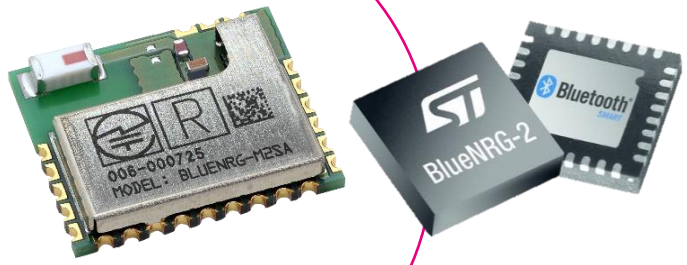
2.4GHz Proprietary

Bluetooth 5

Bluetooth SIG Mesh



Powered by



BlueNRG-M2SA

BlueNRG-M2 **Wireless SoC FW Package**
STSW-BLUENRG1-DK
including interactive, simple and user-friendly PC Graphical User Interfaces (GUIs)

- **BlueNRG Navigator**
- **BlueNRG Radio Initialization Wizard**

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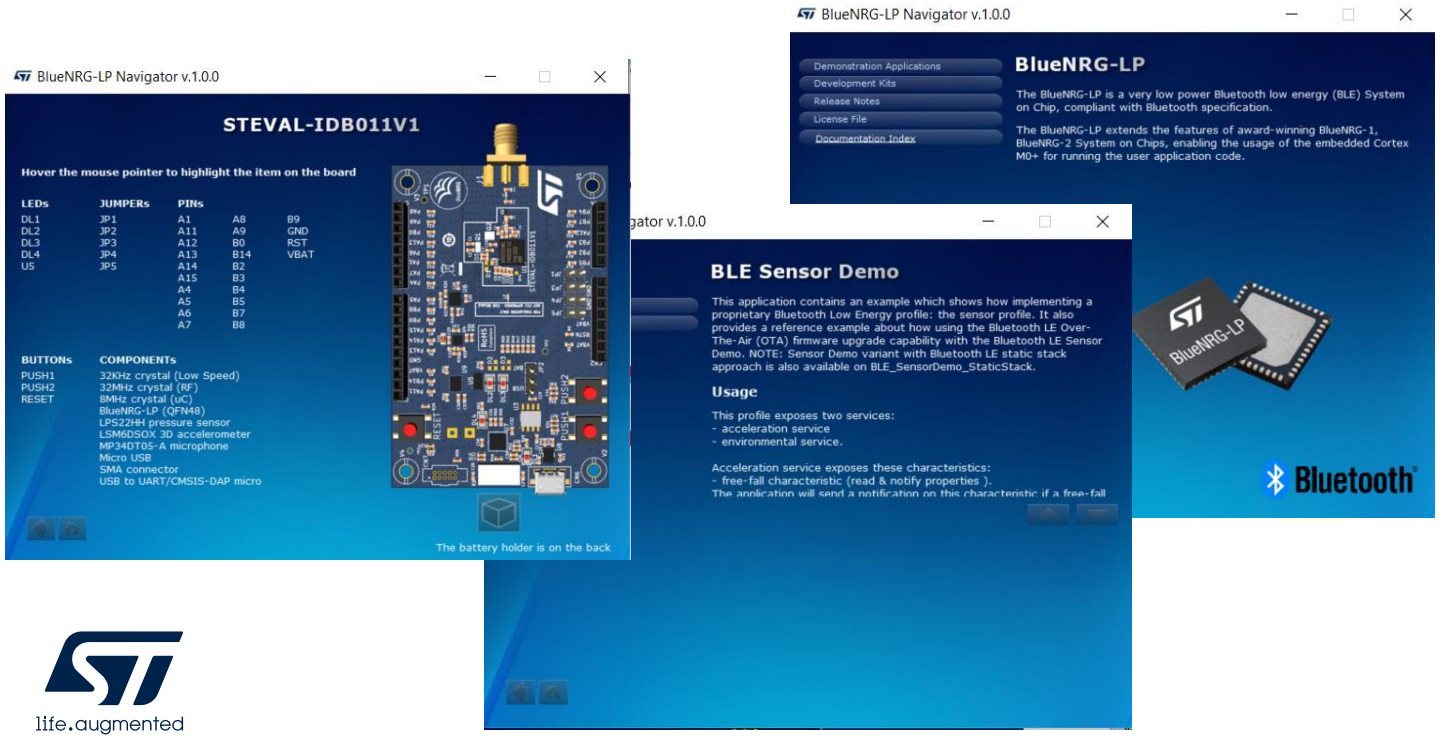
BlueNRG PC tools ecosystem

BlueNRG Navigator: out-of-the-box

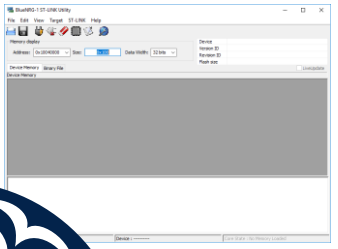
Graphical user interface (GUI) that provides simple and user-friendly interface to browse, flash, and run application examples included in the SDK package. It also allows to explore STEVAL KIT in each and all of its features.

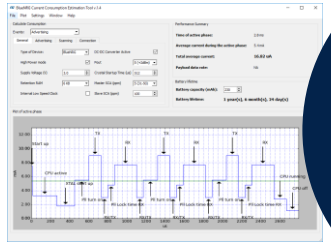


BlueNRG Dev tools: hands-on

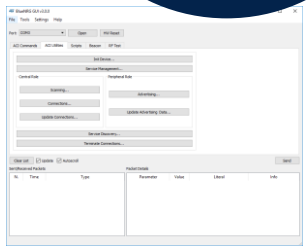
Radio Init Wizard

ST-Link Utility

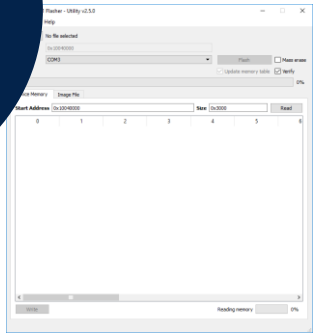




Power Consumption

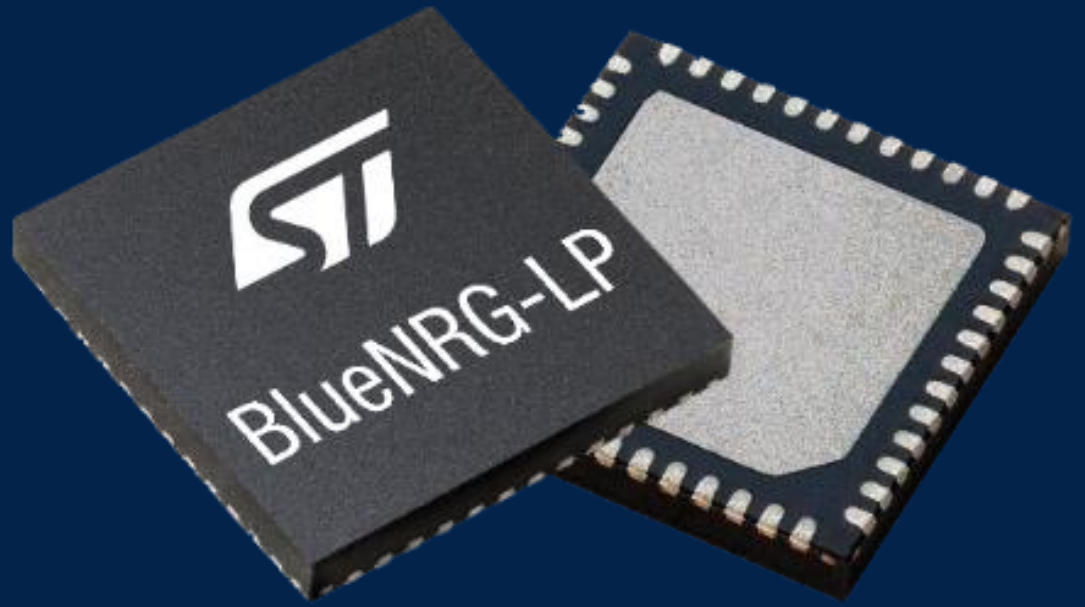


Graphical User I/f



Flasher utility

BlueNRG-LP introduction



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BlueNRG-LP
Bluetooth LE 5.2 certified SoC

Key benefits and enhancements

QFN48	BlueNRG-345Mx	BlueNRG-355Mx
QFN32	BlueNRG-345Ax	BlueNRG-355Ax
WLCSP49	BlueNRG-345Vx	BlueNRG-355Vx
	32KB RAM	64KB RAM

Dual option available for Temperature operating range
(up to +85 ºC and up to +105 ºC)

1	BLE 5.2 core certified
2	Faster data transfer (2Mbps)
3	Long range communication
4	Multiple concurrent connections
5	Robust BLE protocol stack
6	Ultra-low-power architecture
7	Cryptographic security

BlueNRG-LP wireless processor technology highlights

Faster data transfer	The **2 Mbps** feature has now doubled the bandwidth, allowing lower latency and OTA upgrade in less than 5 seconds
Long range communication	The higher **maximum output power (+8 dBm)**, together with **Long Range** feature, will enable to cover greater distance and to communicate effectively
Multiple concurrent connections	World's first Bluetooth® LE 5.2-certified SoC supporting **up to 128 concurrent connections**
Robust BLE protocol stack	**Highly optimized, upgradable and robust-proven Bluetooth® Low Energy stack** developed and maintained by ST expertise team
Ultra-low-power architecture	Optimized power consumption thanks to the **ultra-low-leakage memories** and **sophisticated power-management architecture (< 1µA in deep stop mode)**
Cryptographic security	Built-in **image authentication technology** enhances cyber-security by always checking the stack before starting to allow only signed firmware images to run

BlueNRG-LP applications

Tracking and monitoring

Asset tracking and beacons

- Ultra-low power consumption
- Market leading BLE range
- SigFox LPWAN with S2-LP
- Cost optimized (2-layer PCB, integrated Balun & xtal caps, device variants)

People and animal tracking

- Social distancing and tracing, worker tracking,
  pet & livestock tracking, prisoner tags
- Ultra-low power, application security
- Cost effective in application

Lighting and building automation

- Lighting, ventilation, heating, HVAC, smart locks
- MESH, +105ºC, security
- Adv. ext., Long Range, CSA #2

Industrial applications

Industrial connectivity

- Remote UI, remote control units
- Enhanced processing & peripherals
- Audio IF (PDM, Analog, I2S)
- 10 years longevity
- Device security

Smart tools and appliances

- Future proof with BTH5.2 certification
- 10 years longevity
- Flexible architecture (SoC or add on)
- Device security

Healthcare, wearable

- Auto injectors, dispensers, inhalers, sports sensors
- 10 years longevity, security

Consumer applications

Personal electronics

- Toothbrush, shaver, e-cigarette, massage tools, gaming, etc.
- Enhanced processing & peripherals
- MEMS sensor libraries
- BLE stack flexibility, RF driver
- 2Mbps PHY and secure OTA
- Device package and memory variants

Connected toys, consumer robots

- Toys, robot vacuum, lawn mover, pool robot. etc.
- Flexible architecture (SoC or add on)
- Cost optimized (2-layer PCB, integrated Balun & xtal caps, device variants)

Tracking and monitoring application

Typical end products

Asset Monitoring, Beacons (static installation)

Asset Tracking (moving objects)

Real time localization system (way finding)

People and animal monitoring and tracing

Tracking and monitoring application

BlueNRG-LP benefits by KPI

Ultra-low current consumption

- **Market leading current**
- Peak Rx 3.4mA, Tx 4.3mA
- Market best sleep current down to 0.6uA

Longest possible communication range

- Market best dynamic range
- **Long Range 1.3 km** and 1Mbps 0.9km range demonstrated
- LPWAN may co-exist like SigFox with S2-LP and BlueNRG

Cost optimized

- **Cost effective BLE SoC family**
- 2-layer PCB, integrated balun and xtal load caps

Asset Monitoring, Beacons (static installation)

Asset Tracking (moving objects)

Real time localization system (way finding)

People and animal monitoring and tracing

Industrial application

Typical end products

Connected tools

Metering

Industrial HMI

mPOS

Medical

Industrial application

BlueNRG-LP benefits by KPI

Future proof solution

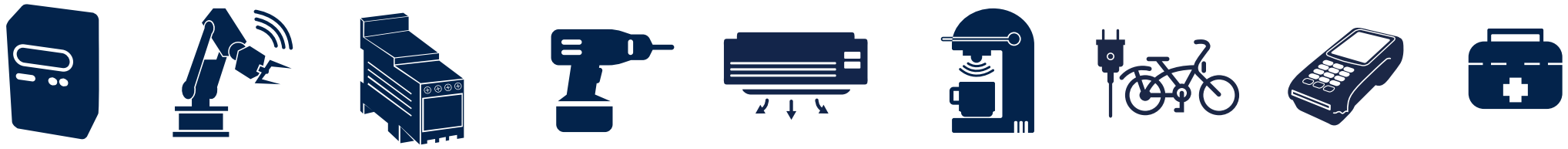
- **10 years longevity**
- Bluetooth 5.2 certified with 5.0 full features including Long Range & CSA#2
- Bluetooth mesh or ultra-low latency proprietary 2.4GHz radio driver

Security

- **Secure bootloader** execute only signed FW image
- Flash protection against external access
- OTA for on field BLE stack and application update
- 105 ºC compliant for harsh environment

Flexible architecture

- **'Add on BLE' architecture** fit to add wireless for special requirement end appliations like metering, mPOS, medical
- 'BLE SoC' architecture optimal to include also application to the same device for cost, size and current optimization



Consumer application

Typical end products





Toothbrush, shaver

e-cigarettes

Toys, educational products

Consumer robotics

Consumer application

BlueNRG-LP benefits by KPI

All features for mid and low tier applications

- **Application capability** Cortex M0+ 64MHz, 256/64 kB, up to 32 GPIO, rich peripherals set
- Secure and fast OTA capable with 2Mbps PHY
- Flexible architecture (add on or SoC)

Ultra-low current consumption

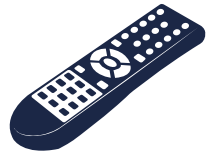
- **Market leading current**
- Peak Rx 3.4mA, Tx 4.3mA
- Market best sleep current down to 0.6uA

Cost and size optimized

- **Cost effective BLE SoC family**
- 2-layer PCB, integrated balun and xtal load caps
- Down to 45 mm^2 application size (ant. excluded)



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BlueNRG-LP
Go faster, go further!

Up to 1.3 Km communication range…

STANDARD mode: **960 m**
LE1M PHY

LONG RANGE: **1.3 km**
Coded PHY LE S=8

Range measurement report available on demand

… and up to 128 concurrent connections

BlueNRG-LP
Bluetooth® Low Energy 5.2 certified SoC

Key highlights

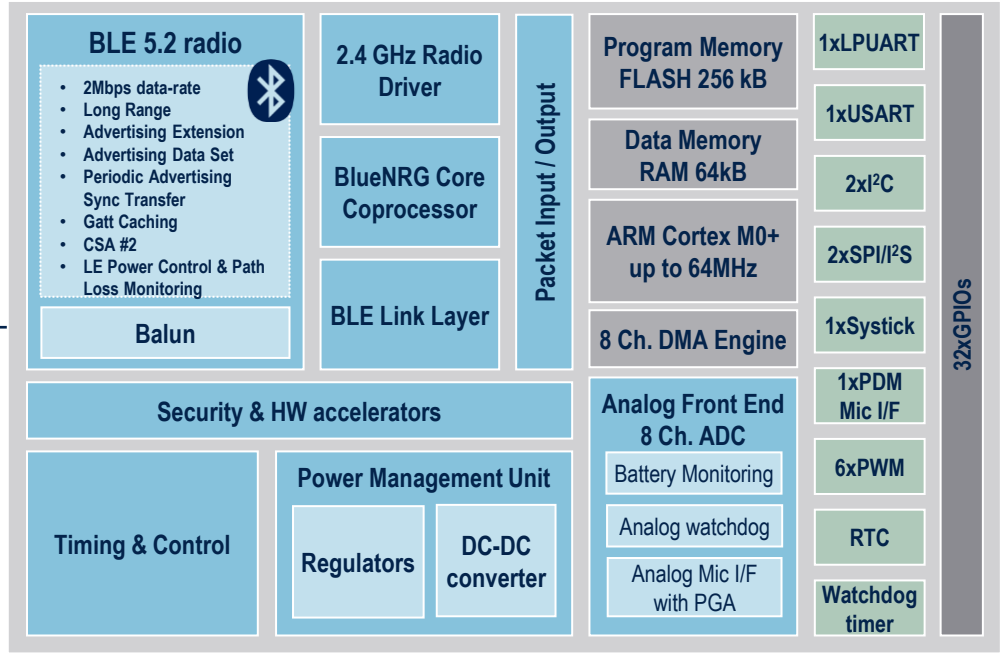
Bluetooth® LE 5.2 certified

Radio performance
- RX Sensitivity level
- **-97dBm** @ 1Mbps
- **-104 dBm** @ 125kbps
- Up to **+8 dBm** output power level
- **4.3 mA** TX current
- **3.4 mA** RX current

Reduced BOM cost
- **Integrated Balun**
- **Capacitor-less** 32MHz crystal.

Advanced security set
- **Flash read/write protection.**
- **Secure bootloader**
- **SWD access can be disabled**

Block Diagram



Device information

- High Throughput: **2 Mbps** 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 Algor. #2
- GATT caching
- LE Power Control & Path Loss Monitoring
- **ARM Cortex-M0+, 64 MHz**
- **256-Kbyte** Flash, **64-Kbyte** (32-KByte) SRAM , MPU
- Extensive peripheral set: 2 x SPI / I2S, 1x SPI, 2 x I²C, 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 V to 3.6 V**
- Operating temperature: from -40 up to 85 ‘C / **-40 up to 105 ‘C**
- Package available: **QFN32** (20 GPIOs), **QFN48** (32 GPIOs), **WLCSP49** (26 GPIOs)

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BlueNRG-LP ordering information

BlueNRG – 3 5 5 M C

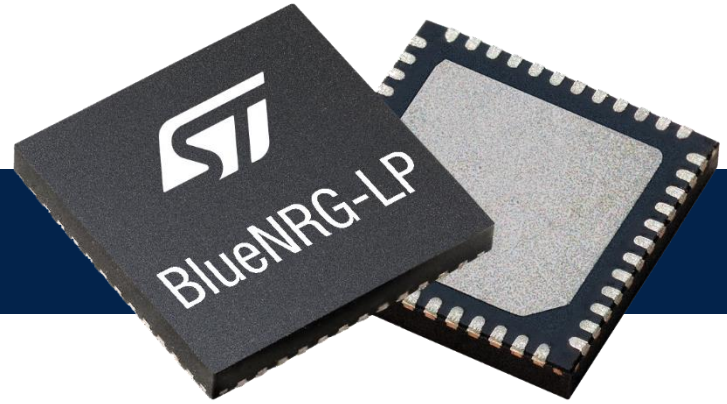
Product Family
Bluetooth® Low Energy Processor

Temperature Range
C – -40C up to +85C
T – -40C up to +105C

Package Type
A – QFN32
M – QFN48
V – WLCSP

Memory Configuration
4 – 256KB Flash / 32KB RAM
5 – 256KB Flash / 64KB RAM

Device Generation
3 – BlueNRG-LP based



Bluetooth®

LONGEVITY 10 YEARS COMMITMENT

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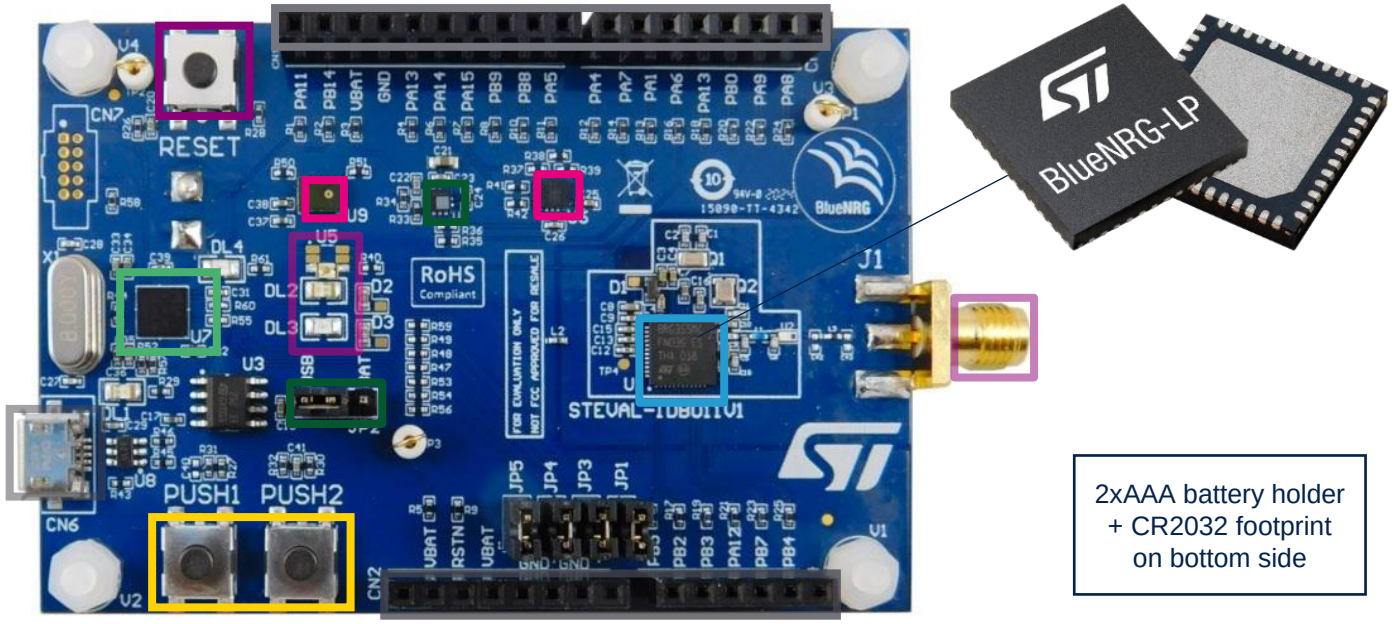
STEVAL-IDB011V1 and STSW-BNRGLP-DK

BlueNRG-LP evaluation HW and SW development kit



2xAAA battery holder + CR2032 footprint on bottom side

https://www.st.com/en/evaluation-tools/steval-idb011v1.html

- BlueNRG-355MC
- MP34DT05-A
- LPS22HB
- LSM6DSOX
- User LED (2 + 1 RGB)
- User button (2)
- Reset button
- USB/Battery power selection
- USB connector
- Arduino UNO R3 connector
- SMA connector
- CMSIS-DAP debugger/programmer

BLE_ANCS
BLE_Beacon
BLE_Beacon_FlashManagement
BLE_Beacon_FreeRTOS
BLE_HID_Peripheral
BLE_MultipleConnections
BLE_OTA_ResetManager
BLE_OTA_ServiceManager
BLE_Power_Consumption
BLE_Privacy
BLE_RC_LongRange
BLE_RemoteControl
BLE_Security
BLE_SensorDemo
BLE_SensorDemo_BlueMSap
BLE_SensorDemo_Central
BLE_SensorDemo_StaticStack
BLE_SerialPort
BLE_SerialPort_Master_Slave
BLE_StaticStack
BLE_Throughput
DTM
DTM_basic
DTM_Updater

BLE_Beacon

Enabling Advertsing Extension, and getting 8x Broadcast (BLE5.0 feature)

BLE_MultipleConnections

Allow a MasterSlave device to connect to a configurable number of peers (up to 128)

BLE_RC_LongRange

Enabling Long Range, and getting 1.5x Range (BLE5.0 feature)

BLE_SensorDemo_BlueMSapp

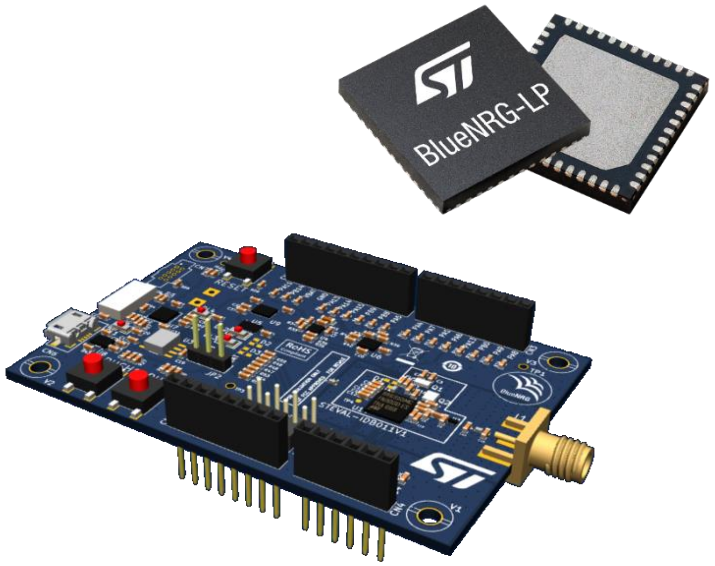
Connect and share data sensor with ST BLE Sensor App

BLE_Thoughput

Enabling 2Mbps, and getting 2x Speed (BLE5.0 feature)

BlueNRG-LP SW Development Kit

HW Evaluation Kit → **SW Development Kit** → **Tackle your market!**



STSW-BNRGLP-DK

https://www.st.com/en/embedded-software/stsw-bnrglp-dk.html

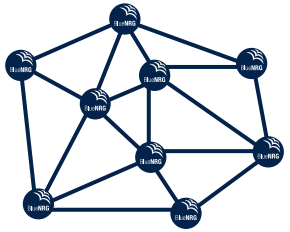
STSW-BNRGLP-MESH

https://www.st.com/en/embedded-software/stsw-bnrglp-mesh.html

Bluetooth™ **BLE**

2.4Ghz proprietary protocol

1 Byte	4 Bytes	1 Byte	1 Byte	0 to 31 Bytes	3 Byte
Preamble	NetworkID	Header	Length	Data	CRC



BLE- Mesh

STEVAL-IDB010V1 (WLCSP)
STEVAL-IDB011V1 (QFN48)

Free of charge certified stack: BLE and Mesh

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BlueNRG-LP Mesh brings smart-home to your fingertip

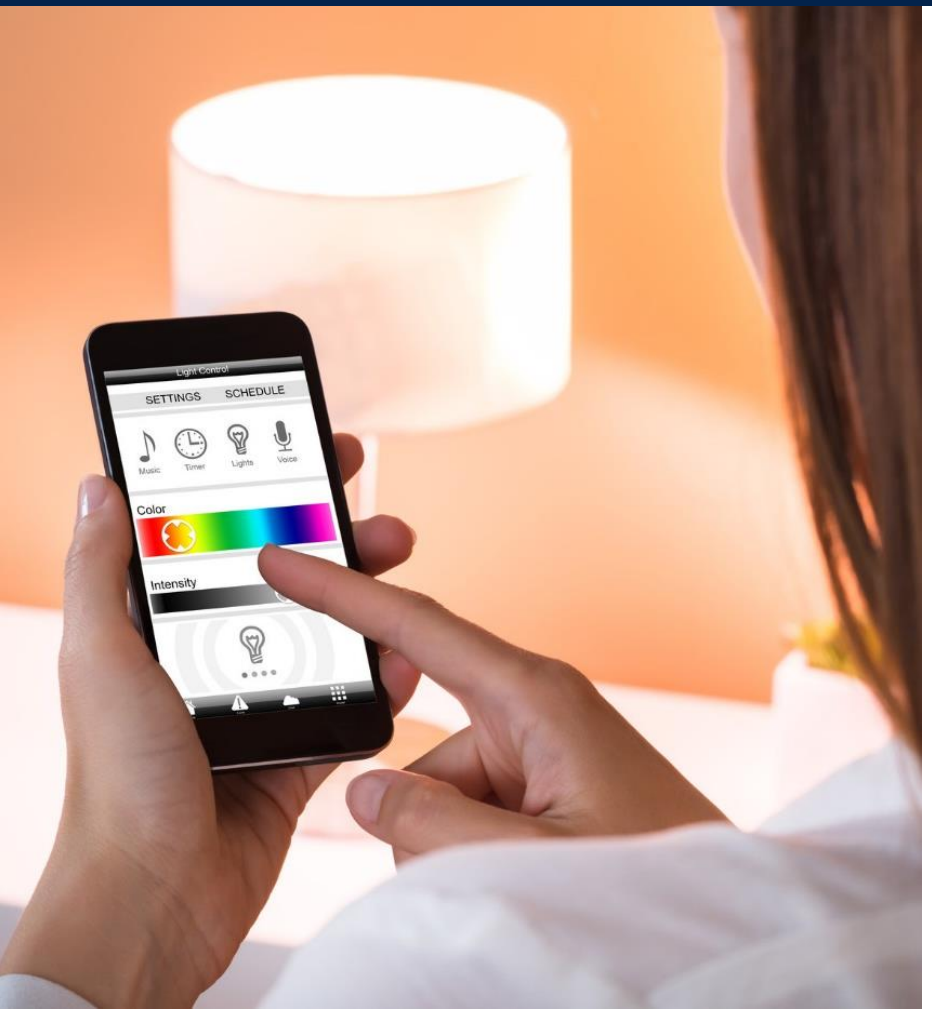
Easily connecting appliances to iOS/Android, out-of-the-box

- Bluetooth® **Mesh 1.0.1 certified Profile Library, Server and Client Model,** 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

BlueNRG-LP: dual option for smart lighting

Bluetooth® LE 5.2 certified SoC solution



Sensors

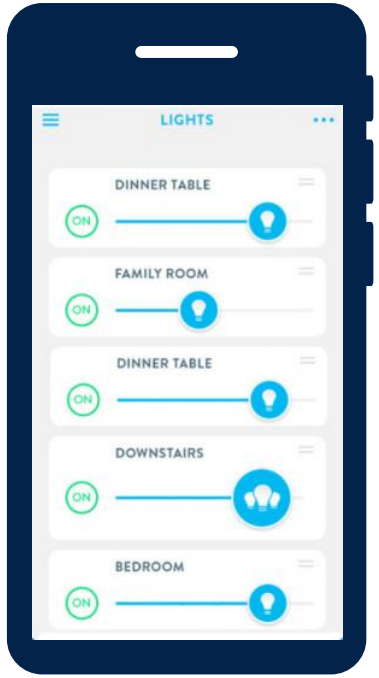
STSW-BNRGLP-DK

BlueNRG-LP has been designed to support up to **128** concurrent connection

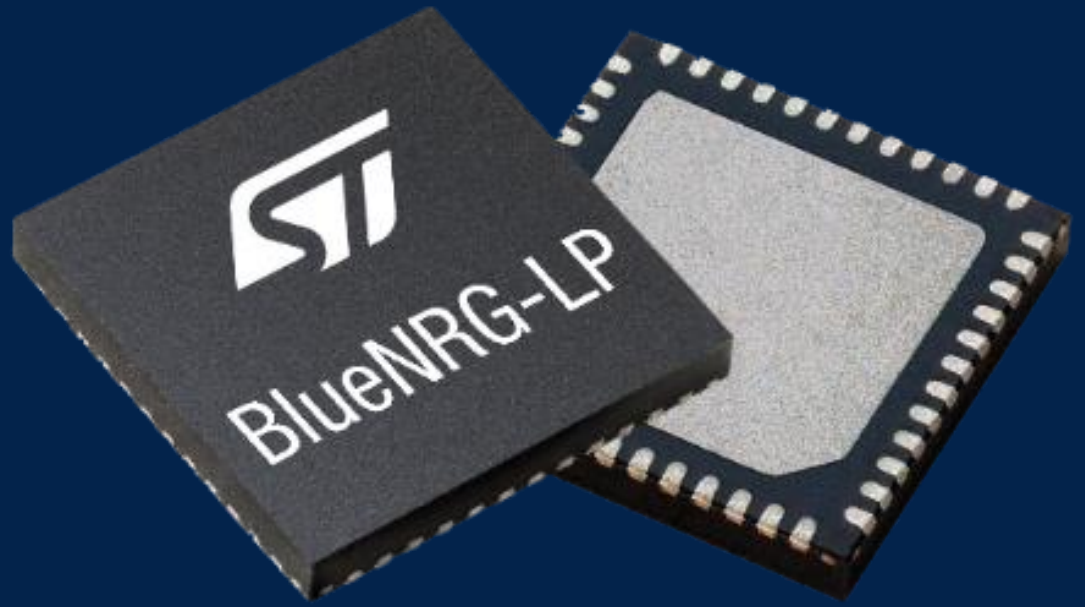
STSW-BNRGLP-MESH

Bluetooth® SIG-certified Mesh stack: up to **126** hops and **32,767** nodes

Extended temperature range
-40°C to +105°C



BlueNRG-LP key benefits and enhancements



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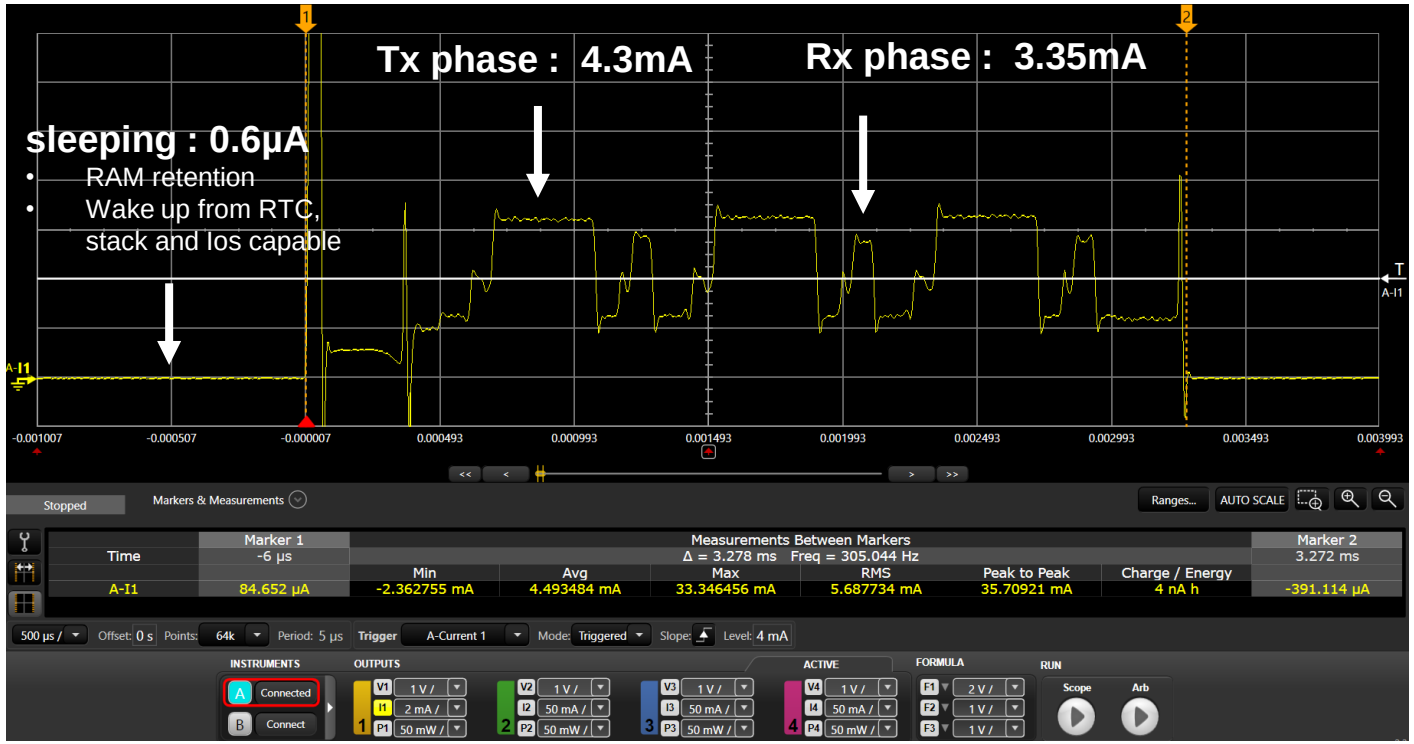
The lowest average power consumption



5.8uA average power consumption (advertising 31 bytes, every 3secs, 3V, +0dbm)

0.6µA sleep current : best on the market.

Outstanding active Rx and Tx current

BlueNRG-LP designed for ultra low power applications

BlueNRG-LP is offering one of the best power efficient solution on the market

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The best range
Mont saint michel bay

1 Mbps - 960m
LE1M PHY

Long Range - 1.3km
Coded PHY LE S=8

Range measurement report available

BlueNRG-LP flexible & integrated

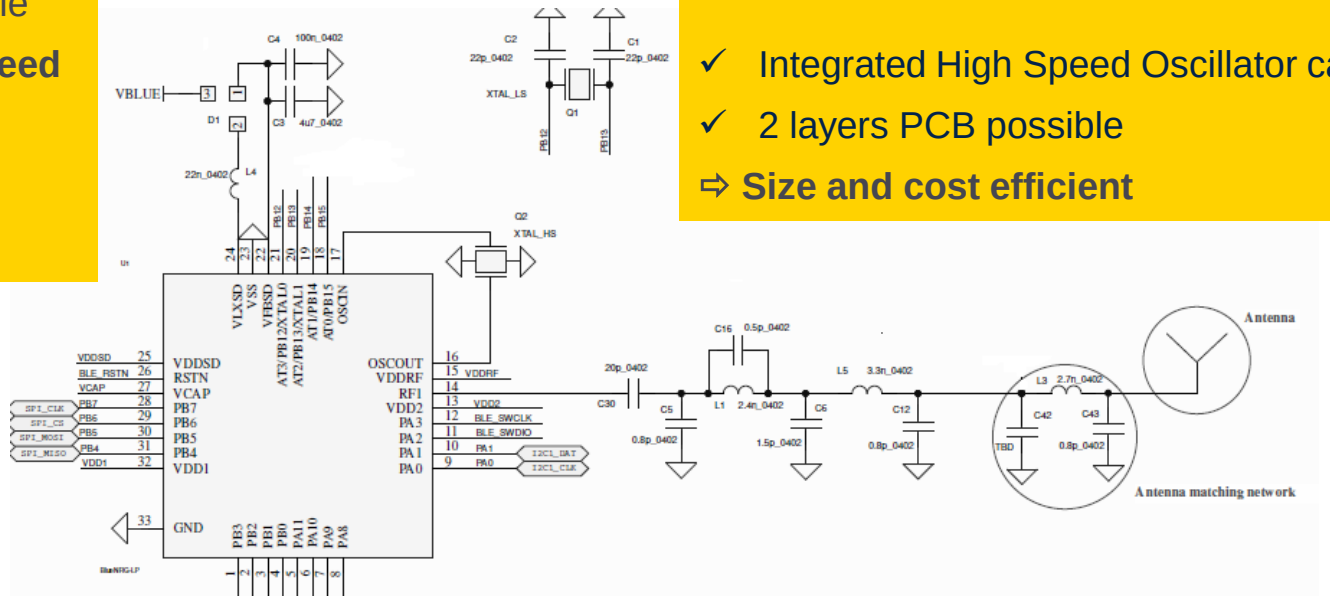
Flexible

- ✓ Internal SMPS or internal LDO
- ✓ External 32kHz or internal RO
- ✓ QFN32, QFN48 and WCSP49 package available

⇨ **Adapt HW size and cost versus application need**

- ✓ Flexible Cortex-M0+ Core speed

⇨ **Processing power on demand**



Integrated

- ✓ Integrated balun - 50Ω single ended output

⇨ **Only few discretes matching/filtering needed**

- ✓ Integrated High Speed Oscillator capacitor
- ✓ 2 layers PCB possible

⇨ **Size and cost efficient**

BlueNRG-LP offers flexibility with cost and size integrated solution

BlueNRG-LP fast OTA capability

Firmware upgrade - ST BLE Sensor App protocol

ST BLE Sensor App

upgrade of a Sensor BLE typical application
~80KB (stack included)

BlueNRG-1
65 secs

BlueNRG-2
12 secs

BlueNRG-LP
5 secs

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BlueNRG-LP peripherals enhancement

Enhanced set of Standard peripherals

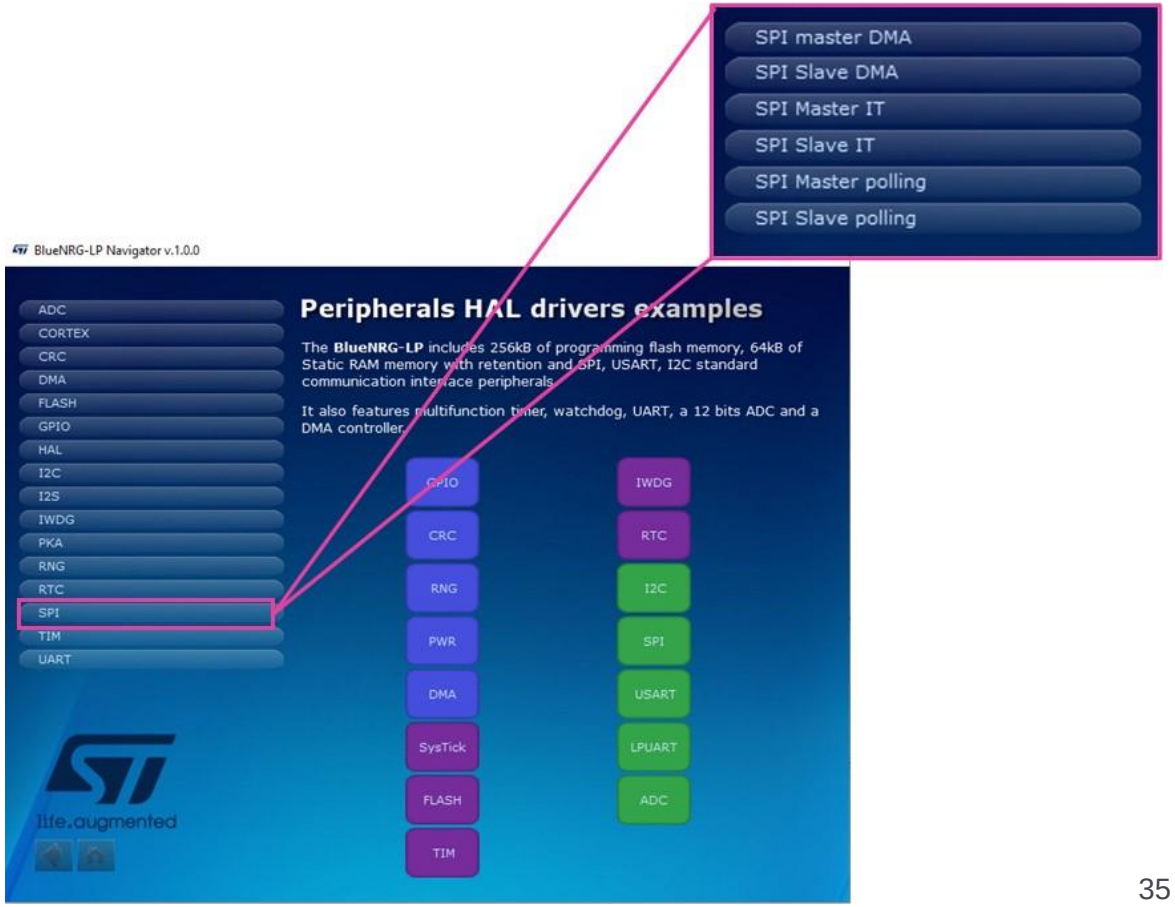
- USART, LPUART, I2S/SPI **(x3)** , I²C **(x2)**
- PDM, 16-bit 6 channel **advanced timer**
- Independent RTC with capabilities to wake-up system.
- Independent WDG, Independent SysTick, …
- **12bits ADC – 8 channels**, **analog µPhone input**, PGA,…
- Battery monitoring
- …

Comprehensive and easy to use APIs

Based on ST HAL or LL APIs

Multiple code Examples for each peripherals

Covering multiple customer use case



BlueNRG-LP core & DMIPS enhancement

Opening to more demanding application

Improving system clock X 2

M0+ Cortex up to **64Mhz**

Extended RAM

Up to 64KB RAM

Thanks to enhancement BlueNRG-LP customers taking benefits from wide in-house product portfolio

Easy integration of any ST MEMS sensors portfolio, thanks to drivers available @GitHub and fully compatible with BlueNRG-LP DK

Capability to run advanced SW algorithm

Voice over BLE
DMIPS improvement allowing more performant algorithm integration (OPUS)

Motion Algorithms
Gesture and Activity recognition

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Enhanced security features

Flash protection : disabling SWD & UART access (refer RM0479)

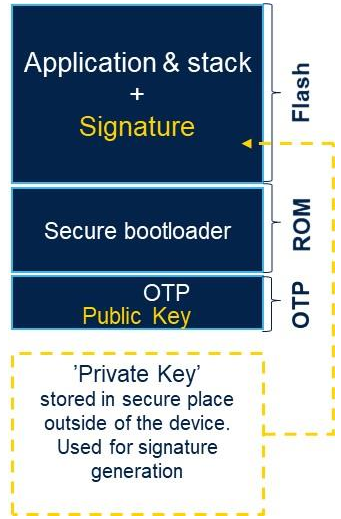
3 level of **Protection** preventing application cloning & modification

- 3 level of **Protection** preventing application cloning & modification.
- Protection against external memory access (Reversible or Irreversible)

Secure boot : FW image authentication (refer AN5471)

Ensure that only a firmware image **signed** with a correct Private Key is executable

- Secure bootloader in ROM
- FW image authentication before execution - Only Signed image can be executed.



Secure application access with BLE Security

STSW-BNRGLP-DK

- BLE_ANCS
- BLE_Beacon
- BLE_Beacon_FlashManagement
- BLE_Beacon_FreeRTOS
- BLE_HID_Peripheral
- BLE_MultipleConnections
- BLE_OTA_ResetManager
- BLE_OTA_ServiceManager
- BLE_Power_Consumption
- BLE_Privacy
- BLE_RC_LongRange
- BLE_RemoteControl
- BLE_Security
- BLE_SensorDemo
- BLE_SensorDemo_BlueMSapp
- BLE_SensorDemo_Central
- BLE_SensorDemo_StaticStack
- BLE_SerialPort
- BLE_SerialPort_Master_Slave
- BLE_StaticStack
- BLE_Throughput
- DTM
- DTM_basic
- DTM_Updater

BLE_Privacy

Enable Pairing, Bonding and Privacy through White-list mechanism

Code example for Peripheral & Central role

BLE_Security

Enable BLE state of the art security methods: Just Works, Pass Key, Numeric Comparison

Code example for Peripheral & Central role

Documentation resources

Programming Guide (PM0269)

Table 9. **Mapping of IO capabilities to possible key generation methods**

Initiator/ responder	Display only	Display yes/no	Keyboard only	No input no output	Keyboard display
Display only	Just Works	Just Works	Passkey Entry	Just Works	Passkey Entry
Display yes/no	Just Works	Just Works (LE legacy) Numeric comparison (LE secure connections)	Passkey Entry	Just Works	Passkey Entry (LE legacy) Numeric comparison (LE secure connections)
Keyboard only	Passkey Entry	Passkey Entry	Passkey Entry	Just Works	Passkey Entry
No input no output	Just Works	Just Works	Just Works	Just Works	Just Works
Keyboard display	Passkey Entry	Passkey Entry (LE legacy) Numeric comparison (LE secure connections)	Passkey Entry	Just Works	Passkey Entry (LE legacy) Numeric comparison (LE secure connections)

BLE security summary

3.11.1 **Controller-based privacy and the device filtering scenario**

On Bluetooth LE stack v2.x, the `aci_gap_init()` API supports the following options for the `privacy_type` parameter:

- 0x00: privacy disabled
- 0x01: host privacy enabled
- 0x02: controller privacy enabled.

When a slave device wants to resolve a resolvable private address and be able to filter on private addresses for reconnection with bonded and trusted devices, it must perform the following steps:

1. Enable privacy controller on `aci_gap_init()`: use 0x02 as `privacy_type`parameter.
2. Connect, pair and bond with the candidate trusted device using one of the allowed security methods: the private address is created using the devices IRK.
3. Get the bonded device identity address and type using the `aci_gap_get_bonded_devices()` API.
4. Add the bonded device identity address and type to the Bluetooth LE device controller whitelist and to the list of address translations used to resolve resolvable private addresses in the controller, by using the `aci_gap_configure_white_and_resolving_list(0x01|0x02);` API.
5. The device configures the undirected connectable mode by calling the `aci_gap_set_advertising_configuration()` API with `Advertising_Filter_Policy` =

API usage summary

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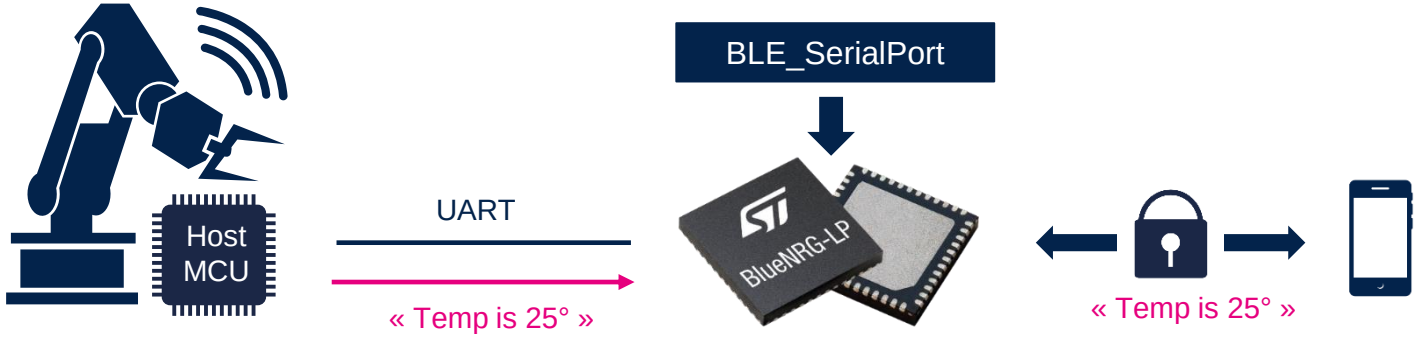
BLE as basic add-on for UART to BLE bridge

STSW-BNRGLP-DK

- BLE_ANCS
- BLE_Beacon
- BLE_Beacon_FlashManagement
- BLE_Beacon_FreeRTOS
- BLE_HID_Peripheral
- BLE_MultipleConnections
- BLE_OTA_ResetManager
- BLE_OTA_ServiceManager
- BLE_Power_Consumption
- BLE_Privacy
- BLE_RC_LongRange
- BLE_RemoteControl
- BLE_Security
- BLE_SensorDemo
- BLE_SensorDemo_BlueMSapp
- BLE_SensorDemo_Central
- BLE_SensorDemo_StaticStack
- BLE_SerialPort
- BLE_SerialPort_Master_Slave
- BLE_StaticStack
- BLE_Throughput
- DTM
- DTM_basic
- DTM_Updater

BLE_SerialPort
Enable a basic UART to BLE bridge “SPP” like turnkey example exposing a basic profile to enable a cable replacement application



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ST sensor ecosystem

STSW-BNRGLP-DK

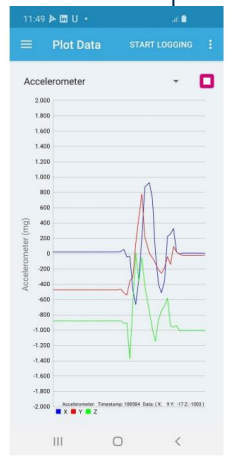
- BLE_ANCS
- BLE_Beacon
- BLE_Beacon_FlashManagement
- BLE_Beacon_FreeRTOS
- BLE_HID_Peripheral
- BLE_MultipleConnections
- BLE_OTA_ResetManager
- BLE_OTA_ServiceManager
- BLE_Power_Consumption
- BLE_Privacy
- BLE_RC_LongRange
- BLE_RemoteControl
- BLE_Security
- BLE_SensorDemo
- BLE_SensorDemo_BlueMSapp
- BLE_SensorDemo_Central
- BLE_SensorDemo_StaticStack
- BLE_SerialPort
- BLE_SerialPort_Master_Slave
- BLE_StaticStack
- BLE_Throughput
- DTM
- DTM_basic
- DTM_Updater

BLE_SensorDemo_BlueMSapp

ST driver ecosystem driver integration

LPS22HB pressure sensor, LSM6DSOx 6-axis MEMS and MP34DT05-A audio MEMS

ST Voice Library integration



ST BLE Sensor App in source

Sensors

https://github.com/STMicroelectronics/STMems_Standard_C_drivers

M0+ up to 64Mhz

HW RF state machine

RF activities sustain w/o preempting core resources

ST Motion Library integration : Voice over BLE, MotionFX, FFT, …

X-CUBE-MEMS1

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Firmware upgrade over the air

STSW-BNRGLP-DK

- BLE_ANCS
- BLE_Beacon
- BLE_Beacon_FlashManagement
- BLE_Beacon_FreeRTOS
- BLE_HID_Peripheral
- BLE_MultipleConnections
- BLE_OTA_ResetManager
- BLE_OTA_ServiceManager
- BLE_Power_Consumption
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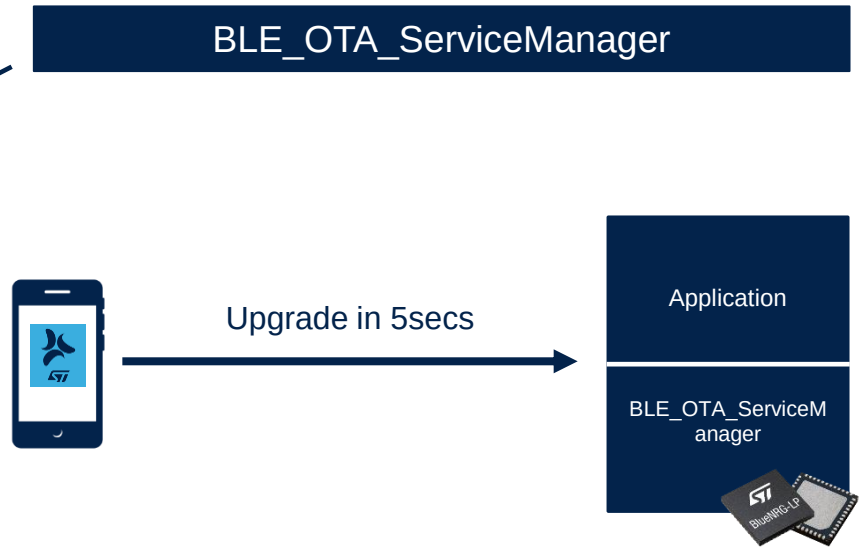
- BLE_SensorDemo
- BLE_SensorDemo_BlueMSapp
- BLE_SensorDemo_Central
- BLE_SensorDemo_StaticStack
- BLE_SerialPort
- BLE_SerialPort_Master_Slave
- BLE_StaticStack
- BLE_Throughput
- DTM
- DTM_basic
- DTM_Updater



FOTA turnkey solution
FOTA FW in source : **plug & play**
App in source : integrate into your own App

Documentation resources

AN FOTA (AN5463)

2 OTA FW upgrade service description

The OTA FW upgrade service is addressed through the files OTA_btl.[ch] provided within the BlueNRG-LP DK SW package (Middlewares\ST\BLE_Application\OTA folder).
A short description of the OTA FW upgrade service and its related characteristics follows:

- Btl OTA service (OTA_SRVC_UUID): it is the FW upgrade service
  - aci_gatt_srv_add_service((ble_gatt_srv_def_t *)&ota_service);
- Btl image characteristic (IMAGE_CHR_UUID): it contains some information about lower and higher bounds of free memory as suggested by the current application that includes the OTA FW upgrade service
- Btl new image characteristic (NEW_IMAGE_CHR_UUID): it contains the base address and the size of the image that the master pretends to send over-the-air and the notification range requested to the slave for sending acks during OTA FW transfers
- Btl new image content characteristic (IMAGE_CONTENT_CHR_UUID): it contains a 16-byte block of firmware image data sent by the master (through a characteristic write command) along with some control information such as: block sequence number (2 bytes) and checksum for integrity check (1 byte)
- Btl expected image sequence number characteristic (IMAGE_SEQ_NUM_CHR_UUID: it allows the slave device to notify the master about the next block it expects and error conditions

Note: OTA FW upgrade service and characteristics proprietary UUIDs (128 bits) are defined within the file OTA_btl.c.

2.1 OTA firmware upgrade transactions

In this section the steps for OTA firmware upgrade are dealt with:

1. Once the master and slave device running the OTA FW upgrade service are set, a discovery procedure needs to be fulfilled in order to allow the two devices to be connected. Discovery is achieved listening to advertisements coming from the devices within the radio range (active scan) and selecting the ones containing the OTA FW upgrade service UUID (128 bits) within the scan response.

Data rate enhancement

STSW-BNRGLP-DK

- BLE_ANCS
- BLE_Beacon
- BLE_Beacon_FlashManagement
- BLE_Beacon_FreeRTOS
- BLE_HID_Peripheral
- BLE_MultipleConnections
- BLE_OTA_ResetManager
- BLE_OTA_ServiceManager
- BLE_Power_Consumption
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- BLE_SerialPort
- BLE_SerialPort_Master_Slave
- BLE_StaticStack
- BLE_Throughput
- DTM
- DTM_basic
- DTM_Updater

BLE_Throughput

Enable and increase data rate playing with

connection interval

MTU size

data packet length & 2Mpbs

data packet size

1.2Mpbs front of S10+

Documentation resources

Programming Guide (PM0269)

3.12 ATT_MTU and exchange MTU APIs, events

ATT_MTU is defined as the maximum size of any packet sent between a client and a server:

- default ATT_MTU value: 23 bytes

This determines the current maximum attribute value size when the user performs characteristic operations (notification/write max. size is ATT_MTU-3).

The client and server may exchange the maximum size of a packet that can be received using the exchange MTU request and response messages. Both devices use the minimum of these exchanged values for all further communications:

```
tBleStatus aci_gatt_clt_exchange_config(uint16_t Connection_Handle);
```

In response to an exchange MTU request, the `aci_att_exchange_mtu_resp_event()` callback is triggered on both devices:

```
void aci_att_exchange_mtu_resp_event(uint16_t Connection_Handle, uint16_t
                                     Server_RX_MTU);
```

`Server_RX_MTU` specifies the ATT_MTU value agreed between the server and client.

3.13 LE data packet length extension APIs and events

On Bluetooth LE specification v4.2, packet data unit (PDU) size has been increased from 27 to 251 bytes. This allows data rate to be increased by reducing the overhead (header, MIC) needed on a packet. As a consequence, it is possible to achieve: faster OTA FW upgrade operations, more efficiency due to less overhead.

The Bluetooth LE stack v3.x supports LE data packet length extension features and related APIs, events:

- HCI LE APIs (API prototypes on bluenrg_lp_api.h)

Low latency with proprietary 2.4Ghz radio

STSW-BNRGLP-DK

Peripheral_Examples\Examples_MIX\RADIO

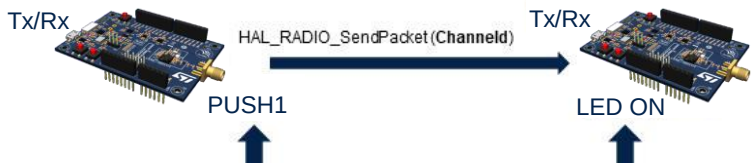
- RADIO_AutomaticChMgm
- RADIO_Beep
- RADIO_BeepMultiState
- RADIO_OTA_ResetManager
- RADIO_RemoteControl
- RADIO_SerialPort
- RADIO_Sleep
- RADIO_Sniffer
- RADIO_SnifferMultiState
- RADIO_StarNetwork
- RADIO_Throughput
- RADIO_TxRx

Radio_RemoteControl

Enable Remote Control over BlueNRG-LP radio driver with built-in acknowledge mechanism

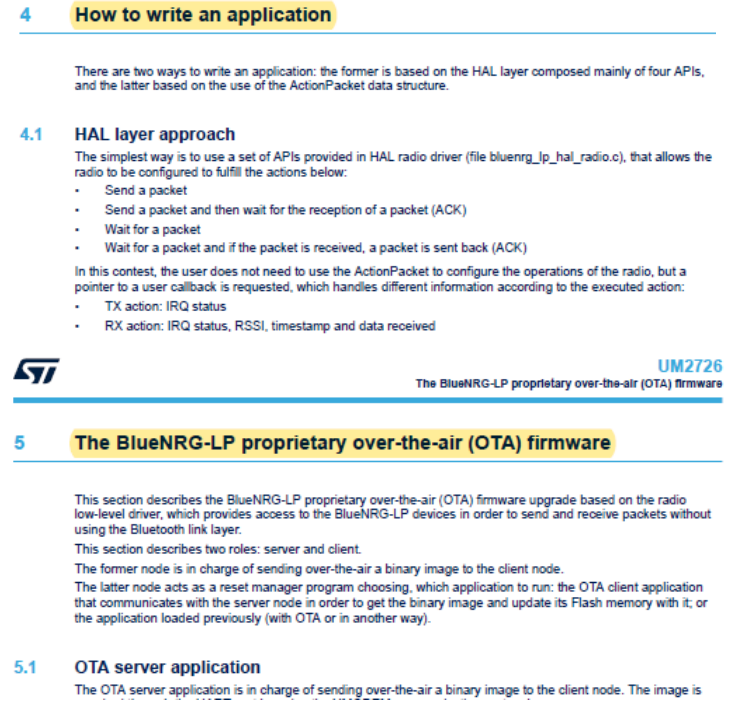
- Ultra-low latency RF link (~ 200µs)
- Carrier Sense capability before transmission

1 Byte	4 Bytes	1 Byte	1 Byte	0 - 255 Bytes	3 Bytes
Preamble	NetworkID	Header	Length	Data	CRC



Documentation resources

User manual (UM2726)



4 How to write an application

There are two ways to write an application: the former is based on the HAL layer composed mainly of four APIs, and the latter based on the use of the ActionPacket data structure.

4.1 HAL layer approach

The simplest way is to use a set of APIs provided in HAL radio driver (file bluenrg_lp_hal_radio.c), that allows the radio to be configured to fulfill the actions below:

- Send a packet
- Send a packet and then wait for the reception of a packet (ACK)
- Wait for a packet
- Wait for a packet and if the packet is received, a packet is sent back (ACK)

In this contest, the user does not need to use the ActionPacket to configure the operations of the radio, but a pointer to a user callback is requested, which handles different information according to the executed action:

- TX action: IRQ status
- RX action: IRQ status, RSSI, timestamp and data received

UM2726
The BlueNRG-LP proprietary over-the-air (OTA) firmware

5 The BlueNRG-LP proprietary over-the-air (OTA) firmware

This section describes the BlueNRG-LP proprietary over-the-air (OTA) firmware upgrade based on the radio low-level driver, which provides access to the BlueNRG-LP devices in order to send and receive packets without using the Bluetooth link layer.

This section describes two roles: server and client.

The former node is in charge of sending over-the-air a binary image to the client node.

The latter node acts as a reset manager program choosing, which application to run: the OTA client application that communicates with the server node in order to get the binary image and update its Flash memory with it; or the application loaded previously (with OTA or in another way).

5.1 OTA server application

The OTA server application is in charge of sending over-the-air a binary image to the client node. The image is

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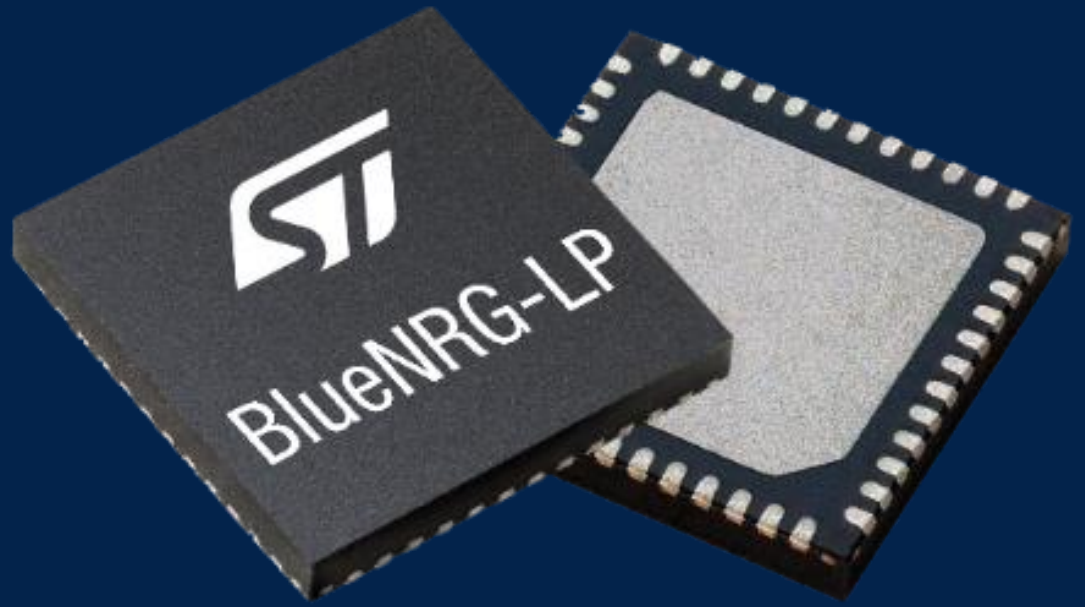
BlueNRG-2N
Bluetooth LE 5.2 Network Processor



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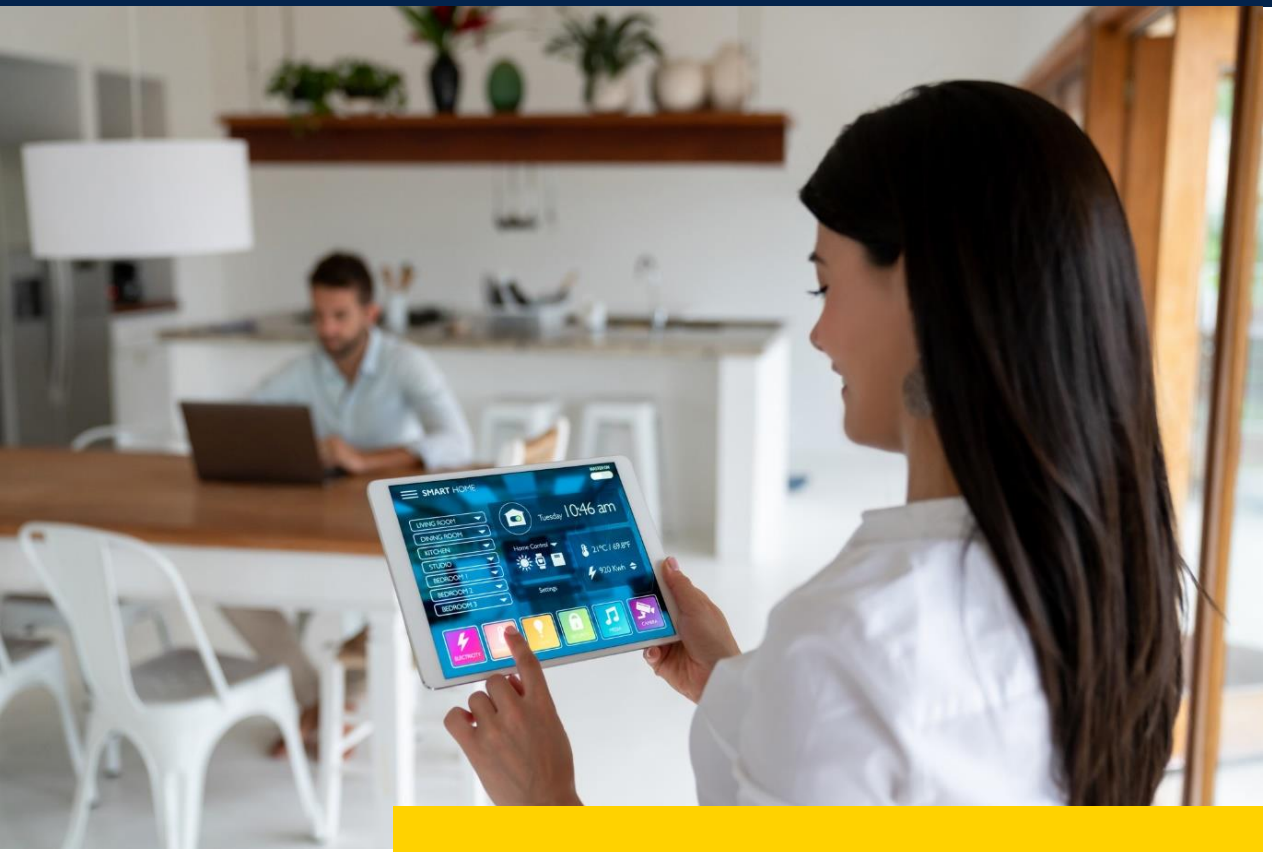
BlueNRG-2N family overview

Bluetooth® Low Energy 5.2 Network Processor



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

Ultra low current consumption

- Sleep current consumption down to 900 nA
- TX current consumption 6.8 mA (@ -2 dBm)
- RX current consumption 6.2 mA (@ sensitivity level)

Optimized Bluetooth Low Energy protocol stack

- Bluetooth® Low Energy 5.2 certified
- Fully compliant with Bluetooth v4.2 standard
  - LE Data Length Extension (up to 700kbps @ appl. level)
  - LE Privacy 1.2
  - LE Secure Connections
- Multi master to multi slave communication guaranteed
  - 2 Masters to 6 slaves simultaneously
  - Up to 8 simultaneous connections handled
- FOTA supported (256kB embedded Flash), 2.5 times faster

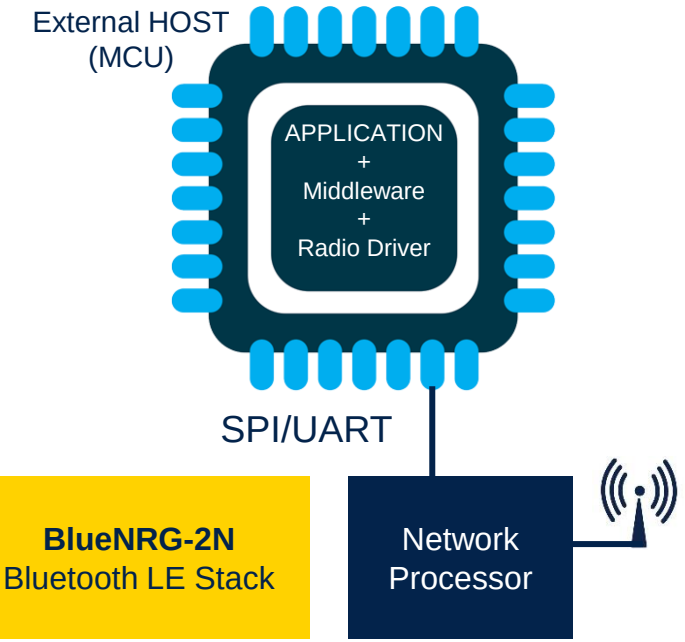
Flexibility

- **BlueNRG-232N** QFN32 / B**lueNRG-234N** WLCSP
- Selectable SPI or UART interface (via 1 GPIO)

BlueNRG-2N: what is a Network Processor?

NETWORK PROCESSOR

Application is running over a dedicated MCU along with **BLE middleware**



Specific integration of radio middleware/driver required

Who	Bluetooth LE **Network Processor** architecture
What	HW **scalability**, and SW design **flexibility**
How	Requiring or Re-using an external host, such approach just adds BLE functionality in a **modular** HW and SW integration
Why	Leverages software efforts, and minimizes deployment risks
When	now! Using **BlueNRG-2N**

BlueNRG-2N block diagram

Embedding pre-loaded, certified, and upgradable Bluetooth LE stack

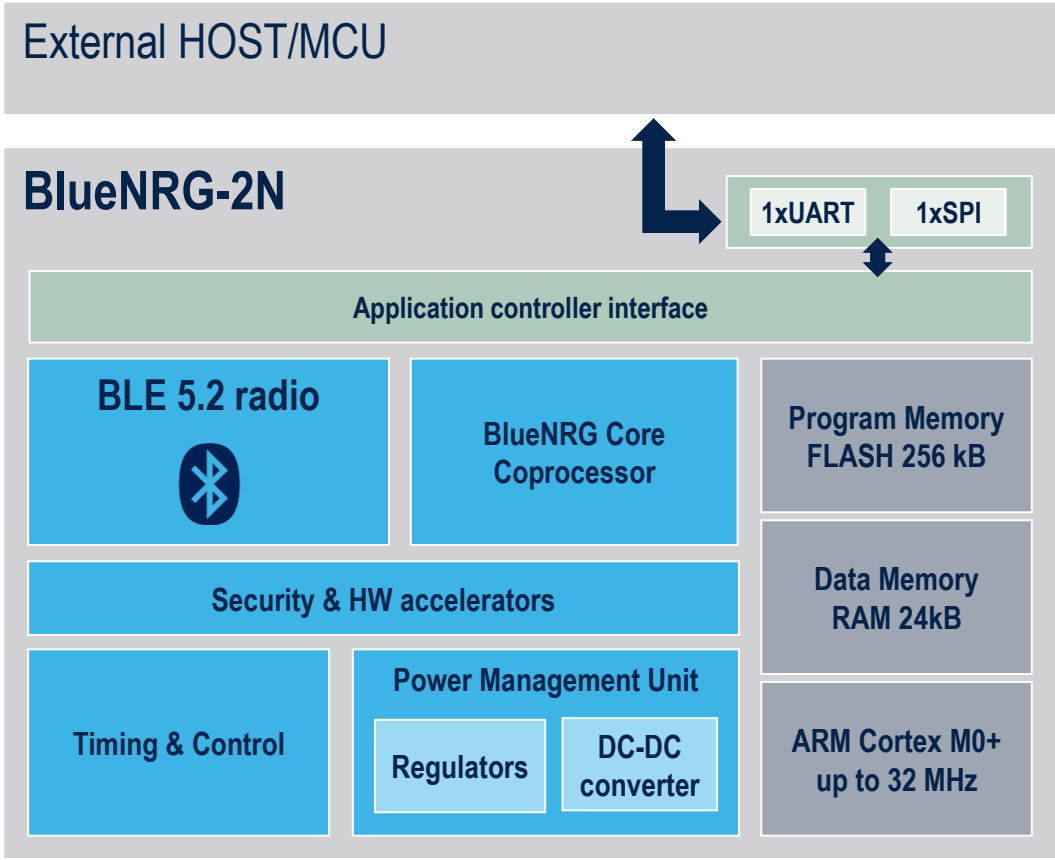
Key features → benefits

Bluetooth 5.2 certification
→ Ensuring interoperability with the latest generation of smartphones and tablets

Faster data transfer rate
→ Packet length extension boosts Over-The-Air firmware update in the field.

Extended battery life
→ Highest radio efficiency in the market combined with an ultra-low latency technology.

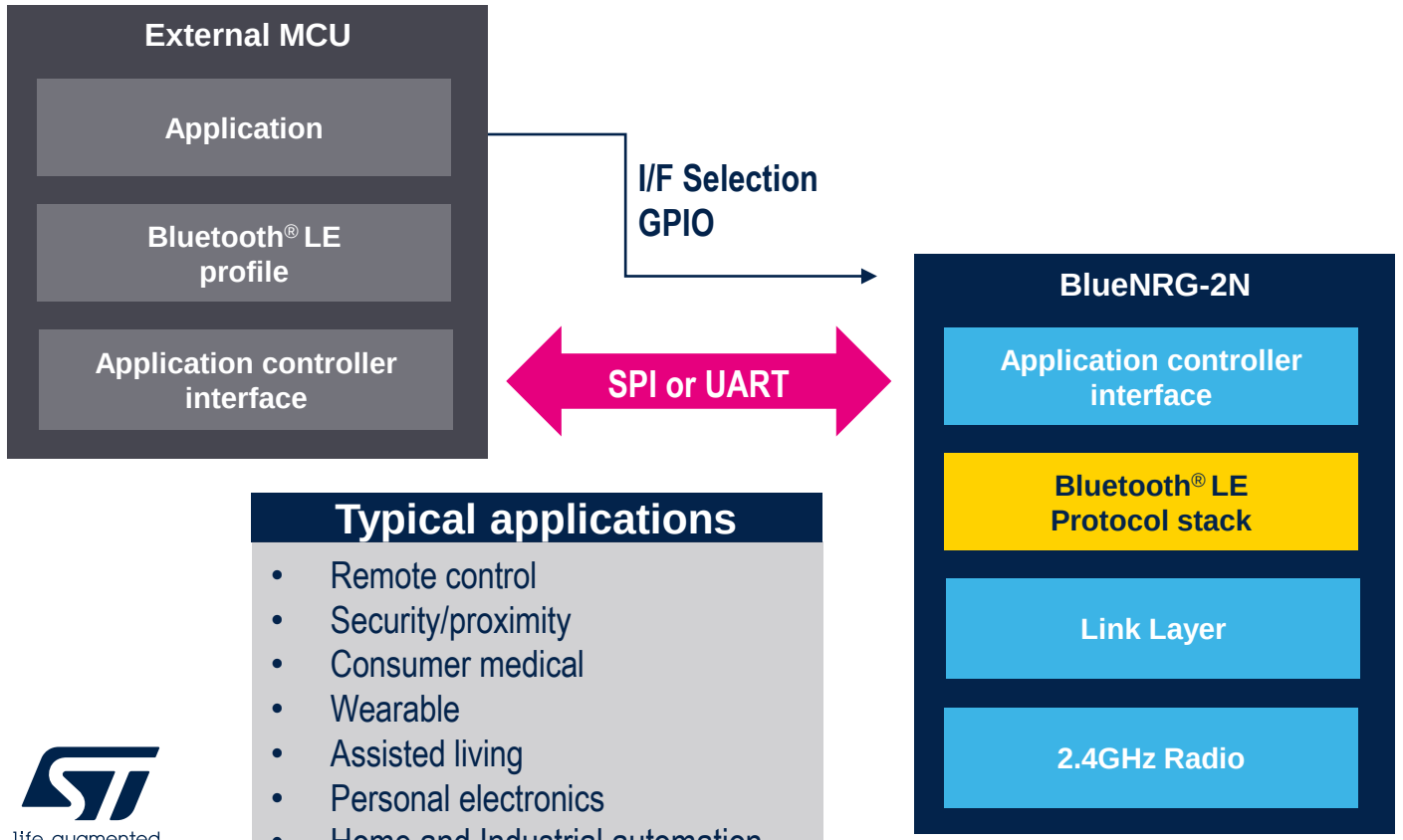
10-years longevity
→ Granting long-term availability for industrial applications.



BlueNRG-2N typical application

Suitable for applications where Bluetooth Low Energy be added on existing products

Easy integration



Typical applications

- Remote control
- Security/proximity
- Consumer medical
- Wearable
- Assisted living
- Personal electronics
- Home and Industrial automation

Pin-out - top view

BlueNRG-232N

QFN32
5 x 5 mm

BlueNRG-234N

WLCSP
2.66 x 2.56 mm

Pin count (main ones)	Name	Description
5x	SPI	Communication Interface + IRQ
2x	UART	Communication Interface
1	Sel	Interface Selection
1	Reset	Reset
1	SMPS	**Optional** DC/DC Converter (embedded LDO Regulator)

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BlueNRG-2N collaterals

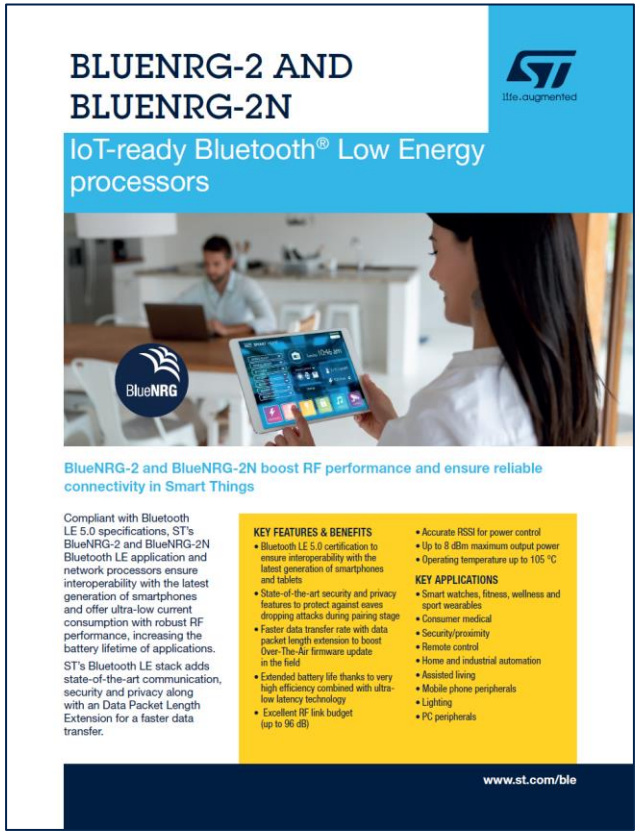
Tools for mass market effectiveness

- X-NUCLEO-BNRG2A1, embedding BlueNRG-M2SP
- X-CUBE-BLE2
- X-CUBE-BLEMESH1
- FP-SNS-BLEMESH1
- 10 years longevity program
- Product Labeled Sustainable Technology
- BLE Quick Reference Guide
- BlueNRG-2 and BlueNRG-2N flyer

STM32 Open Development Environment

by ST SUSTAINABLE TECHNOLOGY

LONGEVITY 10 YEARS COMMITMENT



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BlueNRG-2N key benefits

Maximum performance for wide variety of applications

Cost competitive BLE network processor solution	Minimizing Bluetooth LE connectivity software efforts in a cost-efficient flavor
Multi master to multi slave communication guaranteed	2 Masters to 6 slaves simultaneously, up to 8 simultaneous connections handled
Pre-loaded, upgradable, and certified Bluetooth LE stack	State-of-the-art communication, security, privacy, and Data Length Extension for a faster data transfer
Ready-to-go software, libraries, and hardware development kits	User friendly development tools that will help you to cut the wires: from setup to Cloud connection
10-years longevity	Part of ST longevity program: long-term availability for industrial applications

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WiSE Studio for BlueNRG family

BlueNRG Wireless Software Environment STSW-WISE-STUDIO

A new Integrated Development Environment to support all the BlueNRG wireless application processors

WiSE Studio is eclipse for BlueNRG SoCs

Free-of-Charge	All-in-one package	Community support	Jump-start development
No contract, no fees, no royalties. Download now from st.com/wise	Including GUI, ARM-GCC Compiler, Programmer and GDB/OpenOCD Debugger	Browse online and look for your preferred plug-ins	Quickly create, build, and deploy your application for ST BlueNRG SoC products

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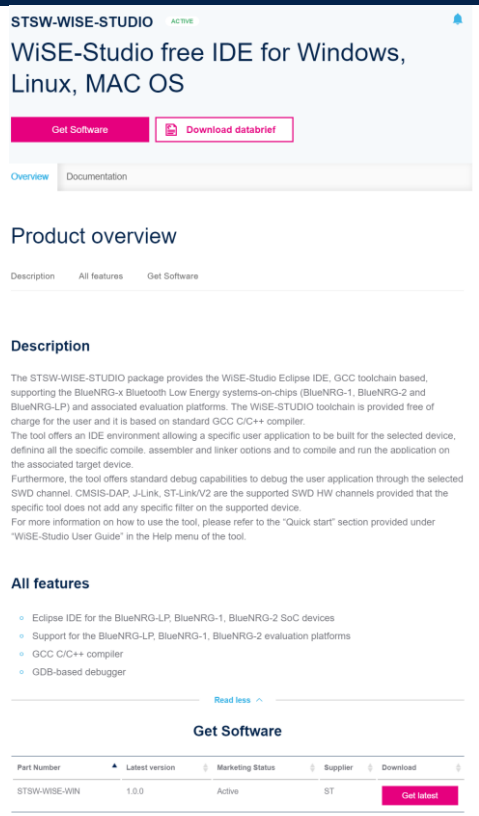
WiSE Studio

BlueNRG product family: Your best choice for Bluetooth®-enabled devices

- Free IDE based on C/C++ for BlueNRG family
  - BlueNRG-LP, BlueNRG-1, BlueNRG-2
- Eclipse-based
- Supported OS
  - Windows x86_64
  - Linux x86_64 (1)
  - MacOSX x86_64 (1)
- ARM GNU GCC 9.2.1
- OpenOCD debugger 0.11.0
- Debug probes support
  - CMSIS-DAP, ST-Link, J-Link



(1) Available upon request – they are not yet available online for download

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