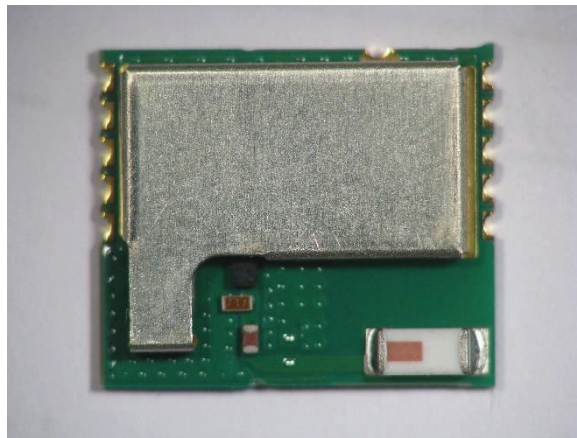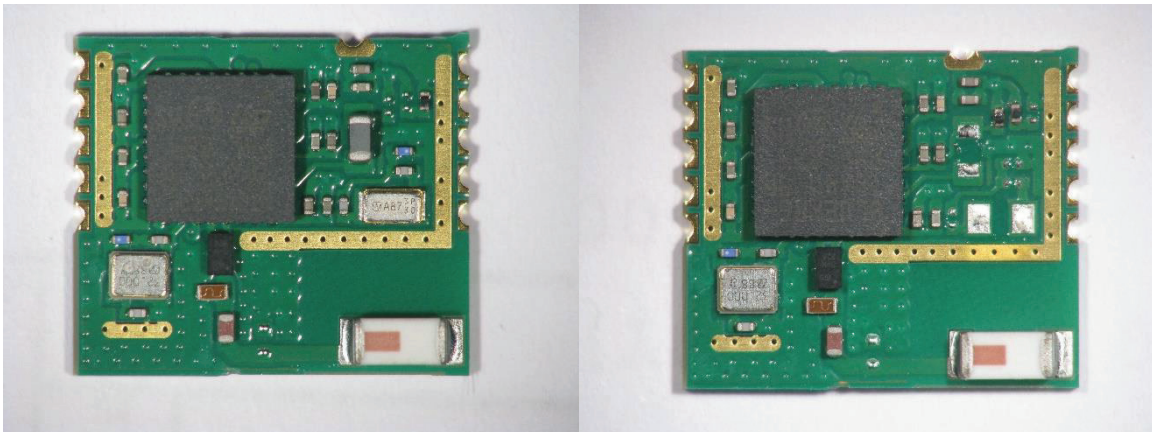# Technical Description Document

BLUENRG-M0x

(BLUENRG-M0A and BLUENRG-M0L)

FCC ID S9NBNRGM0AL and IC-ISED ID 8976C-BNRGM0AL

The BLUENRG-M0x family represented by photographs:

Photograph showing a generic BLUENRG-M0x, covered by metallic shield.

(a)   *(b)*

(*a*) Photograph showing a BLUENRG-M0A, with shield removed.

(*b*) Photograph showing a BLUENRG-M0L, with shield removed.

What exactly is the BLUENRG-M0x family?

The BLUENRG-M0x family is an easy to use Bluetooth$^{\circledR}$ low energy master/slave network processor module, compliant with Bluetooth v4.2. The BLUENRG-M0x module supports multiple roles simultaneously, and can act at the same time as Bluetooth low energy sensor and hub device.

The entire Bluetooth low energy stack and protocols are embedded into BLUENRG-M0x module. The external host application processor, where the application resides, is connected to the BLUENRG-M0x module through a standard SPI interface.

The BLUENRG-M0x module provides a complete RF platform in a tiny form factor. Radio, antenna, high frequency and LPO oscillators are integrated to offer a certified solution to optimize the time to market of the final applications.

The BLUENRG-M0x can be powered directly with a standard 3 V coin cell battery, a pair of AAA batteries or any power source from 1.7 to 3.6 V.

List of possible applications

- Watches

- Fitness, wellness and sports

- Consumer medical

- Security/proximity

- Remote control

- Home and industrial automation

- Assisted living

- Mobile phone peripherals

- PC peripheral

Some detailed features

- Bluetooth v4.2 compliant
  - Supports master and slave modes
  - Multiple roles supported simultaneously

- Embedded Bluetooth low energy protocol stack
  - GAP, GATT, SM, L2CAP, LL, RFPHY

- Bluetooth low energy profiles provided separately

- Bluetooth radio performance:
  - Embedded ST BlueNRG-MS
  - Tx power: + 5.31 dBm e.i.r.p.
  - Rx sensitivity: down to - 88 dBm
  - Provides up to 94 dB link budget with excellent link reliability

- Host interface
  - SPI, IRQ, and RESET
  - On-field stack upgrading available via SPI

- AES security co-processor

- Certification
  - CE qualified
  - FCC, IC modular approval certified
  - ARIB qualified
  - BQE qualified

- On-board chip antenna

- Operating supply voltage: from 1.7 to 3.6 V

- Operating temperature range: -40 °C to 85 °C

A general overview about the modules family

The BLUENRG-M0x is a single-mode Bluetooth low energy master/slave network processor module compliant with Bluetooth® v4.2.

The BLUENRG-M0x module integrates a 2.4 GHz RF radio the ST BlueNRG-MS on which a complete power-optimized stack for Bluetooth single mode protocol runs, providing:

- Master, slave role support

- GAP: central, peripheral, observer or broadcaster roles

- ATT/GATT: client and server

- SM: privacy, authentication and authorization

- L2CAP

- Link Layer: AES-128 encryption and decryption

The BlueNRG-MS radio embeds nonvolatile Flash memory allows on-field stack upgrading. In addition, according the Bluetooth specification v4.2 the BLUENRG-M0x module provides:

- Multiple roles simultaneously support

- Support simultaneous advertising and scanning

- Support being slave of up to two masters simultaneously

- Privacy V1.1

- Low duty cycle directed advertising

- Connection parameters request procedure

- LE Ping

- 32 bits UUIDs

- L2CAP connection oriented channels

The BLUENRG-M0x module is equipped with Bluetooth low energy profiles in C source code, available for the ST radio BlueNRG-MS.

The external host application processor, where the application resides, is interfaced with the BLUENRG-M0x module through an application controller interface protocol, which is based on a standard SPI interface.

The BLUENRG-M0x module enables wireless connectivity into electronic devices, not requiring any RF experience or expertise for integration into the final product. The BLUENRG-M0x module provides a complete RF platform in a tiny form factor and being a certified solution optimizes the time to market of the final applications.

The BLUENRG-M0x module allows applications to meet of the tight advisable peak current requirements imposed with the use of standard coin cell batteries. Optimized results are obtained when the embedded high-efficiency DC-DC step-down converter is used (BLUENRG-M0A). Instead, for the BLUENRG-M0L the best performances in terms of power consumption are achieved using a 1.8V DC power supply.

BLUENRG-M0x can be powered directly with a standard 3 V coin cell battery, a pair of AAA batteries or any power source from 1.7 to 3.6 V.

ST may update the FW provided with the modules at any time. ST recommends that users regularly check for documentation and the current FW version available at www.st.com/bluemodules.

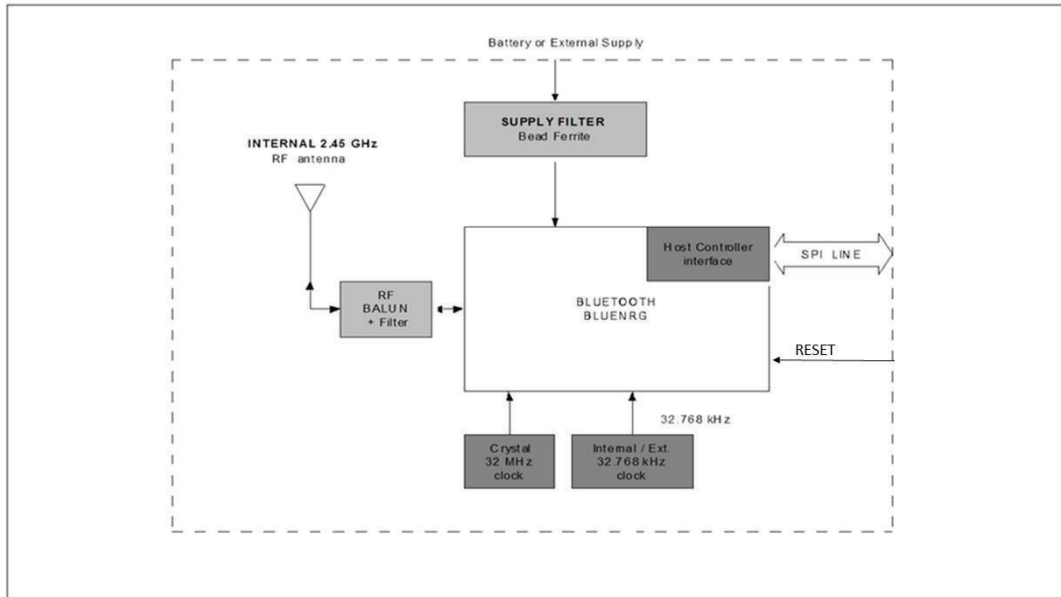Software architecture (BLUENRG-M0x family)

Bluetooth firmware implementation

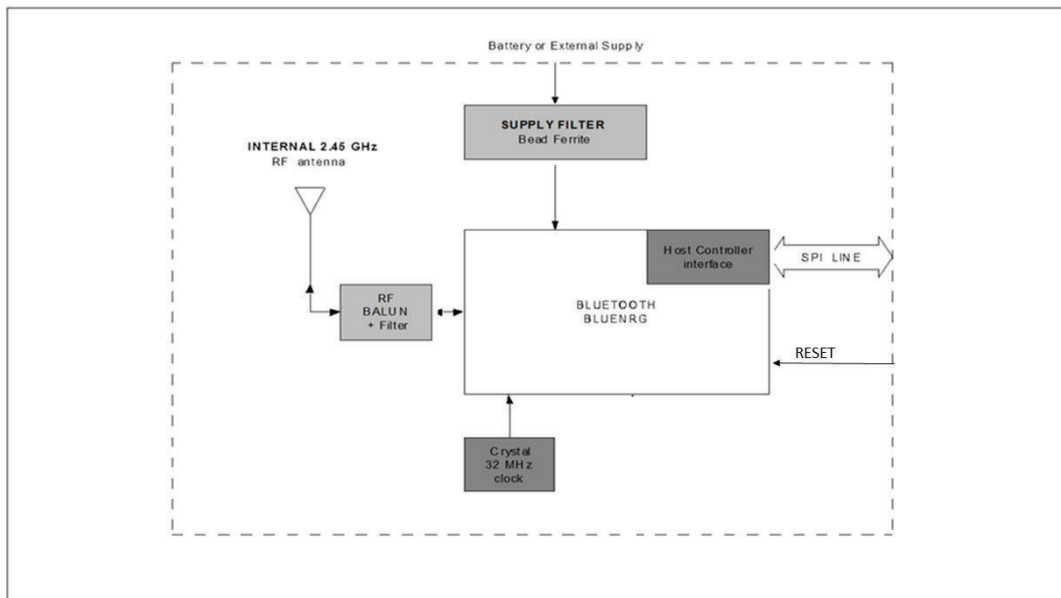BLUENRG-M0A and BLUENRG-M0L application block diagram
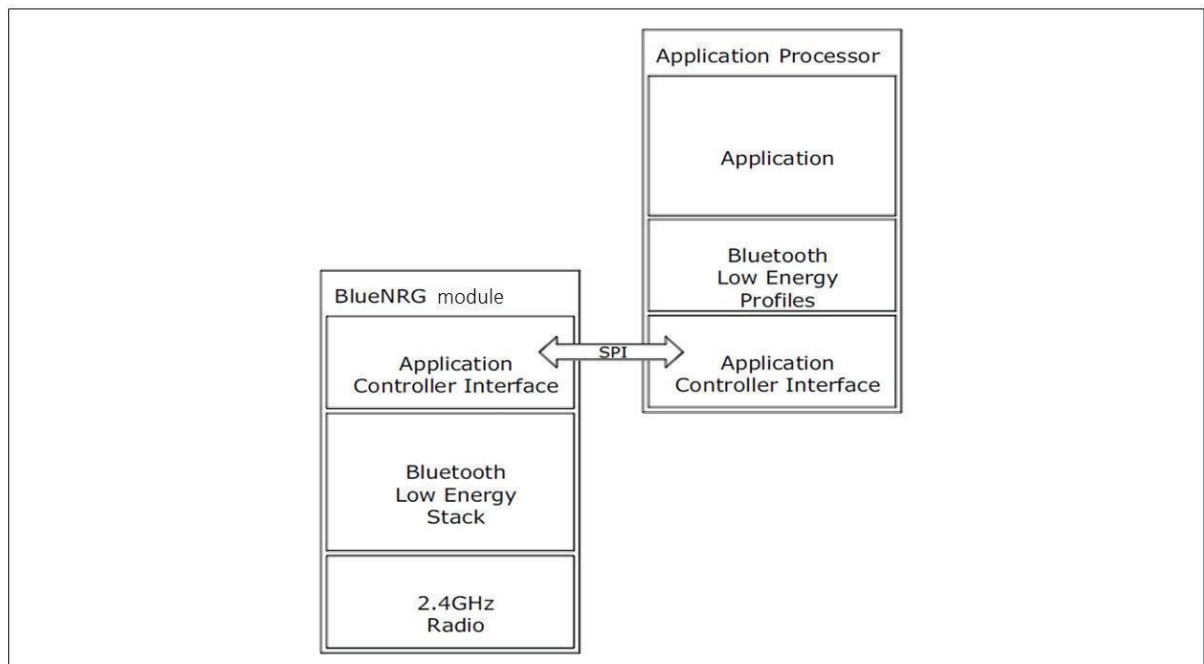
Block diagrams for the BLUENRG-M0x family

HW block diagram for BLUENRG-M0A

HW block diagram for BLUENRG-M0L

Power Management and Voltage Regulation

This section is dedicated to the power management and voltage regulation description for the BLUENRG-M0x family products. In particular, the voltage regulation is achieved internally to the BlueNRG-MS chip, following the schematics highlighted below. A short description is presented in the following document, please, for a complete overview do consult the data sheet of the BlueNRG-MS on ST website.

The BlueNRG-MS integrates both a low dropout voltage regulator (LDO) and a step-down DC-DC converter, and one of them can be used to power the internal BlueNRG-MS circuitry. However even when the LDO is used, the stringent maximum current requirements, which are advisable when coin cell batteries are used, can be met and further improvements can be obtained with the DC-DC converter at the sole additional cost of an inductor and a capacitor.

The internal LDOs supplying both the 1.8 V digital blocks and 1.2 V digital blocks require decoupling capacitors for stable operation. When the VBAT voltage is below 1.8 V, the LDO 1.8 V output follows the VBAT value.

Figure 10. Power management strategy using LDO and Figure 11. Power management strategy using step-down DC-DC converter, show the simplified power management schemes using LDO and DC-DC converter.

Figure 10. Power management strategy using LDO (BLUENRG-M0L)
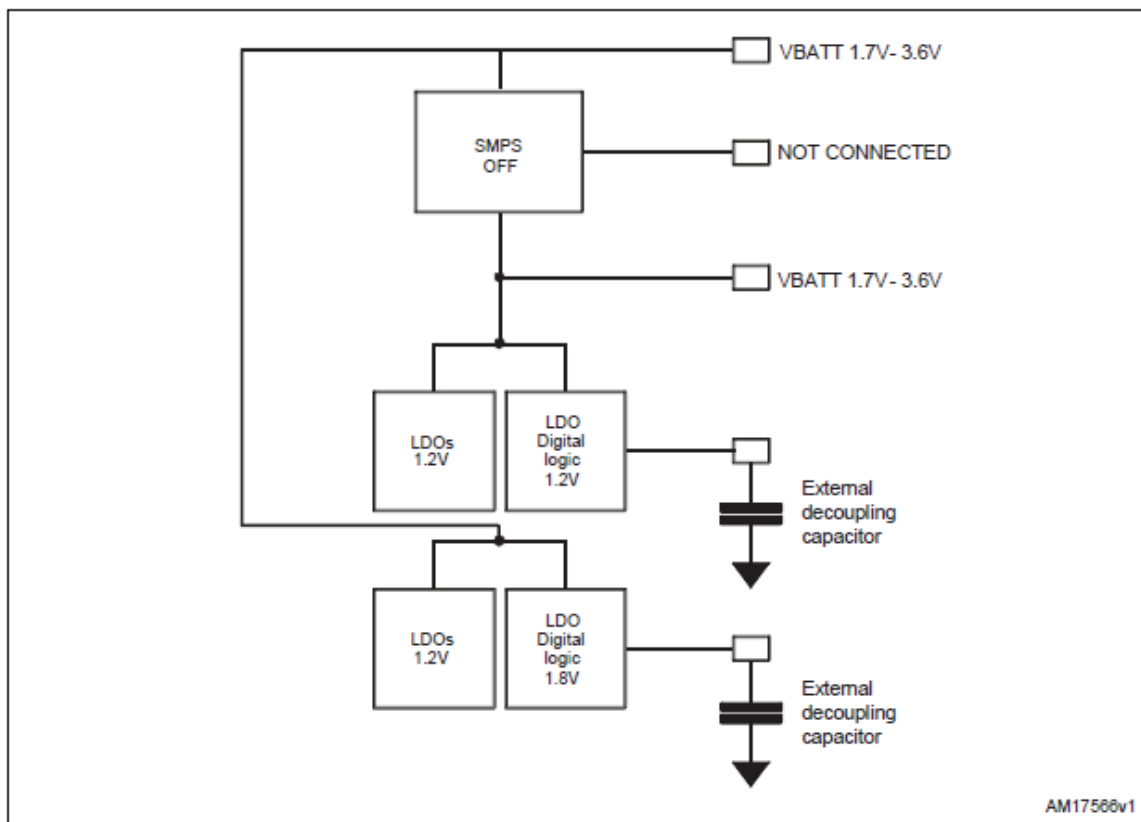
Figure 11. Power management strategy using step-down DC-DC converter (BLUERNG-M0A)

VBATT 1.7V - 3.6V

SMPS

External Inductor

Vout_SMPS

External decoupling capacitor

LDOs 1.2V

LDO Digital logic 1.2V

External decoupling capacitor

LDOs 1.2V

LDO Digital logic 1.8V

External decoupling capacitor

AM17667v1
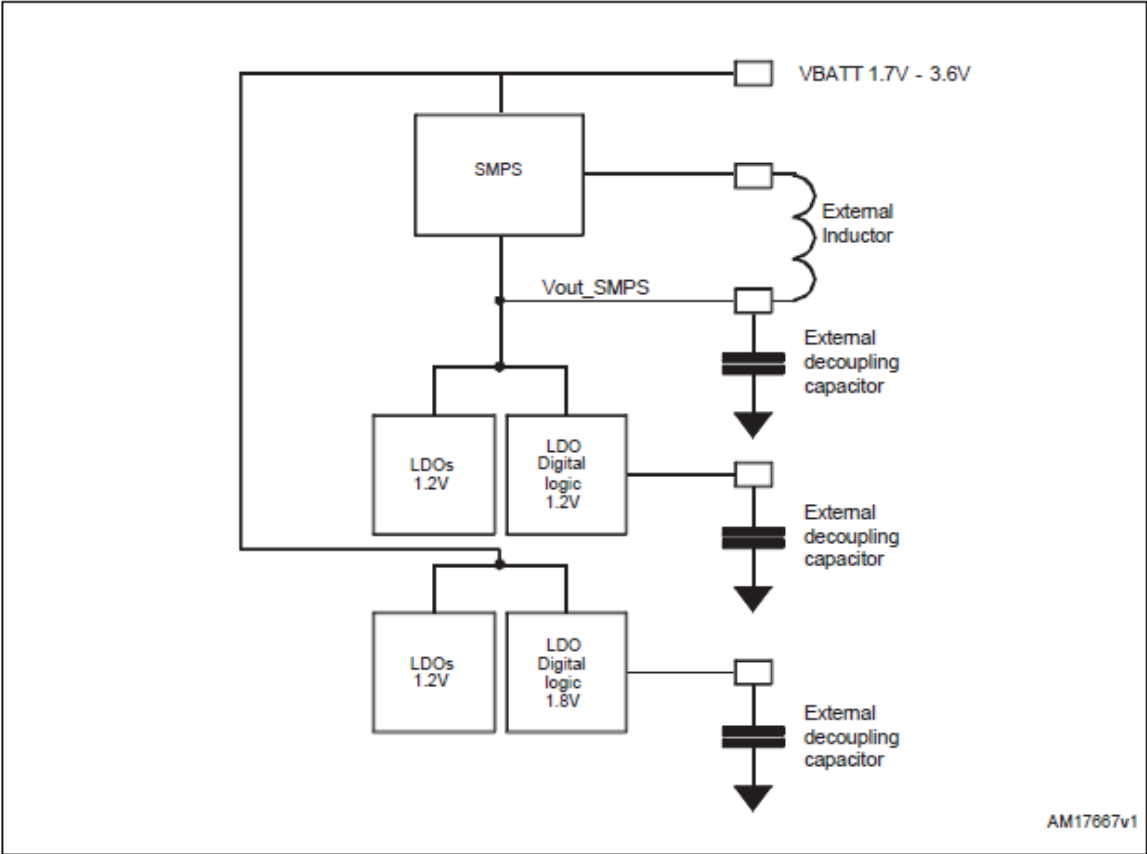
General characteristics of the BLUENRG-M0x family

In the following two Tables are summarized the minima fundamental parameters for the BLUENRG-M0x family modules.

Absolute maximum ratings

Table related to the absolute maximum ratings

Rating	Min	Typ.	Max	Unit
Storage temperature range	-40	-	+85	°C
Supply voltage, V_{IN}	-0.3	-	3.9	V
I/O pin Voltage (V_{IO} five-volt tolerant pin)	-0.3	-	3.9	V
RF saturation input power	-	8	-	dBm
VESD-HBM Electrostatic discharge voltage		±2.0 kV		kV

Operating conditions

Table related to the operating conditions

Rating	Min	Typ.	Max	Unit
Storage temperature range	-40	-	+85	°C
Operating ambient temperature range	-40	-	+85	°C
Supply voltage, V_{IN}	1.7	3.3	3.6	V
Signals & I/O pin voltage (according supply voltage)	1.7	-	3.6	V
Frequency range	2402	-	2480	MHz

Electrical specification of the BLUENRG-M0x family

In the following Tables are summarized the fundamental electrical specification parameters for the BLUENRG-M0x family modules.

Electrical characteristics

Characteristic measured over recommended operating condition unless otherwise specified.
Typical value are referred to VIN= 3.3 V, 25 °C, DC/DC on, XO 32KHz and XO 32MHz.

Electrical characteristics for the BLUENRG-M0A

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{DD}	Supply current	Reset		5		nA
		Standby		1.8		uA
		Sleep mode: 32 kHz XO ON (24 KB retention RAM)		1.7		μA
		Sleep mode: 32 kHZ RO ON (24 KB retention RAM)		2.2		
		Active mode		2.12		mA
		RX		9.36		mA
		TX +8 dBm		16.50		mA
		TX +4 dBm		12.04		mA
		TX +2 dBm		10.40		mA
		TX -2 dBm		9.44		mA
		TX -5 dBm		8.79		mA
		TX -8 dBm		8.29		mA
		TX -11 dBm		8.01		mA
		TX -14 dBm		7.82		mA

Electrical characteristics for the BLUENRG-M0L

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{DD}	Supply current	Reset		N/A		nA
		Standby		1.7		uA
		Sleep mode: 32 kHz XO ON (24 KB retention RAM)		2.8		μA
		Sleep mode: 32 kHZ RO ON (24 KB retention RAM)		3.2		
		Active mode		2.54		mA
		RX		16.36		mA
		TX +8 dBm		29.16		mA
		TX +4 dBm		21.3		mA
		TX +2 dBm		18.29		mA
		TX -2 dBm		16.44		mA
		TX -5 dBm		15.18		mA
		TX -8 dBm		14.19		mA
		TX -11 dBm		13.61		mA
		TX -14 dBm		13.25		mA

Digital I/O specifications of the BLUENRG-M0x family

IO pins are directly connected to the embedded state of the art BlueNRG-MS chipset. For more details about the digital I/I specification, please refer directly to the BlueNRG-MS datasheet available on www.st.com.
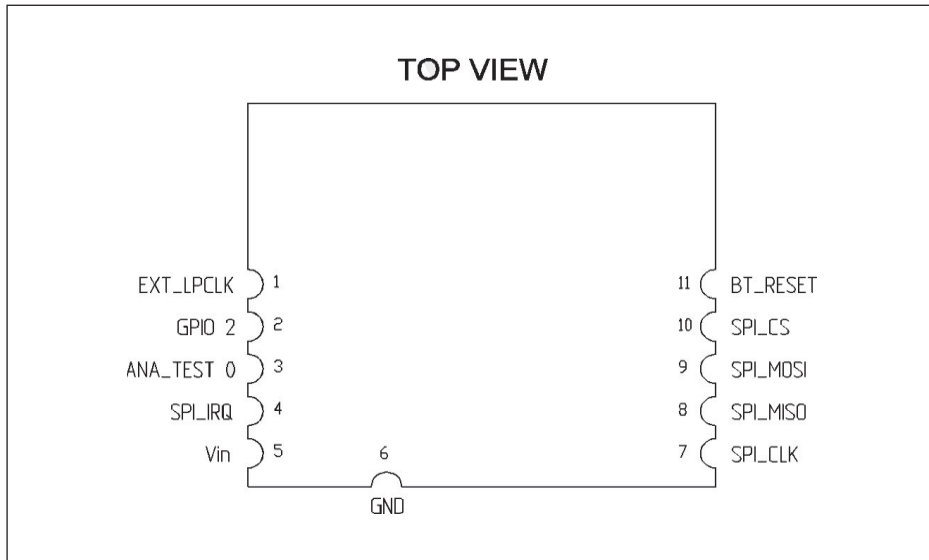
RF General characteristics of the BLUENRG-M0x family

Characteristic measured over recommended operating condition unless otherwise specified. Typical value are referred to VIN = 3.3 V, 25 °C, DC/DC on, XO 32KHz and XO 32MHz.

Electrical characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
FREQ	Frequency range		2400	-	2483.5	MHz
FCH	Channel spacing		-	2	-	MHz
RF ch.	RF Channel center frequency		2402	-	2480	MHz

Pin assignment of the BLUENRG-M0x family

TOP VIEW

|		
EXT_LPCLK	1	11 BT_RESET
GPIO 2	2	10 SPI_CS
ANA_TEST 0	3	9 SPI_MOSI
SPI_IRQ	4	8 SPI_MISO
Vin	5	7 SPI_CLK
	6	
	GND	

Pin connection of the BLUENRG-M0x family

Pin assignment of the BLUENRG-M0x family

Name	Type	Pin #	Description	V max. Tolerant
SPI Interface				
SPI_IRQ	O	4	SPI IRQ (SLAVE has data for MASTER)	V_{in}
SPI_CLK	I	7	SPI CLOCK (Max. 8 MHz)	V_{in}
SPI_MISO	O	8	SPI MISO (MASTER in / SLAVE out)	V_{in}
SPI_MOSI	I	9	SPI MOSI (MASTER out SLAVE in)	V_{in}
SPI_CS	I	10	SPI "Chip select" (SPI slave select)	V_{in}
Power and ground				
V_{in}		5	V_{in}	(1.7V - 3.6V max.)
GND		6	GND	
Reset				
BT_RESET	I	11	Reset input (active low < 0.35 V_{in})	(1.7V - 3.6V max.)
LPO				
EXT_LPCLK	I	1	Not connected	
GPIO2	I/O	2	Not connected	
ANA TEST 0	I	3	Not connected	

Mechanical dimensions of the BLUENRG-M0x family
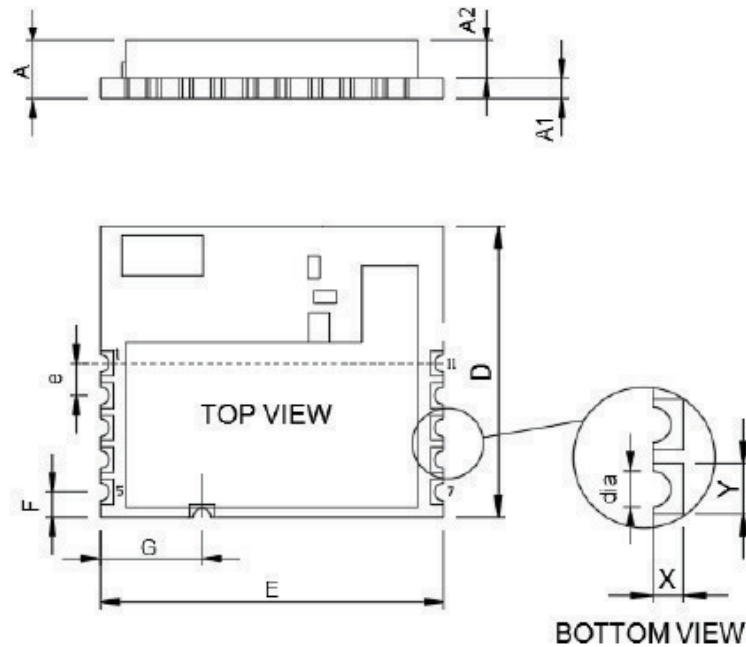
Recommend land pattern top view

RECOMMENDED LAND PATTERN TOP VIEW
All Dimensions are in millimeters
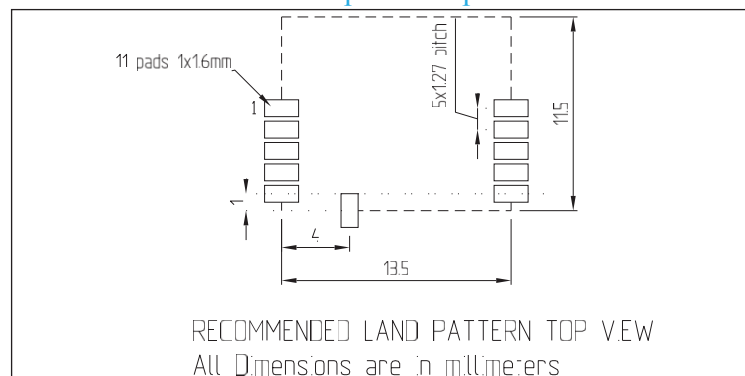
Hardware design of the BLUENRG-M0x family

BLUENRG-M0x module supports SPI hardware interfaces.

Note: - All unused pins should be left floating; do not ground.

- All GND pins must be well grounded.

- The area around the module should be free of any ground planes, power planes, trace routings, or metal for 6 mm from the module antenna position, in all directions.

- Traces should not be routed underneath the module.

Reflow soldering of the BLUENRG-M0x family

The BLUENRG-M0x is a high temperature strength surface mount Bluetooth® module supplied on a 11 pin, 4-layer PCB. The final assembly recommended reflow profiles are indicated here below.

Soldering phase has to be executed with care: in order to avoid undesired melting phenomenon, particular attention has to be taken on the set up of the peak temperature.

Here following some suggestions for the temperature profile based on following recommendations.

Soldering profile

Profile feature	PB-free assembly
Average ramp up rate (T_{SMAX} to T_p)	3°C/ sec max
Preheat Temperature min (T_S mn) Temperature max (T_S max) Time (t_S min to t_S max) (t_S)	150 °C 200 °C 60-100 sec
Time maintained above: Temperature T_L Time t_L	217 °C 60-70 sec
Peak temperature (T_P)	240 + 0 °C
Time within 5 °C of actual peak temperature (T_P)	10-20 sec
Ramp down rate	6 °C/sec
Time from 25 °C to peak temperature	8 minutes max
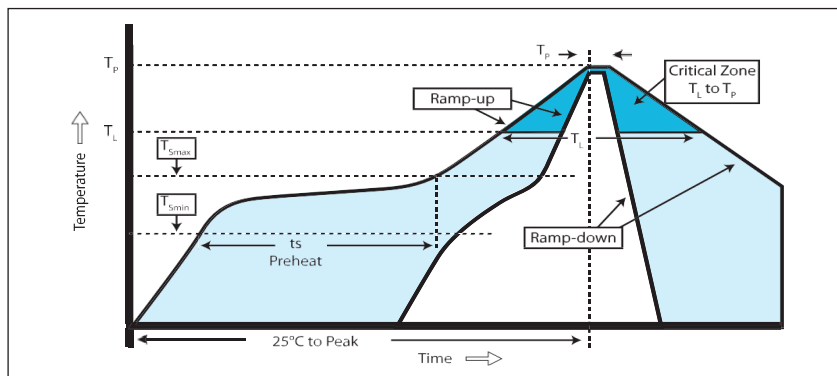
For a complete and detailed overview of additional technical info please consult the Data Sheet of the referenced BLUENRG-M0x modules.

Revision History

Revision	Date	Author	Comment
1.0	31/01/2019	Enrico Massoni	First version
1.1	14/03/2019	Enrico Massoni	Minor changes
1.2	21/03/2019	Enrico Massoni	Minor changes
1.3	04/04/2019	Enrico Massoni	Minor changes