



a module solution provider

WS2116-A0


WS2116-F0

Ultralow Power Sub-1GHz and BLE Wireless MCU Module

STM S2-LP with PA & BlueNRG-2 Solution

Datasheet

Revision. 0.4

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1. OVERVIEW

The WS2116-A0 is a sub-1GHz with PA and Bluetooth® low energy ultralow power wireless MCU module. This module is built-in STM S2-LP and BlueNRG-2 chip.

The module is a cost-effective, high performance, ultra-low power, sub-1GHz and Bluetooth® low energy RF devices. Very low active RF and MCU current and low-power mode current consumption provide excellent battery lifetime and allow for operation on small coin cell batteries and in energy-harvesting applications.

The module is also designed for Sigfox Monarch application.

1.1. General Features

- STM BlueNRG-2, S2-LP, sub-1GHz PA, 32MHz, 50MHz & 32.768KHz crystals, and DC2DC on a single module.
- Stamp-hole 54pins package.
- Dimension 22mm(L) x 22mm(W) x 2.8mm(H)
- High performance, ultra-low power Cortex-M0 32-bit Microcontroller
- Programmable 256 KB Flash
- 24 KB RAM with retention (two 12 KB banks)
- Up to +8dBm BLE RF output power, up to +27dBm sub-1GHz RF output power⁽¹⁾
- Excellent performance of receiver sensitivity. Up to -88dBm (BLE) and -130dBm (Sub-1GHz).
- Low Power and Wide I/O Voltage Range: 1.8 to 3.6V⁽¹⁾
 - Internal DC-DC converter built-in
- Operating temperature range: -40 °C to +85 °C

(1) In order to comply with Sigfox limits, the maximum RF output power and power voltage must be reduced.

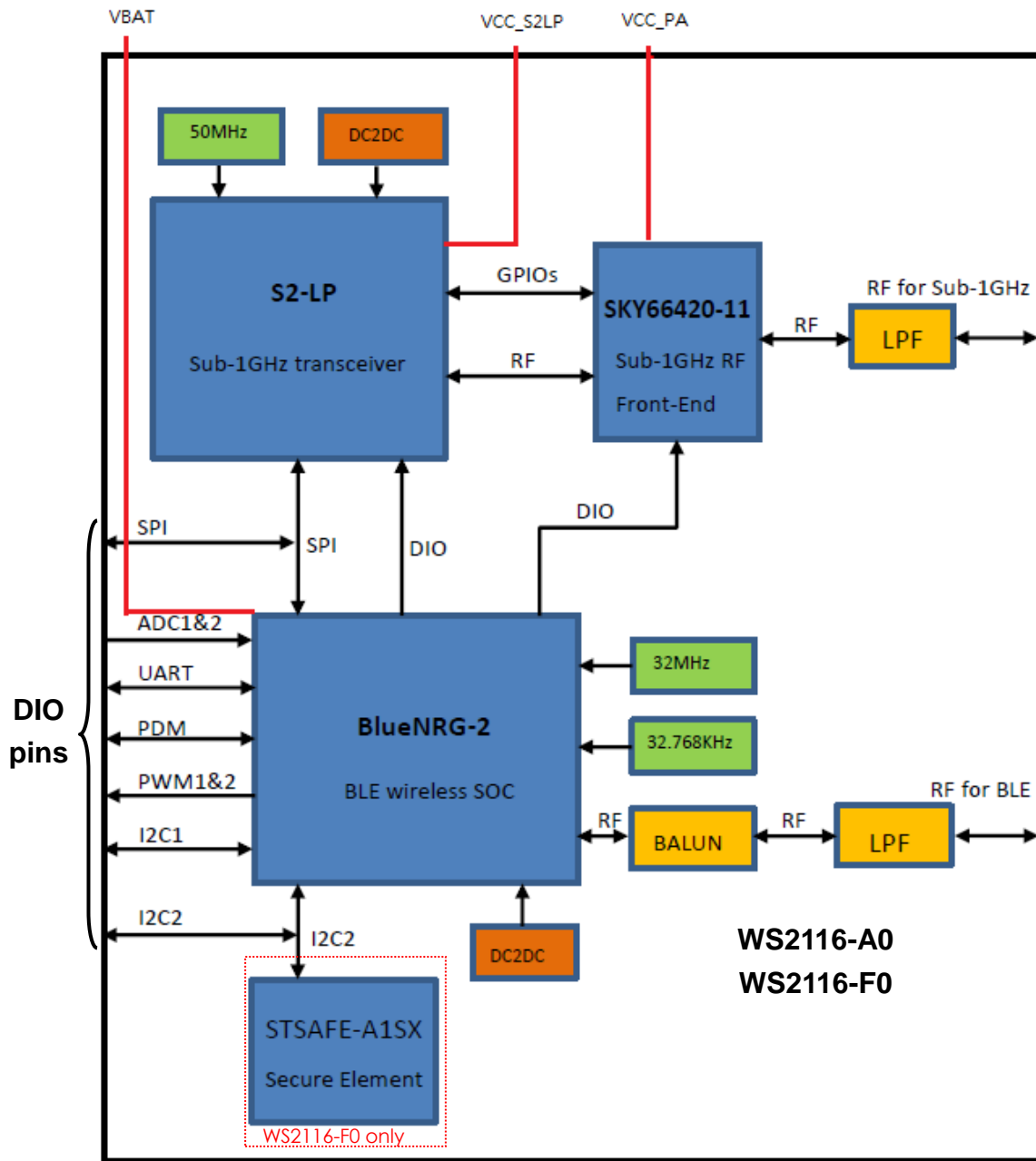
See the chapter 4. MODULE SPECIFICATIONS for details.

1.2. Models Functional Blocks

| Model | BLE & Sub-1GHz | Secure Element |
|-----------|----------------|----------------|
| WS2116-A0 | V | - |
| WS2116-F0 | V | V |

2. FUNCTIONAL FEATURES

2.1. Module Block Diagram



2.2. Block Functional Feature

BlueNRG-2: Bluetooth low energy wireless SOC

- Bluetooth low energy single mode system-on-chip compliant with Bluetooth 5.0 specifications:
 - master, slave and multiple simultaneous roles
 - LE data packet length extension
- Integrated linear regulator and DC-DC step-down converter
- High performance, ultra-low power Cortex-M0 32-bit based architecture core
- Programmable 256 KB Flash
- 24 KB RAM with retention (two 12 KB banks)
- 1 x UART interface
- 1 x SPI interface
- 2 x I²C interface
- 26 GPIOs
- 2 x multifunction timer
- 10-bit ADC
- Watchdog & RTC
- DMA controller
- PDM stream processor
- 32 MHz crystal oscillator built-in.
- 32 kHz crystal oscillator built-in.
- Battery voltage monitor and temperature sensor
- Up to +8 dBm available output power (at RF pin)
- Excellent RF link budget (up to 96 dB)
- Accurate RSSI to allow power control

S2-LP: Sub-1Ghz transceiver

- Narrow band ultra-low power Sub-1GHz transceiver tuned for 860-943 MHz frequency bands.
- Suitable for Sigfox applications
- Modulation schemes: 2-FSK, 2-GFSK, 4-FSK, 4-GFSK, OOK, and ASK
- Air data rate from 0.3 to 500 kbps

- Programmable RF output power up to +27 dBm (with SKY66420-11 RF front-end chip)
- Excellent performance of receiver sensitivity: down to -130 dBm
- Programmable RX digital filter
- Programmable channel spacing
- Low duty cycle RX/TX operation mode
- Integrated linear regulator and DC-DC step-down converter

SKY66420-11: Sub-1GHz RF Front-End Module

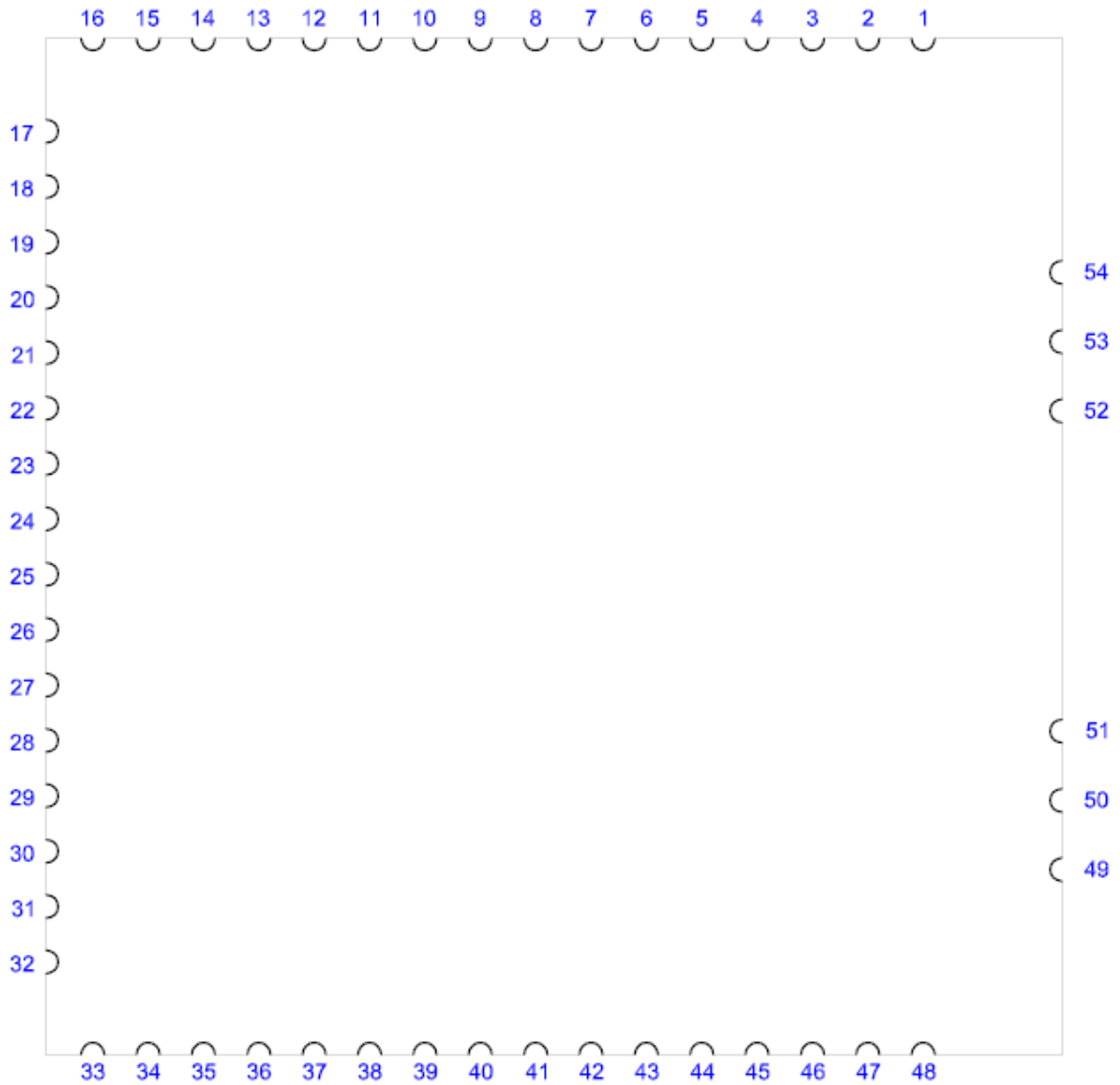
- Integrated PA
- Integrated LNA with programmable bypass

STSAFE-A1SX: Secure Element (WS2116-F0 only)

- Data integrity over the Sigfox network:
 - Signature of payloads before uplink
 - Signature of payloads before uplink
- Optional data confidentiality over the Sigfox network:
 - Encryption of payloads before uplink
 - Decryption of downlink payloads
- Advanced symmetric cryptography : AES-128

3. MODULE OUTLINE

3.1. Signal Layout (Top View)



3.2. Pin Description

Table 3-1. Pin Description

| Pin No. | Pin Name | Type | Description |
|---------|----------|---------------|---|
| 1 | GND | GND | GND |
| 2 | RESETN | Digital Input | System reset, active low. Built-in 100K ohm pull-up resistor, and 0.01uF capacitor to GND. |
| 3 | DIO13 | Digital Input | General purpose digital Input of BlueNRG-2 |
| 4 | DIO12 | Digital Input | General purpose digital Input of BlueNRG-2 |
| 5 | TEST | Digital Input | Test pin put to GND |
| 6 | DIO11 | Digital I/O | General purpose digital I/O of BlueNRG-2 |
| 7 | DIO10 | Digital I/O | General purpose digital I/O of BlueNRG-2 |
| 8 | DIO9 | Digital I/O | General purpose digital I/O of BlueNRG-2 |
| 9 | DIO25 | Digital I/O | General purpose digital I/O of BlueNRG-2 / Connected internally to SDN pin of S2-LP Built-in pull-up 100K ohm resistor. |
| 10 | DIO7 | Digital I/O | General purpose digital I/O of BlueNRG-2 / Built-in pull-down 100K ohm resistor. |
| 11 | DIO8 | Digital I/O | General purpose digital I/O of BlueNRG-2 |
| 12 | DIO22 | Digital I/O | General purpose digital I/O of BlueNRG-2 / Connected internally to CTX pin of SKY66420-11 |
| 13 | DIO23 | Digital I/O | General purpose digital I/O of BlueNRG-2 / Connected internally to CPS pin of SKY66420-11 |
| 14 | GND | GND | GND |
| 15 | VBAT | POWER | Power for BlueNRG-2 |
| 16 | GND | GND | GND |
| 17 | DIO24 | Digital I/O | General purpose digital I/O of BlueNRG-2 / Connected internally to CSD pin of SKY66420-11 |
| 18 | DIO21 | Digital I/O | General purpose digital I/O of BlueNRG-2 / Connected internally to GPIO3 pin of S2-LP |
| 19 | DIO6 | Digital I/O | General purpose digital I/O of BlueNRG-2 / Connected internally to RESET pin of STSAFE-A1SX (-F0 only) |

| | | | |
|----|----------|---------------|--|
| 20 | DIO4 | Digital I/O | General purpose digital I/O of BlueNRG-2 Connected internally to SCL pin of STSAFE-A1SX (-F0 only) |
| 21 | DIO5 | Digital I/O | General purpose digital I/O of BlueNRG-2 Connected internally to SDA pin of STSAFE-A1SX (-F0 only) |
| 22 | DIO20 | Digital I/O | General purpose digital I/O of BlueNRG-2 / SPI master CS pin connected internally to CS pin of S2-LP |
| 23 | DIO19 | Digital I/O | General purpose digital I/O of BlueNRG-2 / Connected internally to GPIO2 pin of S2-LP |
| 24 | DIO18 | Digital I/O | General purpose digital I/O of BlueNRG-2 |
| 25 | DIO16 | Digital I/O | General purpose digital I/O of BlueNRG-2 |
| 26 | DIO0 | Digital I/O | General purpose digital I/O of BlueNRG-2 / SPI master CLK pin connected internally to SCLK pin of S2-LP |
| 27 | DIO17 | Digital I/O | General purpose digital I/O of BlueNRG-2 |
| 28 | DIO1 | Digital I/O | General purpose digital I/O of BlueNRG-2 |
| 29 | DIO2 | Digital I/O | General purpose digital I/O of BlueNRG-2 / SPI master output pin connected internally to SDI pin of S2-LP |
| 30 | DIO3 | Digital I/O | General purpose digital I/O of BlueNRG-2 / SPI master input pin connected internally to SDO pin of S2-LP |
| 31 | GND | GND | GND |
| 32 | GPIO3 | Digital I/O | General purpose I/O of S2-LP. Connected internally to DIO21 pin of BlueNRG-2. |
| 33 | GND | GND | GND |
| 34 | VCC_S2LP | POWER | Power for S2-LP |
| 35 | GND | GND | GND |
| 36 | GPIO2 | Digital I/O | General purpose I/O of S2-LP. Connected internally to DIO19 pin of BlueNRG-2. |
| 37 | GPIO1 | Digital I/O | General purpose I/O of S2-LP. |
| 38 | GPIO0 | Digital I/O | General purpose I/O of S2-LP. |
| 39 | DIO15 | Digital I/O | General purpose digital I/O of BlueNRG-2 |
| 40 | DIO14 | Digital I/O | General purpose digital I/O of BlueNRG-2 |
| 41 | ANATEST1 | Analog Output | Analog output of BlueNRG-2 |
| 42 | ANATEST0 | Analog Output | Analog output of BlueNRG-2 |
| 43 | GND | GND | GND |

| | | | |
|----|-----------|--------------|--------------------------|
| 44 | ADC1 | Analog Input | ADC input1 of BlueNRG-2 |
| 45 | ADC2 | Analog Input | ADC input1 of BlueNRG-2 |
| 46 | VCC_PA1 | POWER | Power for SKY66420-11 |
| 47 | VCC_PA2 | POWER | Power for SKY66420-11 |
| 48 | GND | GND | GND |
| 49 | GND | GND | GND |
| 50 | SUB-1G RF | RF I/O | Sub-1GHz antenna port |
| 51 | GND | GND | GND |
| 52 | GND | GND | GND |
| 53 | BLE RF | RF I/O | 2.4 GHz BLE antenna port |
| 54 | GND | GND | GND |

4. MODULE SPECIFICATIONS

4.1. Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted)

| Pin | Parameter | MIN | MAX | Unit |
|---|---|------|------|------|
| 15, 34 | Power for BlueNRG-2 and S2-LP | -0.3 | +3.6 | V |
| 46, 47 | Power for SKY66420-11 | -0.3 | +5.5 | V |
| 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 32, 36, 37, 38, 39, 40 | DC voltage on digital input/output pins | -0.3 | +3.9 | V |
| 41, 42, 44, 45 | DC voltage on analog pins | -0.3 | +3.9 | V |
| 50 | Input RF level | | +10 | dBm |
| 53 | Input RF level | | +5 | dBm |
| | Storage temperature range | -40 | +85 | °C |

4.2. ESD Ratings

| Parameter | | | Value | Unit |
|-------------------------------------|----------|----------------|-------|------|
| Electrostatic discharge performance | VESD+HBM | BlueNRG-2 pins | ±2000 | V |
| | VESD+HBM | S2-LP pins | ±500 | V |
| | VESD+HBM | RF pins | ±500 | V |

4.3. Recommended Operating Conditions

| Parameter | Conditions | MIN | MAX | Unit |
|---------------------------------|-----------------|------|------|------|
| Ambient temperature range | | -40 | 85 | °C |
| VBAT ⁽¹⁾ | For BlueNRG-2 | +1.7 | +3.6 | V |
| VCC_S2LP ⁽¹⁾ | For S2-LP | +1.8 | +3.6 | V |
| VCC_PA1, VCC_PA2 ⁽¹⁾ | For SKY66420-11 | +2.0 | +4.8 | V |

(1) The VBAT, VCC_S2LP, VCC_PA1, VCC_PA2 are limited from min 2.2V to max 3.6V in Sigfox application

4.4. Power Consumption Summary

Ta = 25°C, VBAT=3.3 V, VCC_S2LP=3.3 V, VCC_PA = 3.3 V with internal DC-DC converter, unless otherwise noted.

| Parameter | Test Conditions | Min | Typ | Max | Units | |
|-----------------------------|--|-------------------|------|------|-------|----|
| BlueNRG-2 Supply current | Reset | | 5 | | nA | |
| | Standby | | 500 | | nA | |
| | Sleep mode: 32 kHz XO ON (24 KB retention RAM) | | 0.9 | | µA | |
| | Sleep mode: 32 kHz RO ON (24 KB retention RAM) | | 2.1 | | µA | |
| | Active mode: CPU, Flash and RAM on | | 1.9 | | mA | |
| | RX | | 8.8 | | mA | |
| | BLE TX +7 dBm | | 15.1 | | mA | |
| | BLE TX +2 dBm | | 11.2 | | mA | |
| | BLE TX +0 dBm | | 9.4 | | mA | |
| | BLE TX -5 dBm | | 8.7 | | mA | |
| | BLE TX -8 dBm | | 8.2 | | mA | |
| | BLE TX -10 dBm | | 7.7 | | mA | |
| | BLE TX -14 dBm | | 7.5 | | mA | |
| | BLE TX -17 dBm | | 7.3 | | mA | |
| IBAT | Peripheral Current Consumption (Adds to core current for each peripheral unit activated) | | | | | |
| | BlueNRG-2 Peripheral current | GPIO | | 11.0 | | µA |
| | | Flash controller | | 6.0 | | µA |
| | | System controller | | 0.75 | | µA |
| | | UART | | 77.0 | | µA |
| | | SPI | | 41.0 | | µA |
| | | Watchdog | | 4.0 | | µA |
| | | ADC | | 5.0 | | µA |
| | | I2C1/I2C2 | | 92.0 | | µA |
| | | MFT1 | | 7.5 | | µA |
| | | MFT2 | | 7.5 | | µA |
| | | RTC | | 7.5 | | µA |
| | | DMA | | 16.5 | | µA |
| | | RNG | | 25.0 | | µA |
| | | PKA | | 26.0 | | µA |
| Ivcc_ S2LP | Shutdown | | 5 | | nA | |
| | Standby | | 30.5 | | µA | |

| | | | | | | |
|-------------|-------------------------------|-------------------------------|--|-------|---|----|
| | S2_LP Supply current | Sleep | | 5 | | nA |
| | | Sleep (FIFOs retained) | | 30.95 | | nA |
| | | Ready | | 400 | | μA |
| | | RX @ sensitivity level | | 8.5 | | mA |
| | | TX CW @ 14 dBm(in boost mode) | | 25 | | mA |
| | | TX CW @ 10 dBm(in boost mode) | | 16 | | mA |
| Ivcc_ PA | SKY66420-11 Supply current | Sleep Current | | | 1 | μA |
| | | Transmit bypass mode | | 200 | | μA |
| | | TX CW @ 27 dBm | | 280 | | mA |
| | | RX | | 5 | | mA |

4.5. 2.4GHz GFSK (Bluetooth Low Energy) RF Characteristics

RF performance is specified in a single ended 50 ohm reference plane at the RF connector with $T_a = 25^\circ\text{C}$, $V_{BAT} = 3.3\text{ V}$, $f_{RF} = 2440\text{ MHz}$, unless otherwise noted. Please see the more detail data in the STM's BlueNRG-2 datasheet.

| Parameter | Test Conditions | Min | Typ | Max | Units |
|--------------------------|-----------------|------|-----|--------|-------|
| Frequency range | | 2400 | - | 2483.5 | MHz |
| Channel spacing | | - | 2 | - | MHz |
| Channel center frequency | | 2402 | | 2480 | MHz |
| Receiver sensitivity | BER = 10^{-3} | | -86 | | dBm |
| Receiver saturation | BER = 10^{-3} | | 11 | | dBm |
| Maximum Output Power | At RF connector | | +7 | | dBm |
| Minimum Output Power | At RF connector | | -17 | | dBm |

4.6. Sub-1GHz RF Characteristics

RF performance is specified in a single ended 50 ohm reference plane at the RF connector with $T_a = 25^\circ\text{C}$, $V_{CC_S2LP} = 3.3\text{ V}$, $V_{CC_PA} = 3.3\text{ V}$, unless otherwise noted. Please see the more detail data in the STM's S2_LP and Skyworks's SKY66420-11 datasheet.

| Parameter | Test Conditions | Min | Typ | Max | Units |
|--------------------------|-----------------|------|-----|-----|-------|
| Frequency range | | 860 | - | 930 | MHz |
| Data rate – 2-(G)FSK | | 0.3 | - | 250 | kbps |
| Data rate – 4-(G)FSK | | 0.6 | - | 500 | kbps |
| Data rate – OOK/ASK | | 0.3 | - | 125 | kbps |
| Frequency deviation FDEV | | 0.15 | - | 500 | kHz |

| | | | | | |
|---|--|--|------|--|-----|
| Sensitivity @ 920MHz, Low Gain Mode, 1% BER @ 2-GFSK BT = 0.5 | DR = 0.3 kbps, FDEV = 0.25 kHz, CHF = 1 kHz | | -128 | | dBm |
| | DR = 1.2 kbps, FDEV = 1.2 kHz, CHF = 4 kHz | | -122 | | dBm |
| | DR = 38.4 kbps, FDEV = 20 kHz, CHF = 100 kHz | | -109 | | dBm |
| | DR = 100 kbps, FDEV = 50 kHz, CHF = 200 kHz | | -105 | | dBm |
| Sensitivity @ 920MHz, Low Gain Mode, 1% BER @ 4-GFSK BT = 0.5 | DR = 4.8 kbps, DEV = 2.4 kHz, CHF = 10 kHz | | -114 | | dBm |
| | DR = 9.6 kbps, DEV = 4.8 kHz, CHF = 20 kHz | | -112 | | dBm |
| | DR = 19.2 kbps, DEV = 9.6 kHz, CHF = 40 kHz | | -108 | | dBm |
| Maximum Output Power ⁽¹⁾ | At RF pin (PA enable) | | +27 | | dBm |
| | At RF pin (PA bypass) | | +14 | | |
| Minimum Output Power | At RF pin | | 0 | | dBm |

(1) In order to comply with Sigfox limits, the maximum RF output power must be as below.

| | | | | | |
|---------|---------|---------|---------|---------|---------|
| RC1 | RC2 | RC3 | RC4 | RC5 | RC6 |
| 12.8dBm | 22.4dBm | 12.4dBm | 21.7dBm | 12.0dBm | 12.7dBm |

4.7. Internal 16-MHz Crystal Oscillator (for BlueNRG-2)

over operating free-air temperature range (unless otherwise noted)

| Parameter | Test Conditions | Min | Typ | Max | Units |
|--|-----------------|-----|-----|-----|-------|
| Crystal frequency | | | 32 | | MHz |
| Crystal frequency tolerance ⁽¹⁾ | | -40 | | +40 | ppm |

(1) Includes initial tolerance of the crystal, drift over temperature, aging (5 years).

4.8. Internal 32.768-kHz Crystal Oscillator (for BlueNRG-2)

over operating free-air temperature range (unless otherwise noted)

| Parameter | Test Conditions | Min | Typ | Max | Units |
|--|-----------------|-----|--------|-----|-------|
| Crystal frequency | | | 32.768 | | KHz |
| Crystal frequency tolerance ⁽¹⁾ | | -40 | | 40 | ppm |

(1) Includes initial tolerance of the crystal, drift over temperature, aging (5 years).

4.9. Internal 50MHz Crystal Oscillator (for S2-LP)

over operating free-air temperature range (unless otherwise noted)

| Parameter | Test Conditions | Min | Typ | Max | Units |
|--|---|-----|-----|-----|-------|
| Crystal frequency | | | 50 | | MHz |
| Crystal frequency tolerance ⁽¹⁾ | Without initial frequency calibration | -40 | | 40 | ppm |
| Crystal frequency tolerance ⁽²⁾ | Initial frequency is calibrated by software | -20 | | 20 | ppm |

(1) Includes initial tolerance of the crystal, drift over temperature, aging (5 years).

(2) Includes only drift over temperature, aging (5 years).

4.10. BlueNRG-2 Digital I/O specifications

Ta = 25°C

| Parameter | Test Conditions | Min | Typ | Max | Units |
|-----------------------------|-----------------------------|---------|-----|---------|-------|
| Trise | 0.1*VDD to 0.9*VDD, CL=50pF | 1.4(TC) | - | 19(TC2) | ns |
| Tfall | 0.9*VDD to 0.1*VDD, CL=50pF | 1.5(TC) | - | 22(TC2) | ns |
| T(RST)L | | - | 1.5 | - | ms |
| TC | | 3 | 3.3 | 3.6 | V |
| TC1 | | 2.25 | 2.5 | 2.75 | V |
| TC2 | | 1.72 | 1.8 | 1.98 | V |
| VIL | TC | -0.3 | - | 0.9 | V |
| | TC1 | -0.3 | - | 0.67 | V |
| | TC2 | -0.3 | - | 0.54 | V |
| VIH | TC | 1.95 | - | 3.6 | V |
| | TC1 | 1.46 | - | 2.75 | V |
| | TC2 | 1.1 | - | 1.98 | V |
| VOL | TC | - | - | 0.4 | V |
| | TC1 | - | - | 0.42 | V |
| | TC2 | - | - | 0.45 | V |
| VOH | TC | 2.4 | - | - | V |
| | TC1 | 1.72 | - | - | V |
| | TC2 | 1.35 | - | - | V |
| IOL (Low drive strength) | TC (VOL = 0.4V) | 3.4 | 5.6 | 7.9 | mA |
| | TC1 (VOL= 0.42V) | 3.8 | 6.6 | 10.1 | mA |
| | TC2 (VOL =0.45V) | 1.6 | 3 | 5 | mA |

| | | | | | |
|------------------------------|------------------|-----|------|------|----|
| IOL (High drive strength) | TC (VOL = 0.4V) | 6.8 | 11.2 | 15.8 | mA |
| | TC1 (VOL= 0.42V) | 7.6 | 13.2 | 20.1 | mA |
| | TC2 (VOL =0.45V) | 3.3 | 6 | 9.9 | mA |
| IOH (Low drive strength) | TC (VOH = 2.4V) | 5.5 | 10.6 | 17.6 | mA |
| | TC1 (VOH= 1.72V) | 3.7 | 7.2 | 12 | mA |
| | TC2 (VOH =1.35V) | 1.4 | 3 | 5.6 | mA |
| IOH (High drive strength) | TC (VOH = 2.4V) | 9.9 | 19.2 | 31.7 | mA |
| | TC1 (VOH= 1.72V) | 6.7 | 12.9 | 21.6 | mA |
| | TC2 (VOH =1.35V) | 2.4 | 5.5 | 10.1 | mA |

4.11. S2-LP Digital interface specification

| Parameter | Test Conditions | Min | Typ | Max | Units |
|---------------------|--|------------------------------|-----|-----------------------|-------|
| SPI clock frequency | | | 8 | 10 | MHz |
| VIH | | $V_{CC_S2LP}/2+0.3$ | - | - | V |
| VIL | | - | - | $V_{CC_S2LP}/8 +0.3$ | V |
| VOH | IOH = -2.4 mA (-4.2 mA into high output current mode). | $0.625 * V_{CC_S2LP} + 0.1$ | - | - | V |
| VOL | IOL = +2.0 mA (+4.0 mA into high output current mode). | | | 0.5 | V |

4.12. SKY66420-11 Electrical Specifications: Control Logic Characteristics¹

| Parameter | Test Conditions | Min | Typ | Max | Units |
|----------------------|---------------------------|------------------|-----|------------------|-------|
| Control Voltage High | RXEN, TXEN, and MODE Pins | 1.6 ² | - | VCC_PA | V |
| Control Voltage Low | RXEN, TXEN, and MODE Pins | | | 0.3 ² | V |

¹ Performance is guaranteed only under the conditions listed in this table.

² Logic inputs must be VCC_PA or GND to achieve specified sleep currents.

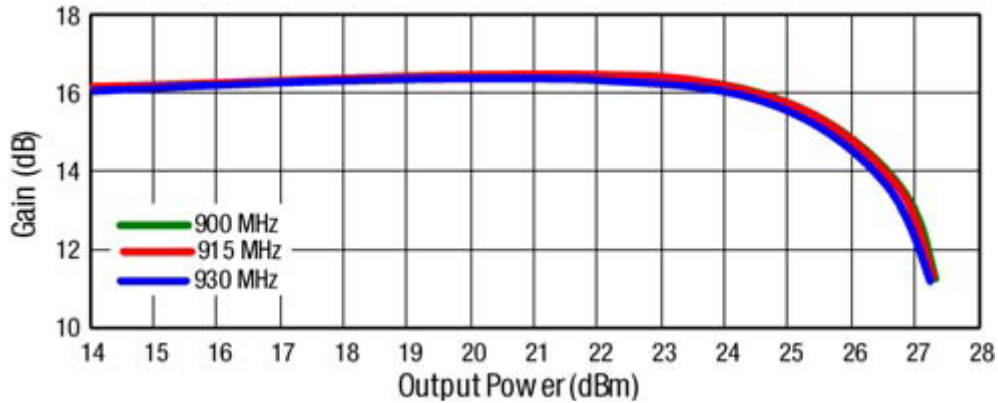
4.13. SKY66420-11 Electrical Specifications: Mode Control Logic

| Mode | CSD | CTX | CPS |
|------------------|-----|----------------|----------------|
| Shutdown | 0 | X ¹ | X ¹ |
| Receive LNA mode | 1 | 0 | X ¹ |
| Transmit bypass | 1 | 1 | 0 |
| Transmit | 1 | 1 | 1 |

¹ X (don't care) inputs must be held at VCC_PA or GND to achieve specified sleep current.

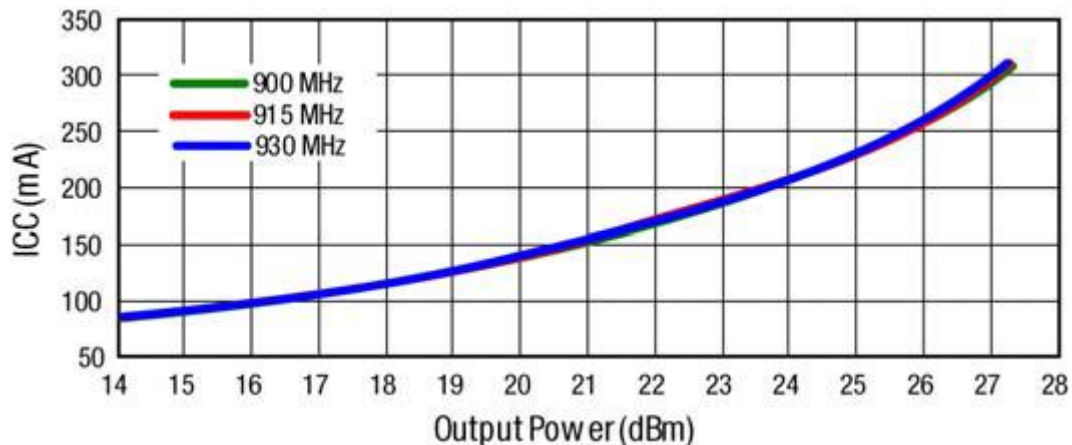
4.14. SKY66420-11 Gain vs. Pout

Tc = 25°C, VCC_PA = 3.3 V



4.15. SKY66420-11 Current vs. Pout

Tc = 25°C, VCC_PA = 3.3 V



4.16. More Characteristics

If you need more detail characteristics, please visit STM and Skyworks web site.

BlueNRG-2

https://www.st.com/content/st_com/en/products/wireless-transceivers-mcus-and-modules/bluetooth-bluetooth-low-energy/bluenrg-2.html

S2-LP:

http://www.st.com/content/st_com/en/products/wireless-connectivity/sub-1ghz-rf/s2-lp.html

SKY66420-11

<http://www.skyworksinc.com/Product/4124/SKY66420-11>

5. DESIGN RECOMMENDATIONS

5.1. GPIO Usage of BlueNRG-2

Because the function of some pins has been used in the module internally. The other functions of these pins could not be defined. Please refer the below table.

| Pin Name | Mode "000" | | Mode "001" | | Mode "100" | | Mode "101" | | Note |
|----------|------------|--------------------|------------|---------------------|------------|---------------------|------------|---------------------|--|
| | Type | Signal | Type | Signal | Type | Signal | Type | Signal | |
| DIO0 | I/O | GPIO 0 | I | UART_CTS | I/O | SPI_CLK | O | CPJCLK | To SCLK pin of S2-LP |
| DIO1 | I/O | GPIO 1 | O | UART_RTS | I/O | SPI_CS1 | I | PDM_DATA | |
| DIO2 | I/O | GPIO 2 | O | PWM0 | O | SPI_OUT | O | PDM_CLK | To SDI pin of S2-LP |
| DIO3 | I/O | GPIO 3 | O | PWM1 | I | SPI_IN | - | - | To SDO pin of S2-LP |
| DIO4 | I/O | GPIO 4 | I | UART_RXD | I/O | I2C2_CLK | O | PWM0 | To SCL pin of STSAFE-A1SX ⁽¹⁾ |
| DIO5 | I/O | GPIO 5 | O | UART_TXD | I/O | I2C2_DAT | O | PWM1 | To SDA pin of STSAFE-A1SX ⁽¹⁾ |
| DIO6 | I/O | GPIO 6 | O | UART_RTS | I/O | I2C2_CLK | I | PDM_DATA | To reset pin of STSAFE-A1SX ⁽¹⁾ |
| DIO7 | I/O | GPIO 7 | I | UART_CTS | I/O | I2C2_DAT | O | PDM_CLK | |
| DIO8 | I/O | GPIO 8 | O | UART_TXD | I/O | SPI_CLK | I | PDM_DATA | |
| DIO9 | I/O | GPIO 9 | I | SWCLK | I | SPI_IN | O | XO16/32M | |
| DIO10 | I/O | GPIO 10 | I | SWDIO | O | SPI_OUT | O | CLK_32K | |
| DIO11 | I/O | GPIO 11 | I | UART_RXD | I/O | SPI_CS1 | O | CLK_32K | |
| DIO12 | OD | GPIO 12 | I | - | I/O | I2C1_CLK | - | - | |
| DIO13 | OD | GPIO 13 | I | UART_CTS | I/O | I2C1_DAT | - | - | |
| DIO14 | I/O | GPIO 14 | I/O | I2C1_CLK | I/O | SPI_CLK | - | - | |
| DIO15 | I/O | GPIO 15 | I/O | I2C1_DAT | I/O | SPI_CS1 | | | |
| DIO16 | I/O | GPIO 16 | O | PWM0 | I | SPI_IN | | | |
| DIO17 | I/O | GPIO 17 | O | PWM1 | O | SPI_OUT | | | |
| DIO18 | I/O | GPIO 18 | O | SPI_CS2 | O | UART_RTS | | | |
| DIO19 | I/O | GPIO 19 | O | SPI_CS3 | I | UART_CTS | | - | To GPIO2 of S2-LP |
| DIO20 | I/O | GPIO 20 | I | UART_CTS | O | SPI_CS2 | | - | To CS pin of S2-LP |
| DIO21 | I/O | GPIO 21 | O | PWM1 | I/O | SPI_CS1 | | - | To GPIO3 of S2-LP |
| DIO22 | I/O | GPIO 22 | O | PWM0 | O | SPI_CS3 | | - | To CTX pin of SKY66420-11 |
| DIO23 | I/O | GPIO 23 | O | UART_TXD | O | SPI_OUT | O | PDM_CLK | To CPS pin of SKY66420-11 |
| DIO24 | I/O | GPIO 24 | I | UART_RXD | I | SPI_IN | I | PDM_DATA | To CSD pin of SKY66420-11 |
| DIO25 | I/O | GPIO 25 | O | UART_RTS | I/O | SPI_CLK | O | PDM_CLK | To SDN pin of S2-LP |

(1) Only limitation for WS2116-F0

(2) All the IOs are in high impedance under reset. In low power modes (sleep and standby) the I/Os are configured as follows:

-DIO0 to DIO8 and DIO14 to DIO25 are in high impedance state.

-DIO9, DIO10, DIO11 are in input state with configurable internal pull by using the SLEEPIO_PE register. Please see the BlueNRG-2 datasheet for details register information.

-DIO12, DIO13 are in input state no pull. **If DIO12 or DIO13 are not used, they must be put at GND through pull-down resistor.**

5.2. Debug Port

The BlueNRG-2 embeds the ARM serial wire debug (SWD) port. It is two pins (clock and single bi-directional data) debug interface, providing all the debug functionality plus real-time access to system memory without halting the processor or requiring any target resident code.

| Pin functionality | Pin Name | Pin description |
|-------------------|----------|------------------|
| SWCLK | DIO9 | SWD clock signal |
| SWDIO | DIO10 | SWD data signal |

The Cortex-M0 subsystem of the BlueNRG-1 embeds two breakpoints and one watch point.

5.3. Debugging Tips

There are certain situations where debug access is disabled and the chip cannot be accessed, including:

- application that disables debug pins
- application that set the device in sleep or standby state, in which the debug port is not powered.

These cases are common during application development and device can end up in a state where debug access is no longer possible. To recover this situation, it is recommended to force DIO7 pin high and hardware reset the device in order to force execution of the updater code. The user can then connect with SWD interface and erase the device Flash memory.

5.4. Pre-programmed bootloader

BlueNRG-2 device has a pre-programmed bootloader supporting UART protocol with automatic baudrate detection. Main features of the embedded bootloader are:

- Auto baudrate detection up to 460 kbps
- Flash mass erase, section erase
- Flash programming
- Flash readout protection enable/disable

The pre-programmed bootloader is an application which is stored on the BlueNRG-1 internal ROM at manufacturing time by STMicroelectronics. This application allows upgrading the device Flash with a user application using a serial communication channel (UART).

Bootloader is activated by hardware by forcing IO7 high during power-up or hardware Reset, otherwise, application residing in Flash will be launched.

The customer application must ensure that IO7 is forced low during power up. There is a built-in 100K pull-down resistor in IO7. Bootloader protocol is described in a separate application note.

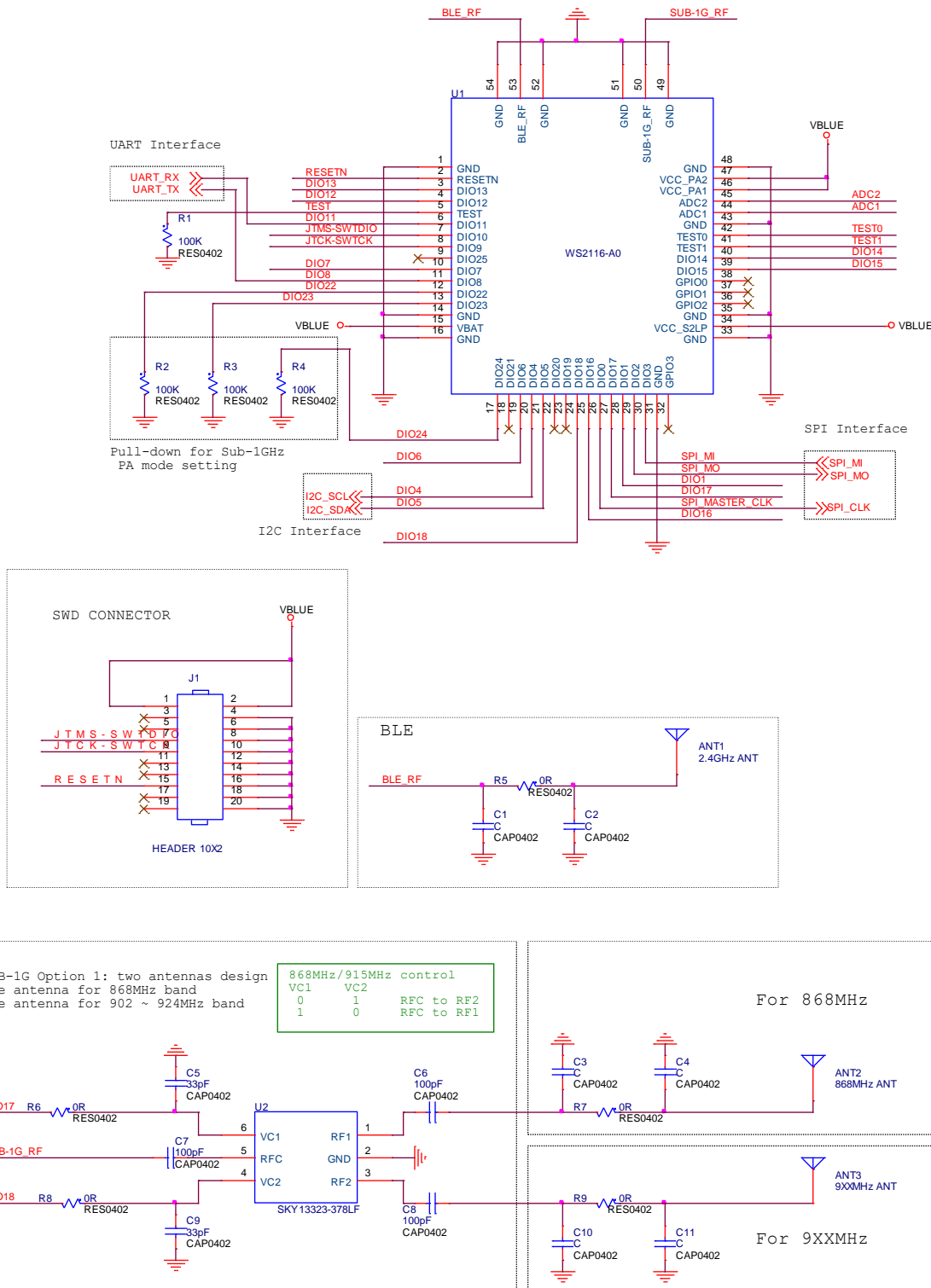
5.5. TX/RX event alert

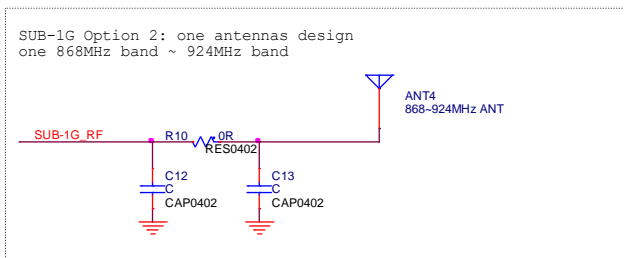
The BlueNRG-2 is provided with the ANATEST1 (pin 41 in the module) signal which alerts forthcoming transmission or reception event. The ANATEST1 pin switches to high level about 18 μ s before transmission and about 10 μ s before reception. Then, it switches to low level at the end of the event. The signal can be used for controlling external antenna switching and supporting coexistence with other wireless technologies.

5.6. Standby mode of SKY66420-11

The DIO22, DIO23, DIO24 of BlueNRG-2 are in high impedance state under standby mode. The three DIO pins must be pull-down 100K ohm resistors to GND in order to avoid unstable state issue for mode setting of SKY66420-11 in the standby mode of the module.

5.7. Reference Schematic



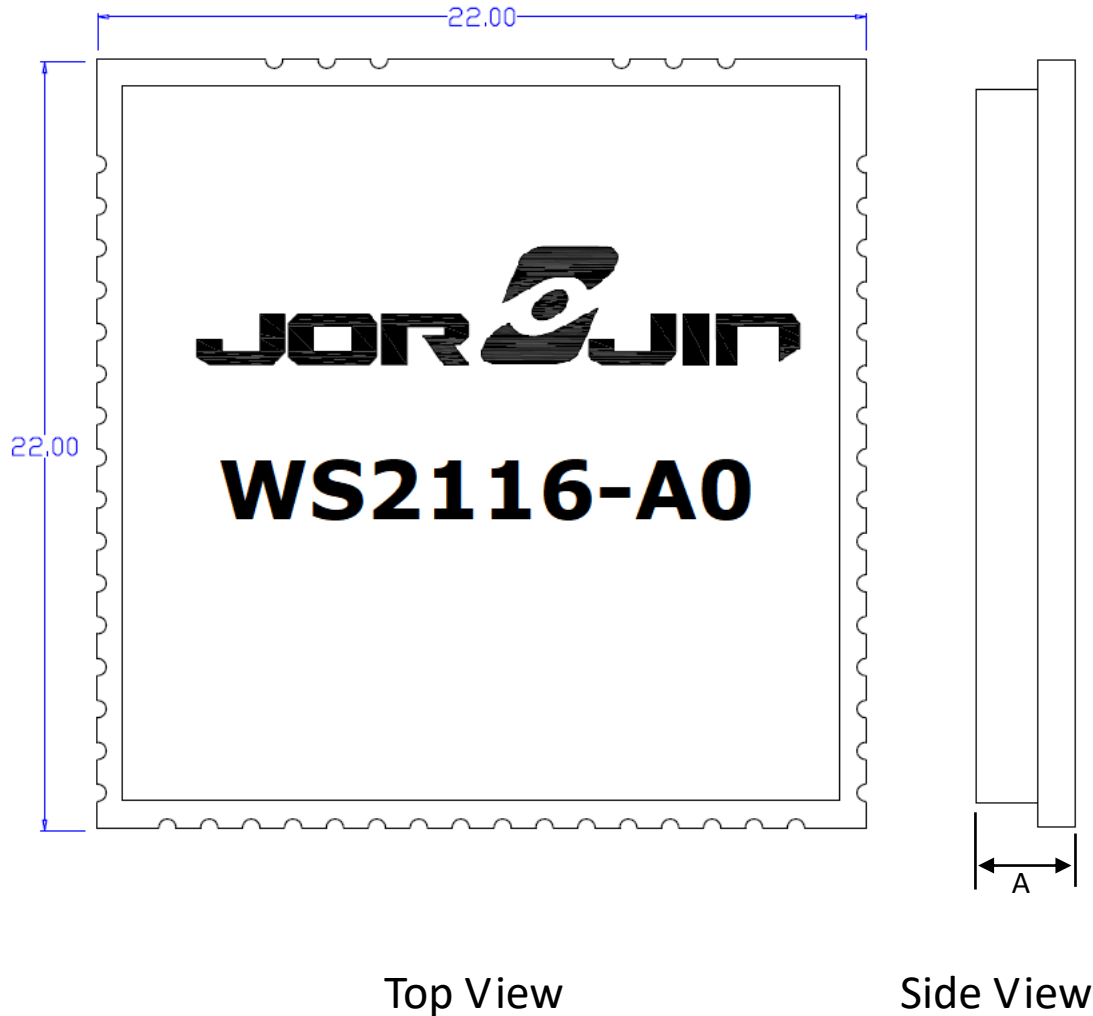


5.8. Module Layout Recommendations

- Power Trace – Power trace for VCC_PA should be 25mil wide. VBAT and VCC_S2LP traces should be 15mil wide, at least.
- RF Trace & Antenna
 - Keep 50ohm trace impedance.
 - Move all the high-speed traces and components far away from the antenna.
 - Check antenna vendor for the layout guideline and clearance.

6. PACKAGE INFORMATION

6.1. Module Mechanical Outline

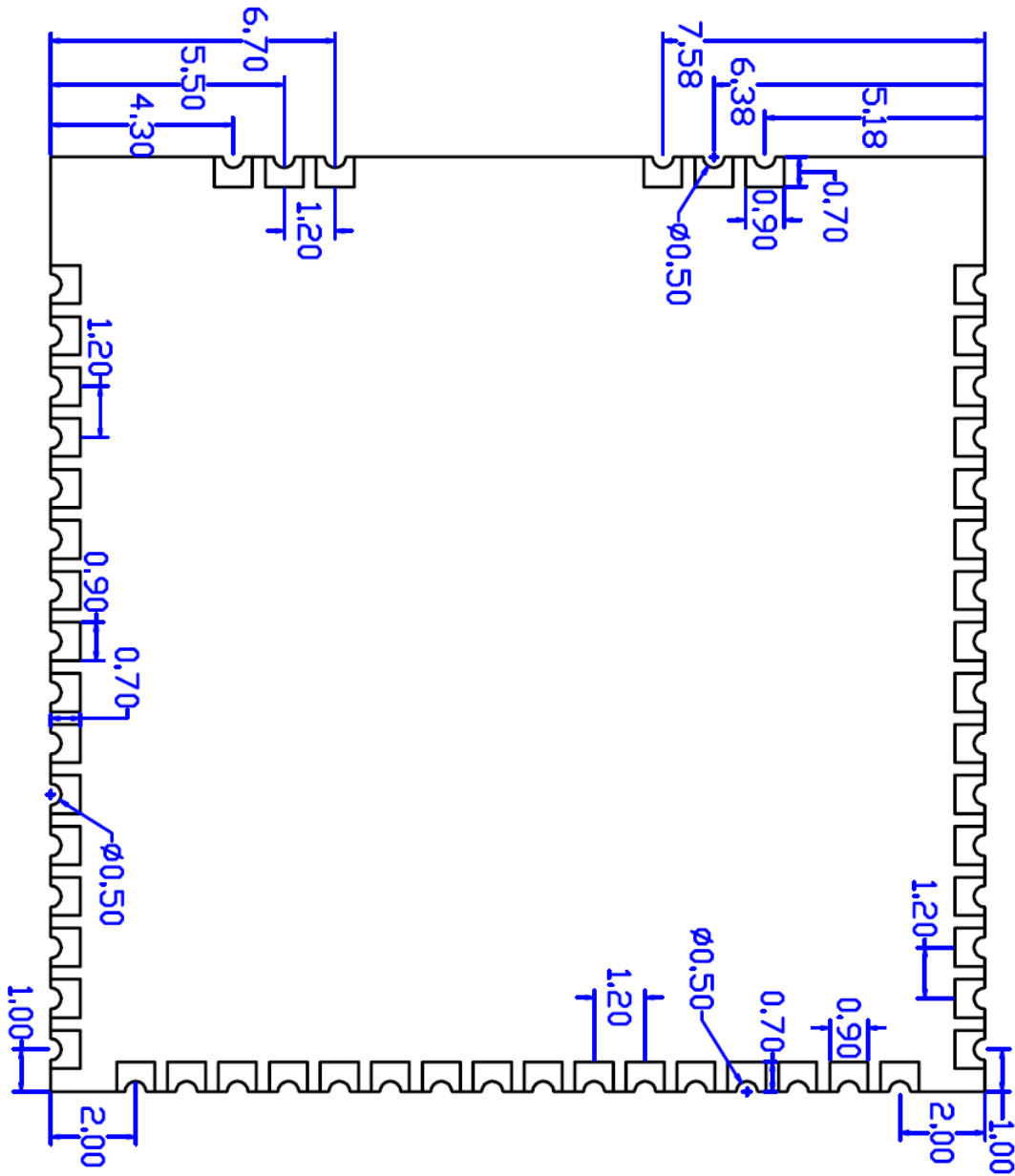


Note:

A: Typical: 2.8mm, Maximum: 3.0mm

Unit: mm

Tolerance: +/- 0.2mm

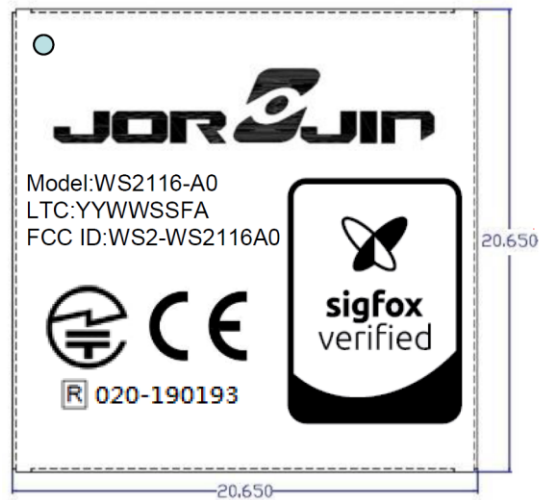





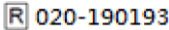

Bottom View

Note:

- 1> Pad tolerance as +/-30um
- 2> Recommend pad layout size on PCB at least 0.9 mm,
- 3> Unit: mm

6.2. Package Marking



| Marking | Description |
|--|---|
|  | Brand name: JORJIN |
| WS2116-A0 or WS2116-F0 | Model name |
| YYWSSFX | Lot Trace Code: YYWSSFX YY= Digit of the year, ex: 2017=17 WW= Week (01~52) SS= Serial number from 01~98 match to MFG's lot number, or 99 to repair control code F= Reverse for internal use X = A to Z for Module version |
| WS2-WS2116A0 | FCC ID |
|  | CE compliance mark |
|   | JRF compliance mark, and ID |
|  | Sigfox P1 certified logo |

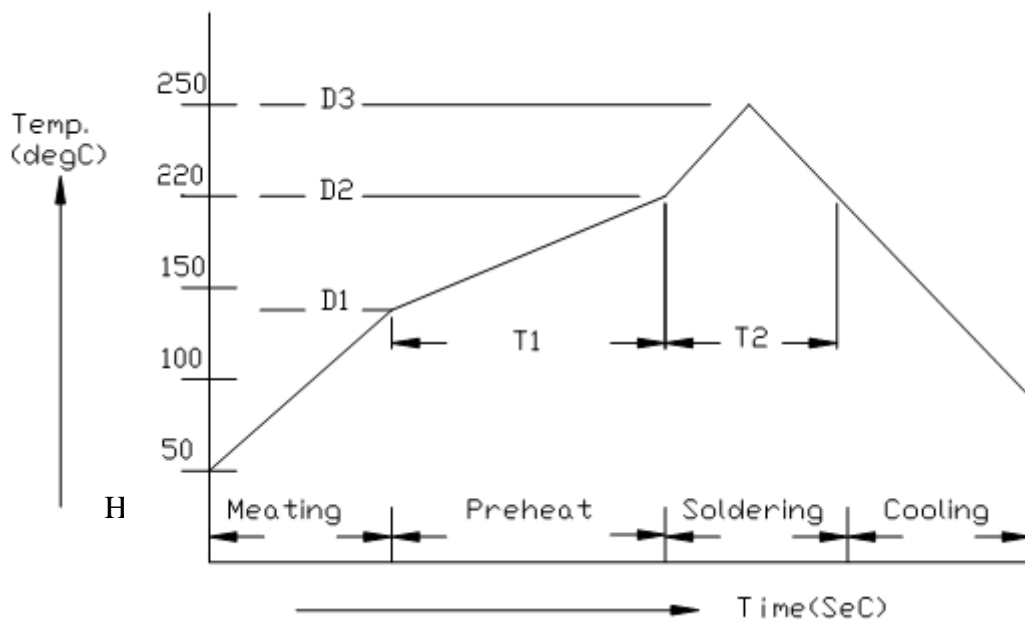
7. SMT AND BAKING RECOMMENDATION

7.1. Baking Recommendation

- Baking condition :
 - Follow MSL Level 4 to do baking process.
 - After bag is opened, devices that will be subjected to reflow solder or other high temperature process must be
 - a) Mounted within 72 hours of factory conditions <30°C/60% RH, or
 - b) Stored at <10% RH.
 - Devices require bake, before mounting, if Humidity Indicator Card reads >10%
- If baking is required, Devices may be baked for 8 hrs. at 125 °C.

7.2. SMT Recommendation

- Recommended Reflow profile :



| No. | Item | Temperature (°C) | Time (sec) |
|-----|------------|-------------------|---------------|
| 1 | Pre-heat | D1: 140 ~ D2: 200 | T1: 80 ~ 120 |
| 2 | Soldering | D2: = 220 | T2: 60 +/- 10 |
| 3 | Peak-Temp. | D3: 250 °C max | |

Note: (1) Reflow soldering is recommended two times maximum.

(7) Add Nitrogen while Reflow process : SMT solder ability will be better.

- **Stencil thickness** : 0.1~ 0.13 mm (Recommended)
- **Soldering paste (without Pb)** : Recommended SENJU N705-GRN3360-K2-V can get better soldering effects.

8. REGULATORY INFORMATION

This section outlines the regulatory information for the following countries:

- United States
- Europe
- Japan

8.1. United States

Federal Communications Commission Interference Statement

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generate, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

FCC Caution:

- Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.
- This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

FCC RF Radiation Exposure Statement:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.

This device is intended only for OEM integrators under the following conditions:

- 1) The antenna must be installed such that 20 cm is maintained between the antenna and users, and
- 2) The transmitter module may not be co-located with any other transmitter or antenna.

As long as **2** conditions above are met, further transmitter test will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed

IMPORTANT NOTE: In the event that these conditions can not be met (for example certain laptop configurations or co-location with another transmitter), then the FCC authorization is no longer considered valid and the FCC ID can not be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC authorization.

End Product Labeling:

This transmitter module is authorized only for use in device where the antenna may be installed such that 20 cm may be maintained between the antenna and users. The final end product must be labeled in a visible area with the following: "Contains FCC ID:WS2-WS2116A0". The grantee's FCC ID can be used only when all FCC compliance requirements are met.

Manual Information to the End User

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module.

The end user manual shall include all required regulatory information/warning as show in this manual.

8.2. Europe

Hereby, Jorjin Technologies Inc. declares that the radio equipment type RF module is in compliance with Directive 2014/53/EU.

The compliance has been verified in the operating frequency band of 2400 MHz to 2483.5 MHz, and 868.055MHz to 868.205MHz. Developers and integrators that incorporate the WS2116-A0 RF Module in any end products are responsible for obtaining applicable regulatory approvals for such end product.

The WS2116-A0 has been tested in the 2400-GHz to 2483.5-GHz, and 868.055MHz to 868.205MHz ISM frequency band at 3.3 V across the temperature range -40°C to $+85^{\circ}\text{C}$ and tolerance.

Labeling and User Information Requirements

As a result of the conformity assessment procedure described in Annex III of the Directive 2014/53/EC, the end-customer equipment should be labeled as follows:



8.3. Japan

The WS2116-A0 is certified as a module with type certification number. End products that integrate this module do not need additional MIC Japan certification for the end product.

9. HISTORY CHANGE

| Revision | Date | Description |
|----------|------------|--|
| D 0.1 | 2018/10/12 | Product Preview |
| D 0.2 | 2019/03/04 | BLE Max output power modify Update Table 4.4 of power consumption |
| D 0.3 | 2019/06/28 | Update voltage limited and Sigfox maximum output power in Sigfox certification report. |
| D 0.4 | 2019/07/22 | Update Sigfox RC5 certification power at page 14. |
| D 0.5 | 2019/08/12 | Add Part 8 : REGULATORY INFORMATION |
| R 0.1 | 2019/11/07 | Correct some typo. |
| R 0.2 | 2019/12/30 | Add more information in 5. DESIGN RECOMMENDATIONS |
| R 0.3 | 2020/05/29 | Add more description in 5.1 GPIO Usage of BlueNRG-2 |
| R 0.4 | 2020/09/17 | Correct the bottom side dimension |