JOR JIN 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
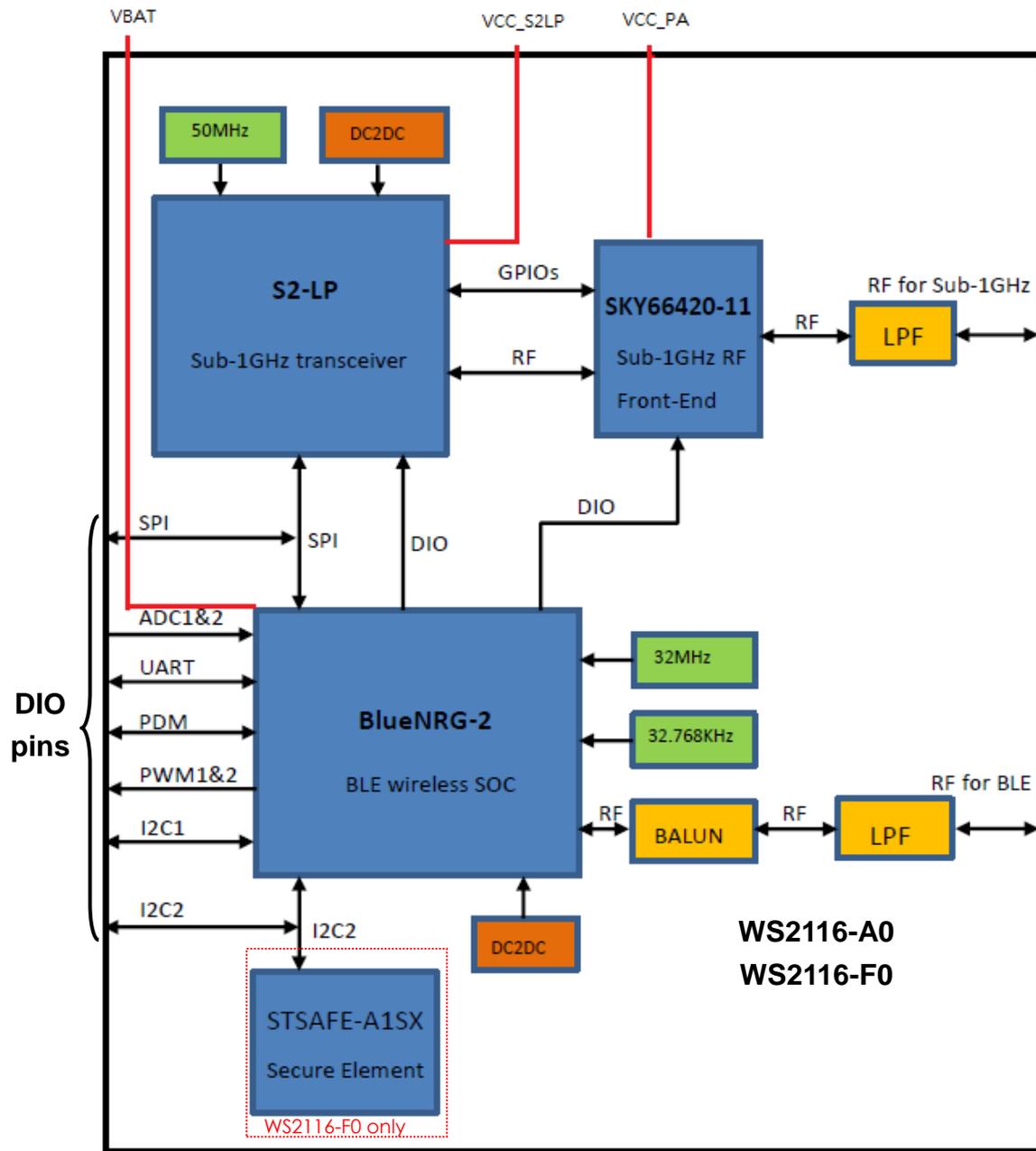
2.2. Block Functional Feature

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 I^{2}C 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

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- 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)
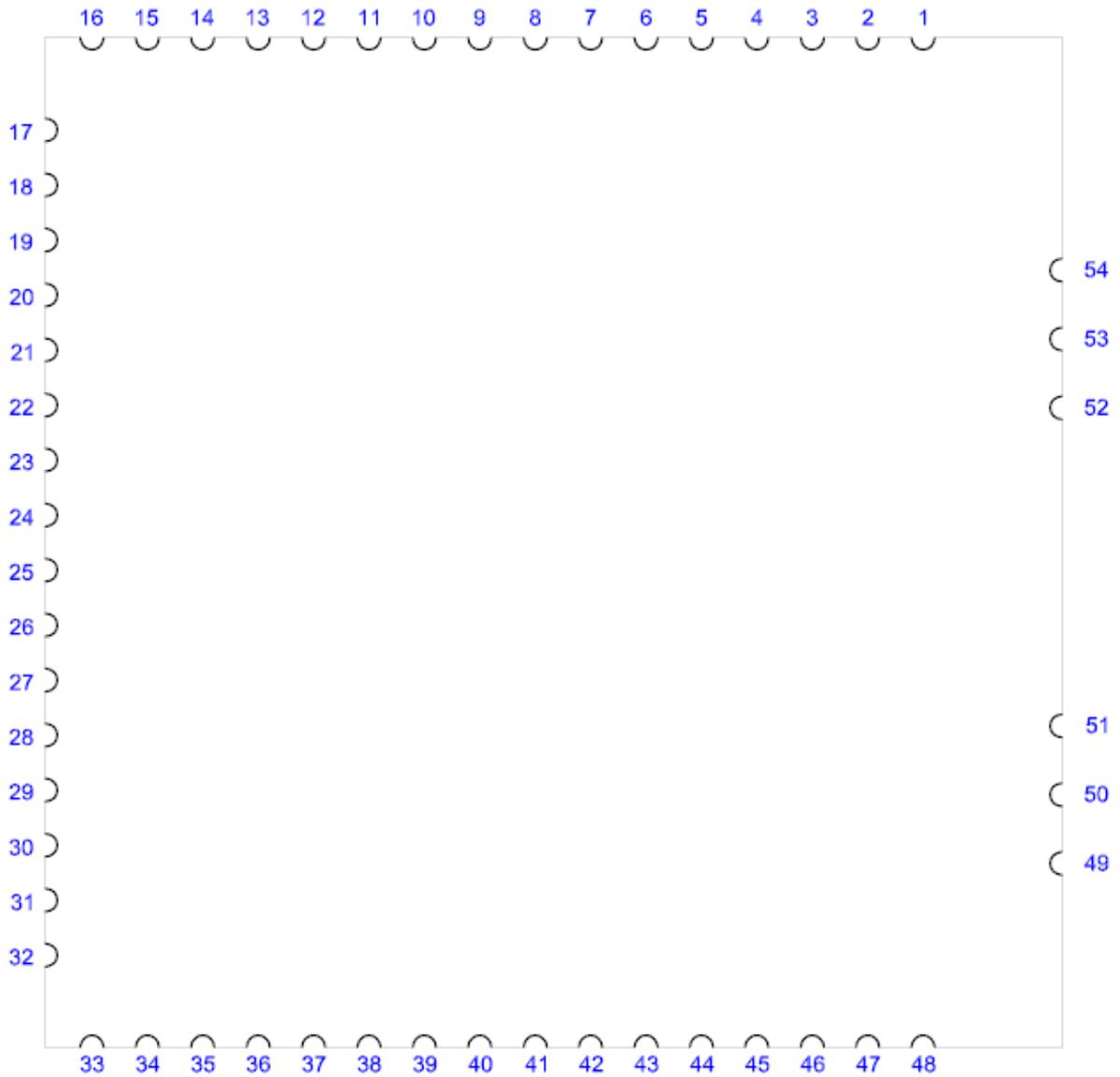
3.2. Pin Description

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
I_{BAT}	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
	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
I_{VCC_S2LP}		Shutdown		5		nA
		Standby		30.5		µA

		Sleep		5		nA
	S2_LP	Sleep (FIFOs retained)		30.95		nA
	Supply current	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
I$_{VCC\_}$	SKY66420-11	Sleep Current			1	µA
		Transmit bypass mode		200		µA
$_{PA}$	Supply current	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 Ta = 25°C, VBAT = 3.3 V, f$_{RF}$ = 2440 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 Ta = 25°C, VCC_S2LP = 3.3 V, VCC_PA=3.3V, 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		dBm
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	TC (VOL = 0.4V)	6.8	11.2	15.8	mA
(High drive strength)	TC1 (VOL= 0.42V)	7.6	13.2	20.1	mA
	TC2 (VOL =0.45V)	3.3	6	9.9	mA
IOH	TC (VOH = 2.4V)	5.5	10.6	17.6	mA
(Low drive strength)	TC1 (VOH= 1.72V)	3.7	7.2	12	mA
	TC2 (VOH =1.35V)	1.4	3	5.6	mA
IOH	TC (VOH = 2.4V)	9.9	19.2	31.7	mA
(High drive strength)	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		VCC_S2LP/2+0.3	-	-	V
VIL		-	-	VCC_S2LP/8 +0.3	V
VOH	IOH = -2.4 mA (-4.2 mA into high output current mode).	0.625*VCC_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 Characteristics[1]

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.

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4.14. SKY66420-11 Gain vs. Pout

Tc = 25°C, VCC_PA = 3.3 V
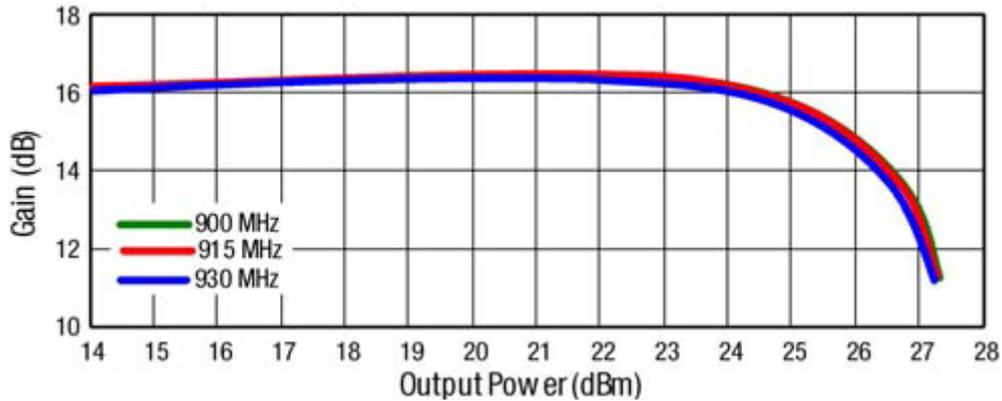
4.15. SKY66420-11 Current vs. Pout

Tc = 25°C, VCC_PA = 3.3 V
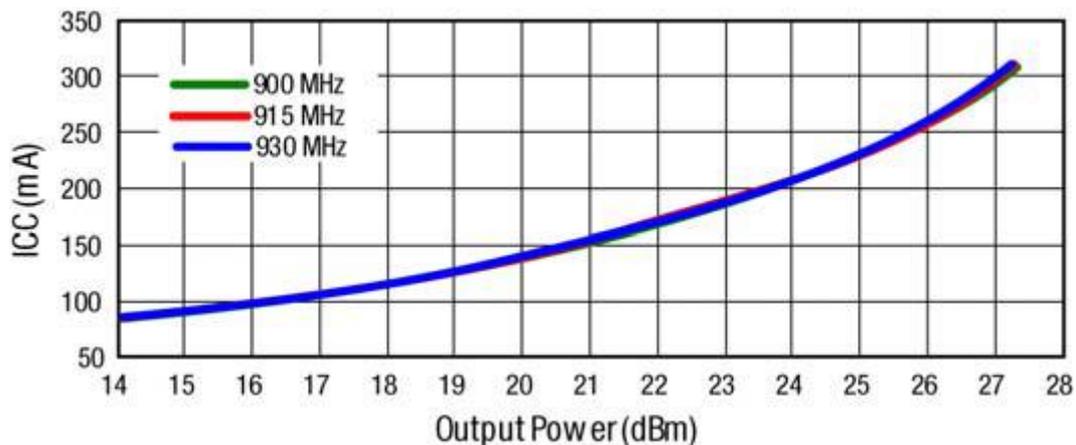
4.16. More Characteristics

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

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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	CPUCLK	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	2C1_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 µs before transmission and about 10 us 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

```
SUB-1G Option 2: one antennas design
one 868MHz band ~ 924MHz band
```
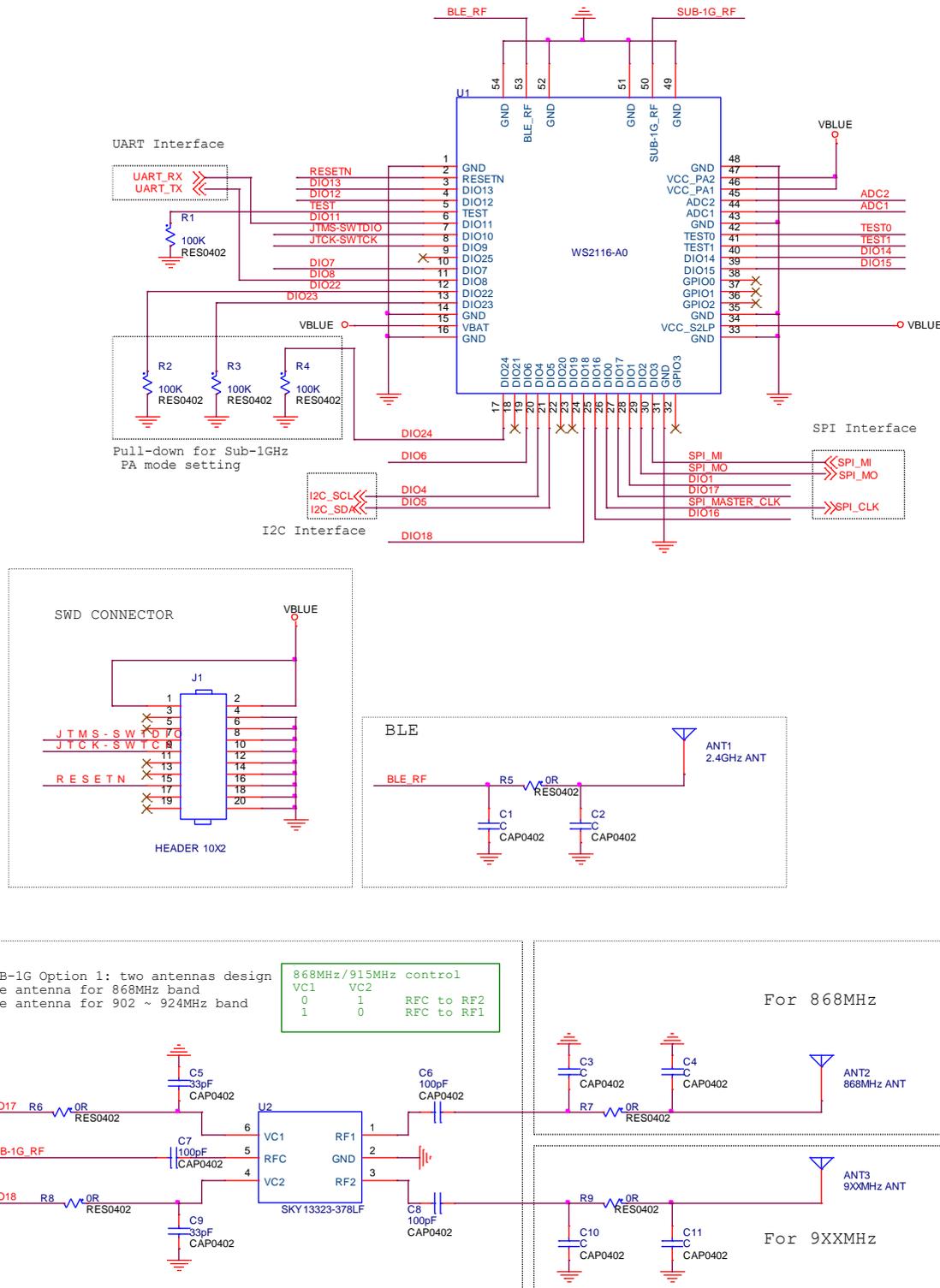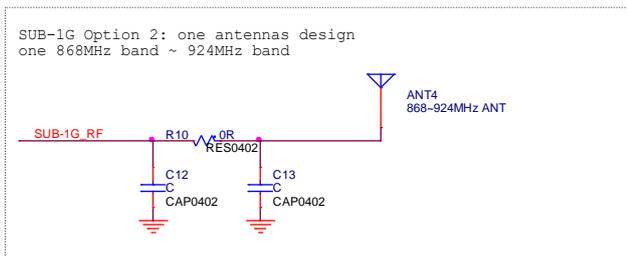
5.8. Module Layout Recommendations

- 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

Top View   Side View
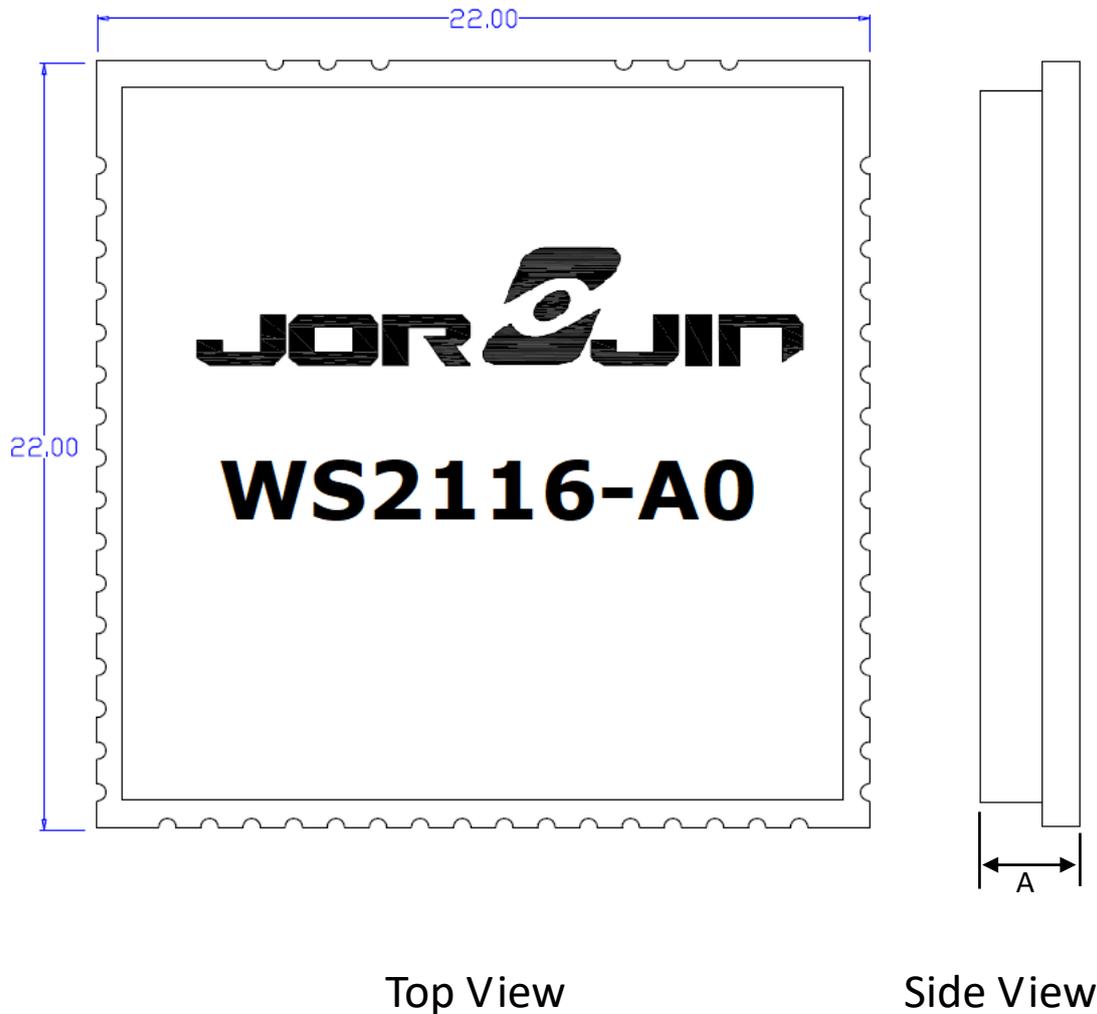
Note:

A: Typical: 2.8mm, Maximum: 3.0mm

Unit: mm

Tolerance: +/- 0.2mm
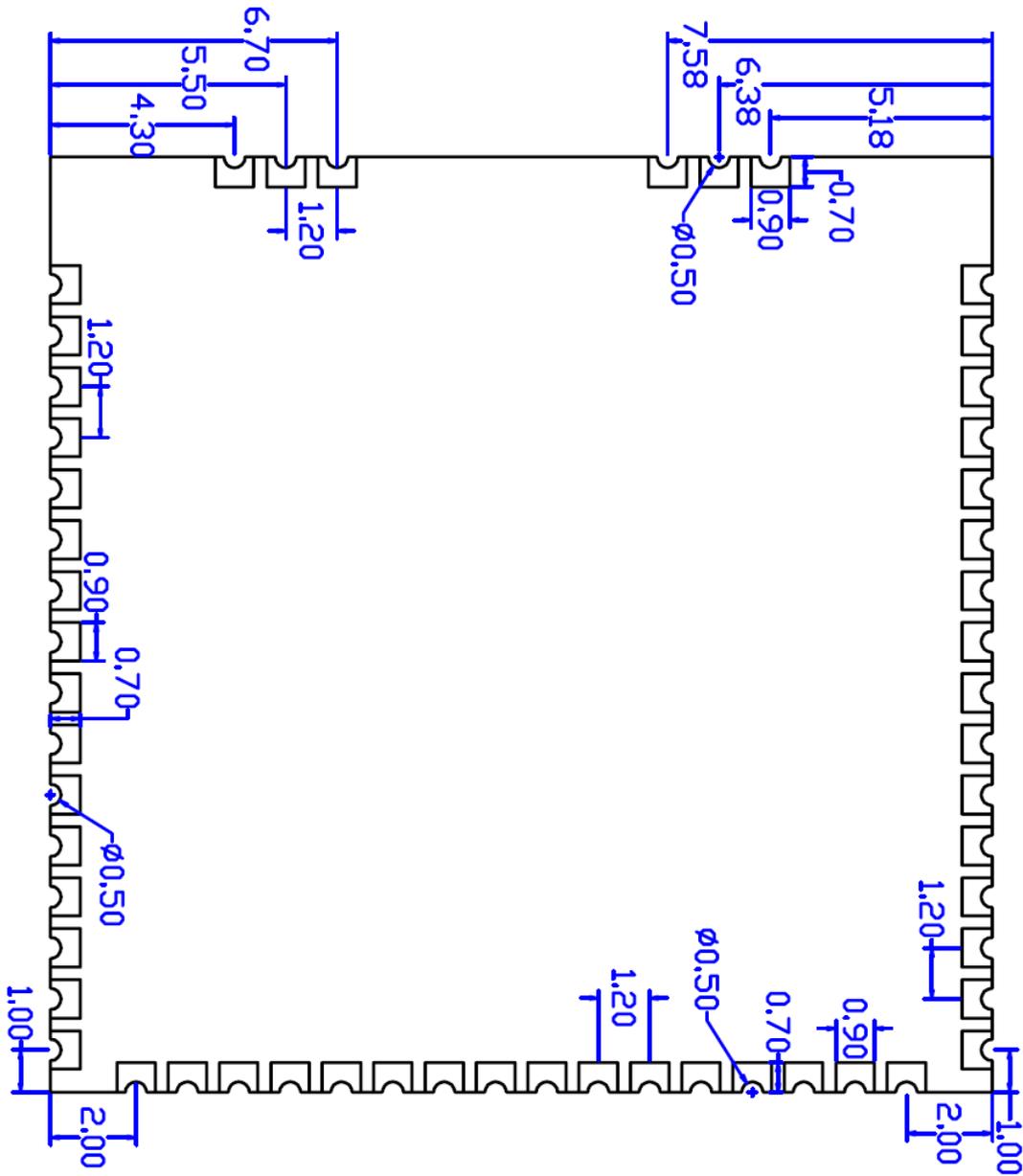
Bottom View

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
YYWWSSFX	Lot Trace Code: YYWWSSFX 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
$C\epsilon$	CE compliance mark
020-190193	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：
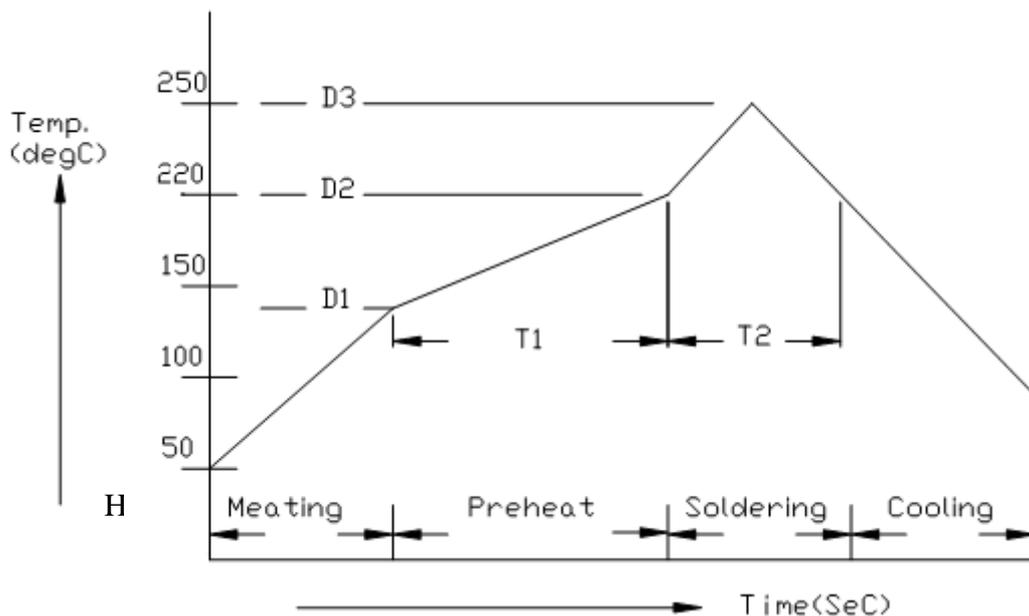
No.	Item	Temperature (°C)	Time (sec)
1	Pre-heat	D1: 140 ~ D2: 200	T1: 80 ~ 120
2	Soldering	D2: = 220	T2: 60 +/- 10
3	Peak-Temp.	D3: 250 °C max	

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 <u>transmitter</u> 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 <u>can not be met</u> (for example certain laptop configurations or co-location with another transmitter), then the FCC authorization is no longer considered valid and the FCC ID <u>can not</u> 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°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