

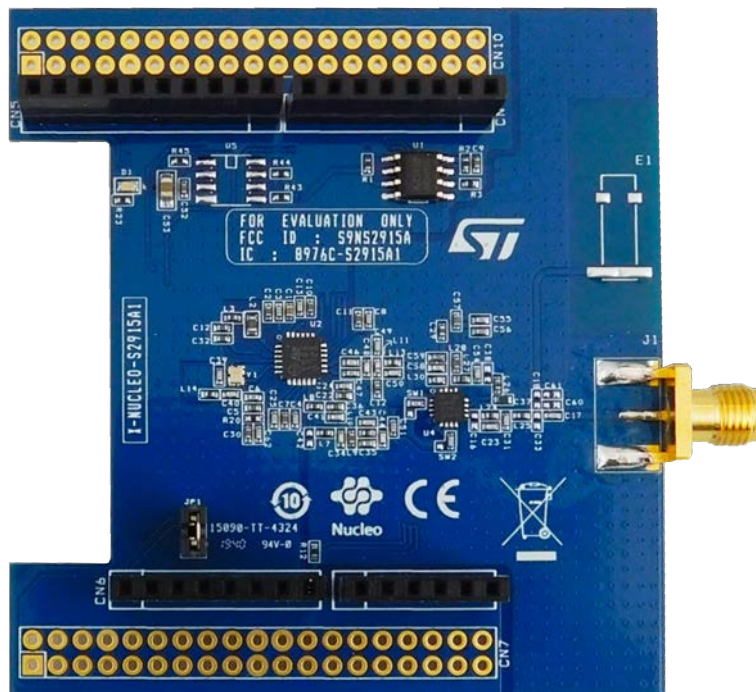
## Getting started with the X-NUCLEO-S2915A1 Sub-1 GHz 915 MHz RF expansion board based on S2-LP radio for STM32 Nucleo

### Introduction

The X-NUCLEO-S2915A1 expansion board is based on the S2-LP radio and operates in the 915 MHz ISM frequency band. The expansion board is compatible with ST morpho and Arduino UNO R3 connectors.

The X-NUCLEO-S2915A1 interfaces with the STM32 Nucleo microcontroller via SPI connections and GPIO pins. You can change some of the GPIOs by mounting or removing the resistors.

Figure 1. X-NUCLEO-S2915A1 expansion board



## 1 Acronyms and abbreviations

**Table 1. List of acronyms**

Acronym	Description
AMR	Automatic meter reading
EEPROM	Electrically erasable programmable read only memory
GHz	Giga Hertz
GUI	Graphical user interface
LED	Light emitting diode
MCU	Microcontroller unit
P2P	Point-to-point communication
RF	Radio frequency communication
SPI	Serial peripheral interface
USB	Universal serial bus
wM-Bus	Wireless metering bus
WSN	Wireless sensors network

## 2 Getting started

### 2.1 Overview

The [X-NUCLEO-S2915A1](#) main features are:

- Based on [S2-LP](#) radio
- [S2-LP](#) narrow band ultra-low power sub-1 GHz transceiver tuned for 860-940 MHz frequency band
- Programmable RF output power up to +27 dBm
- Modulation schemes: 2-FSK, 2-GFSK, 4-FSK, 4-GFSK, OOK and ASK
- Air data rate from 0.1 to 500 kbps
- Ultra-low power consumption: 7 mA RX and 10 mA TX at +10 dBm
- IEEE 802.15.4g hardware packet support with whitening, FEC, CRC and dual SYNC word detection
- RX and TX 128 byte FIFO buffers
- Support to wireless M-Bus
- Excellent performance of receiver sensitivity (up to -130 dBm)
- Automatic acknowledgement, retransmission and timeout protocol engine
- Compatible with [STM32 Nucleo](#) boards
- Compatible with Arduino UNO R3 connectors
- Sigfox compatible
- Sample firmware for P2P communication
- 6LoWPAN compatible thanks to [STM32Cube](#)
- FCC ID: S9NS2915A
- IC ID: 8976C-S2915A1
- RoHS and WEEE compliant

### 2.2 Typical applications

The [X-NUCLEO-S2915A1](#) expansion board can be used for the evaluation of the [S2-LP](#) device in multiple applications:

- wM-Bus application
- Point-to-point communication protocol
- 6LoWPAN applications
- SigFox communication

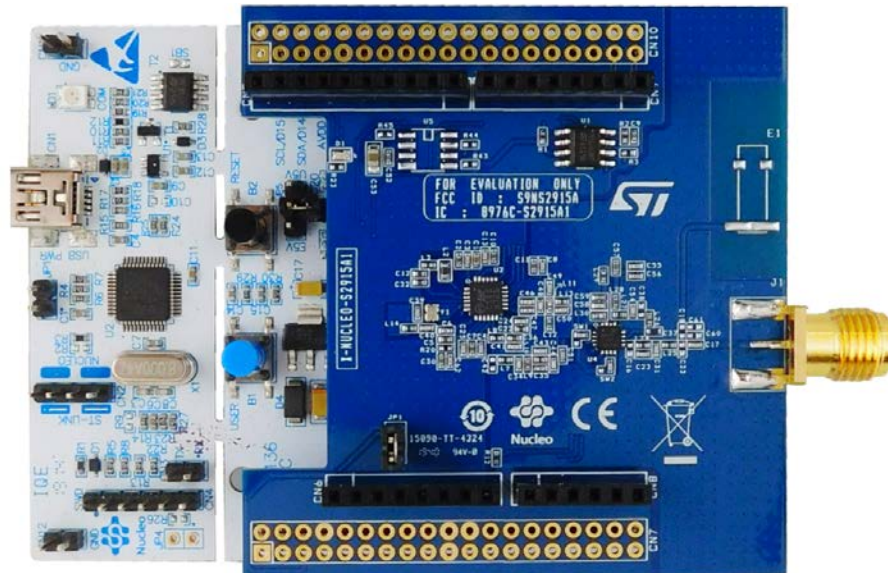
You can develop other applications for evaluating the devices, such as:

- Automatic meter reading
- Home and building automation
- WSN
- Industrial monitoring and control
- Wireless fire and security alarm systems

## 2.3 Hardware and software requirements

To use [STM32 Nucleo](#) development boards with the [X-NUCLEO-S2915A1](#) expansion board, connect the boards as shown below.

**Figure 2.** X-NUCLEO-S2915A1 expansion board connected to an STM32 Nucleo development board



The interconnection between the [STM32 Nucleo](#) and the [X-NUCLEO-S2915A1](#) has been designed to allow using any [STM32 Nucleo](#) board, although complete testing has been performed using [NUCLEO-L053R8](#), [NUCLEO-F401RE](#) and [NUCLEO-L152RE](#) boards hosting the ultra-low power STM32.

The following software and hardware specifications are required:

- a PC/laptop with Microsoft Windows (7 and above) to install the software package ([X-CUBE-SUBG1](#))
- a type A USB to mini-B USB cable to connect the STM32 Nucleo board to the PC/laptop
- 128 MB of RAM
- Approximately 40 MB of hard disk space for the firmware
- Approximately 15 MB of hard disk space for the wM-Bus GUI

The use of the wM-Bus concentrator with the GUI requires additional boards to be connected to the PC. The GUI can be used to check the wM-Bus communication protocol.

## 2.4 Board setup

- Step 1.** Check that the jumper on JP1 connector is connected to provide the required voltage to the board devices.
- Step 2.** Connect the [X-NUCLEO-S2915A1](#) to the [STM32 Nucleo](#) board.
- Step 3.** Power the Nucleo development board using the Mini-B USB cable.
- Step 4.** Program the firmware in the STM32 on the Nucleo development board using the firmware sample provided.
- Step 5.** Reset the MCU board using the reset button on the Nucleo development board.  
The evaluation kit is ready-to-use.

## 3 Hardware description and configuration

### 3.1 Interconnection details

The [X-NUCLEO-S2915A1](#) expansion board and the [NUCLEO-F401RE](#) or [NUCLEO-L152RE](#) board connection details are listed in the table below.

**Table 2. X-NUCLEO-S2915A1 and NUCLEO-L152RE connection details (left connector)**

Signal name													
NC	IOREF	RESET	3V3	5 <sup>V</sup>	GND	GND	VIN	A0	A1	A2	A3	A4	A5
Connector name													
CN6 Power							CN8 Analog						
Pin number													
1	2	3	4	5	6	7	8	1	2	3	4	5	6
NUCLEO-L152RE MCU port													
								PA0	PA1	PA4	PB0	PC1	PC0
X-NUCLEO-S2915A1 expansion board signals													
			3V3		GND	GND		GPIO0	CSN	GPIO1	GPIO2	GPIO0 <sup>(1)</sup>	GPIO3

1. *Optional connection.*

**Table 3. X-NUCLEO-S2915A1 and NUCLEO-L152RE connection details (right connector)**

Signal name																	
D15	D14	AREF	GND	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
Connector name																	
CN5 Digital									CN9 Digital								
Pin number																	
10	9	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
NUCLEO-L152RE MCU port																	
PB8	PB9			PA5	PA6	PA7	PB6	PC7	PA9	PA8	PB10	PB4	PB5	PB3	PA10	PA2	PA3
X-NUCLEO-S2915A1 expansion board signals																	
SCL	SDA		GND	SPI_C LK <sup>(1)</sup>	SPI_MI SO	SPI_M OSI	SPI_C SN <sup>(1)</sup>		nS <sup>(1)</sup>	SDN	SDN <sup>(1)</sup>	nS		SPI_C LK			

1. *Optional connection.*

### 3.2 SPI and GPIO connection options

The SPI and GPIO connection options between the [STM32 Nucleo](#) and [S2-LP](#) can be used to enable different configurations in case a signal conflict occurs when using other expansion boards.

**Table 4. S2-LP interface with STM32 Nucleo board**

S2-LP signal	Default STM32 port	Optional STM32 port
CSn	PA1	PB6 To use the optional connection, mount R9, unmount R13

S2-LP signal	Default STM32 port	Optional STM32 port
CLK	PB3	PA5 To use the optional connection, mount R6, unmount R11
nS	PB4	PA9 To use the optional connection, mount R7, unmount R19
SDN	PA8	PB10 To use the optional connection, mount R18, unmount R10

To use the optional connections, modify the firmware on the basis of the STM32 resources used.

**Table 5. SKY66420 power amplifier settings**

SKY66420	SW1	SW2
LNA ON (default)	100 pF capacitor between pin1 and pin2 (pin1 and pin3 open)	100 pF capacitor between pin1 and pin3 (pin1 and pin2 open)
LNA OFF	100 pF capacitor between pin1 and pin3 (pin1 and pin2 open)	100 pF capacitor between pin1 and pin2 (pin1 and pin3 open)

**Table 6. SKY66420 interface with STM32 Nucleo board**

SKY66420 signal	Default STM32 port	Optional STM32 port
GPIO0	PA0	PC1 To use optional connection mount R25, unmount R12
GPIO1	PA4	N.A.
GPIO2	PB0	N.A.

### 3.3 Current measurement

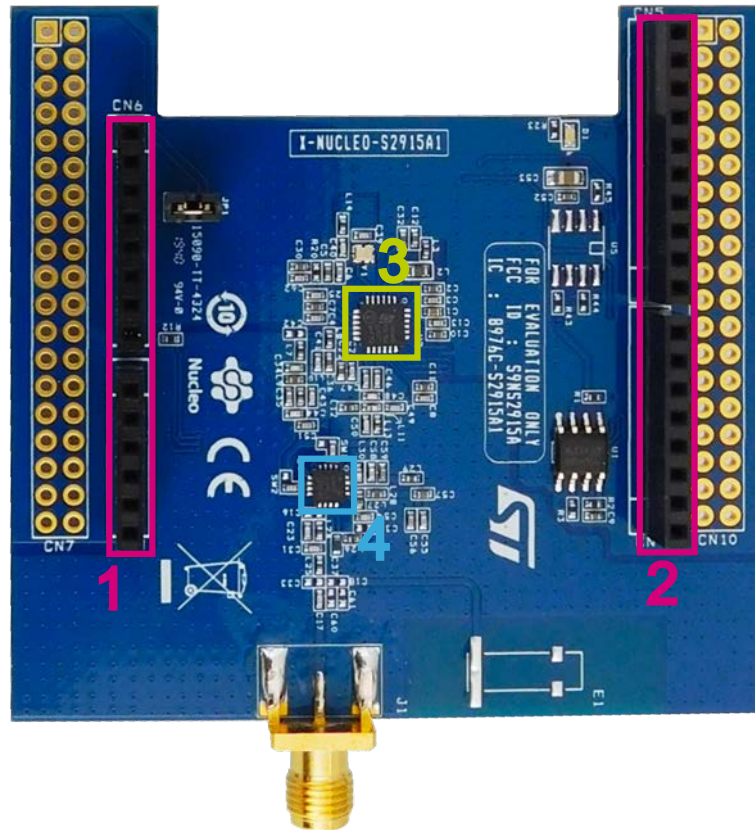
To monitor the [X-NUCLEO-S2915A1](#) expansion board power consumption, use jumper J1: connect an ammeter probe between the connector pins 1 and 2 for measurements.

### 3.4 X-NUCLEO-S2915A1 component placement details

The figure below shows the component placement on the [X-NUCLEO-S2915A1](#) expansion board.

**Figure 3. X-NUCLEO-S2915A1 on-board device placement**

1. Arduino UNO R3 left connector
2. Arduino UNO R3 right connector
3. S2-LP
4. SKY66420



## 4 X-NUCLEO-S2915A1 on-board device description

### 4.1 S2-LP radio

The [X-NUCLEO-S2915A1](#) expansion board is based on the [S2-LP](#) standalone RF transceiver. It operates in the 915 MHz ISM frequency band and wireless M-Bus.

[S2-LP](#) narrow band ultra-low power sub-1 GHz transceiver is tuned for 430-470 MHz and 860 - 940 MHz, frequency bands and programmable RF output power up to +16 dBm.

**Table 7. S2-LP details**

Features	Description
Order code	<a href="#">S2-LPQTR</a>
Package	QFN24 4x4x1
Operating voltage	1.8 to 3.6 V

### 4.2 SPI EEPROM

The [M95640-R](#) is a 64 Kbit serial SPI bus EEPROM with high-speed clock interface. The device can be used to store the configuration parameters related to [S2-LP](#) RF device application or settings.

Features	Description
Order code	<a href="#">M95640-RMC6TG</a>
Package	MLP8
Operating voltage	1.8 to 5.5 V



## 5 Schematic diagrams

Figure 4. X-NUCLEO-S2915A1 circuit schematic

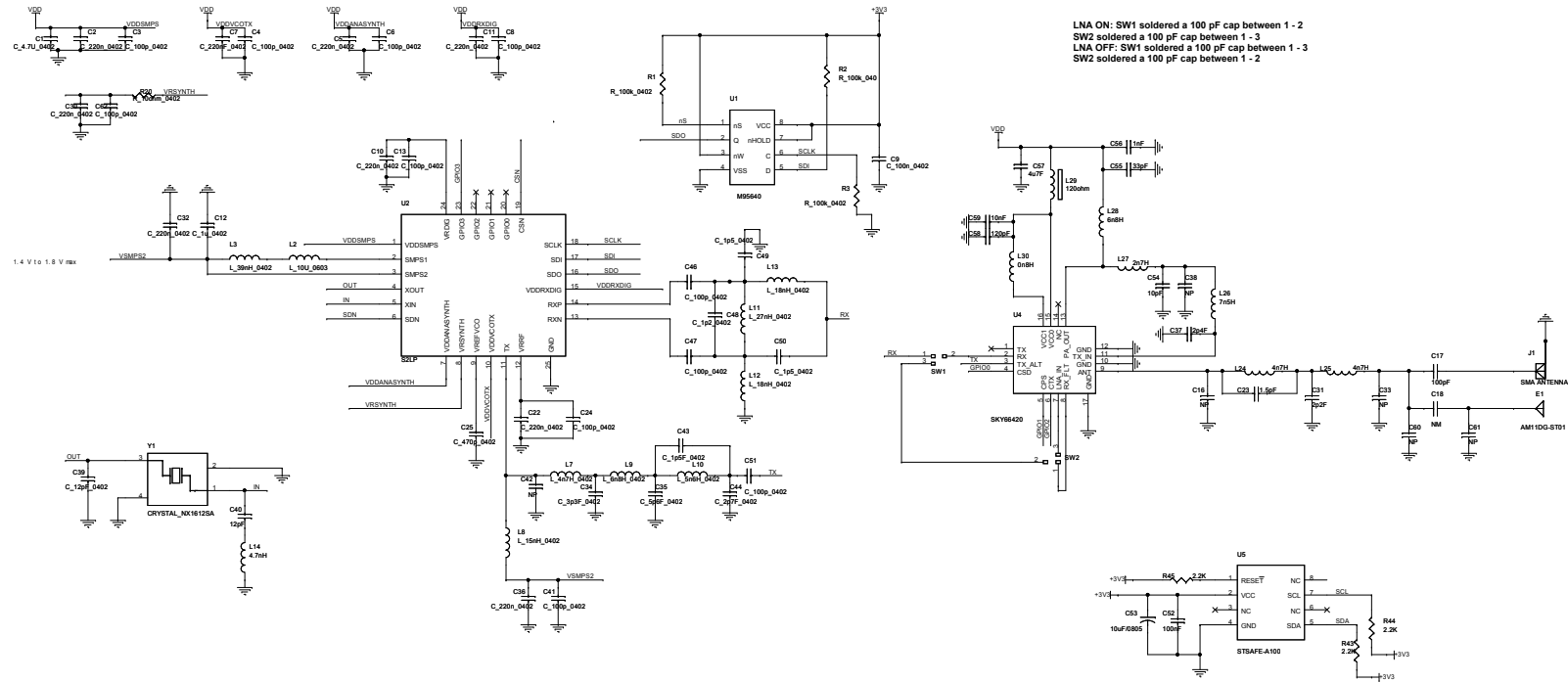


Figure 5. X-NUCLEO-S2915A1 circuit schematic - Arduino connectors

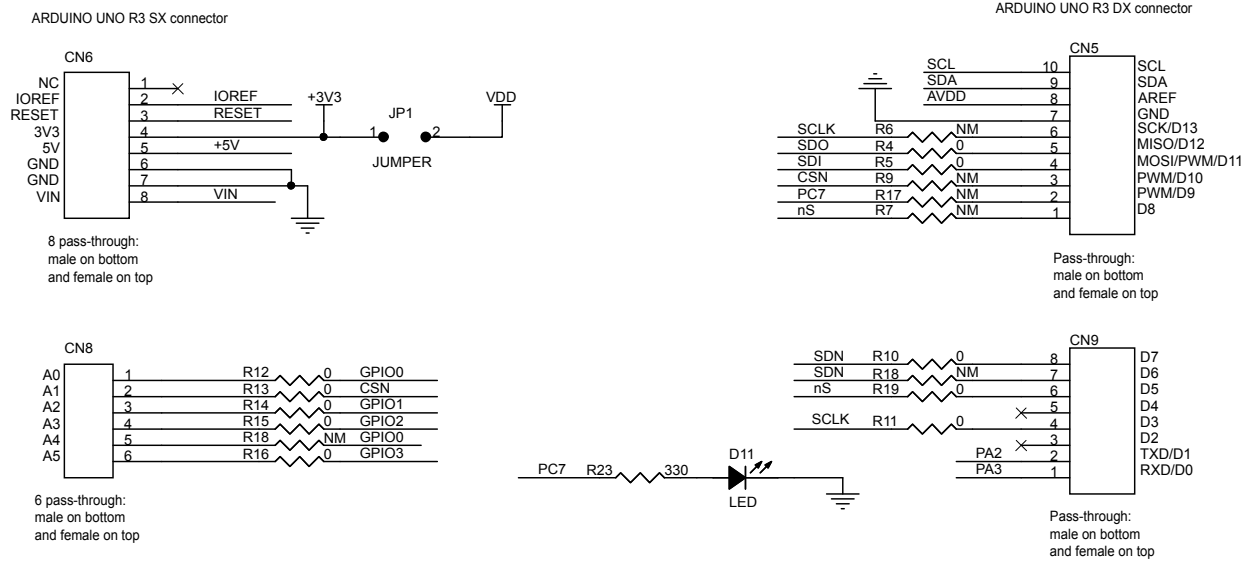
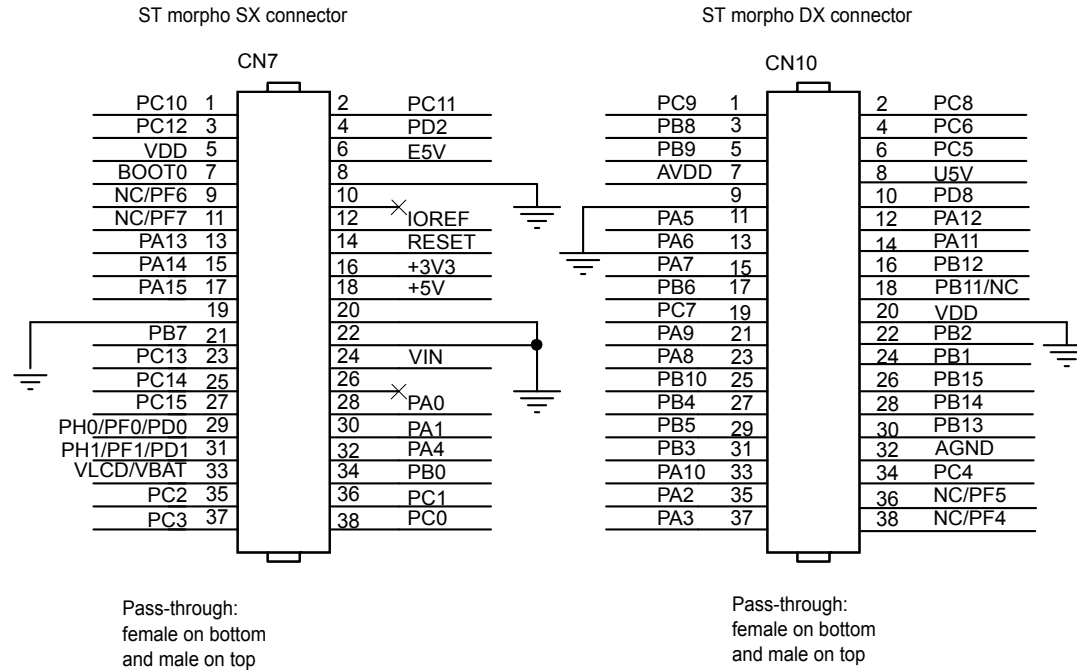


Figure 6. X-NUCLEO-S2915A1 circuit schematic - ST morpho connectors



## 6 Bill of materials

**Table 8. X-NUCLEO-S2915A1 bill of materials**

Item	Qty	Ref.	Part/Value	Description	Manufacturer	Order code
1	1	CN5	CON10 550 V <sub>AC</sub> 2.54 mm pitch	Connector	SAMTEC	SSQ-110-03-F-S
2	2	CN6, CN9	CON8 550 V <sub>AC</sub> 2.54 mm pitch	Connectors	SAMTEC	SSQ-108-03-F-S
3	2	CN7, CN10	2.54 mm pitch	Header 19x2 (not mounted)		
4	1	CN8	CON6 550 V <sub>AC</sub>	Connector	SAMTEC	SSQ-106-03-F-S
5	9	C2, C5, C10, C11, C22, C30, C32, C36, C7	220 nF 16 V -20%, +80% SMD-0402	Capacitors	Yageo	CC0402ZRY5V7BB224
6	12	C3, C4, C6, C8, C13, C24, C41, C46, C47, C51, C62, C17	100 pF 25 V ±5% SMD-0402	VBAT bypass capacitors	KEMET	C0402C101J3GACTU
7	2	C9, C52	100 nF 16 V ±5% SMD-0402	Decoupling capacitors	Murata	GRM155R71C104KA88D
8	1	C12	1 μF 25 V ±5% SMD-0402	Capacitor	Taiyo Yuden	TMK105BJ105MV-F
9	6	C16, C33, C38, C42, C60, C61	SMD-0402	Capacitors (not mounted)		
10	7	R6, R7, R9, R17, R18, C18, R25	SMD-0402	Resistors (not mounted)		
11	1	C25	470 pF 50 V ±10% SMD-0402	VREFVCO filter	Taiyo Yuden	UMK105B7471KV
12	1	C31	2.2 pF 25 V ±5 % SMD-0402	Capacitors	Würth Electronics	8.85012E+11
13	1	C34	3.3 pF 16 V ±5% SMD-0402	Capacitors	Taiyo Yuden	EVK105CH3R3JW-F
14	1	C35	5.6 pF 16 V ±5% SMD-0402	Capacitors	AVX	0402YA5R6JAT2A
15	1	C37	2.4 pF 25 V SMD-0402	Capacitors	AVX	MP023J2R4BBSGTR\500
16	2	C39, C40	12 pF 16 V ±10% SMD-0402	Capacitors	Vishay	VJ0402A120KXJCW1BC
17	1	C48	1.2 pF 16 V ±0.5% SMD-0402	Capacitors	KEMET	C0402C129D4GACTU
18	1	C44	2.7 pF 16 V ±25% SMD-0402	Capacitors	KEMET	C0402C279C4GACTU
19	4	C23, C43, C49, C50	1.5 pF 10 V ±5% SMD-0402	Capacitors	Würth Electronics	885012005002
20	1	C53	10 μF 16 V ±10% SMD-0805	Capacitors	Samsung Electro-Mechanics	CL21A106KOQNNNG
21	1	C54	10 pF 50 V ±5% SMD-0402	Capacitors	Yageo	311-1014-1-ND
22	1	C55	33 pF 5 0V ±5% SMD-0402	Capacitors	Murata	GCM1555C1H330JA16D

Item	Qty	Ref.	Part/Value	Description	Manufacturer	Order code
23	1	C56	1 nF 50 V ±10% SMD-0402	Capacitors	Murata	GCM155R71H102KA37D
24	2	C57, C1	4.7 µF 10 V ±10% SMD-0402	Capacitors	Murata	ZRB15XR61A475KE01D
25	1	C58	120 pF 50 V ±2% SMD-0402	Capacitors	Murata	GRM1555C1H121GA01D
26	1	C59	10 nF 16 V ±10% SMD-0402	Capacitors	Taiyo Yuden	EMK105B7103KV-F
27	1	D1	20 mA SMD-0603	Red LED	OSRAM	LS Q976-NR-1
28	1	E1	AM11DG-ST01	SMD antenna (not mounted)	Mitsubishi	AM11DG-ST01B
29	1	JP1	WALCON.100/VH/T M2OE/W.325/10/ MOD	Jumper	Any	Any
30	1	J1		SMA antenna	LPRS	ANT-900M
31	1	L2	10 µH 10 mA ±20% 603	Inductor	TDK Corporation	MLF1608E100M
32	4	L7, L14, L24, L25	4.7 nH 700 mA ±0.3% 0402	Inductor	Murata	LQG15HS4N7S02D
33	1	L3	39 nH 300 mA ±5% SMD_0402		Murata	LQG15HS39NJ02D
34	2	L9, L28	6.8 nH 250 mA ±5% SMD-0402	Inductor	Johanson Technology Inc.	L-07C6N8JV6T
35	1	L8	15 nH 300 mA ±5% SMD-0402	Inductor	Murata	LQG15HS15NJ02
36	1	L10	5.6 nH 600 mA ±0.3 SMD-0402	Inductor	Murata	LQG15HS5N6S02D
37	1	L11	27 nH 300 mA ±5% SMD-0402	Inductor	Taiyo Yuden	HK100527NJ-T
38	2	L12, L13	18 nH 400 mA ±5% SMD-0402	Inductor	Murata	LQG15HS18NJ02D
39	1	L26	7.5 nH 500 mA ±5% SMD-0402	Inductor	Murata	LQG15HN7N5J02D
40	1	L27	2.7 nH 900 mA ±3% SMD-0402	Inductor	Murata	LQG15WZ2N7S02D
41	1	L29	120 Ohm 300 mA SMD-0402	Ferrite bead	Taiyo Yuden	587-1836-1-ND
42	1	L30	0.8 nH 1 A ±10% SMD-0402	Inductor	TDK Corporation	MLG1005S0N8BTD25
43	3	R1, R3, R2	100 k 1/16 W ±1% SMD-0402	Resistor	Tyco Electronics	CRG0402F100K
44	10	R4, R5, R10, R11, R12, R13, R14, R15, R16, R19	1/16 W ±1% SMD-0402	Resistor	Tyco Electronics	CRG0402ZR
45	1	R20	10 Ohm 1/16 W ±1% SMD-0402	Resistor	Yageo	RC0402FR-0710RL
46	1	R23	330 1/10 W ±5% SMD-0402	Resistor	Panasonic	ERJ-2GEJ331X
47	3	R43, R44, R45	2.2 K 1/16 W 0.01 SMD-0402	Resistor	Yageo	RC0402FR-072K2L

Item	Qty	Ref.	Part/Value	Description	Manufacturer	Order code
48	2	SW1, SW2	SW KEY-SPDT (100 pF) 25 V ±5% SMD-0402	VBAT bypass capacitors (SW1 : 1-3 NM SW2 : 1-2 NM)	Kemet	C0402C101J3GACTU
49	1	U1	M95640 8-SOIC	64 Kbit SPI bus EEPROM with high-speed clock	ST	<a href="#">M95640-RMN6</a>
50	1	U2	S2LP QFN-24L	Ultra-low power, high performance, sub-1GHz transceiver	ST	<a href="#">S2-LPQTR</a>
51	1	U4	SKY66420	860 to 930 MHz RF front-end module	Skyworks	SKY66420-11
52	1	U5	STSAFE-A100 SO8N	Authentication and brand protection secure solution (not mounted)	ST	<a href="#">STSAFE-A100</a>
53	1	Y1	CRYSTAL_NX1612SA	Crystal	NDK	644-1297-1-ND

## 7 Formal notices required by the U.S. Federal Communications Commission ("FCC")

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FCC NOTICE: This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.

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- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the 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.

## 8 Formal product notice required by the Industry Canada ("IC")

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## Revision history

**Table 9. Document revision history**

Date	Revision	Changes
18-Nov-2019	1	Initial release.



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