EMB-ZRF231PA

Datasheet

Document information

Versions & Revisions

Version	Date	Author	Comments
1.0	02/04/2011	A. Sala	Preliminary version
1.1	13/12/2012	C. Biagi	Minor fixes
1.2	09/01/2013	C. Biagi	Minor fixes
1.3	12/04/2013	A. Sala	Added power consumption
1.4	16/04/2013	C. Biagi	Minor fixes
1.5	29/04/2013	C. Biagi	Removed references to EMB-ZRF2xx
1.6	21/05/2013	C. Biagi	Updated notes, compliance and packaging
1.7	29/07/2013	F. Montorsi	Fix typos
1.8	02/10/2014	C. Biagi	Updated MCU to ATxmega256A3U

References

Ref	Version	Date	Author	Title

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1 Description

EMB-ZRF231PA is the latest IEEE 802.15.4 OEM wireless module for Low Range Wireless Personal Area Network applications developed by Embit. The module combines high performance to small dimensions and low cost, providing the system integrator a simple and easy way to add IEEE 802.15.4 / 6LoWPAN / ZigBee / RF4CE low-power wireless connectivity and multi-hop networking into existing products.

EMB-ZRF231PA is configured as an embedded micro system or simple data modem for low power applications in the 2.4 GHz band. It is based on Atmel® AT86RF231 coupled with an AVR® ATxmega256A3U MCU equipped with 256 kByte of Flash memory, 16 kByte of RAM memory and up to 4 kByte of EEPROM, hardware acceleration for both IEEE 802.15.4 MAC and AES security.

The ad-hoc RF section, implemented by a PA/LNA stage, guarantees best-inclass performance in terms of covered area and power consumption. The output power can be increased up to +20 dBm by simple software configurations, while input signals are amplified by the LNA section, covering distances up to 1 kilometers (LoS for the 2,4 GHz module); the U.FL receptacle allows the connection of an external antenna.

EMB-ZRF231PA can communicate with other devices through a wide range of serial interfaces: two UART ports, I2C and SPI, several digital and analog I/O ports (up to 42 digital lines and 8 ADC) useful for the management of external devices and interfaces. Targets of the module are flexibility and power-awareness: EMB-ZRF231PA can be configured as network coordinator or router, as well as an end-device thanks to the extremely reduced power consumption (less than 1.5 µA in sleep mode).

EMB-ZRF231PA firmware can be easily developed being the module compatible with BitCloud ZigBee stack. The software and development tools provided by Atmel can be used with this product without effort.

1.1 Specifications

- 8-bit ATxmega256A3U MCU
- 256 kB Flash, 16 kB RAM, 4 kB EEPROM
- Output power: up to +20 dBm (100 mW)
- Sensitivity: up to -105 dBm
- PIFA (PCB Inverted F) or U.FL connector
- Coverage: up to 1000 meters LoS (for the 2,4 GHz)
- Edge SMD connector

1.2 Applications

- **Metering**: thermostat, meters, remote devices, displays, etc..
- **Home/Buildings Automation**: safety systems and access control, HVAC, door/window control, lightning, etc..
- **Industrial Automation**: process control, wireless sensor networks, identification and asset tracking, etc..
- **Healthcare**: blood pressure monitoring, thermometers, ECG, etc..

1.3 Block diagram

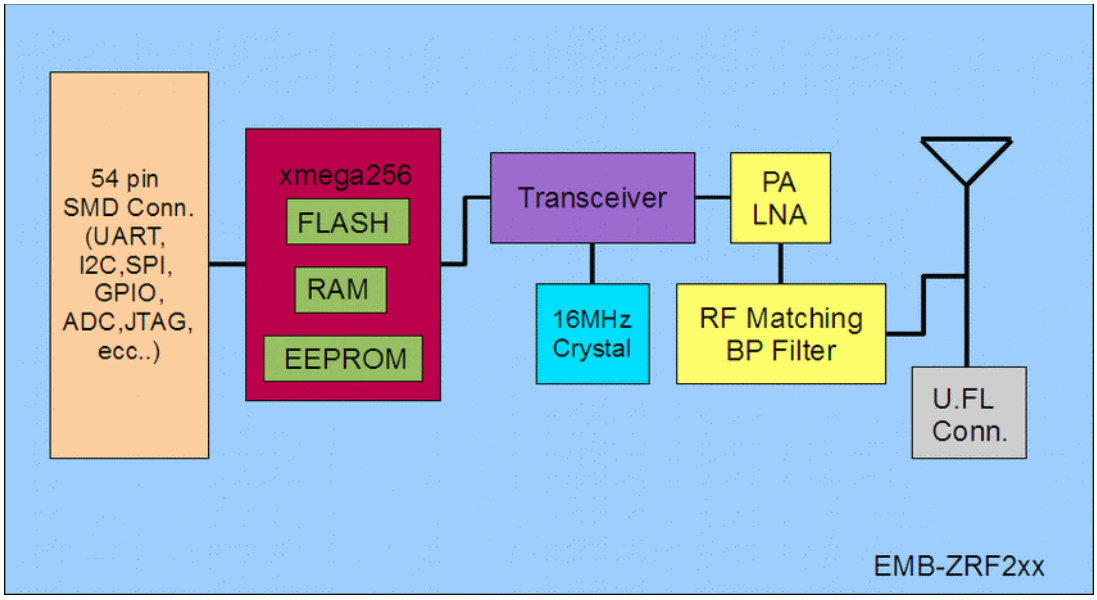

Image 1**: block diagram for the **EMB-ZRF231PA

1.4 Microcontroller

ATxmega256 is a recent 8/16 bit microcontroller from Atmel. It features very interesting low power functionalities and a good amount of processing power for wireless sensor applications. An AES is integrated in the chip and none of the common peripherals that are usually found on microcontrollers is missing. The microcontroller communicates with the RF transceiver through an SPI line and some GPIOs.

1.5 Antenna

The **EMB-ZRF231PA** offers two options for the antenna:

- Printed antenna: PIFA antenna directly printed on the PCB with an omnidirectional emission diagram (xz plane). The performances of this antenna are influenced by the positioning of the module in the system (see paragraph “Antenna positioning”). The antenna specifications are provided in next paragraph.
- External antenna connector (optional): 50 Ohm single ended U.FL connector.

1.5.1 PIFA antenna radiation diagrams

The printed antenna of the **EMB-ZRF231PA** is a simple and powerful solution for a 2,4 GHz system. It has a maximum gain of +2,28 dBi, positioned in the xy plane perpendicular to the module (see 3D radiation diagram). Here are the details:

- Total antenna efficiency: 87,7 %;
- Bandwidth: 165 MHz (S11{dB}@ -10dBm);
- VSWR: <1,468 over the entire ISM 2.4GHz frequency range;

Here is the 3D radiation pattern:

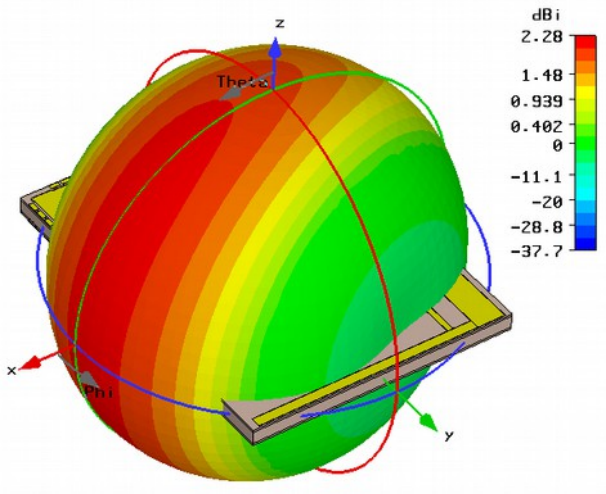

***Image 2:** 3D radiation pattern*

Polar radiation pattern:

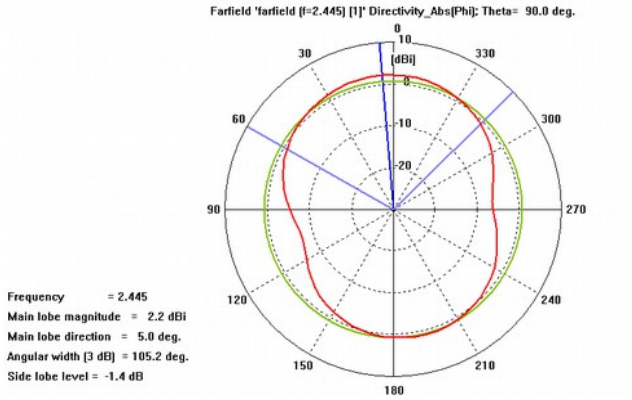

***Image 3**: polar radiation pattern, xy plane*

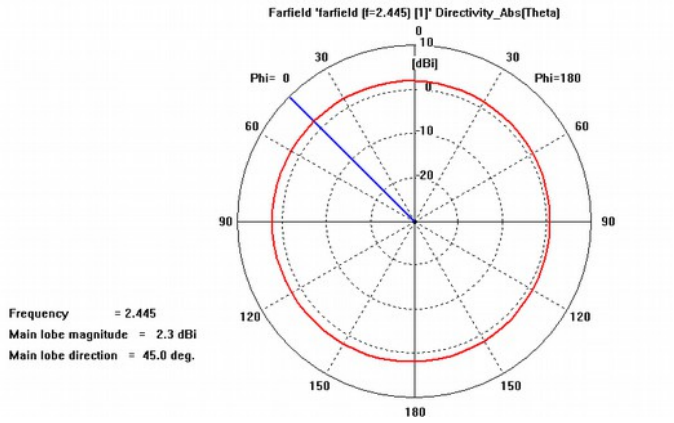

***Image 4**: polar radiation pattern, xz plane*

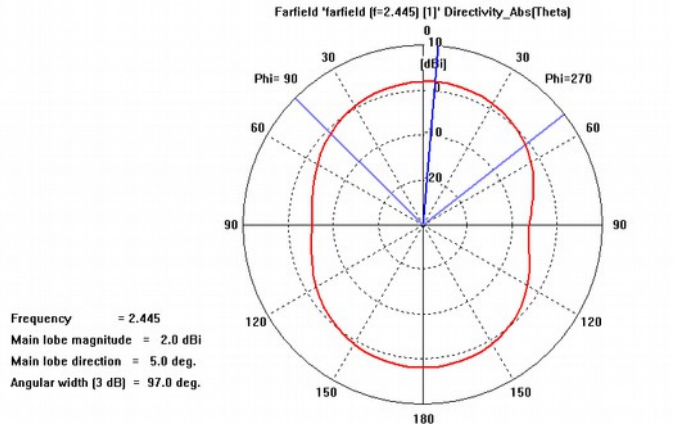

***Image 5**: polar radiation pattern, xz plane*

1.5.2 Antenna selection (PIFA/external)

If the PIFA antenna is desired, the C3 capacitor (ceramic capacitor of 10 pF, case 0402) must be installed in vertical position, as shown in the following picture:

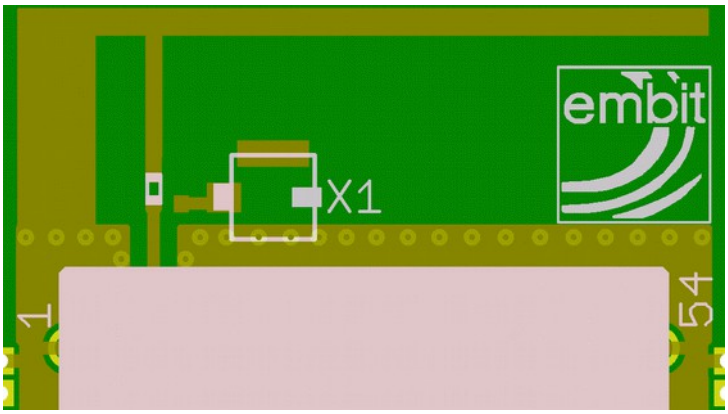

***Image 6**: C3 capacitor installation for PIFA antenna*

If an external antenna is to be used, either through U.FL connector or wire soldering point, the C3 capacitor must be installed in horizontal position, as shown in the following picture:

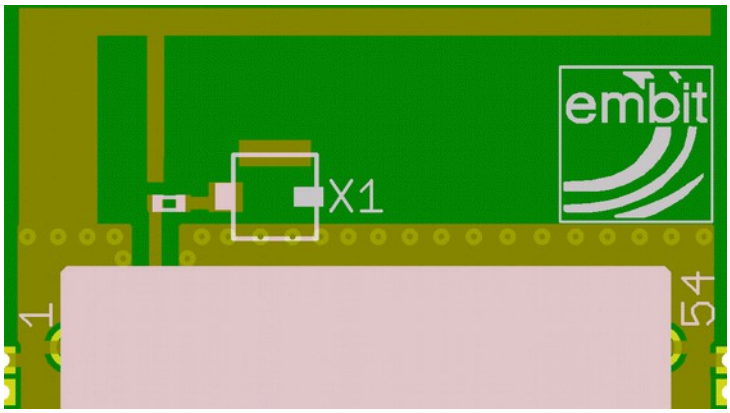

***Image 7**: C3 capacitor installation for external antenna*

1.6 Power Amplifier / Low Noise Amplifier

The **EMB-ZRF231PA** module is equipped with a PA / LNA combination to increase the communication range of the device. The PA provides a fixed gain of +20 dBm and the LNA can provide a gain of +11 dBm or +1 dBm selectable from the MCU. To switch between low gain and high gain the MCU must drive the pin 0 of port R low (high gain) or high (low gain).

1.7 Development tools

The EMB-ZRF231PA module is supported by Atmel BitCloud stack and the 802.15.4 stack can be easily ported too.

Please refer to EMB-ZRF2xx-BitCloud-Getting-Started for further informations.

2 Size and footprint

2.1 Size

The mechanical dimensions of the **EMB-ZRF231PA** are, as every other module from Embit: 29,50 x 22,60 mm. The thickness is 3,6 mm, CAN Shield included.

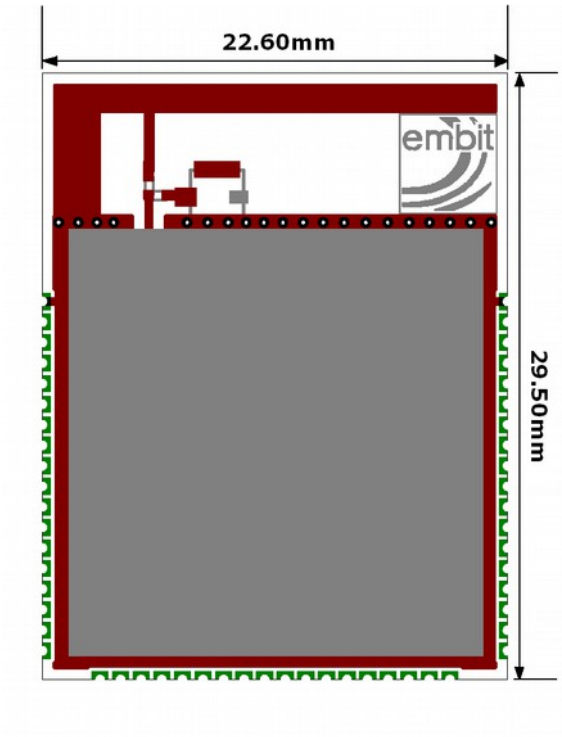

Image 8: *Outline*

2.2 Connector positioning

The EMB-ZRF231PA module has three 18 pin “edge” connector with a 1,00 mm pitch, for a sum of 54 contacts. Each pin is a metalized half hole 0,50 mm in diameter. The positioning of the connector is shown in the following images:

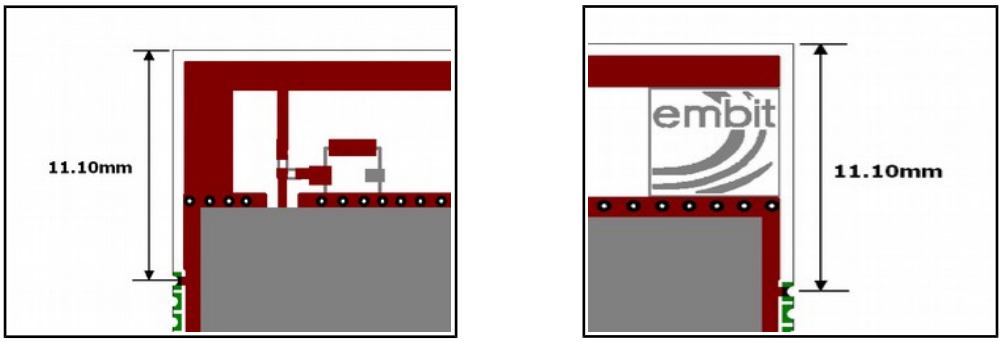

***Image 9**: Connector positions*

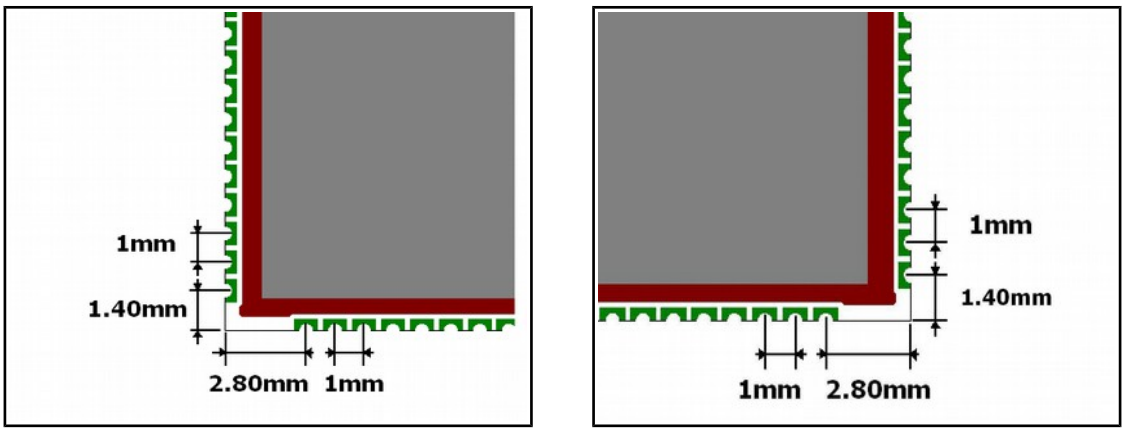

***Image 10**: Connector positions*

2.3 Footprint

The EMB-ZRF231PA footprint consists in 54 smd pads 1,00 x 0,80 mm in dimensions positioned as following:

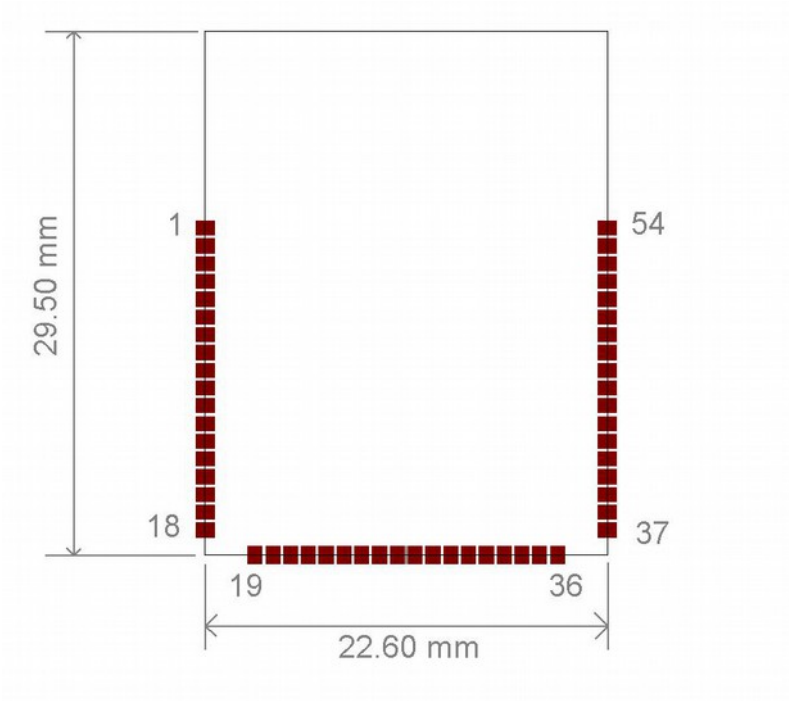

***Image 11**: Footprint EMB-ZRF231PA*

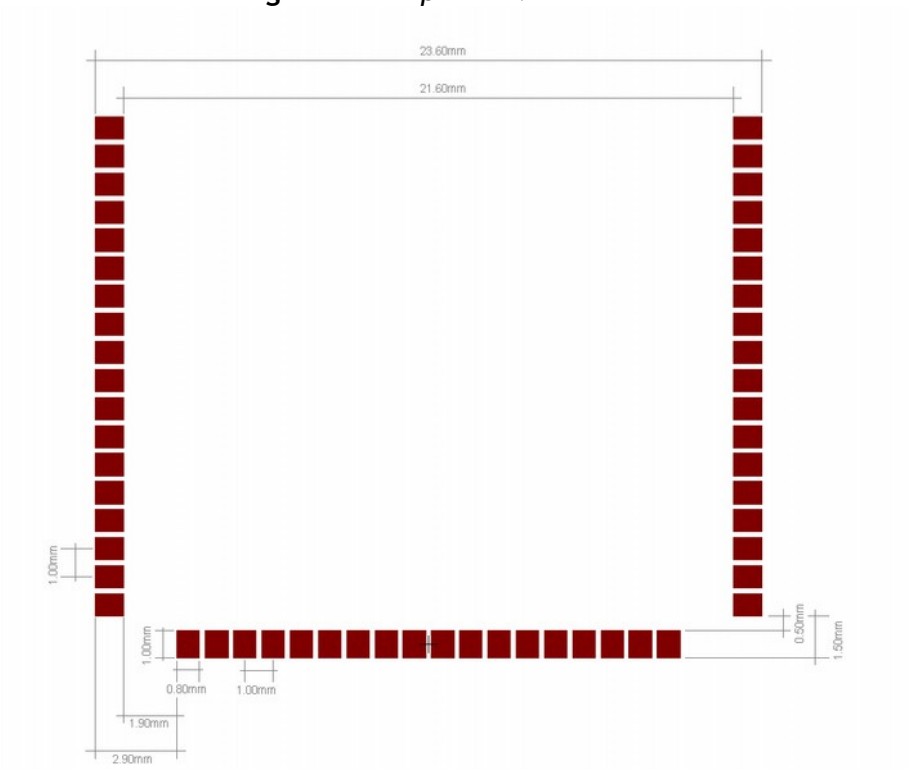

***Image 12**: Pad distribution*

2.4 Antenna positioning

The module must be installed on a PCB, keeping the area dedicated for the PIFA antenna outside the PCB outline. In the following image is shown an example of installation:

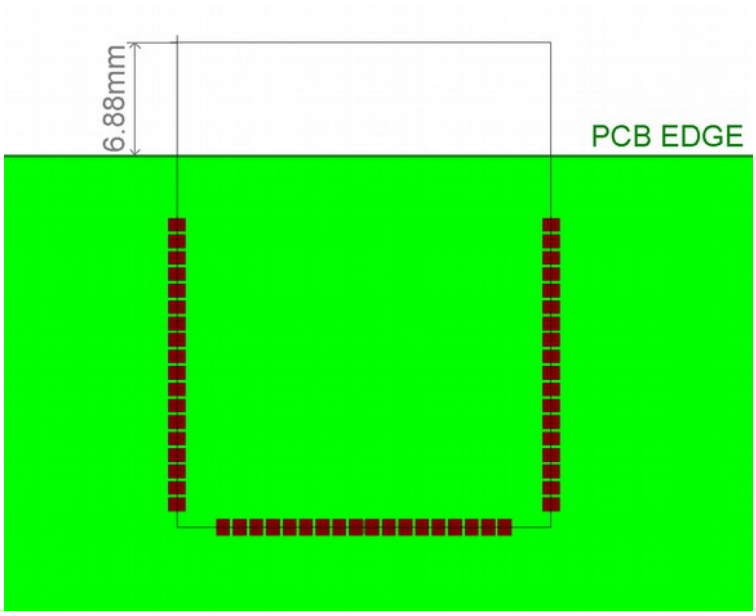

***Image 13**: Antenna positioning*

2.5 Notes

- The area underneath the module must be kept free of components (both top and bottom layers) and must be covered with solder resist.
- The PCB top layer underneath the module must be free of nets, power planes and vias. The bottom layer shall provide a ground plane.
- The power supply of the module must be as clean as possible; it must be decoupled placing a ceramic capacitor as near as possible at the Vcc pins, additional filtering made by a ferrite bead is recommended.
- Noisy electronic components (such as switching power supply) must be placed as far as possible and adequately decoupled.
- The ground pins of the module shall be connected to a solid ground plane.
- Keep antenna clear of metal parts of the casing or system.
- Don't use metal enclosures to avoid RF signal degradation.

Note: Taking no account this recommendations may affect the radio performances.

3 Connections

Pin #	Pin Name	Type	Description	IC Pin #
1	GND	GND	GND	--
2	N.C.	Not connected	Not connected pin	--
3	PA0_AREF	Analog input or digital I/O	High reference voltage for ADC/ PA0	62
4	AVCC	Analog input	Analog power supply	61
5	N.C.	Not connected	Not connected pin	--
6	PA1_ADC1	Analog input or digital I/O	ADC analog input Channel 1/PA1	63
7	PA2_ADC2	Analog input or digital I/O	ADC analog input Channel 2/PA2	64
8	PA3_ADC3	Analog input or digital I/O	ADC analog input Channel 3/PA3	1
9	PA4_ADC4	Analog input or digital I/O	ADC analog input Channel 4/PA4	2
10	PA5_ADC5	Analog input or digital I/O	ADC analog input Channel 5/PA5	3
11	PA6_ADC6	Analog input or digital I/O	ADC analog input Channel 6/PA6	4
12	PA7_ADC7	Analog input or digital I/O	ADC analog input Channel 7/PA7	5
13	PB7_TDO	Digital Input/Output	JTAG test data output/PB7	13
14	PB5_TDI	Digital Input/Output	JTAG test data input/PB5	11
15	PB6_TCK	Digital Input/Output	JTAG test clock input/PB6	12
16	PB4_TMS	Digital Input/Output	JTAG test mode select input/PB4	10
17	N.C.	Not connected	Not connected pin	--
18	VCC	Power Input	Supply voltage	--
19	N.C.	Not connected	Not connected pin	--
20	PD2_UART0_RX	Digital Input/Output	UART0 rx data input/PD2	28
21	PD3_UART0_TX	Digital Input/Output	UART0 tx data output/PD3	29
22	PD4_UART1_RTS	Digital Input/Output	UART1 request to send input/PD4	30
23	PD5_UART1_CTS	Digital Input/Output	UART1 clear to send output/PD5	31
24	PD6_UART1_RX	Digital Input/Output	UART1 rx data input/PD6	32
25	PD7_UART1_TX	Digital Input/Output	UART1 tx data output/PD7	33
26	PE0_I2C_SDA	Digital Input/Output	I2C bus data/PE0	36
27	PE1_I2C_SCL	Digital Input/Output	I2C bus clock/PE1	37

Pin #	Pin Name	Type	Description	IC Pin #
28	PF3_TMR3	Digital Input/Output	Timer 3 IO signal/PF3	49
29	PF2_TMR2	Digital Input/Output	Timer 2 IO signal/PF2	48
30	PF1_TMR1	Digital Input/Output	Timer 1 IO signal/PF1	47
31	PF0_TMR0	Digital Input/Output	Timer 0 IO signal/PF0	46
32	PE7_SPI_SCK	Digital Input/Output	SPI Port Clock/PE7	43
33	PE5_SPI_MOSI	Digital Input/Output	SPI Port MOSI/PE5	41
34	PE6_SPI_MISO	Digital Input/Output	SPI Port MISO/PE6	42
35	PE4_SPI_SS	Digital Input/Output	SPI Port Slave Select/PE4	40
36	N.C.	Not connected	Not connected pin	--
37	VCC	Power Input	Supply voltage	--
38	PD1_GPIO	Digital Input/Output	PD1	27
39	PE2_GPIO	Digital Input/Output	PE2	38
40	PE3_GPIO	Digital Input/Output	PE3	39
41	PF7_GPIO	Digital Input/Output	PF7	55
42	PF6_GPIO	Digital Input/Output	PF6	54
43	PF5_GPIO	Digital Input/Output	PF5	51
44	PF4_GPIO	Digital Input/Output	PF4	50
45	PB3_GPIO	Digital Input/Output	PB3	9
46	PB2_GPIO	Digital Input/Output	PB2	8
47	PB1_GPIO	Digital Input/Output	PB1	7
48	PB0_GPIO	Digital Input/Output	PB0	6
49	PE6_SPI_MISO_XTL	Analog input	SPI port MISO/Optional 32,768KHz crystal oscillator input/PE6	42
50	PE7_SPI_SCK_XTL	Analog output	SPI port SCK/Optional 32,768KHz crystal oscillator output/PE7	43
51	PDI_CLK_RST	Digital Input	System reset input (active low)/PDI clock signal	57
52	PDI_CLK_RST	Digital Input/Output	PDI clock signal	57
53	PDI_DATA	Digital Input/Output	PDI data signal	56
54	GND	GND	GND	--

4 Typical Application Circuit

A basic application circuit for the **EMB-ZRF231PA** is shown in Image 11. The **EMB- ZRF231PA** allows for a minimal number of external components (thus decreasing system costs).
In Image 14 a LED indicator (LED1) and a push button (SW1) are used to provide a minimal user interface and a 32 kHz crystal is connected to the **EMB-ZRF231PA**, in case an accurate timer functionality is required (please refer to the ATxmega256A3U datasheet for more information). Either the JTAG or the PDI programming/debugging interfaces, generally speaking, will be routed to a connector on the host board for in-circuit programming.

In addition, a simple supply section (based on a 3.3V LDO stabilizing the input voltage VIN) and a simple reset circuitry are shown. In particular, the reset circuitry of Image 14 allows to

1. program the MCU of the **EMB- ZRF231PA** (thanks to the weak pull-up to VCC);
2. manually reset the MCU, if needed (thanks to SW_RESET).

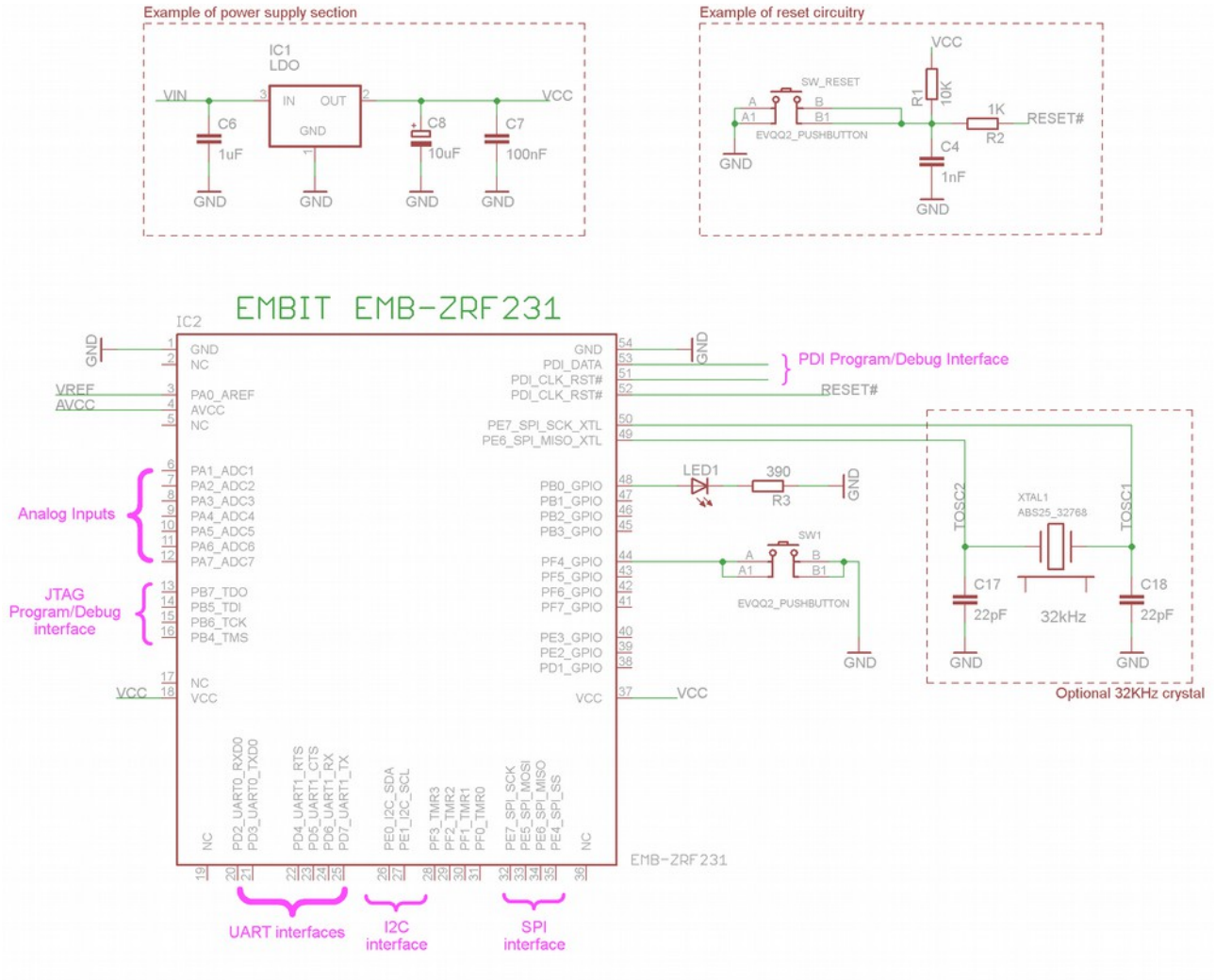

***Image 14**: Typical application circuit for the EMB-ZRF231PA*

5 Electrical characteristics

5.1 Absolute Maximum Ratings

	Value	Unit
Power Supply Voltage	+3,6	Vdc
Voltage on any pin	Vcc+0,3 (Max 3,6)	Vdc
RF input power (P_{MAX})	10	dBm
Storage Temp. Range	-45 ~ +125	ºC

5.2 Operating Conditions

Parameter	Min	Typ	Max	Unit
Power Supply Voltage (Vcc)	2,1		3,6	Vdc
Operating Temperature Range	-40		85	ºC
Logic Input Low Voltage	0		0,2xVcc	Vdc
Logic Input High Voltage	0,8xVcc		Vcc	Vdc
Logic Output Low Voltage	0		0,18xVcc	Vdc
Logic Output High Voltage	0,82xVcc		Vcc	Vdc

5.3 Power Consumption

Test condition: 25 ºC, max output power (+20 dBm), VDD = 3.3 Vdc

Mode	Typ. value	Unit
Transmit	132	mA
Receive	24	mA
Idle	TBD	mA
Sleep	≤ 1,5*	µA

* i.e.: 1,5 µA with RTC running. Up to 80 nA without RTC running (hardware interrupts wake up)

6 Soldering

Temperature profile for reflow soldering:

	Nm	Val.
Pre-heating	Ramp-up	3°C/s max
Minimum pre-heating temperature	Tsoak min	150°C
Maximum pre-heating temperature	Tsoak max	200°C
Pre-heating interval	Tsoak	60-120 s
Reflow temperature	Tl	217°C
Reflow interval	Tl	60-150 s
Peak temperature	Tpeak	260°C
Interval to 5°C from tpeak	--	20-30 s
Interval to 25°C from tpeak	--	8 min. max
Cool down	Ramp-down	6°C/s max

Pb-Free Soldering Paste: it is suggested to used soldering pastes that don't need later clean for residuals.

Cleaning: it's not suggested to clean the module. Solder paste residuals underneath the module cannot be removed.

- Water cleaning: the cleaning process using water can involve water entering underneath the module between the two PCBs creating short circuits.
- Alcohol cleaning: the cleaning process with alcohol can damage the module.
- Untrasound cleaning: the cleaning process with ultrasound can damage the module.

It is suggested to use no clean solder paste to avoid any need for cleaning.

Cycles: it is suggested to do only one soldering cycle.

IMPORTANT: In case of reflow soldering, a drying bake should be done in order to prevent a popcorn effect. Re-baking should be done following IPC standards. Any unused modules that has been open for more than 168 hours or not stored at <10% RH should be baked before any subsequent reflow.

7 Compliance: Introduction

7.1 Introduction

The purpose of this chapter is to describe which behavior the user MUST have in order to operate the device under compliance with current regulations. The details described here are then to be read carefully and applied literally. Also, please read carefully all the other documentation available in order to understand all the limits and ensure compliance of the final application.

The module **EMB-ZRF231PA** is certified for CE compliance. The main aspect that the user MUST consider is the output power. The module itself is compliant and ready to be used but care must be taken in setting an appropriate output power when programming the devices. The module can output up to 20 dBm of conducted power which translates into up to 21.5 dBm of eirp with the integrated antenna or more if using an external antenna. Please follow the directives in this document to set the appropriate output power for the antenna you are using.

7.2 Compliance: Important information

The module is to be used in accordance with the current guide.

The antennas used must be one of those indicated by the manufacturer and the output power must be set as required by the present document. There is no duty cycle limit for this module if the appropriate power settings are respected. Any modification on the module will void the certification.

It is responsibility of the user to set the appropriate output power in order to avoid passing the limits imposed by the regulations. The CE regulation allows for up to 20 dBm of EIRP output power but imposes a maximum power spectral density of +10 mW/MHz. Considering the bandwidth of the 802.15.4 and ZigBee, this translates into a reduction of the maximum usable output power. Also spurious emission regulations might impose a lower output power.

When using an external antenna, tests should be done to ensure that all limits are satisfied. EMBIT can provide support in this direction.

7.3 CE compliance

The EBM-ZRF231PA is in compliance with the essential requirements and other relevant provisions of Directive 1999/5/EC.

The Declaration of Conformity made under Directive 1999/5/EC is available for viewing at the following location in the EU community:

Embit s.r.l.
via Emilia Est, 911
41122 Modena (MO)
Italy

WARNING: The exclamation mark indicates that this device is classified as “Class 2” radio equipment. The radio equipment is reprogrammable. It is not guaranteed that all limits and regulation compliance are satisfied once the device is reprogrammed. The user must take the full responsibility of operating the module properly satisfying regulation constrains that applies. The antenna is permanently attached to the card, removing the included antenna or modifying the board or antenna connector invalidates the certification.

This radio module has been designed to be embedded into other products (“final products”). According to the RTTE directive, the declaration of compliance and the “CE” labeling is within the responsibility of the manufacturer of the final product.

8 Ordering information

8.1 Types

Module variations:

Part No.	Description
EMB-ZRF231PA/IA	EMB-ZRF231PA integrated PIFA antenna
EMB-ZRF231PA/UL	EMB-ZRF231PA U.FL connector for external antenna

Related products:

Part No.	Description
EMB-ZRF231PA-EVK	EMB-ZRF231PA Evaluation Kit

8.2 Packaging

Embit's modules are delivered in tubes, each tube including 20 items.

The tube dimensions are approximately: 508mm x 33mm x 8mm.

9 Disclaimer

The user must read carefully all the documentation available before using the product. In particular, care must be taken in order to comply with the regulations (i.e. power limits, duty cycle limits, etc.).

9.1 Handling precautions

This product is an ESD sensitive device. Handling precautions should be carefully observed.

9.2 Limitations

Every operation involving a modification on the internal components of the module will void the warranty.

9.3 Disclaimer of liability

The information provided in this and other documents associated to the product might contain technical inaccuracies as well as typing errors. Regulations might also vary in time. Updates to these documents are performed periodically and the information provided in these manuals might change without notice. The user is required to ensure that the documentation is updated and the information contained is valid. Embit reserves the right to change any of the technical/functional specifications as well as to discontinue manufacture or support of any of its products without any written announcement.

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