Application Note: AN1200.91

Design Guide for the SX1261/2 Integrated Passive Device

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4 Overview

Electronic designs are often under pressure to provide increasingly complex functionality but with ever decreasing board space. To help meet the conflicting demands of modern applications and their miniaturization, Semtech has partnered with Johanson Technologies to make the SX1261/2 Integrated Passive Device (IPD) reference design. This IPD helps the designer achieve very small RF designs by replacing the discrete matching components of the radio by a single 2.00 x 1.25 mm LTCC device.

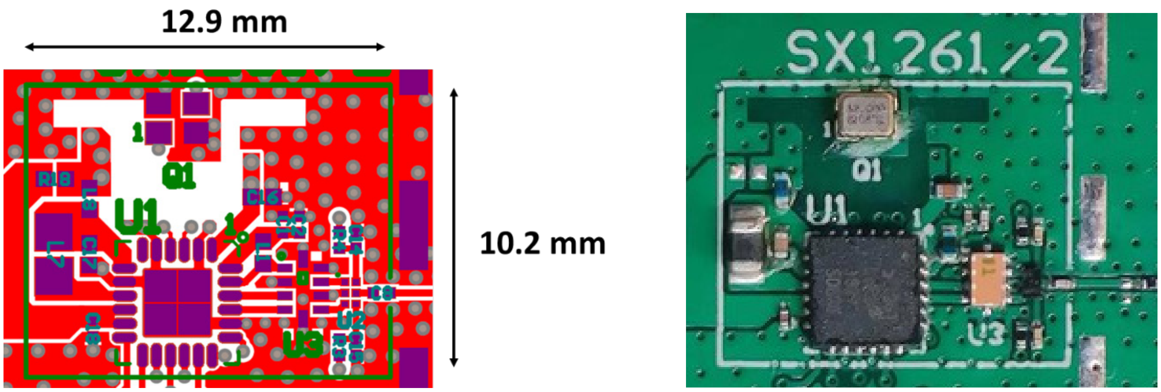

Figure 1. Johanson Technologies P/N: 0900FM15K0039E - IPD PCB Design and Layout

Figure 1 shows the dimensions of the PCB design and the IPD populated with the SX1261/2 reference design. The IPD reference design has the following features:

Dual Band: a sinlge IPD is designed to cover both the US 902 to 928 MHz ISM band and the Eureopean 863 to 870 MHz band.

SX1261 and SX1262 Compatible: The designer can therefore choose between the low energy solution of the SX1261 or the high output power performance of the SX1262.

Full RF Performance: irrespective of the band of operation, the full RF performance of the SX1261 and SX1262 can be realised (to within +/- 1 dB of the datasheet specification) in the following configurations:

- SX1261 +14 dBm operation in the ETSI 868 MHz band
- SX1261 +14 dBm operation in the FCC 915 MHz band
- SX1262 +22 dBm operation in the FCC 915 MHz band

In this application note we examine the IPD reference design features and its measured RF and consumption performance for both SX1261 and SX1262 implementations.

5 IPD Reference Design Implementation

5.1 The SX1261/2 Reference Design

The conventional, discrete component SX1261 and SX1262 reference designs comprise three main elements:

1. The transmitter matching and harmonic filtering,
2. the receiver matching and
3. a common mode PI filter that also attenuates the harmonics in transmit and contributes to blocker attenuation in receive.

These components are highlighted in the RF front end schematic for the SX1262 below.

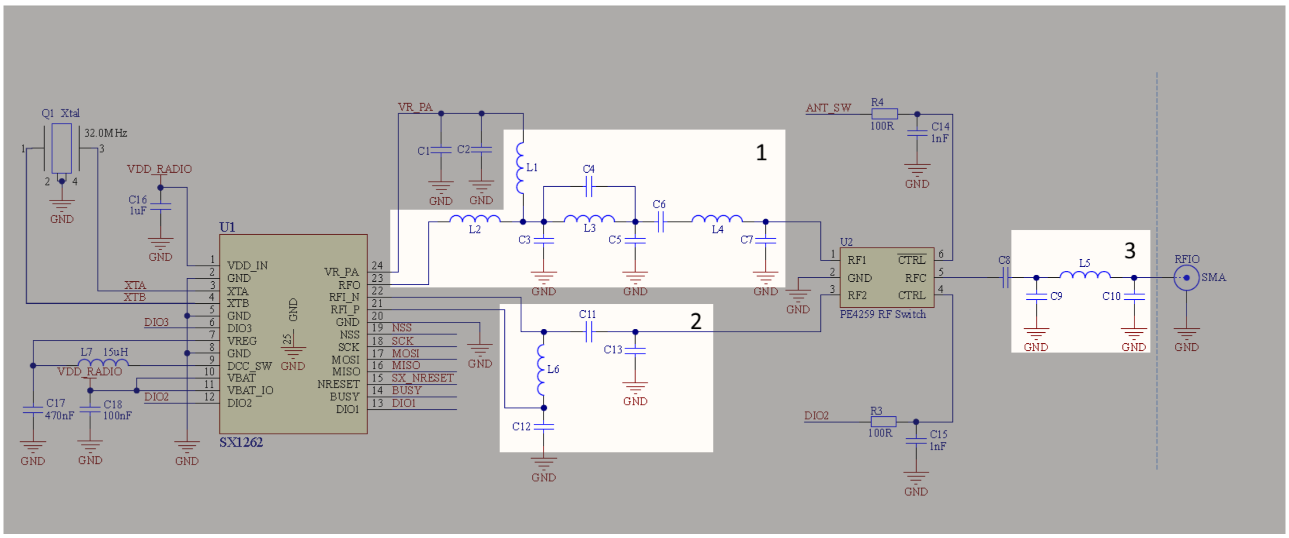

Figure 2. The SX1262 Reference Design Main RF Blocks

5.2 The IPD Reference Design

The IPD incorporates all three of these front-end elements, this is achieved by relocating the PI filter to the transmit chain only, where the harmonic filtering influence is principally required. The trade-off of this relocation is increased Rx sensitivity at odd harmonic frequencies.

The following figure shows the new schematic for the IPD reference design – the highlighted area is the IPD, that incorporates all of the passive, RF, signal chain components of the previous figure. Because the PI filter is integrated within the IPD, components C9, L5 and C10 are available for custom antenna matching components (not populated in the IPD reference design).

When implementing the design, in addition to copying the schematic, it is also highly recommended to precisely replicate the PCB layout. To guarantee RF performances this should include the precise distances between components, layer stack-up, track widths and the via placement.

More details and precise dimensions can be found in the IPD reference design PCB design files, available on the Semtech website [1] and the Johanson Technologies IPD P/N: 0900FM15K0039E page [2].

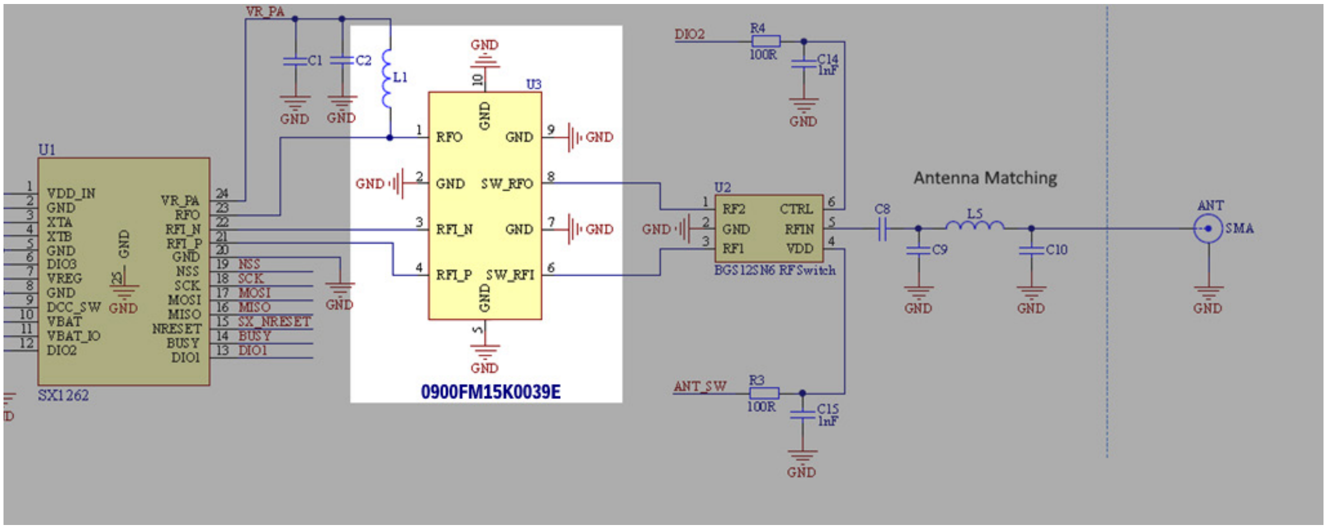

Figure 3. The SX1261/2 IPD Reference Design

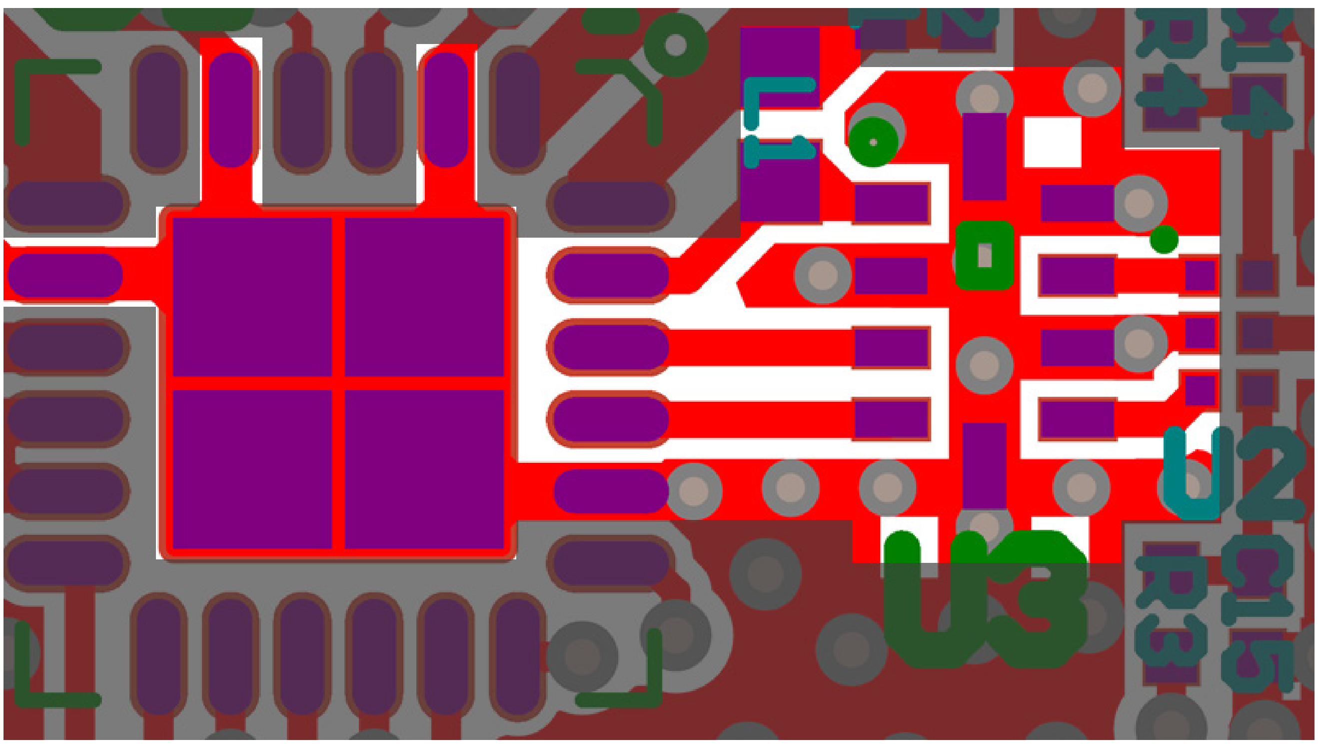

Figure 4. IPD Layout Details to Replicate in an IPD Design Implementation

6 Transmit Performance with the IPD

The transmit performance of the IPD has three main metrics of interest: transmit output power, transmitter consumption and harmonic emissions. In the following series of subsections, we report these performance numbers as a function of frequency.

6.1 SX1261 ETSI 868 MHz +14dBm Performance

When operating at +14 dBm expected current consumption is 25.5 mA. The output power and consumption are within specified limits and have a compliant harmonic output.

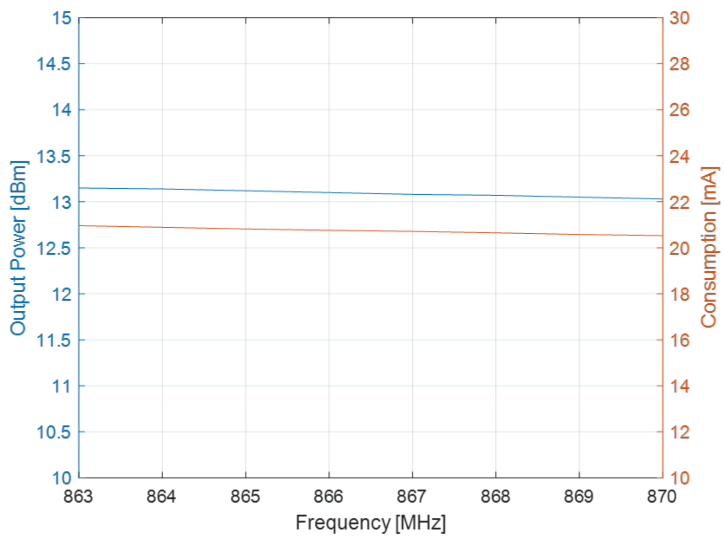

Figure 5. +14 dBm Transmit Output Power and Current Consumption in the 868 MHz ISM Band

The harmonics were measured for the same frequency sweep across the ISM band, hence multiple points are recorded per harmonic with the regulatory limit is shown by the solid line.

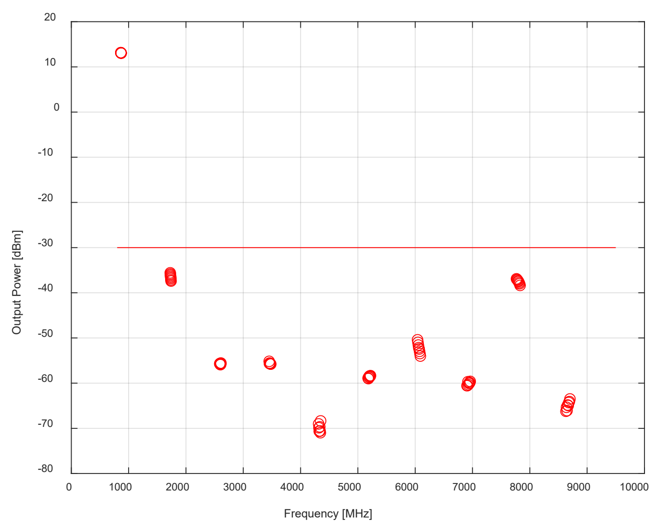

Figure 6. ETSI Harmonic Performance for a Swept CW Signal from the SX1261

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6.2 SX1262 FCC 915MHz +22 dBm Performance

When operating at +22 dBm expected current consumption is 118 mA. The output power and consumption are within specified limits and have a compliant harmonic output.

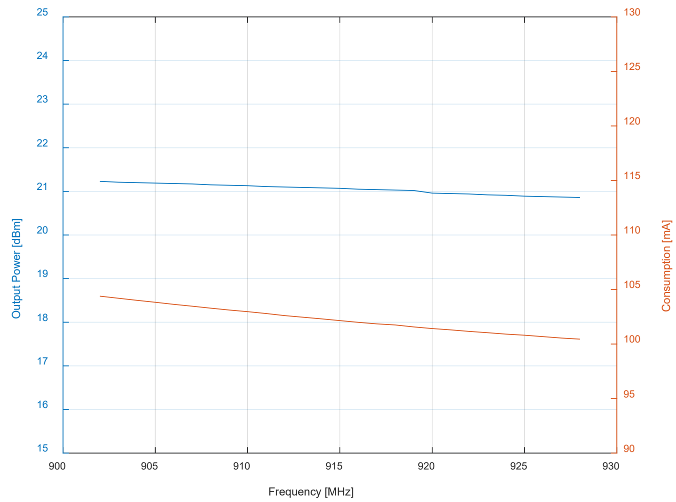

Figure 7. +22 dBm Transmit Output Power and Current Consumption in the 915 MHz ISM Band

For FCC testing the -41 dBm restricted band limit is shown, but does not apply to all harmonics. Note that the 2nd and 7th harmonics do not fall into a restricted band and the less stringent -30 dBc limit instead applies.

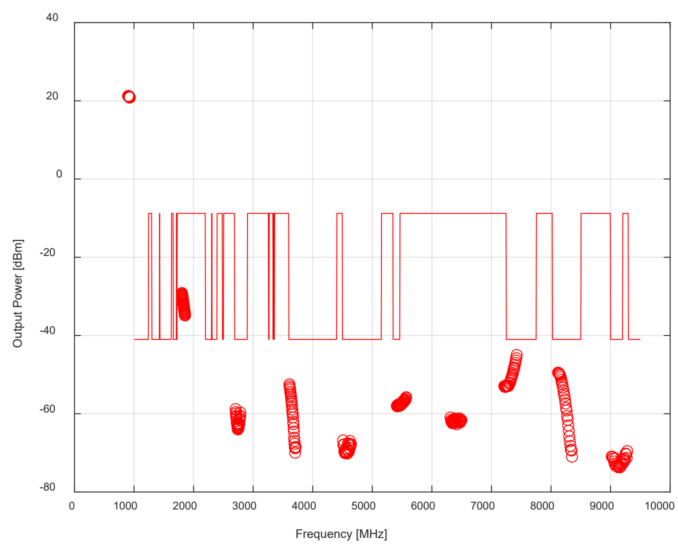

Figure 8. FCC Harmonic Performance for a Swept CW Signal from the SX1262

6.3 SX1261 FCC 915 MHz +14 dBm Performance

When operating at +14 dBm expected current consumption is 25.5 mA. The output power and consumption are within specified limits and have a compliant harmonic output.

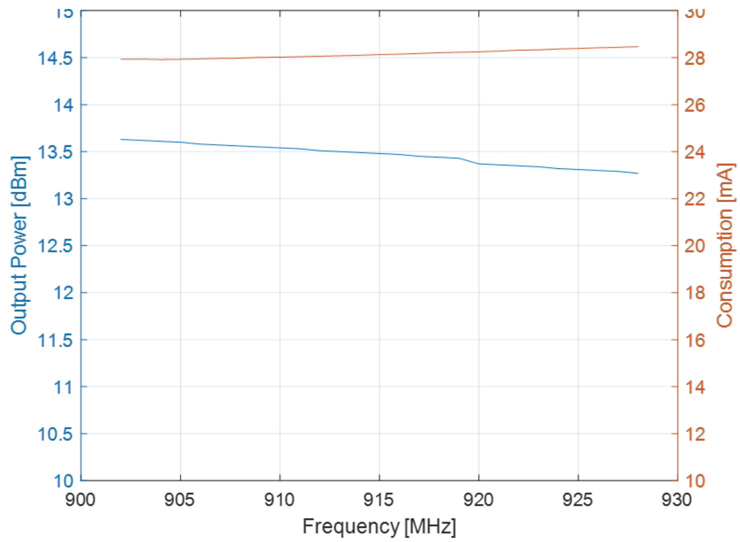

Figure 9. +14 dBm Transmit Output Power and Current Consumption in the 915 MHz ISM Band

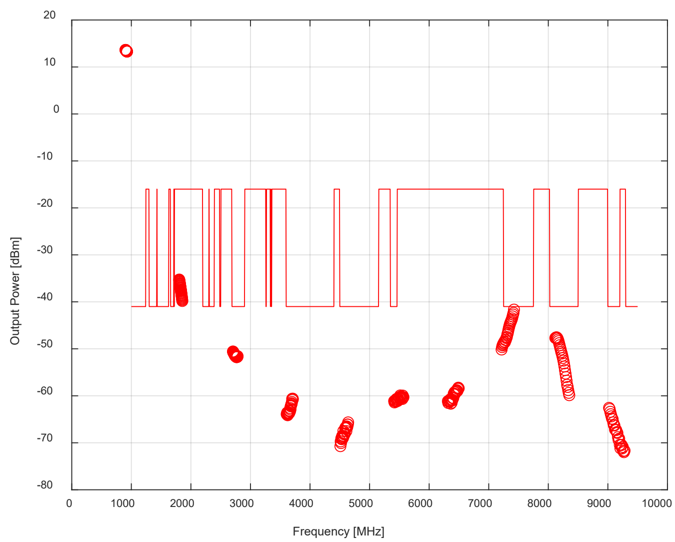

Figure 10. FCC Harmonic Performance for a Swept CW Signal from the SX1261

Note that the 8th harmonic approaches (within 2 dB of) the regulatory limit. It should be noted that fundamental frequencies below 925 MHz have >3 dB margin. Another point to consider is that FCC testing is radiated, so some selectivity is expected from both the antenna and antenna matching in a practical implementation that will augment the 8th harmonic rejection.

6.4 Transmitter Settings

The following settings were used in transmit mode with the IPD to yield the performances demonstrated in this section. The power setting denotes the value passed in the SetTxParams() command and the remaing configuration (paDutyCycle, hpMax and paLut) is given in the argument to the SetPaConfig() command. See the SX1261/2 datasheet [3] for more details.

Table 1. PA Settings Used to Generate Transmit Performance

Configuration	power	paDutyCycle	hpMax	deviceSel	paLut
SX1261 ETSI	+14 dBm	0x04	0x00	0x01	0x01
SX1261 FCC	+14 dBm	0x07	0x00	0x00	0x01
SX1262 FCC	+22 dBm	0x04	0x07	0x00	0x01

7 Receive Performance with the IPD

The sensitivity performance of the IPD reference design was checked using LoRa modulation at SF7 and a bandwidth of 125 kHz with the packet setting as per the datasheet settings [3]. The datasheet specification for performance with these settings is -124 dBm at a 1% packet error rate (PER).

7.1 SX1261 Performance

The SX1261 sensitivity measured using the IPD is shown as a function of frequency in the image below. The average sensitivity shown in the plot below exceeds the datasheet specification. Note the presence of some frequencies where the sensitivity is marginally reduced, due to internal coupling within the circuit. Such behaviour is normal and can be seen in all reference designs.

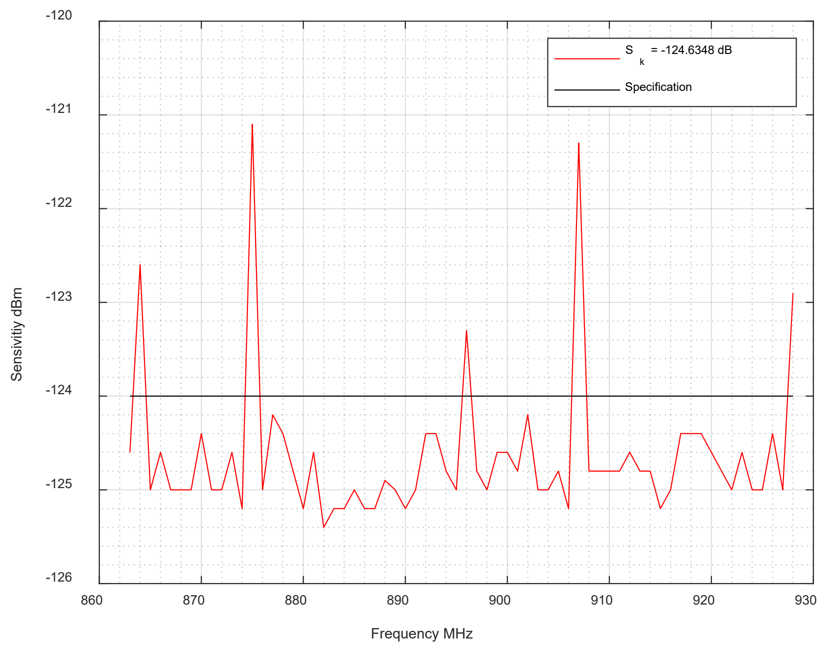

Figure 11. SX1261 Measured Receiver Performance in the sub-GHz ISM Bands

7.2 SX1262 Performance

The performance of the SX1262 was measured in identical datasheet conditions to the SX1261 with equivalent performance reported.

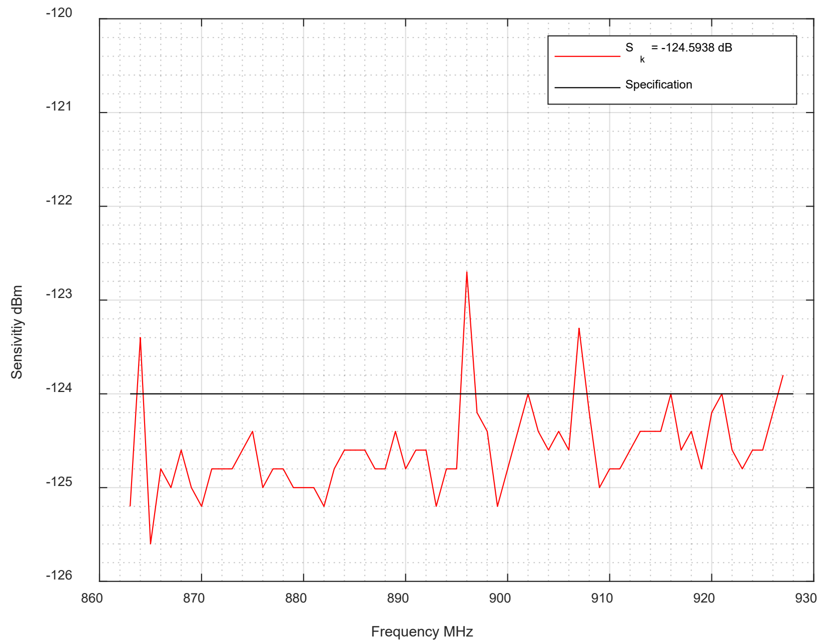

Figure 12. SX1262 Measured Receiver Performance in the sub-GHz ISM Bands

8 Conclusion

We have presented the performance of the SX1261/2 IPD in the main configurations of interest. The device output power and sensitivity performances are achieved, to within 1 dB of the datasheet specification, but in a dual band configuration that reduces the reference design dimensions down to only 12.9 x 10.2 mm.

9 References

[1] SX1261/2 IPD Dual Band Reference Design - SX1261/62 Miniaturized Ref Design with Johanson Technology IPD (see AN1200.91) - available from the SX1261/2 website:
https://www.semtech.com/products/wireless-rf/lora-connect/sx1261
https://www.semtech.com/products/wireless-rf/lora-connect/sx1262

[2] Johanson Technologies website - Semtech webpage:
https://www.johansontechnology.com/semtech

[3] SX1261/2 Datasheet Rev 2.1 December 2021, available from the SX1261/2 website:
https://www.semtech.com/products/wireless-rf/lora-connect/sx1261
https://www.semtech.com/products/wireless-rf/lora-connect/sx1262

10 Glossary

BB	BaseBand
BoM	Bill Of Materials
BW	BandWidth
CLK	Clock
CW	Continuous Wave
ETSI	European Telecommunications Standard Institute
DFU	Device Firmware Update
EU	Europe
EUI	Extended Unique Identifier
GB	GigaByte
HW	HardWare
IP	Intellectual Property
IPD	Integrated Passive Device
ISM	Industrial, Scientific and Medical applications
LO	Local Oscillator
LoRa®	Long Range modulation technique
LoRaWAN®	LoRa® low power Wide Area Network standard
PA	Power Amplifier
RSSI	Received Signal Strength Indication
RF	Radio-Frequency
RX	Receiver
SF	Spreading Factor
SPI	Serial Peripheral Interface
SPDT	Single-Pole, Double-Throw switch
SW	SoftWare
TX	Transmitter

11 Revision History

Version	Date	Modifications
1.0	January 2024	First Release
1.1	May 2024	Updated Template and AN1200.91 Document Number

Important Notice