JODY-W5 antenna reference design

Antenna integration guidance

Application note

Abstract

This application note describes the module and integrated antenna reference design, which was subsequently used to acquire the appropriate FCC and ISED grant. It highlights the module and antenna requirements, performance expectations, and explains the RF path implemented between the various components of the test setup used during the certification.

Document information

Title	**JODY-W5 antenna reference design**	
Subtitle	Antenna integration guidance	
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This document applies to the following products:

Product name
JODY-W5 series

Contents

1 Introduction

This document describes the antenna reference design integrated with JODY-W5 modules, which was subsequently used to acquire the appropriate FCC and ISED grant. To leverage this existing u-blox grant, customers must copy this design exactly into their application product. Any proposed deviation from this reference design must be filed with the FCC/ ISED to determine whether it can be considered as a "permissive change" to the original grant or is significantly different to warrant the application of a completely new equipment grant of certification (new FCC ID). See also the FCC Permissive Change Policy [3].

The given information should be sufficient to allow for a skilled person to implement the antenna design on an application product. It provides the designer with the necessary PCB layout details including microstrip type, dimensions, and antenna interface requirements.

☞ The JODY-W5 antenna design supports a connector-based design for use with two (JODY-W562) external antennas.

2 General description and requirements

The antenna ports **ANT0** and **ANT1** have a nominal characteristic impedance of 50 Ω. To allow proper impedance matching along the RF path, each port must be connected to the related antenna through a 50 Ω transmission line. A bad termination of the pin can result in poor performance or even damage the RF section of the module. Antenna interface and antenna requirements are described in Table 1.

Item	Requirements	Remarks
Impedance	50 Ω nominal characteristic impedance	The impedance of the antenna RF connection must match the 50 Ω impedance of the antenna pins.
Frequency range	2400 - 2500 MHz 4900 - 5925 MHz	For 802.11b/g/n/ax and Bluetooth. For 802.11a/n/ac/ax
Return loss	S11 < -10 dB (VSWR < 2:1) recommended S11 < -6 dB (VSWR < 3:1) acceptable	The return loss, or the S11, as the VSWR (Voltage Standing Wave Ratio), refers to the amount of reflected power. It provides a measurement of how well the primary antenna RF connection matches the 50 Ω characteristic impedance of antenna pins. To maximize the amount of power transferred to the antenna, the impedance of the antenna termination must match the 50 Ω nominal impedance of antenna pins over the entire operating frequency range.
Efficiency	> -1.5 dB (> 70%) recommended > -3.0 dB (> 50%) acceptable	The radiation efficiency is the ratio of the radiated power to the power delivered to antenna input; the efficiency is a measure of how well an antenna receives or transmits.
Maximum gain		To comply with the radiation exposure limits of the various regulatory agencies, the peak antenna gain must not exceed that specified in the Approved antennas section in the system integration manual [1].

Table 1: Summary of antenna interface requirements

For optimal performance in multiradio mode, the isolation between the antennas must meet the requirements specified in Table 2.

Item	Requirements	Remarks
Isolation (in-band)	S_{21} > 25 dB recommended S_{21} > 20 dB acceptable	The S_{21} parameter represents the antenna-to-antenna isolation between the two antennas in their band of operation.
Isolation (out-of-band)	S_{21} > 35 dB recommended S_{21} > 30 dB acceptable	Out-of-band isolation is evaluated in the band of the aggressor. This ensures that the transmitting signal from the other radio is sufficiently attenuated by the receiving antenna to avoid any saturation or intermodulation effect at the receiver port.
Envelope Correlation Coefficient (ECC)	ECC < 0.1 recommended ECC < 0.5 acceptable	The ECC parameter correlates the far-field parameters between antennas in the same system.

Table 2: Summary of MIMO and Wi-Fi/Bluetooth coexistence requirements

3 RF design of antenna path

The PCB traces connecting the module antenna pins to the U.FL connectors on the module board are designed with coplanar microstrips, as shown in Figure 1. The artwork is shown in Figure 2 and Figure 3. The schematic including RF antenna matching components is shown in Figure 4.

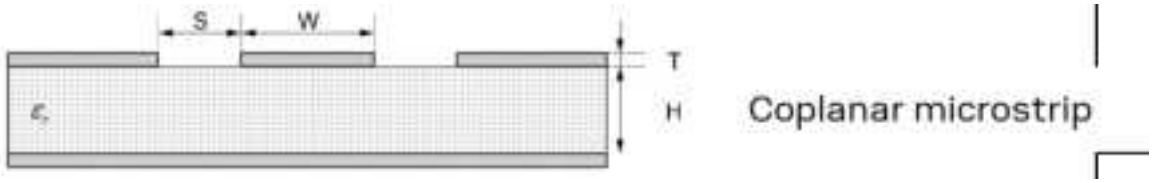

Figure 1: Coplanar microstrip dimension specification

Item	Value	Description
S	150 µm	Distance between the top copper layer and the two adjacent GND planes
W	523 µm	Width of the copper on the top layer
T	35 µm	Thickness of the copper layer, which can also be represented by “Base Copper Weight” and is commonly used as the parameter for PCB stack-up
H	614 µm	Dielectric substrate thickness showing the distance between the GND reference on the bottom plane and the copper layer on the top layer
ε_r	4.3	Dielectric constant defining the ratio between the electric permeability of the material against the electric permeability of free space

Table 3: Coplanar microstrip specification

The antenna ports shown in Figure 2 are from left to right: **ANT1** and **ANT0. ANT2** to the far right is not used. It also shows the artwork of the RF traces with dimensions listed in Antenna coplanar microstrip dimensions.

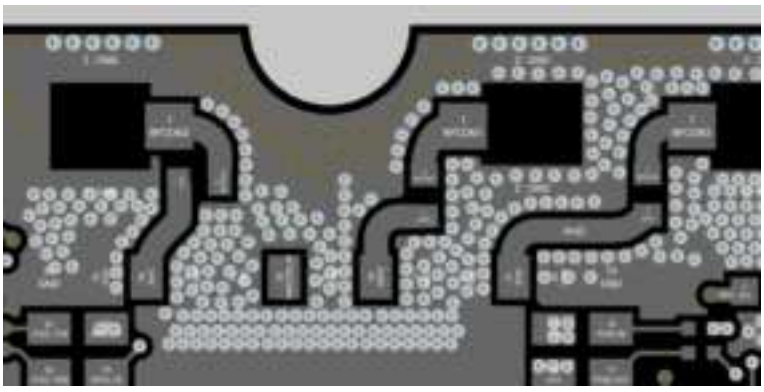

Figure 2: Module board showing antenna microstrip implementation

☞ The antenna pin configuration is described in the JODY-W5 data sheet [2].

Figure 3: PCB assembly of M.2-JODY-W5.

Figure 4 shows the components used for the Pi network impedance matching.

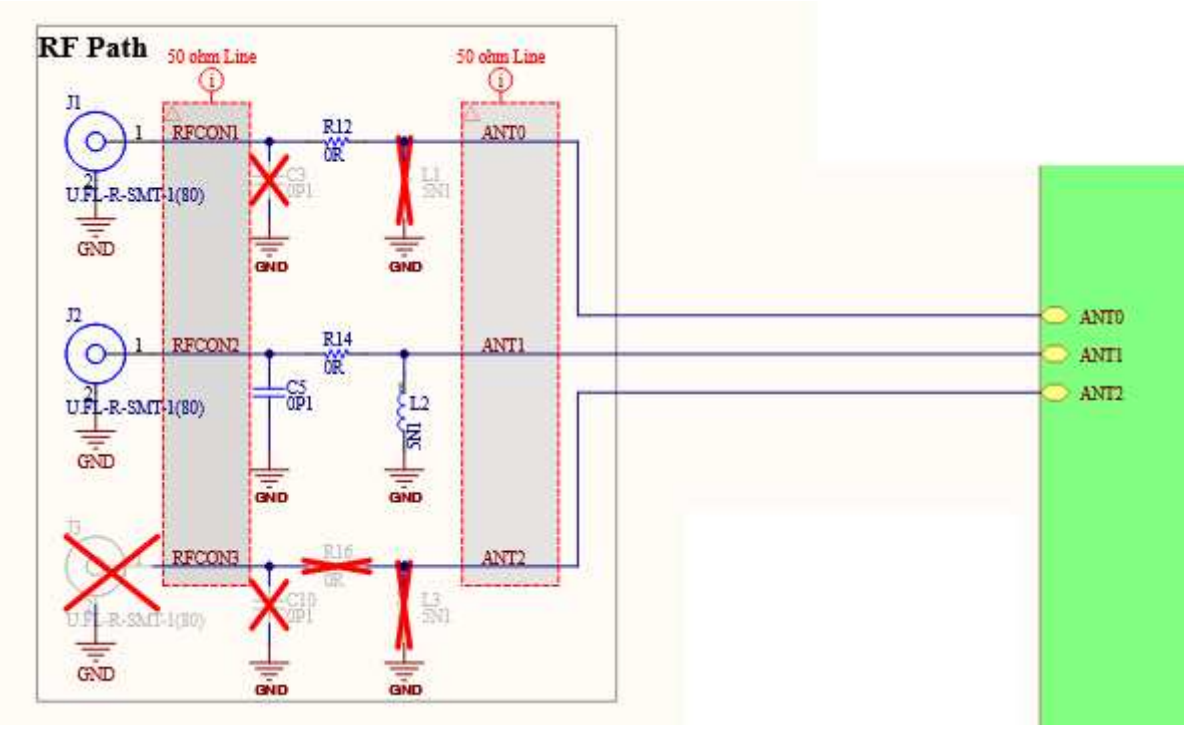

Figure 4: Component selection for RF matching network on module board

Table 4 lists the parts used for the RF matching network and antenna connector design.

Reference	Part	Description
J1, J2	Hirose U.FL-R-SMT-1(80)	Coaxial connector, 0 – 6 GHz, for external antenna
C5		Multilayer Ceramic Capacitor 0.1 pF 50 VDC ±0.05 pF 0201
L2		RF Inductor 5.1 nH 350 mA ±3% 0201
R12, R14		Resistor 0 Ω 0402

Table 4: Included parts in the RF matching network and antenna connector design

3.1 Antenna coplanar microstrip dimensions

Table 5 shows the dimensions of the RF trace between module pin **ANT1** and u.FL connector **J2**.

Trace	Radius	Length
From U.FL connector to series component R14	0.523 / 0.923 mm	1.099 mm
From series component R14 to module	1.312 mm	1.031 mm

Table 5: Dimensions for the ANT1 RF trace from U.FL connector to module RF pin

Table 6 shows the dimensions of the RF trace between module pin **ANT0** and u.FL connector **J1**.

Trace	Radius	Length
From U.FL connector to series component R12	0.523 / 1.254 mm	1.337 mm
From series component R12 to module	0.523 mm	0.822 mm

Table 6: Dimensions for the ANT0 RF trace from U.FL connector to module RF pin

☞ The trace length is defined from the center of start to center of end pad.

☞ The coplanar microstrip and PCB substrate properties are included in Table 3.

Appendix

A Glossary

Abbreviation	Definition
ECC	Envelope Correlation Coefficient
FCC	Federal Communications Commission (US)
ISED	Innovation, Science and Economic Development (Canada)
MIMO	Multiple-Input and Multiple-Output
RF	Radio Frequency
SMA	SubMiniature version A (connector)
VSWR	Voltage Standing Wave Ratio

Table 7: Explanation of the abbreviations and terms used

Related documentation

[1] JODY-W5 system integration manual, UBX-23001477
[2] JODY-W5 series data sheet, UBX-23002865
[3] FCC Permissive Change Policy, KDB 178919

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Revision history

Revision	Date	Name	Comments
R01	3-Jul-2025	lber	Initial release

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