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MAYA-W1 antenna reference design

Antenna integration guidance

Application note

Abstract

This application note describes the integration of the antennas in MAYA-W1 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.

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This document applies to the following products:

Product name
MAYA-W1 series

Contents

1 Introduction

This document describes the implementation of antennas in MAYA-W1 reference design, 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 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 [1].

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 characteristic antenna interface requirements.

☞ MAYA-W160, MAYA-W161, and MAYA-W166-01B support a connector-based design for use with one or two external antennas. MAYA-W166-00B includes a PCB antenna.

2 Module description and requirements

The antenna ports **RF_ANT0**, and **RF_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.

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

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 5150 - 5850 MHz	For 802.11b/g/n and Bluetooth. For 802.11a/n/ac.
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 datasheet [2].

Table 1: Summary of antenna interface requirements

For optimal performance in multiradio mode, the isolation and antenna correlation coefficient 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. Although MAYA-W1 does not currently support MIMO, a low ECC parameter is fundamental for improving the performance of any future implementation in MIMO-based systems.

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

3 Reference design of RF path

The FCC grant of certification for MAYA-W1 is based on a setup configuration that includes MAYA-W1 mounted on an evaluation board.

3.1 Stack-up

MAYA-W2 EVK reference design is designed on a four-layer PCB, as shown in Figure 1. The dielectric constant "ε_r" of prepreg and core is about 4.4 @ 2 GHz. See also PCB RF trace routing.

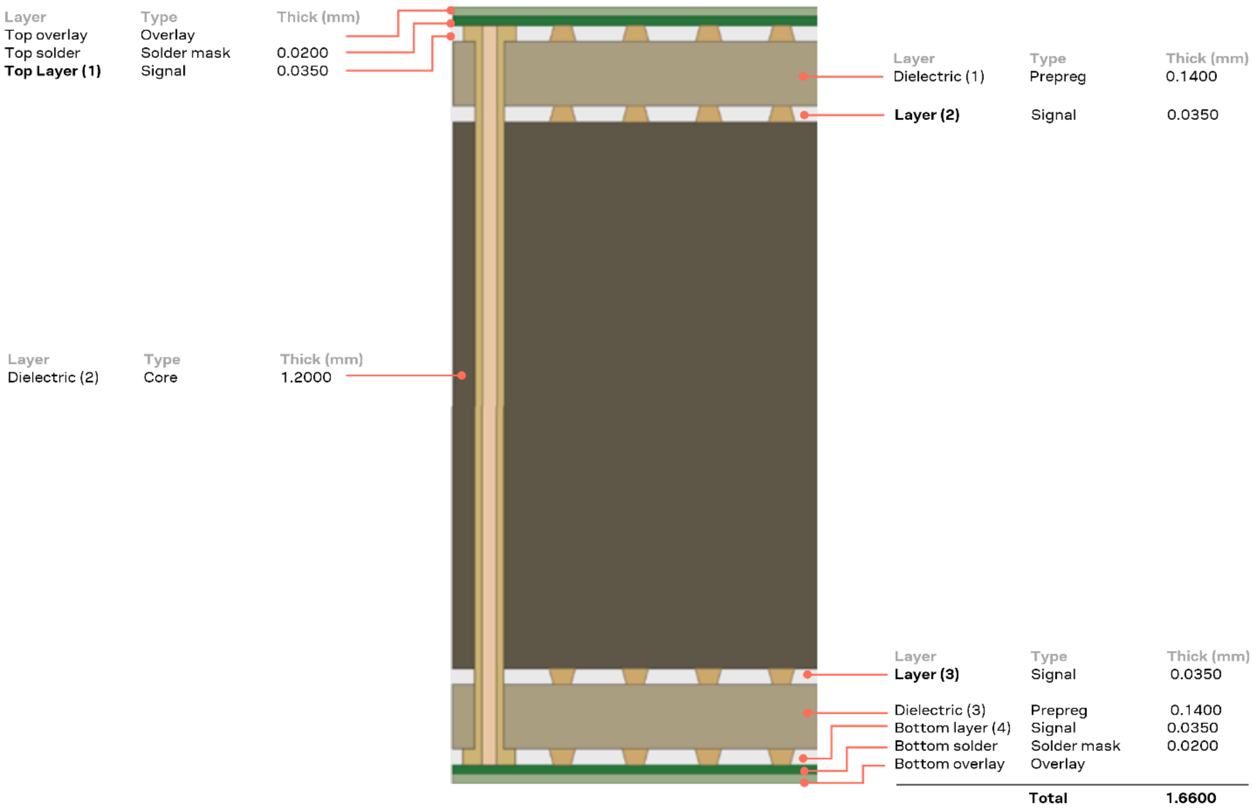

Figure 1: EVK PCB stack-up

3.2 PCB RF trace routing

The antenna traces are implemented with coplanar microstrips routed on top layer with GND reference plane on layer 3. GND on Layer 2 is masked underneath the RF trace. The two coplanar ground planes beside the signal trace should be connected to the lower ground plane using vias. It is advisable to place the vias with a maximum distance of 0.5 mm to the coplanar ground edge with a maximum pitch of 2 mm. The top side should be coated with generic LPI solder stop mask.

Figure 2 shows a cross section of a coplanar microstrip implemented on a PCB, where:

- The top layer shows the copper layer microstrip with the width marked "W" surrounded by GND separated with the distance "S" from the microstrip.
- The bottom layer represents the microstrip's GND reference. Between the top and bottom layer is the dielectric substrate with a thickness of "H" and dielectric constant "ε_r". The width of a 50 Ω microstrip depends on mainly "ε_r" and "H" and must be calculated for each PCB layer stack-up.
- "T" is the thickness of the copper layer. This can also be represented by "Base Copper Weight", which is commonly used as the parameter for PCB stack-up.

For acceptable microstrip losses it is advised to implement a reasonably wide trace and with the GND reference. For example, on the second inner layer with the copper GND on the first inner layer removed underneath the microstrip.

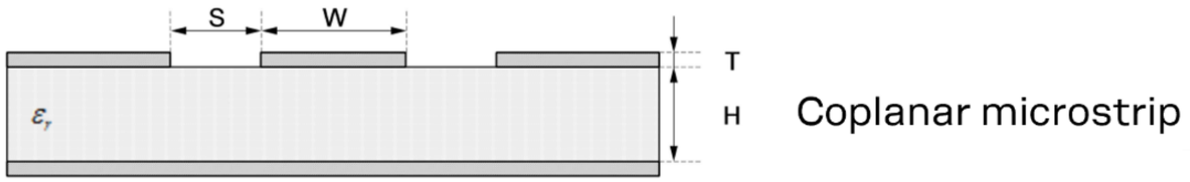

Figure 2: Coplanar microstrip structure

3.2.1 MAYA-W160, MAYA-W161, and MAYA-W166-01B

Figure 2 shows the coplanar microstrip design implemented on the u-blox reference design, where the MAYA-W1 antenna pads **RF_ANT0**, and **RF_ANT1** are connected to the SMA connectors J10 and J11. In this design, the dimensions of the coplanar microstrips, marked “NetJ10_1” and “NetJ11_1”, are W=1.30 mm and S=0.3 mm. The microstrips length is about 7.6 mm.

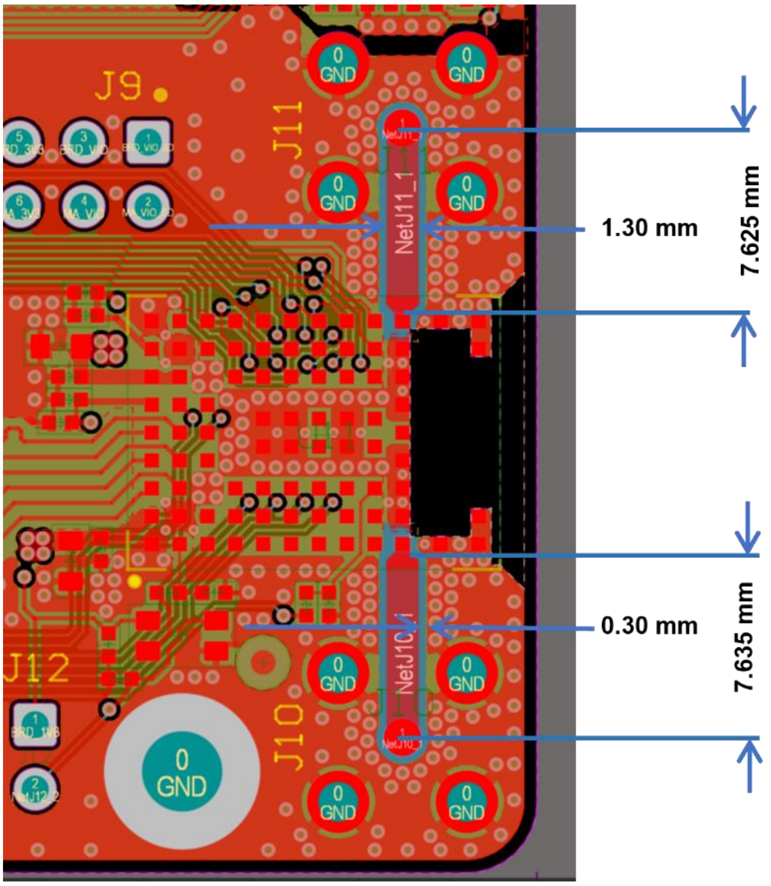

Figure 3: Evaluation board artwork with dimensions

☞ On MAYA-W166-01B, **RF_ANT1** is used for shared Bluetooth and Wi-Fi, and **RF_ANT0** is not connected.

3.3 MAYA-W166-00B

To minimize the effect of electromagnetic interference, the MAYA-W166 module, which includes a PCB trace antenna, is placed along the edge of the PCB, as shown in Figure 3.

All layers underneath the antenna area cleared from GND and other copper traces according with the dimensions of "Copper free area", as shown in Figure 4.

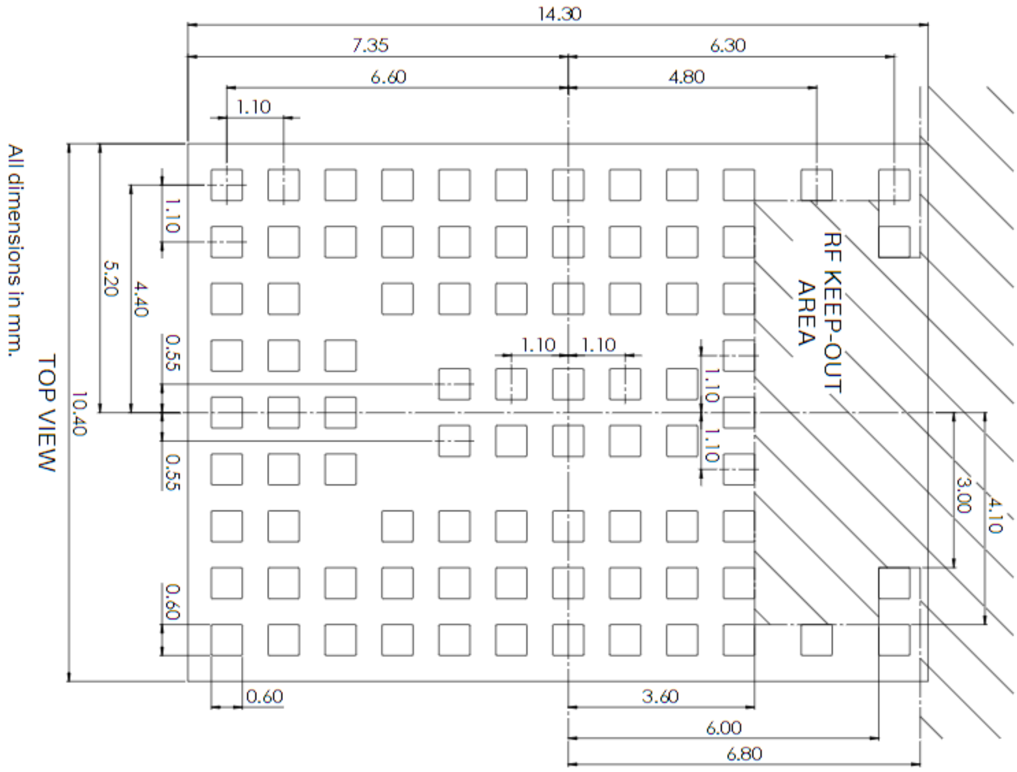

Figure 4: MAYA-W1 footprint showing the PCB RF KEEP-OUT AREA for MAYA-W166-00B

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 3: Explanation of the abbreviations and terms used

Related documentation

[1] MAYA-W1 system integration manual, UBX-21010495
[2] MAYA-W1 series data sheet, UBX-21006380
[3] FCC Permissive Change Policy, 178919

☞ For product change notifications and regular updates of u-blox documentation, register on our website, www.u-blox.com.

Revision history

Revision	Date	Name	Comments
R01	13-Feb-2023	lber	Initial release
R02	08-Apr-2024	mzes	Corrected UBX document number. Included guidelines for MAYA-W166-00B with other minor changes in Reference design of RF path. Added section Stack-up.

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