JODY-W263

Host-based multiradio module with Wi-Fi and Bluetooth 5

Integration Instructions

Abstract

This document describes the system integration of JODY-W263 module into a host product. This host-based modules support Wi-Fi 802.11n/ac and Bluetooth® 5 and is designed for both simultaneous and independent operations. The JODY-W263 module includes an integrated MAC/baseband processor and RF front-end components. This document is to only be used internally for Foresight Sports, as the grant pertaining to this module is not intended for distribution of the module.

Document Information

Title	**JODY-W2**
Subtitle	Host-based multiradio modules with Wi-Fi and Bluetooth 5
Document type	Integration Instructions
Document name	FSS JODY-W263 System integration manual
Revision and date	Rev 02 08-Sep-2022
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This document applies to the following products.

Product name
JODY-W263-00B

Table of Contents

1 List of applicable FCC rules

The following FCC rules are applicable to the equipment:

- CFR 47, Part 15, Subpart C
- CFR 47, Part 2, Subpart J – Radiofrequency radiation exposure: portable devices

2 Summary of operational use conditions

2.1 Antenna configuration

In addition to the general requirement to use only authorized antennas, the grant also requires a separation distance of at least 20 cm from the antenna(s) to all persons. The antenna(s) must not be co-located with any other antenna or transmitter (simultaneous transmission) as well. If this cannot be met, a Permissive Change as described below must be made to the grant.

☞ In order to support verification activities that may be required by certification laboratories, customers applying for Class-II Permissive changes must implement the setup described in Radio Test Guide for NXP based modules.

If the module is to be co-located with another transmitter, additional measurements for simultaneous transmission are required. The results must be added to the grant file as a Class II Permissive Change.

If the authorized antennas and/or antenna trace design cannot be used, the new antenna and/or antenna trace designs must be added to the grant file. This is done by a Class I Permissive Change or a Class II Permissive Change, depending on the specific antenna and antenna trace design.

- Antennas of the same type and with less or same gain as an already approved antenna can be added under a Class I Permissive Change.
- Antenna trace designs deviating from the reference design and new antenna types are added under a Class II Permissive Change.
- For 5 GHz modules, the combined minimum gain of antenna trace and antenna must be greater than 0 dBi to comply with DFS testing requirements.

2.2 Antenna gain

The antenna gain in each band must not exceed the following:

Wi-Fi Output Power for 2.4GHz band

Channel	Modulation	Channel bandwidth	Data rates	Maximum power setting
1 - 11	CCK and DSSS	20 MHz	1, 2, 5.5, 11 Mbps	12 dBm
1	OFDM	20 MHz	6, 9, 12, 18, 24, 36, 48, 54 Mbps	11 dBm

2 – 10	OFDM	20 MHz	6, 9, 12, 18, 24, 36, 48, 54 Mbps	16 dBm
11	OFDM	20 MHz	6, 9, 12, 18, 24, 36, 48, 54 Mbps	11 dBm
1	OFDM	20 MHz	HT20 MCS0-MCS7	11 dBm
2 – 10	OFDM	20 MHz	HT20 MCS0-MCS7	16 dBm
11	OFDM	20 MHz	HT20 MCS0-MCS7	11 dBm
3	OFDM	40 MHz	HT40 MCS0-MCS7	11 dBm
4 – 8	OFDM	40 MHz	HT40 MCS0-MCS7	16 dBm
9	OFDM	40 MHz	HT40 MCS0-MCS7	11 dBm

Table 1: Wi-Fi power table for operation in the 2.4 GHz band

Wi-Fi Output power for 5 GHz band

Channel	Modulation	Channel bandwidth	Data rates	Maximum power setting
36 - 64	OFDM	20 MHz	6, 9, 12, 18, 24, 36, 48, 54 Mbps	15 dBm
36 - 64	OFDM	20 MHz	HT20 MCS0-MCS7	15 dBm
36 - 64	OFDM	20 MHz	VHT20 MCS0-MCS8	15 dBm
38 - 62	OFDM	40 MHz	HT40 MCS0-MCS7	15 dBm
38 - 62	OFDM	40 MHz	VHT40 MCS0-MCS9	15 dBm
42	OFDM	80 MHz	VHT80 MCS0-MCS9	14 dBm

Table 2: Wi-Fi power table for operation in the 5 GHz U-NII-1 and U-NII-2A bands

Channel	Modulation	Channel bandwidth	Data rates	Maximum power setting
100 - 144	OFDM	20 MHz	6, 9, 12, 18, 24, 36, 48, 54 Mbps	15 dBm
100 - 144	OFDM	20 MHz	HT20 MCS0-MCS7	15 dBm
100 - 144	OFDM	20 MHz	VHT20 MCS0-MCS8	15 dBm
102	OFDM	40 MHz	HT40 MCS0-MCS7	14 dBm
102	OFDM	40 MHz	VHT40 MCS0-MCS9	14 dBm
110-142	OFDM	40 MHz	HT40 MCS0-MCS7	15 dBm
110-142	OFDM	40 MHz	VHT40 MCS0-MCS9	15 dBm
106 - 138	OFDM	80 MHz	VHT80 MCS0-MCS9	14 dBm

Table 3: Wi-Fi power table for operation in the 5 GHz U-NII-2e band

Channel	Modulation	Channel bandwidth	Data rates	Maximum power setting
149 - 165	OFDM	20 MHz	6, 9, 12, 18, 24, 36, 48, 54 Mbps	15 dBm
149 - 165	OFDM	20 MHz	HT20 MCS0-MCS7	15 dBm
149 - 165	OFDM	20 MHz	VHT20 MCS0-MCS8	15 dBm
151 – 159	OFDM	40 MHz	HT40 MCS0-MCS7	15 dBm
151 – 159	OFDM	40 MHz	VHT40 MCS0-MCS9	15 dBm
155	OFDM	80 MHz	VHT80 MCS0-MCS9	14 dBm

Table 4: Wi-Fi power table for operation in the 5 GHz U-NII-3 band

2.2 Co-location

If the module is to be co-located with another transmitter, additional measurements for simultaneous transmission are required. The results must be added to the grant file as a Class II Permissive Change.

The module is not currently approved for co-location with any other modules.

3 RF Exposure conditions

3.1 Installation Instructions

The module is approved for use in a mobile RF exposure environment. A minimum separation distance of 20 cm must be maintained between the antenna and nearby persons.

The module is not approved for co-location with any other modules.

3.2 Warning

A warning must be placed in the host product user instructions stating that:

1) “This device is approved for use in a mobile rf exposure environment. A minimum separation distance of 20 cm must be maintained between the antenna and nearby persons.”
2) The module is not approved for co-location with any other modules.

The host integrator must follow the integration instructions provided by the module manufacturer and ensure that the composite-system end product complies with he FCC requirements by a technical assessment or evaluation to the FCC rules and KDB Publication 996369.

If the required separation distance of 20 cm cannot be fulfilled, a SAR evaluation must be performed. This consists of additional calculations and/or measurements. The result must be added to the grant file as a Class II Permissive Change.

4 Antenna interfaces:

4.1 Wi-Fi and Bluetooth antennas

JODY-W2 provides two antenna pins, one for dual-band Wi-Fi connectivity (**ANT1**) and another for Bluetooth (**ANT0**). The following recommendations apply to developing an antenna interface for the JODY-W2 module:

- Where possible, consider integrating in the end product the u-blox Antenna Reference Design to minimize the effort on the certification process.
- The **ANT0** and **ANT1** pins of JODY-W2 have a nominal characteristic impedance of 50 Ω and must be connected to the external antennas through a 50 Ω transmission line to allow proper RF transmission and reception.
- Good isolation must be provided between the various antennas in the system. Special care shall be taken to maximize isolation between the antennas operating in the same or nearby bands.

For information describing how to properly design circuits compliant with these requirements, see Antenna interfaces.

4.2 Approved antenna designs

JODY-W2 modules come with a pre-certified design that can be used to save costs and time during the certification process. To minimize this effort, the customer is required to implement antenna layout according to u-blox antenna reference designs. Reference design source files can be provided on request by u-blox.[3]

For Bluetooth and Wi-Fi operation, the module has been tested and approved for use with the antennas listed in the JODY-W2 approved antennas. The module may be integrated with other antennas. In this case, the OEM installer must certify his design with respective regulatory agencies.

4.3 Approved antennas

The antenna should be installed and operated with minimum distance of 20 cm between the radiator and nearby persons.

See Antenna Gain for limits by band

Antenna(s) approved for Wi-Fi

Brand	Model	Type	Antenna Gain in 2.4 GHz band	Antenna Gain in 5 GHz band
Pulse	W3006	Chip	2.2dBi	5.2dBi

Table 5: Antennas approved for Wi-Fi

Antenna(s) approved for Bluetooth

Brand	Model	Type	Antenna Gain in 2.4 GHz band	Antenna Gain in 5 GHz band
Pulse	W3006	Chip	2.2dBi	5.2dBi

Table 6: Antennas approved for Bluetooth

3. Reference design will be available after certification.

4.3 Other remarks

4.3.1 Unused pins

☞ JODY-W2 modules have pins that are reserved for future use (NC). These pins must be left unconnected on the application board.

4.3.2 GPIO usage

☞ The reconfiguration of signals marked as GPIOs on the JODY-W2 module for applications not listed in this document depends on the respective firmware release.

5 Design-in

5.1 Overview

For an optimal integration of JODY-W2 series modules in the final application board, it is advisable to follow the design guidelines described in this chapter. Every application circuit must be properly designed to ensure that the related interface functions correctly, but several specific points require special attention during the design of the application device.

The following list provides a rank of importance in the application design, starting from the highest relevance:

- Module antenna connection: ANT0 and ANT1 pins.

  Antenna circuit affects the RF compliance of the device integrating JODY-W2 modules with applicable certification schemes. For schematic and layout design recommendations, see also Antenna interfaces.

- Module supply: VBAT, VIO/1V8, and GND pins.

  The supply circuit affects the RF compliance of the device integrating JODY-W2 modules with applicable certification schemes. Follow the General high-speed layout guidelines.

- High speed interfaces: SDIO pins.

  High speed interfaces can be a source of radiated noise and can affect the compliance with regulatory standards for radiated emissions. Follow the General high-speed layout guidelines and recommendations for the SDIO 3.0 interface.

- System functions: PDn and pins described as Configuration pins.

  Accurate design is required to ensure that the voltage level is well defined during module boot. Follow the General high-speed layout guidelines.

- Other pins: High speed UART, PCM, specific signals and NC pins.

Accurate design is required to ensure proper functionality. Follow the General high-speed layout guidelines and recommendations for the High-speed UART interface.

5.2 Antenna Interfaces

JODY-W2 modules provide the following two RF interfaces for connecting the external antennas:

- The **ANT0** port for Bluetooth connectivity.
- The **ANT1** port for Wi-Fi connectivity.

Both the **ANT0** and the **ANT1** ports have a nominal characteristic impedance of 50 Ω and must be connected to the related antenna through a 50 Ω transmission line to allow proper impedance matching along the RF path. A bad termination of the **ANT0** pin (Bluetooth) or the **ANT1** pin (Wi-Fi) may result in poor performance of the module.

For the dual antenna modules, the isolation between the two antennas should be maximized, the requirements specified in Table 7 and Table 8 should be followed to ensure good performance.

⚠ According to FCC regulations, the transmission line from the antenna pin in the module to the antenna or antenna connector on the host PCB is considered part of the approved antenna design. Consequently, module integrators must either follow exactly one of the antenna reference designs used in the module's FCC type approval or certify their own designs. See also the antenna reference design.

5.2.1 RF Transmission Line Design

RF transmission lines such as the ones from the **ANT0** and **ANT1** pins up to the related antenna connectors must be designed so that the characteristic impedance is as close as possible to 50 Ω illustrates the design options and the main parameters to be considered when implementing a transmission line on a PCB:

- Microstrip: track coupled to a single ground plane, separated by dielectric material),
- Coplanar microstrip: track coupled to ground plane and side conductors, separated by dielectric material).
- Stripline: track sandwiched between two parallel ground planes, separated by dielectric material).

The coplanar microstrip is the most common configuration for a printed circuit board (PCB).

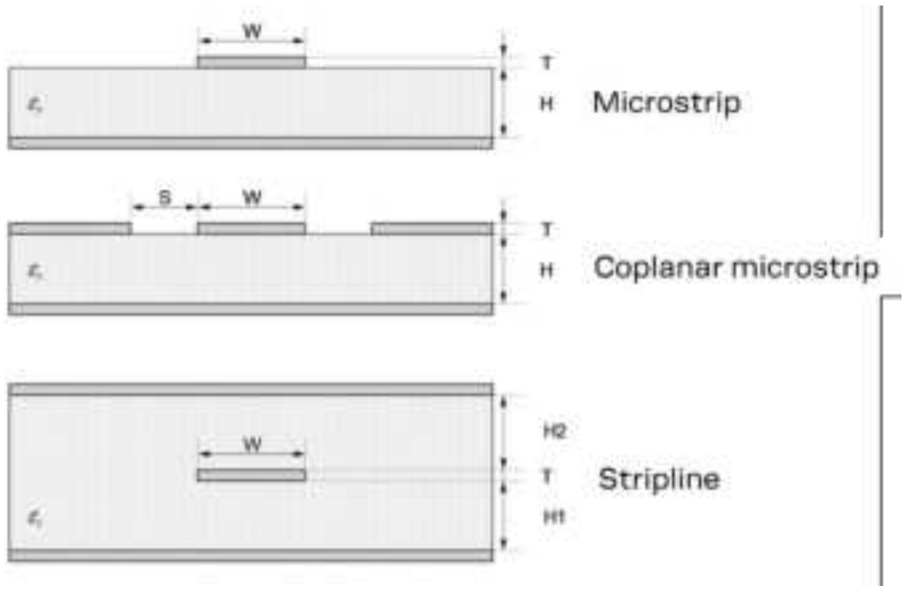

Figure 1: Transmission line trace design

To properly design a 50 Ω transmission line, the following remarks should be considered:

- The designer should provide enough clearance from surrounding traces and ground in the same layer; in general, a trace to ground clearance of at least two times the trace width should be considered, and the transmission line should be "guarded" by ground plane area on each side.
- The characteristic impedance can be calculated as first iteration using tools provided by the layout software. It is advisable to ask the PCB manufacturer to provide the final values that are usually calculated using dedicated software and available stack-ups from production. It could also be possible to request an impedance coupon on panel's side to measure the real impedance of the traces.
- FR-4 dielectric material, although its high losses at high frequencies can be considered in RF designs providing that:
  - RF trace length must be minimized to reduce dielectric losses.
  - If traces longer than a few centimeters are needed, it is recommended to use a coaxial connector and cable to reduce losses.
  - Stack-up should allow for wide 50 Ω traces and at least 200 µm trace width is recommended to assure good impedance control over the PCB manufacturing process.
  - FR-4 material exhibits poor thickness stability and thus less control of impedance over the trace length. Contact the PCB manufacturer for specific tolerance of controlled impedance traces.

- For PCBs using components larger than 0402 and dielectric thickness below 200 µm, it is recommended to add a keep-out (that is, clearance, a void area) on the ground reference layer below any pin present on the RF transmission lines to reduce parasitic capacitance to ground.
- The transmission lines width and spacing to GND must be uniform and routed as smoothly as possible: route RF lines in 45° angle.
- Add GND stitching vias around transmission lines as shown in Figure 2.
- Ensure solid metal connection of the adjacent metal layer on the PCB stack-up to main ground layer, providing enough vias on the adjacent metal layer as shown in Figure 2.
- Route RF transmission lines far from any noise source (as switching supplies and digital lines) and from any sensitive circuit to avoid crosstalk between RF traces and Hi-impedance or analog signals.
- Avoid stubs on the transmission lines, any component on the transmission line should be placed with the connected pin over the trace. Also avoid any unnecessary component on RF traces.

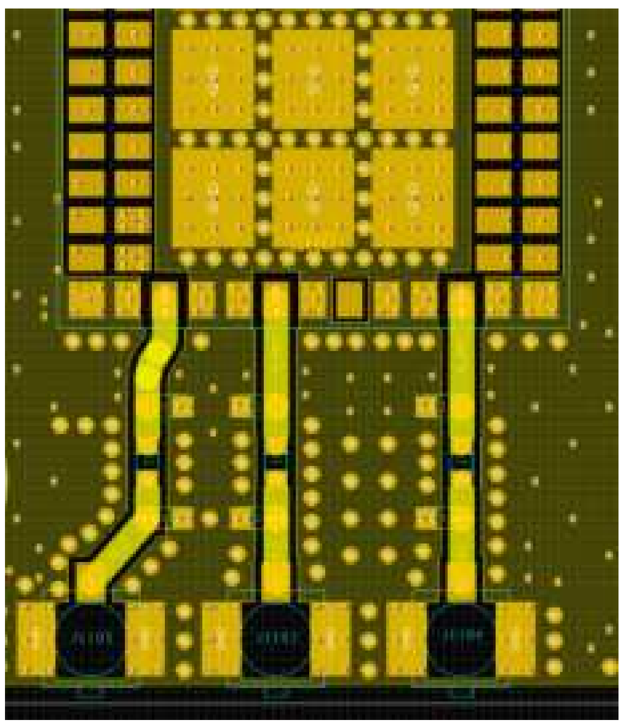

Figure 2: Example of RF trace and ground design from JODY-W2 EVK

5.2.2 Antenna Design

Designers must take care of the antennas from all perspective at the very start of the design phase when the physical dimensions of the application board are under analysis/decision, since the RF compliance of the device integrating JODY-W2 module with all the applicable required certification schemes heavily depends on antennas radiating performance.

- External antennas such as linear monopole:
    - External antennas basically do not imply physical restriction to the design of the PCB where the module is mounted.
    - The radiation performance mainly depends on the antennas. It is required to select antennas with optimal radiating performance in the operating bands.
    - RF cables should be carefully selected with minimum insertion losses. Additional insertion loss will be introduced by low quality or long cable. Large insertion loss reduces radiation performance.
    - A high quality 50 Ω coaxial connector provides proper PCB-to-RF-cable transition.
- Integrated antennas such as patch-like antennas:
    - Internal integrated antennas imply physical restriction to the PCB design:
        - Integrated antenna excites RF currents on its counterpoise, typically the PCB ground plane of the device that becomes part of the antenna; its dimension defines the minimum frequency that can be radiated. Therefore, the ground plane can be reduced down to a minimum size that should be similar to the quarter of the wavelength of the minimum frequency that has to be radiated, given that the orientation of the ground plane related to the antenna element must be considered.
        - The RF isolation between antennas in the system must be as high as possible and the correlation between the 3D radiation patterns of the two antennas has to be as low as possible.
        - In general, an RF separation of at least a quarter wavelength between the two antennas is required to achieve a minimum isolation and low pattern correlation; increased separation should be considered, if possible, to maximize the performance and fulfil the requirements in Table 8.

    - A numerical example for estimating the physical restrictions on a PCB is given here: Frequency = 2.4 GHz → Wavelength = 12.5 cm → Quarter wavelength = 3.5 cm
  - Radiation performance depends on the whole product and antenna system design, including product mechanical design and usage. Antennas should be selected with optimal radiating performance in the operating bands according to the mechanical specifications of the PCB and the whole product.

Table 7 summarizes the requirements for the antenna RF interface while Table 8 specifies additional requirements for dual antenna design implementation.

Item	Requirements	Remarks
Impedance	50 Ω nominal characteristic impedance	The impedance of the antenna RF connection must match the 50 Ω impedance of 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, refers to the amount of reflected power, measuring how well the primary antenna RF connection matches the 50 Ω characteristic impedance of antenna pins. The impedance of the antenna termination must match as much as possible the 50 Ω nominal impedance of antenna pins over the operating frequency range, to maximize the amount of power transferred to the antenna.
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		The maximum antenna gain must not exceed the value specified in type approval documentation to comply with regulatory agencies radiation exposure limits.

Table 7: Summary of antenna interface requirements

Item	Requirements	Remarks
Isolation (in-band)	S21 > 30 dB recommended	The antenna-to-antenna isolation is the S21 parameter between the two antennas in the band of operation. Lower isolation might be acceptable depending on use-case scenario and performance requirements.
Isolation (out-of-band)	S21 > 35 dB recommended S21 > 30 dB acceptable	Out-of-band isolation is evaluated in the band of the aggressor to ensure that the transmitting signal from the other radio is sufficiently attenuated by the receiving antenna to avoid saturation and intermodulation effect at the receiver's port.

Table 8: Summary of Wi-Fi/Bluetooth coexistence requirements

⚠ In dual antenna configuration, a good isolation is critical to achieve optimal throughput performance in Wi-Fi/Bluetooth coexistence mode while operating in the same 2.4 GHz band. In both the cases, while selecting external or internal antennas, observe the following recommendations:

- Select antennas that provide an optimal return loss (or VSWR) over all operating frequencies.
- Select antennas that provide optimal efficiency figure over all operating frequencies.
- Select antennas that provide appropriate gain not to exceed the regulatory limits specified in some countries like the FCC in the United States.

A method to design for antenna micro-strip evaluation is to place an U.FL connector close to the embedded PCB or chip Antenna. The UFL connector needs only to be mounted on units used for verification.

5.2.2.1 RF Connector Design

If an external antenna is required, the designer should consider using a proper RF connector. It is the responsibility of the designer to verify the compatibility between plugs and receptacles used in the design.

Table 9 suggests some RF connector plugs that can be used by the designers to connect RF coaxial cables based on the declaration of the respective manufacturers. The Hirose U.FL-R-SMT RF receptacles (or similar parts) require a suitable mated RF plug from the same connector series. Due to wide usage of this connector, several manufacturers offer compatible equivalents.

Manufacturer	Series	Remarks
Hirose	U.FL® Ultra Small Surface Mount Coaxial Connector	Recommended
I-PEX	MHF® Micro Coaxial Connector	
Tyco	UMCC® Ultra-Miniature Coax Connector	
Amphenol RF	AMC® Amphenol Micro Coaxial	
Lighthorse Technologies, Inc.	IPX ultra micro-miniature RF connector	

Table 9: U.FL compatible plug connector

Typically, the RF plug is available as a cable assembly. Different types of cable assembly are available; the user should select the cable assembly best suited to the application. The key characteristics are:

- RF plug type: select U.FL or equivalent
- Nominal impedance: 50 Ω
- Cable thickness: Typically, from 0.8 mm to 1.37 mm. Thicker cables minimize insertion loss.
- Cable length: Standard length is typically 100 mm or 200 mm; custom lengths may be available on request. Select shorter cables to minimize insertion loss.
- RF connector on the other side of the cable: for example, another U.FL (for board-to-board connection) or SMA (for panel mounting)

SMT connectors are typically rated for a limited number of insertion cycles. In addition, the RF coaxial cable may be relatively fragile compared to other types of cables. To increase application ruggedness, connect U.FL connector to a more robust connector such as SMA fixed on panel.

☞ A de-facto standard for SMA connectors implies the usage of reverse polarity connectors (RP-SMA) on end-user accessible Wi-Fi and Bluetooth interfaces to increase the difficulty to replace the antenna with higher gain versions and exceed regulatory limits.

The following recommendations apply for proper layout of the connector:

- Strictly follow the connector manufacturer's recommended layout. Some examples are provided below:
    - SMA Pin-Through-Hole connectors require GND keep-out (clearance or void area) on all the layers around the central pin up to annular pins of the four GND posts.
    - U.FL surface mounted connectors require no conductive traces (that is, clearance, a void area) in the area below the connector between the GND land pins.
- If the RF pin size on the connector is wider than the microstrip, remove the GND layer beneath the RF connector to minimize the stray capacitance thus keeping the RF line 50 Ω. For example, the active pin of U.FL connector must have a GND keep-out at least on the first inner layer to reduce parasitic capacitance to ground.

5.2.2.2 Integrated Antenna Design

If integrated antennas are used, the transmission line is terminated by the antennas themselves. Follow the guidelines mentioned below:

- The antenna design process should start together with the mechanical design of the product. PCB mock-ups are useful in estimating overall efficiency and radiation path of the intended design during early development stages.
- Use antennas designed by an antenna manufacturer providing the best possible return loss (or VSWR).
- Provide a ground plane large enough according to the related integrated antenna requirements. The ground plane of the application PCB may be reduced down to a minimum size that must be similar to one quarter of wavelength of the minimum frequency that has to be radiated, however overall antenna efficiency may benefit from larger ground planes. Proper placement of the antenna and its surroundings is also critical for antenna performance. Avoid placing the antenna close to conductive or RF-absorbing parts such as metal objects or ferrite sheets as they may absorb part of the radiated power, shift the resonant frequency of the antenna or affect the antenna radiation pattern.
- It is highly recommended to strictly follow the specific guidelines provided by the antenna manufacturer regarding correct installation and deployment of the antenna system, including PCB layout and matching circuitry.
- Further to the custom PCB and product restrictions, antennas may require tuning/matching to reach the target performance. It is recommended to plan measurement and validation activities with the antenna manufacturer before releasing the end-product to manufacturing.
- The receiver section may be affected by noise sources like hi-speed digital busses. Avoid placing the antenna close to busses as DDR or consider taking specific countermeasures like metal shields or ferrite sheets to reduce the interference.

Take care of interaction between co-located RF systems like LTE sidebands on 2.4 GHz band. Transmitted power may interact or disturb the performance of JODY-W2 modules where specific LTE filter is not present.

6 Antenna Reference Design

6.1 Scope

This document defines the essential specifications necessary to implement the JODY-W2 antenna reference designs as used in certification. It is part of the equipment certification application issued to FCC and ISED. The information contained herein and its references should be sufficient to guide a skilled person to implement the design on a host carrier. It will provide the designer with PCB layout details and expected performance specifications.

This document supports a connector-based design for the use of external antennas (one for each antenna pin of the module).

6.2 General description and requirements

JODY-W2 series modules provide two RF interfaces for connecting external antennas. The antenna ports ANT0 and ANT1 have a nominal characteristic impedance of 50 Ω and must be connected to the related antenna through a 50 Ω transmission line to allow proper impedance matching along the RF path. A bad termination of the pin may result in poor performance or even damage the RF section of the module.

For optimal performance in multiradio mode, the isolation between the antennas shall target the requirements as specified in Table 10 and Table 11 in order to ensure good performance.

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, refers to the amount of reflected power, measuring how well the primary antenna RF connection matches the 50 Ω characteristic impedance of antenna pins. The impedance of the antenna termination must match as much as possible the 50 Ω nominal impedance of antenna pins over the operating frequency range, to maximize the amount of power transferred to the antenna.
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		The maximum antenna gain must not exceed the value specified in type approval documentation to comply with regulatory agencies radiation exposure limits.

Table 10: Summary of antenna interface requirements

Item	Requirements	Remarks
Isolation (in-band)	S21 > 25 dB recommended S21 > 20 dB acceptable	The antenna to antenna isolation is the S_{21} parameter between the two antennas in the band of operation.
Isolation (out-of-band)	S21 > 35 dB recommended S21 > 30 dB acceptable	Out-of-band isolation is evaluated in the band of the aggressor to ensure that the transmitting signal from the other radio is sufficiently attenuated by the receiving antenna to avoid saturation and intermodulation effect at the receiver's 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. A low ECC parameter is fundamental to improve performance in MIMO-based systems.

Table 11: Summary of MIMO and Wi-Fi/Bluetooth coexistence requirements. MIMO is not applicable for JODY-W2.

6.3 Reference design of RF path

JODY-W2 is certified with a set-up including JODY-W2 module board with it's RF paths connected to the carrier board with RF coaxial cables. The antennas are connected to the carrier board through SMA connectors. Below are the relevant components listed.

- Module board including U.FL connectors with JODY-W2 mounted.
- Carrier board including U.FL connectors to interface the module board and SMA connectors to connect antennas.
- Coaxial cables with U.FL connectors connecting the module board's RF traces to the carrier board's RF traces.
- Antennas connected to the carrier board's SMA connectors.

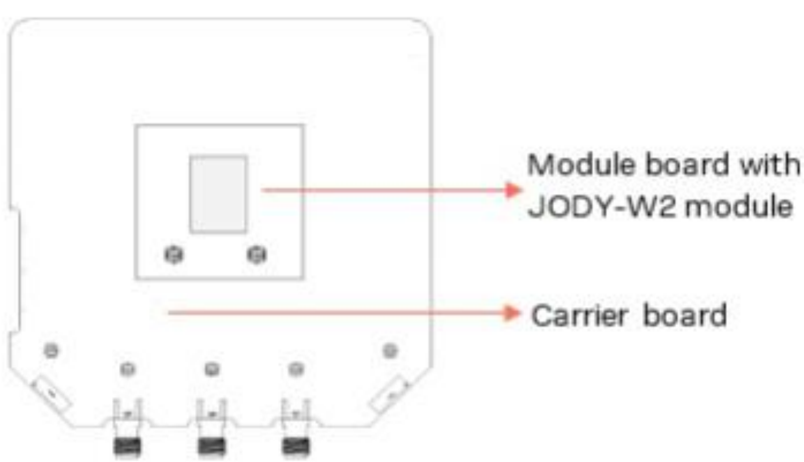

Figure 3: Definition of Module board and Carrier board

Figure 4: Test set-up

3.1 RF trace PCB routing

The PCB routing connecting the module's antenna pins to module board U.FL connectors are designed with coplanar microstrips. Coplanar microstrips are also used on the carrier board connecting the U.FL connectors with the SMA connectors to which the external antennas or test equipment are connected. Figure 5 and Table 12 shows the design stack-up including dimensions of the 50 Ω coplanar microstrips implemented.

Regarding the coplanar microstrips the ground planes beside the signal trace are connected to the inner layer ground plane using vias. The vias are placed with a maximum distance of 0.5 mm to the coplanar ground edge and a maximum pitch of 2 mm. The top layer is coated with generic LPI solder stop mask.

The SMA connectors on the carrier board are used for mounting antennas. For Bluetooth and Wi-Fi operation in the 2.4 GHz band and Wi-Fi operation in the 5 GHz band, the module has been tested and approved for use with antennas up to 2 dBi antenna gain.

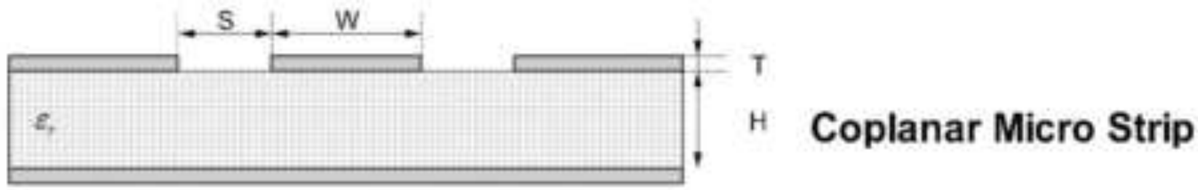

Figure 5: Coplanar micro-strip dimension specification

Item	Value
S	200 µm
W	700 µm
T	35 µm
H	800 µm
ε_r	4.3

Table 12: Coplanar micro-strip specification

The mechanical dimensions of the module board's microstrips and position of the pi network impedance matching components are shown in Figure 6. Figure 7 shows the components used for the PI network impedance matching. Here only series 0 ohm resistors are used. The inner layers have the same dimensions and are filled with ground. No RF traces are routed in these layers.

The antenna ports shown in Figure 4 on the right hand side are from top to bottom: **ANT1**, **ANT0**, and **ANT2**. **ANT2** is not used and shall be left unconnected.

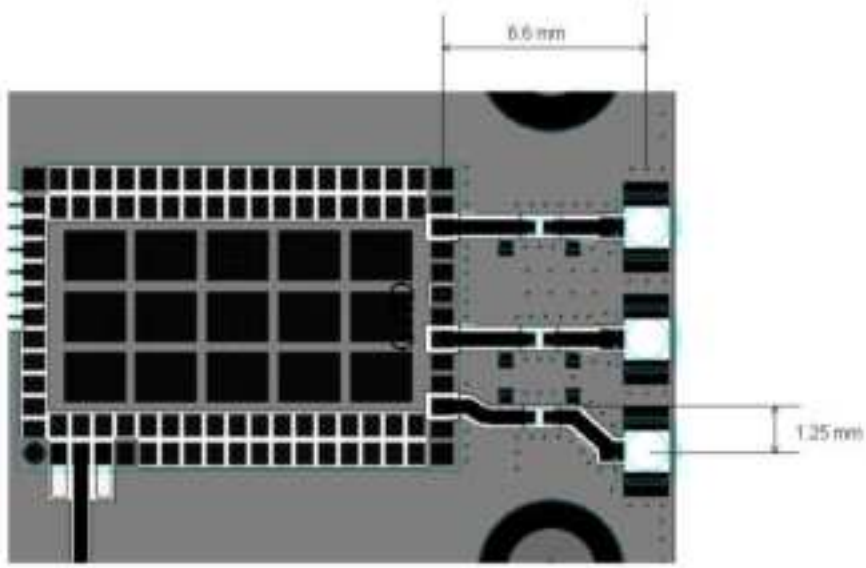

Figure 6: Module board Antenna micro strip implementation

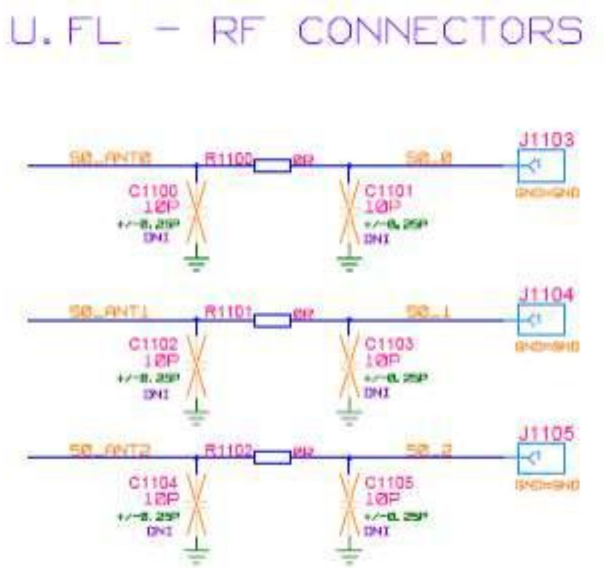

Figure 7: Component selection for RF matching network on module board using 0 ohm series resistor

The carrier board RF traces includes pi network matching components and are routed as coplanar microstrips. Here 10 pF capacitors in series are implemented.

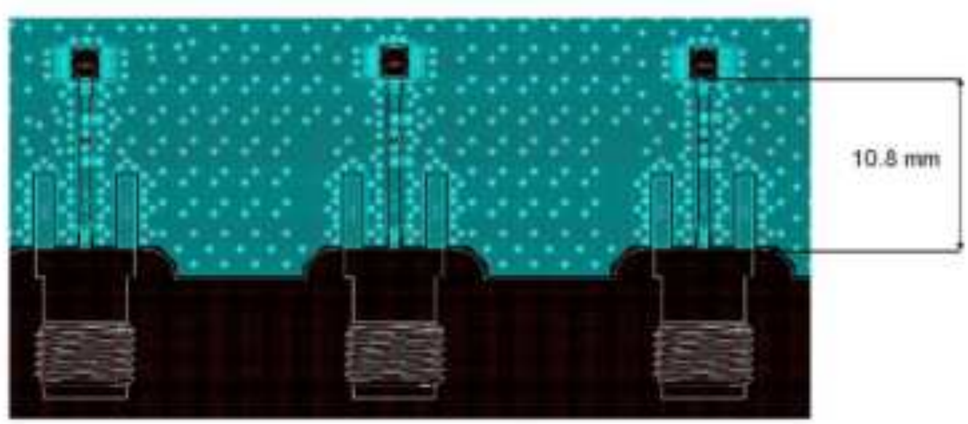

Figure 8: Carrier board Antenna micro strip implementation

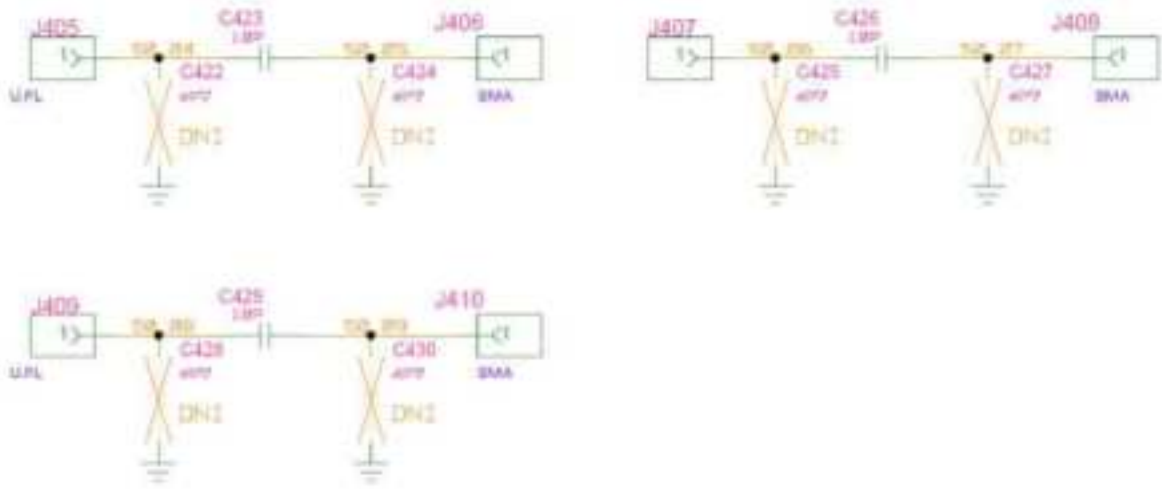

Figure 9: Component selection for RF matching network on carrier board using 10 pF series capacitors.

6.4 Parts

Part	Description	Outline
Evaluation board (EVB)	Evaluation board for JODY-W263 series modules. The board includes SMA antenna connectors that connect to external antennas for Wi-Fi and Bluetooth. It has two internal dual-band Wi-Fi/Bluetooth antennas.	
Internal Antennas (2)	2 x dual band Wi-Fi/Bluetooth antenna, Pulse W3006	
Coax RF cable	U.FL-2LP(V)-04N1-A-(40)	

7 Label and Compliance Information

7.1 Label requirements

7.1.1 United States (FCC)

This section contains the FCC compliance information for the JODY-W263-00B series modules.

Model	ISED certification number
JODY-W263-00B	28505-JODYW263FSS

7.1.2 FCC Compliance statement

JODY-W263 module has modular approval and complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

⚠ Any changes or modifications NOT explicitly APPROVED could cause the JODY-W263 module to cease to comply with FCC rules part 15 thus void the user's authority to operate the equipment.

The internal / external antenna(s) used for this module must provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

In accordance with 47 CFR § 15.19, the end product into which this module is integrated shall bear the following statement in a conspicuous location on the device:

“This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.”

When the end-product is so small or for such use that it is not practical to place the above statement on it, the information shall be placed in a prominent location in the instruction manual or pamphlet supplied to the user or on the container in which the device is marketed. However, the FCC ID label must be displayed on the device.

If the end-product will be installed in locations where the end-user is not able to see the FCC ID and/or this statement, the FCC ID and the statement shall also be included in the end-product manual.

☞ The outside of final products containing the JODY-W2 module must display in a user accessible area a label referring to the enclosed module. This exterior label can use wording such as the following: “Contains Transmitter Module FCC ID: 2A6QA-JODYW263FSS” or “Contains FCC ID: 2A6QA-JODYW263FSS”.

7.1.3 Canada (ISED)

JODY-W2 series module are certified for use in accordance with the Canada Innovation, Science and Economic Development Canada (ISED) Radio Standards Specification (RSS) RSS-247 Issue 2 and RSSGen. Below is the list of the ISED IDs allocated to JODY-W263 module.

Model	ISED certification number
JODY-W263-00B	28505-JODYW263FSS

7.1.4 ISED compliance statement

JODY-W263-00B module complies with ISED (Innovation, Science and Economic Development Canada) license-exempt RSSs. Operation is subject to the following two conditions:

1. This device may not cause interference, and

2. This device must accept any interference, including interference that may cause undesired operation of the device.

☞ Any notification to the end user of installation or removal instructions about the integrated radio module is NOT allowed. Unauthorized modification could void authority to use this equipment.

This equipment complies with ISED RSS-102 radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20 cm between the radiator and your body.

This radio transmitter IC: 28505-JODYW263FSS has been approved by ISED to operate with the antenna types listed below with the maximum permissible gain indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

☞ Operation in the band 5150–5250 MHz is only for indoor use to reduce the potential for harmful interference to co-channel mobile satellite systems;

☞ Operation in the 5600-5650 MHz band is not allowed in Canada. High-power radars are allocated as primary users (i.e., priority users) of the bands 5250-5350 MHz and 5650-5850 MHz and that these radars could cause interference and/or damage to LE-LAN devices.

The ISED certification label of a module shall be clearly visible at all times when installed in the host device; otherwise, the host device must be labeled to display the ISED certification number for the module, preceded by the words “Contains transmitter module”, or the word “Contains”, or similar wording expressing the same meaning, as follows: “Contains transmitter module IC: 28505-JODYW263FSS”.

Le présent appareil est conforme aux CNR d'ISED applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:

(1) l'appareil ne doit pas produire de brouillage, et

(2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Cet équipement est conforme aux limites d'exposition de rayonnement d'ISED RSS-102 déterminées pour un environnement non contrôlé. Cet équipement devrait être installé et actionné avec la distance minimum 20 cm entre le radiateur et votre corps.

Cet émetteur radio, IC: 8595A-JODYW263 été approuvé par ISED pour fonctionner avec les types d'antenne énumérés ci-dessous avec le gain maximum autorisé et l'impédance nécessaire pour chaque type d'antenne indiqué. Les types d'antenne ne figurant pas dans cette liste et ayant un gain supérieur au gain maximum indiqué pour ce type-là sont strictement interdits d'utilisation avec cet appareil.

☞ Le dispositif de fonctionnement dans la bande 5150-5250 MHz est réservé à une utilisation en intérieur pour réduire le risque d'interférences nuisibles à la co-canal systèmes mobiles par satellite

☞ Opération dans la bande 5600-5650 MHz n'est pas autorisée au Canada. Haute puissance radars sont désignés comme utilisateurs principaux (c.-àutilisateurs prioritaires) des bandes 5250-5350 MHz et 5650-5850 MHz et que ces radars pourraient causer des interférences et / ou des dommages à dispositifs LAN-EL.

L'étiquette d'homologation d'ISED d'un module donné doit être posée sur l'appareil hôte à un endroit bien en vue en tout temps. En l'absence d'étiquette, l'appareil hôte doit porter une étiquette sur laquelle figure le numéro d'homologation du module d'ISED, précédé des mots « Contient un module d'émission », ou du mot « Contient », ou d'une formulation similaire allant dans le même sens et qui va comme suit: « Contient le module d'émission IC: 28505-JODYW263FSS ».

This radio transmitter IC: 28505-JODYW263FSS has been approved by ISED to operate with the antenna types listed below with the maximum permissible gain indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Le présent émetteur radio IC: 28505-JODYW263FSS a été approuvé par ISED pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal. Les types d'antenne non inclus dans cette liste, et dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

The internal / external antenna(s) used for this module must provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

☞ The approval type for all JODY-W2 series variants is a single modular approval. Due to ISED Modular Approval Requirements (Source: RSP-100 Issue 10), any application which includes the module must be approved by the module manufacturer (u-blox). The application manufacturer must provide design data for the review procedure.

8 Product Testing

8.1 u-blox in-line production testing

As part of our focus on high quality products, u-blox maintain stringent quality controls throughout the production process. This means that all units in our manufacturing facilities are fully tested and that any identified defects are carefully analyzed to improve future production quality. The Automatic test equipment (ATE) deployed in u-blox production lines logs all production and measurement data – from which a detailed test report for each unit can be generated. Figure 1 shows the ATE typically used during u-blox production. u-blox in-line production testing includes:

- Digital self-tests (firmware download, MAC address programming)
- Measurement of voltages and currents
- Functional tests (host interface communication)
- Digital I/O tests
- Measurement and calibration of RF characteristics in all supported bands, including RSSI calibration, frequency tuning of reference clock, calibration of transmitter power levels, etc.
- Verification of Wi-Fi and Bluetooth RF characteristics after calibration, like modulation accuracy, power levels, and spectrum, are checked to ensure that all characteristics are within tolerance when the calibration parameters are applied.

Figure 10: Automatic test equipment for module test

8.2 OEM manufacturer production test

As all u-blox products undergo thorough in-series production testing prior to delivery, OEM manufacturers do not need to repeat any firmware tests or measurements that might otherwise be necessary to confirm RF performance. Testing over analog and digital interfaces is also unnecessary during an OEM production test.

OEM manufacturer testing should ideally focus on:

- Module assembly on the device; it should be verified that:
    - Soldering and handling process did not damage the module components
    - All module pins are well soldered on application board
    - There are no short circuits between pins
- Component assembly on the device; it should be verified that:
    - Communication with host controller can be established
    - The interfaces between module and device are working
    - Overall RF performance test of the device including antenna

In addition to this testing, OEMs can also perform other dedicated tests to check the device. For example, the measurement of module current consumption in a specified operating state can identify a short circuit if the test result deviates that from that taken against a “Golden Device”. The standard operational module firmware and test software on the host can be used to perform functional tests (communication with the host controller, check interfaces) and perform basic RF performance testing. Special manufacturing firmware can also be used to perform more advanced RF performance tests.

8.2.1 “Go/No go” tests for integrated devices

A “Go/No go” test compares the signal quality of the Device under Test (DUT) with that of “Golden Device” in a location with a known signal quality. This test can be performed after establishing a connection with an external device. A very simple test can be performed by just scanning for a known Bluetooth low energy device and checking that the signal level (Received Signal Strength Indicator (RSSI) is acceptable.

☞ Tests of this kind may be useful as a “go/no go” test but are not appropriate for RF performance measurements.

Go/No go tests are suitable for checking communication between the host controller and the power supply. The tests can also confirm that all components on the DUT are well soldered. A basic RF functional test of the device that includes the antenna can be performed with standard Bluetooth low energy devices configured as remote stations. In this scenario, the device containing JODY-W2 and the antennas should be arranged in a fixed position inside an RF shield box. The shielding prevents interference from other possible radio devices to ensure stable test results.

9 Information on test modes and additional test

For end host implementation the user must refer to the manufacturer integration manual to implement software/firmware that can be used to manipulate the module configuration and put it into to special test modes, set and verify regional power limits and any debugging required.

10 Additional test requirements

Foresight Sports warrants that the modular transmitter fulfills the FCC/ISED regulations when operating in authorized modes on any host product given that the integrator follows the instructions as described in this document.

⚠ The modular transmitter approval of JODY-W263, or any other radio module, does not exempt the end product from being evaluated against applicable regulatory demands.

The evaluation of the end product shall be performed with the JODY-W263 module installed and operating in a way that reflects the intended end product use case. The upper frequency measurement range of the end product evaluation is the 10th harmonic of 5.8 GHz as described in KDB 996369 D04.

The following requirements apply to all products that integrate a radio module:

- Subpart B - UNINTENTIONAL RADIATORS
  To verify that the composite device of host and module comply with the requirements of FCC part 15B, the integrator shall perform sufficient measurements using ANSI 63.4-2014.
- Subpart C - INTENTIONAL RADIATORS
  To validate that the fundamental and out of band emissions of the transmitter part of the composite device complies with the requirements of FCC part 15C, it is required that the integrator carries out sufficient verification measurements using ANSI 63.10-2013.

Revisions

Revision	Description	Date	Author
01	Initial Release	19 May 2022	P. Hicks
02	Changed section 4 from Approved antennas to Antenna interfaces, Added section 5 Design-in, Added section 6 Antenna reference design, added section 8 Production testing, Label and compliance information is now section 7, Information on test modes and additional test is now section 9, additional test requirements is now section 10.	08 Sep 2022	P. Hicks