

RN938V

User Manual



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Due to the nature of wireless communications, transmission and reception of data can never be guaranteed. Data may be delayed, corrupted (i.e., have errors) or be totally lost. Although significant delays or losses of data are rare when wireless devices such as the Rolling Wireless modem are used in a normal manner with a well-constructed network, the Rolling Wireless modem should not be used in situations where failure to transmit or receive data could result in damage of any kind to the user or any other party, including but not limited to personal injury, death, or loss of property. Rolling Wireless accepts no responsibility for damages of any kind resulting from delays or errors in data transmitted or received using the Rolling Wireless modem, or for failure of the Rolling Wireless modem to transmit or receive such data.

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Do not operate the Rolling Wireless modem in areas where cellular modems are not advised without proper device certifications. These areas include environments where cellular radio can interfere such as explosive atmospheres, medical equipment, or any other equipment which may be susceptible to any form of radio interference. The Rolling Wireless modem can transmit signals that could interfere with this equipment. Do not operate the Rolling Wireless modem in any aircraft, whether the aircraft is on the ground or in flight. In aircraft, the Rolling Wireless modem **MUST BE POWERED OFF**. When operating, the Rolling Wireless modem can transmit signals that could interfere with various onboard systems.

NOTE: Some airlines may permit the use of cellular phones while the aircraft is on the ground and the door is open. Rolling Wireless modems may be used at this time.

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1 Introduction

1.1 Modem Features

- Legacy radio access technologies – 4G LTE, 3G (HSDPA, HSUPA, HSPA+, and DC-HSPA+ / WCDMA)
- 5G NR Sub-6 3GPP R16 NSA/SA FDD/TDD¹
- 5G NR Option 2 for SA and Option 3/3x for NSA EN-DC
- Dynamic Spectrum Sharing (DSS) –5G NR and LTE FDD bands
- PAN eCall / ERA-Glonass
- Emergency calls (E911/E112) over LTE/NR
- VoLTE and VoNR
- SMS over IMS (LTE or NR) / SGs
- Up to 12 PDN support, 4/12 can support IPA
- Support embedded Data calls or USB tethering data calls with IPv4 and IPv6 dual stack
- SIM application tool kit with proactive SIM commands
- Traditional modem COM port support for AT commands
- Power saving modes for minimum idle power draw
- MF-GNSS (L1)
- Concurrent GNSS constellations: GPS, GLONASS, Galileo, Beidou, QZSS
- Assisted GNSS: GPS OneXtra, SUPL and A-GPS via Control Plane (US e911)

NOTE: FDD NSA EN-DC is not supported.

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2 Technical Specifications

2.1 Input/output Power Supplies

Table 2-1 *Input Power Supplies Requirements*

SPECIFICATION	MIN	TYP	MAX	UNIT
Voltage range	3.4	4.0	4.2	V

2.2 Environmental

The RN93xx module complies with the environmental specifications in [Table 2-2](#). Final product conformance to these specifications depends on the OEM device implementation.

Table 2-2 *Environmental Specifications*

PARAMETER	MODE	DETAILS
Operating Temperature	-40°C to +85°C	

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2.3 GNSS

2.3.1 GNSS Application

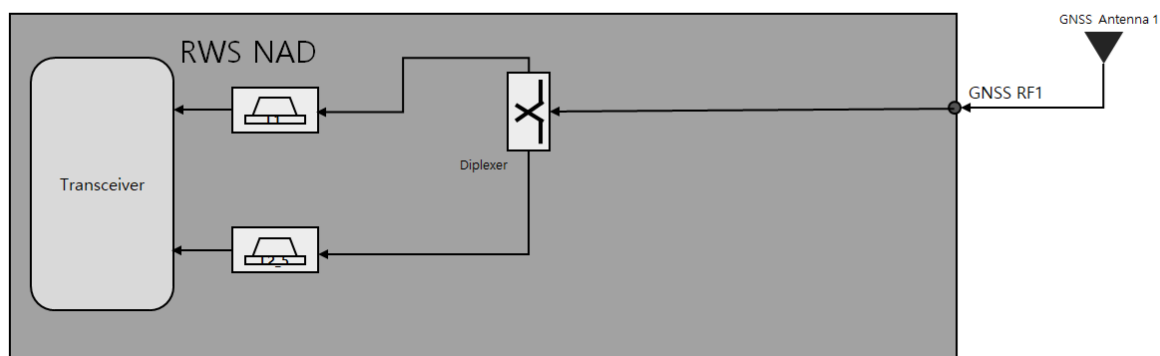


Figure 2-1 RN93V GNSS Block Diagram

2.3.2 Recommended GNSS Antenna Specifications

Table 2-3 GNSS Active Antenna Requirements (RN938V)

PARAMETER	REQUIREMENTS
Frequency range	GPS L1/ BDS B1/GLO G1/GALE1: 1559 MHz to 1610MHz (~50 MHz)
Isolation between GNSS and Ant1	> 15 dB in all uplink bands
Maximum Voltage applied to the antenna	30 Volts
Antenna System Gain from ELNA Input to Module Antenna Pad (Antenna + LNA + Cable + Attenuation Network)	15-18 dB
VSWR	$\leq 2:1$

Table 2-4 GNSS Pre-SAW Rejection Requirements

SAW FILTER REJECTION REQUIREMENTS		NOTES
777MHz-798MHz	>50dB	65dB required if B13 exists ¹
814MHz-915MHz	>40dB	50dB is preferred

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SAW FILTER REJECTION REQUIREMENTS		NOTES
925MHz-960MHz	>30dB	50dB is preferred
1427MHz-1463MHz	>35dB	Ensure the out of band suppression is enough
1710MHz-1785MHz	>35dB	
1850MHz-1980MHz	>40dB	
2010MHz-2025MHz	>40dB	
2305MHz-2315MHz	>40dB	
2401MHz-2483MHz	>40dB	
2500MHz-2570MHz	>35dB	

1. The out of band rejection includes the prefilter (only needed if the B13 exists), the unbalanced SAW filter, and the external LNA.

2.4 Recommended WWAN Antenna Specifications

Table 2-5 Antenna Requirements¹

PARAMETER	REQUIREMENTS	COMMENTS
Antenna System	External multi-band antenna system (WWAN_ANT1/WWAN_ANT2/WWAN_ANT3/WWAN_ANT4)	
Operating Bands	All supporting Tx and Rx frequency bands.	
VSWR of Antennas	< 2:1	On all bands including band edges
Total Radiated Efficiency	> 50% on all bands.	Includes mismatch losses, losses in the matching circuit, and antenna losses, excluding cable loss. Rolling Wireless recommends using antenna efficiency as the primary parameter for evaluating the antenna system. Peak gain is not a good indication of antenna performance when integrated with a host device (the antenna does not provide omni-directional gain patterns). Peak gain can be affected by antenna size, location, design type, etc. — the antenna gains patterns remain fixed unless one or more of these parameters change.
Maximum Antenna Gain	Must not exceed antenna gains due to RF exposure and ERP/EIRP	Refer to the Important Compliance Information for the United States and Canada section.

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PARAMETER	REQUIREMENTS	COMMENTS
	limits, as listed in the module's FCC grant.	
Isolation	>15dB	If antennas can be moved, test all positions for both antennas. Make sure all other wireless devices (Bluetooth or WLAN antennas, etc.) are turned OFF to avoid interference.
Power Handling	>2W	Measure power endurance over 4 hours (estimated talk time) using a 2 W CW signal — set the CW test signal frequency to the middle of each supporting Tx band. Visually inspect the device to ensure there is no damage to the antenna structure and matching components. VSWR/TIS/TRP measurements taken before and after this test must show similar results.

1. These worst-case VSWR figures for the transmitter bands may not guarantee RSE levels to be within regulatory limits. RN93xx module alone meets all regulatory emissions limits when tested into a cabled (conducted) 50Ω system and radiated spurious emissions with the antenna in our development kit. The antenna system may need to be tuned in order to meet the RSE limits as the complex match between the module and antenna can cause unwanted levels of emissions. Tuning may include antenna pattern changes, phase/delay adjustment, and passive component matching. Examples of the application test limits would be included in FCC Part 22, Part 24 and Part 27, test case 4.2.2 for WCDMA (ETSI EN 301 908-1), where applicable.

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3 Routing Constraints and Recommendations

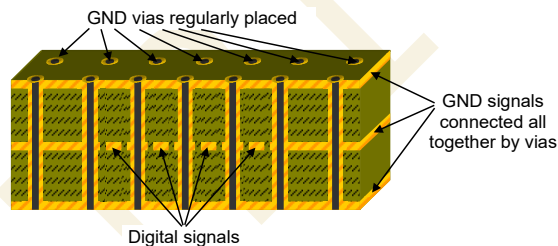
Layout and routing of the RN93xx device in the application are critical to maintaining the performance of the radio. The following sections provide guidance to the developer when designing their application to include an RN93xx device and achieve optimal system performance.

3.1 Digital Signals Recommendations

3.1.1 Routing on Inner Layers

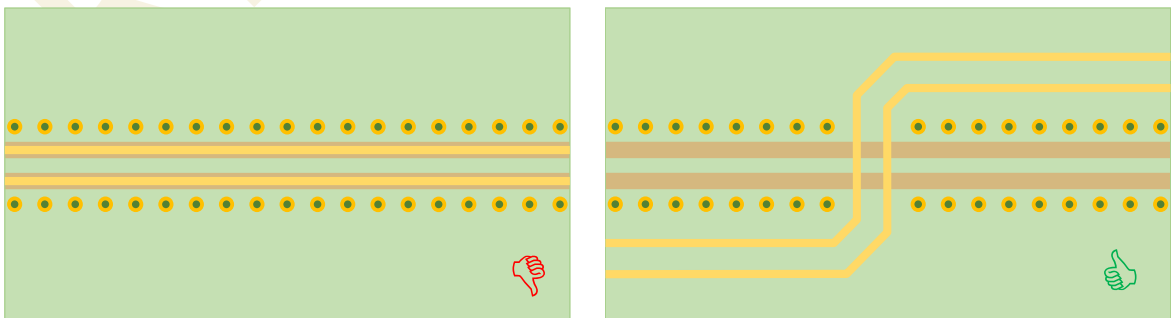
When routed in outer layers, digital signals can be a source of noise affecting highly sensitive receivers. They also can generate unwanted harmonic emissions (spurious) if subjected to an incident or reflected radiated waves from on-board antennas.

To limit the risk of your device being exposed to those problems, avoid routing any digital signals on the outer layers. These signals are recommended to be routed on inner layers and surrounded by GND planes evenly punched by GND vias:



3.1.2 Minimize the Crosstalk

Avoid having parallel and overlapping tracks on adjacent layers. The digital traces on adjacent layers should be routed orthogonally to minimize the crosstalk risk.



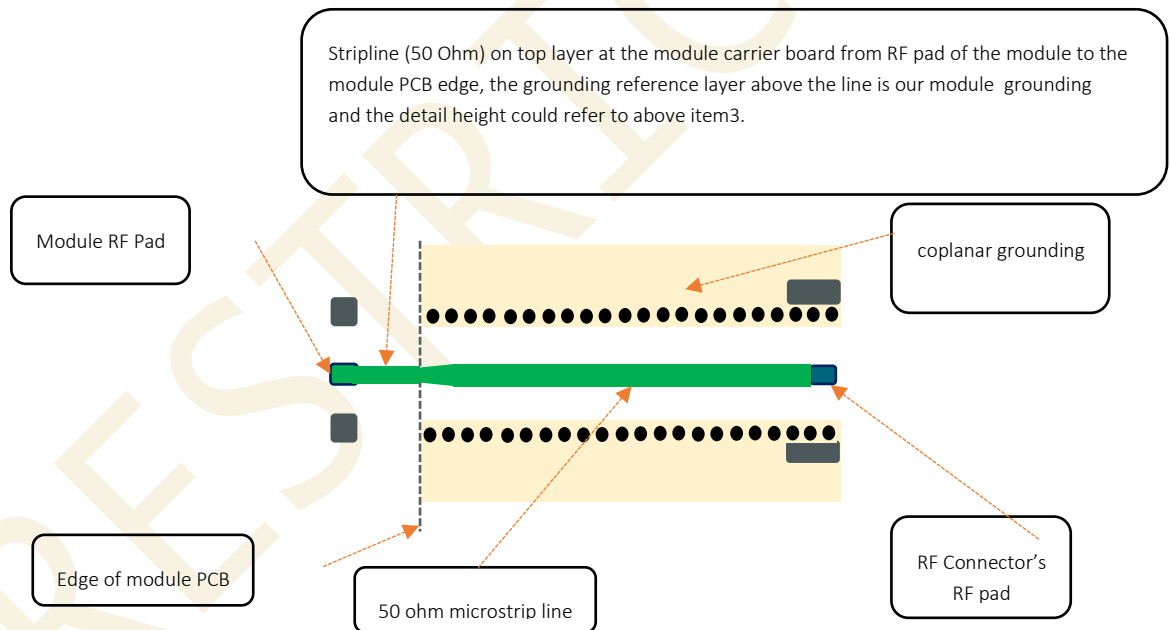
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3.2 RF Routing Recommendations

To route the RF antenna signals, the following recommendations shall be taken into consideration on PCB layout:

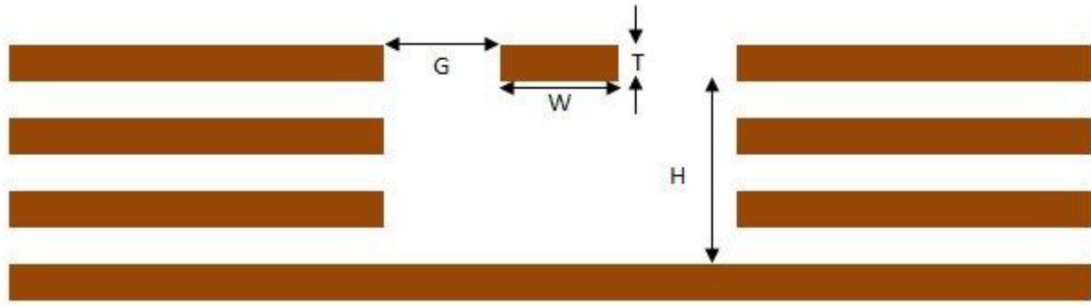
1. The requirement for RF trace impedance is $50\Omega \pm 10\%$
2. Microstrip line is recommended to avoid via transition from module to customer board then to RF antenna, which significantly reduced the RF path loss.
3. The RF microstrip line shall be perpendicularly routed from the RF pad and to the edge of the module. Because the module's RF pads have been optimized with good keepout for better RF impedance for the customer, the keepout height is 961 μm for RN934A/RN932N/RN934R/RN934N/RN937N/RN932V/RN934V/RN938V all antenna ports. For other variants, the keepout height will be updated in the future.
4. The width of the microstrip line is as close to the RF pads' width as possible, the RF pads include the RN93xx RF pad and also the customer antenna pad.
5. For further optimization of RF loss and better impedance, the RF traces under the module can be optimized by routing them as striplines whose up reference grounding layer will be our module grounding, and the total height could refer to the above item 3.



6. RF traces with sharp corners shall be avoided, a smooth radius is recommended.
7. The reference ground of the traces shall be a solid integrated plane.
8. The coplanar ground design for the RF trace must be used for better isolation, and the coplanar clearance (G, below) from the trace to the ground should be at least the trace width (W) and at least twice the height (H). This reduces the parasitic capacitance, which potentially alters the trace impedance and increases the losses. E.g., If $W = 100$ microns then $G = 200$ microns in an ideal setup. $G = 150$ microns would also be acceptable if space is limited.

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9. The ground vias must be placed in the surroundings of the RF traces.
 All RF traces must be well isolated to other noise circuits such as USB, PCIe, external XO, DC power supply, etc.

3.3 High-Speed Interface Recommendations

3.3.1 USB Routing Recommendations

3.3.1.1 USB2

High-Speed USB signals (USB_D_P / USB_D_M) are a differential pair and must be routed with the following considerations/constraints:

- 70~110Ω differential trace impedance
- Differential trace length pair matching < 2mm (15 ps)
- Solid GND reference planes
- Trace lengths < 250 mm
- 3x trace width separation to all adjacent signals

3.3.1.2 USB3

Super-Speed USB signals (USB_SSTX / USB_SSRX) are 2 differential pairs and must be routed with the following considerations/constraints:

- 70~110Ω differential trace impedance
- Differential trace length pair matching < 0.7mm (5 ps)
- Solid GND reference planes
- Trace lengths: Channel differential insertion loss ≤ -6dB@at 5 GHz (Equalization)
- 4x trace width separation to RX and TX signals
- 4x trace width separation to all adjacent signals

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3.3.2 PCIE Routing Recommendations

PCIE signals are very high-speed signals and must be routed with the following considerations/constraints:

- 70~110Ω differential trace impedance
- Intra pair matching < 0.7mm (5ps)
- Inter-lane length match < 2mm
- Trace lengths < 300mm
- 3x line width separation within interface signals and 4x line width separation with a cross interface
- Solid reference planes.

3.3.3 SGMII, USXGMII Routing Recommendations

SGMII signals must be routed with the following considerations/constraints:

- 90~110Ω differential trace impedance
- Intra pair matching < 0.7mm (5ps)
- Solid GND reference planes
- Trace lengths: Channel differential insertion loss ≤ -5dB@at 5.5GHz(Equalization)
- 4x trace width spacing for Tx lane to Rx Lane
- 4x the trace width separation to all adjacent signals

3.3.4 RGMII Routing Recommendations

RGMII signals must be routed with the following considerations/constraints:

- 50Ω single-ended trace impedance
- Length matching < 1.4mm
- Max trace Length < 152mm
- Solid GND reference planes
- Interconnect loss < 0.85 dB @ 125MHz
- 1.5x trace width spacing for Tx bus to Rx bus
- 3x the trace width separation to all adjacent signals

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3.3.5 SDIO Routing Recommendations

SDIO signals are very high-speed signals and must be routed with the following considerations/constraints:

- 36~50Ω single-ended trace impedance
- CLK to DATA/CMD length matching < 2 mm
- Solid GND reference planes
- Total routing length < 50 mm recommended.
- Bus capacitance < 5 pF
- 1.5x trace width separation to all adjacent signals

3.3.6 High Speed Clocks

I2S_MCLK, TCXO_OUT1 and TCXO_OUT2 are high frequency clocks and must be routed with the following considerations/constraints:

- 50Ω single-ended trace impedance
- Solid GND reference planes

3.4 Power and Ground Recommendations

Power and ground routing are critical to achieving optimal performance of the RN93xx devices when integrated into an application.

Recommendations:

- Connections to GND from the RN93xx should be flooded plane using thermal reliefs to ensure reliable solder joints.
- VBATT is recommended to be routed as a wide and short trace(s) directly from the power supply to the LGA pad

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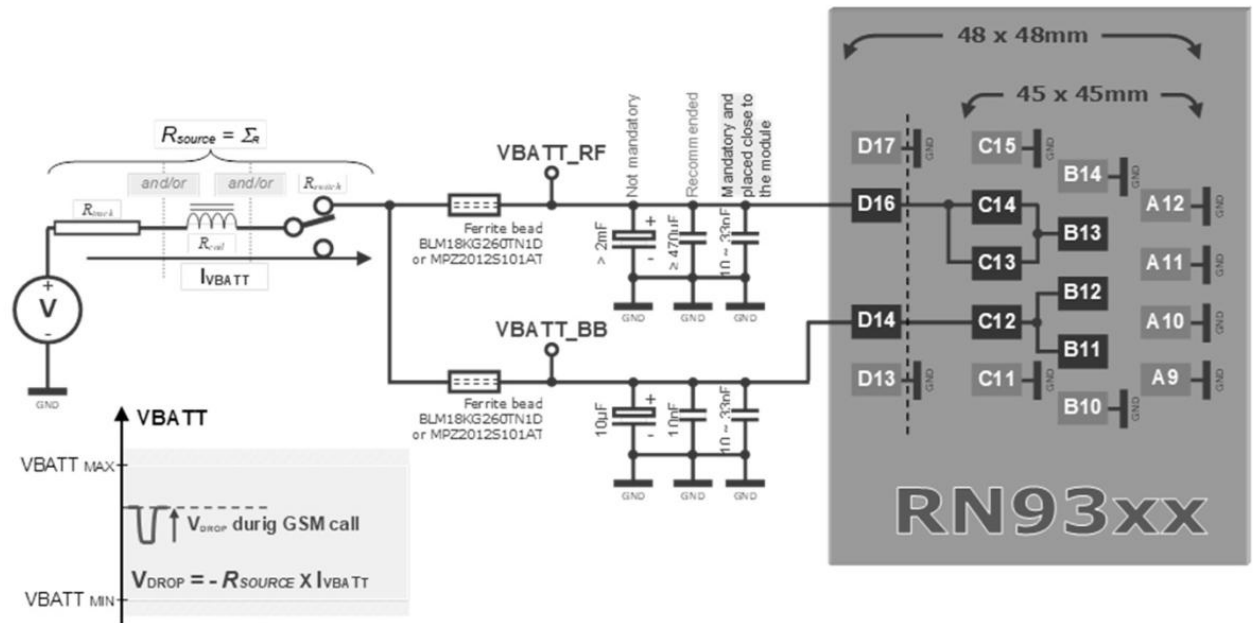


Figure 3-1 Power Recommendation

3.5 Interface Circuit Recommendations

The recommended interface implementation is to use a dual-supply bus transceiver with configurable voltage translation. This allows a host processor operating at a different voltage to communicate with the RN93xx using the appropriate voltage levels.

The figure below is a reference circuit for a digital input/output signal to/from the RN93xx device.

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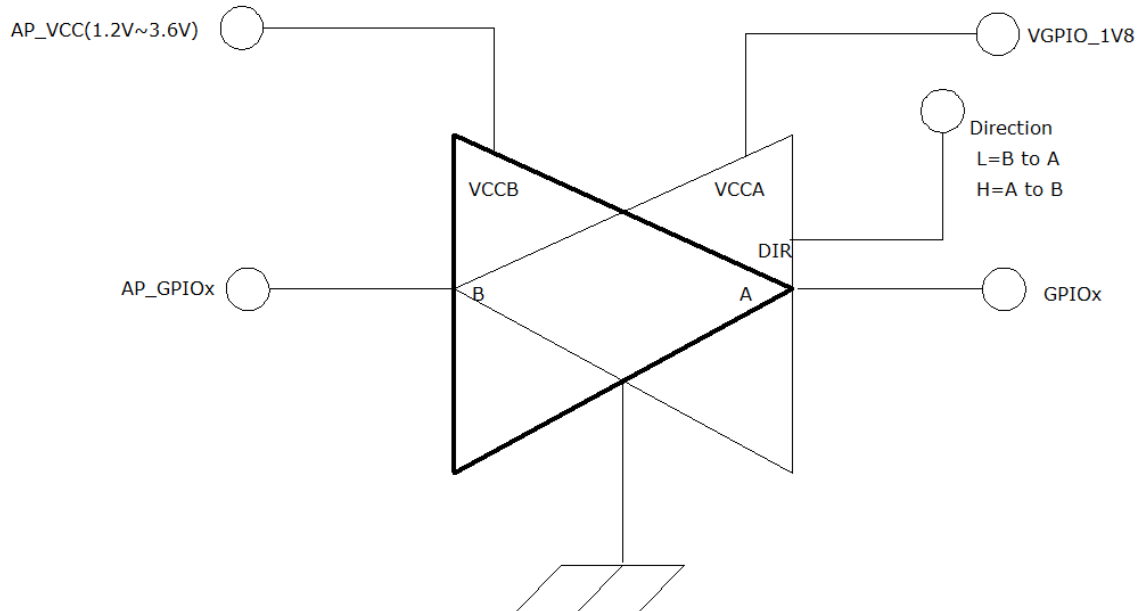


Figure 3-2 RN93xx Interface Reference Circuit

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4 Warnings

4.1 FCC Warning for RN938V

According to the definition of mobile and fixed device is described in Part 2.1091(b), this device is a mobile device.

- List of applicable FCC rules:
47 CFR Part 2/22/24/27/90
- Summarize the specific operational use conditions
This module can be used in automotive devices, the input normal voltage to the module is 4V.
- Limited module procedures
This module is a Single Modular.
- Trace antenna designs
The antenna is not a trace antenna.

And the following conditions must be met:

1. This Modular Approval is limited to OEM installation for mobile and fixed applications only. The antenna installation and operating configurations of this transmitter, including any applicable source-based time averaging duty factor, antenna gain, and cable loss must satisfy MPE categorical Exclusion Requirements of 2.1091.
2. The EUT is a mobile device; maintain at least a 20 cm separation between the EUT and the user's body and must not transmit simultaneously with any other antenna or transmitter.
3. A label with the following statements must be attached to the host end product: This device contains **FCC ID:2AX2URN938V**
4. To comply with FCC regulations limiting both maximum RF output power and human exposure to **RF radiation, maximum antenna gain (including cable loss) must not exceed:**

Operating Band	FCC Max Antenna Gain
WCDMA Band 2	7.30 dBi
WCDMA Band 5	10.87 dBi
LTE Band 2/CA_2C	7.30 dBi
LTE Band 4	4.30 dBi

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LTE Band 5/CA_5B	10.86 dBi
LTE Band 7/CA_7C	7.30 dBi
LTE Band 26(814-824)	10.81 dBi
LTE Band 26(824-849)	10.86 dBi
LTE Band 38/CA_38C	7.30 dBi
LTE Band 41/CA_41C	7.30 dBi
LTE Band 66/CA_66B/CA_66C	4.30 dBi
NR Band n2	7.30 dBi
NR Band n5	10.87 dBi
NR Band n7	7.30 dBi
NR Band n26(814-824)	10.82 dBi
NR Band n26(824-849)	10.87 dBi
NR Band n41	7.30 dBi
NR Band n66	4.30 dBi
NR Band n77	4.30 dBi
NR Band n78	4.30 dBi

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5. This module must not transmit simultaneously with any other antenna or transmitter.
6. The host end product must include a user manual that clearly defines operating requirements and conditions that must be observed to ensure compliance with current FCC RF exposure guidelines.

For portable devices, in addition to the conditions 3 through 6 described above, a separate approval is required to satisfy the SAR requirements of FCC Part 2.1093.

If the device is used for other equipment that separate approval is required for all other operating configurations, including portable configurations with respect to 2.1093 and different antenna configurations.

For this device, OEM integrators must be provided with labelling instructions of finished products.

Please refer to KDB784748 D01 v07, section 8. Page 6/7 last two paragraphs:

A certified modular has the option to use a permanently affixed label, or an electronic label. For a permanently affixed label, the module must be labelled with an FCC ID - Section 2.926 (see 2.2 Certification (labelling requirements) above). The OEM manual must provide clear instructions explaining to the OEM the labelling requirements, options and OEM user manual instructions that are required (see next paragraph).

For a host using a certified modular with a standard fixed label, if (1) the module's FCC ID is not visible when installed in the host, or (2) if the host is marketed so that end users do not have straightforward commonly used methods for access to remove the module so that the FCC ID of the module is visible; then an additional permanent label referring to the enclosed module: "Contains Transmitter Module **FCC ID:2AX2URN938V**" or "Contains **FCC ID:2AX2URN938V**" must be used. The host OEM user manual must also contain clear instructions on how end users can find and/or access the module and the FCC ID.

The final host / module combination may also need to be evaluated against the FCC Part 15B criteria for unintentional radiators in order to be properly authorized for operation as a Part 15 digital device.

The user's manual or instruction manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. In cases where the manual is provided only in a form other than paper, such as on a computer disk or over the Internet, the information required by this

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section may be included in the manual in that alternative form, provided the user can reasonably be expected to have the capability to access information in that form.

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.

Changes or modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.

To ensure compliance with all non-transmitter functions the host manufacturer is responsible for ensuring compliance with the module(s) installed and fully operational. For example, if a host was previously authorized as an unintentional radiator under the Supplier's Declaration of Conformity procedure without a transmitter certified module and a module is added, the host manufacturer is responsible for ensuring that after the module is installed and operational the host continues to be compliant with the Part 15B unintentional radiator requirements.

Manual Information to the End User

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module. The end user manual shall include all required regulatory information/warning as show in this manual.

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4.2 RED Warning for RN938V

Hereby, [Rolling Wireless S.à r.l.] declares that the radio equipment type [RN938V] is in compliance with Directive 2014/53/EU. the full text of the EU declaration of conformity is available at the following internet address: <https://www.xxxxxx>.

The device could be used with a separation distance of 20cm to the human body.
Frequency bands and maximum output power.

Band	Maximum Output Power
WCDMA Band 1	25.70 dBm
WCDMA Band 8	25.70 dBm
LTE Band 1/CA_1C	25.70 dBm
LTE Band 3/CA_3C	25.70 dBm
LTE Band 7/CA_7C	25.70 dBm
LTE Band 8	25.70 dBm
LTE Band 28	25.70 dBm
LTE Band 38/CA_38C	25.70 dBm
LTE Band 41/CA_41C	25.70 dBm
NR Band n1	25.70 dBm
NR Band n3	25.70 dBm
NR Band n7	25.70 dBm
NR Band n8	25.70 dBm
NR Band n28	25.70 dBm
NR Band n41	25.70 dBm
NR Band n77	25.70 dBm
NR Band n78	25.70 dBm

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