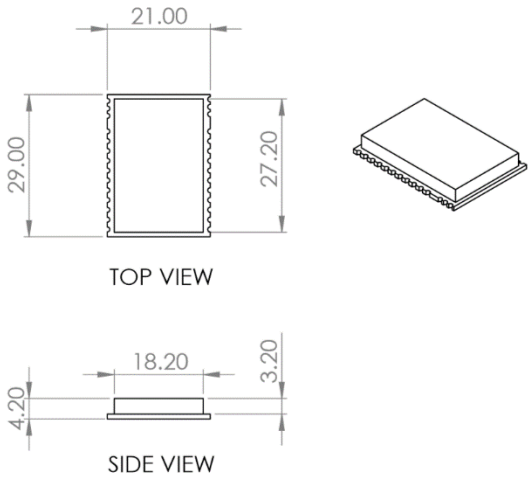
RFD900ux Radio Modem Series

Hardware User Manual
902-928MHz frequency band



General Cautions

During operation there must be a separation distance of 20cm between all persons and the antenna.
Ensure that all used RF connectors are secure and properly terminated.

When used in the US - FCC Caution

Caution: The user is cautioned that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.
Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning
the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
—Reorient or relocate the receiving antenna.
—Increase the separation between the equipment and receiver.
—Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
—Consult the dealer or an experienced radio/TV technician for help.

This equipment complies with FCC's RF radiation exposure limits set forth for an uncontrolled environment. The antenna(s) used for this transmitter must be installed and operated to provide a separation distance of at least 20 cm from all persons and must not be collocated or operating in conjunction with any other antenna or transmitter. Installers must ensure that 20cm separation distance will be maintained between the device (excluding its handset) and users.

When used in Canada - ISED Caution

This device complies with RSS 210 of the Industry Canada Rules. 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.
Le présent appareil est conforme aux CNR d'Industrie Canada 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.

This equipment complies with Canada radiation exposure limits set forth for uncontrolled environments. This equipment should be installed and operated with a minimum distance of 20cm （may be adjusted according to actual calculation result） between the radiator and your body.
This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.
Déclaration d'IC sur l'exposition aux radiations:
Cet équipement est conforme aux limites d'exposition aux radiations définies par le Canada pour des environnements non contrôlés. Cet équipement doit être installé et utilisé à une distance minimum de 20 cm entre l'antenne et votre corps.
Cet émetteur ne doit pas être installé au même endroit ni utilisé avec une autre antenne ou un autre émetteur

Acceptable Antennas

This device has been designed to operate with the antenna(s) listed below and having a maximum gain of 3 dBi. Antennas not included in this list or having a gain greater than 3 dBi are strictly prohibited for use with this device. The required antenna impedance is 50 ohms.
Acceptable antenna – 3dBi RFD whip.

Table of contents

1 Key features

RFD900ux provides compact and yet powerful data communication. The key features are:

- No configuration required for out of the box RF communications.
- Operating frequency range of 902 – 928MHz
- Outdoor RF line-of-site range of 40km or more depending on antennas
- Air data rate speeds of up to 224kbps
- Diversity antenna support
- Operating temperature of -40 to +85 degrees Celsius
- Dimensions of 21mm x 29mm x 4.2mm
- Weight of 3.5g
- USB interface

Compliances and Worldwide Acceptances:

The RFD900ux is designed to be compliant to AS4268:2012, and FCC 15.247. It has not been certified as a standalone modem and should be compliance tested in the final product.

2 Specifications

Performance	
Supported RF Data Rates	12, 56, 64, 100, 125, 200, 224, 500[1] and 750kbps[1]
Indoor Range	500m – 1km
Line-Of-Sight Range	40km or more depending on antennas
Transmit Power	0 to 30dBm in 1dBm steps
Receiver Sensitivity	113dBm @ 10^{-5} BER 12Kbps

[1] High RF data rates are for experimental purposes only

Features		
Serial Data Interface	+3.3V nominal, 3.3V tolerant	
Configuration Method	AT Commands, APM Planner, Customised Configuration Tool	
Frequency Band	Unlocked	902MHz - 928MHz
	AU locked	915MHz - 921MHz
	NZ locked	920.75MHz – 927.25MHz
	US locked	902MHz - 915MHz
Interference Immunity	FHSS (Frequency Hopping Spread Spectrum)	
Serial Interface Data Rate	2400, 4800, 9600, 19200, 38400, 57600, 115200, 460kbps	
Antenna Connection	2 x RPSMA diversity switched ports	
GPIO	6 pins (Digital, PPM capable)	
Compliance Standards	FCC Part 15.247, AS/NZS 4268:2012	

Networking and Security		
Addressing Options	Network ID: 0 –255	
Channels	Unlocked	Up to 50 Frequency Hopping Channels
	AU locked	23
	NZ locked	25
	US locked	51
Supported Network Topologies	Point-to-point, multipoint[2], and asynchronous non-hopping mesh[2]	

[2] Only available in separate firmware versions available in the website

Power Requirements	
Supply Voltage	+5V nominal (+5V min, +5.5V Max, +6V ABS Max),
Transmit Current	~1A peak at max power
Receive Current	~60mA

3 OEM Labelling

For equipment containing the RFD-900x where the RFD-900x label is not visible the following applies.

Equipment using the RFD 900x in the USA must display a label referring to the enclosed module. This label must contain the words “Contains FCC ID: 2ADLE-900X”.

Equipment using the RFD 900x in Canada must display a label referring to the enclosed module. This label must contain the words “Contains IC ID: 24610-900X”.

4 Output power levels

Many countries have different legal power levels. Be sure to operate within the legal power limits of the country that you are operating in. The RFD900ux modem can support the power levels between 0dBm and 30dBm in 1dBm steps. Formula 2-1 can be used to convert the power in dBm into milliwatts.

$$P_{mW} = 10^{(P_{dBm}/10)}$$

Formula 2-1

To calculate Effective Isotropic Radiated Power (EIRP) you can use the formula 2-2 below:

$$EIRP(dBm) = Transmitpower(dBm) - Cableloss(dB) + AntennaGain(dBi)$$

Formula 2-2

The FCC limit for EIRP is 4 Watts, or 36dBm for frequency hopping radios in the ISM 900 MHz band. The Australian EIRP limit is 30dBm as defined by ACMA.

5 Performance characteristics

Figure 4-1 shows how the output power of the RFD900ux varies with supply voltage when the output power is set to +30dBm.

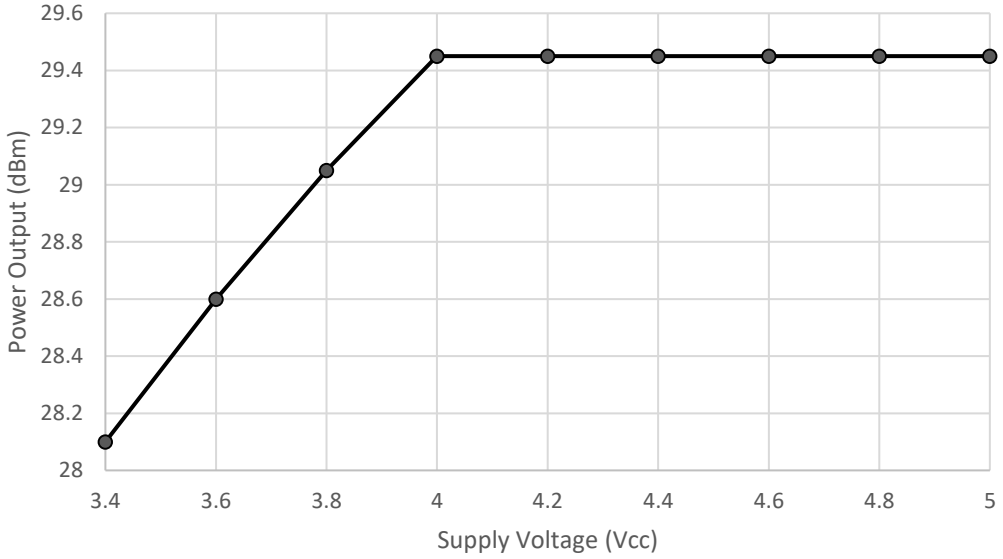


Figure 4-1: Output power vs. input supply voltage

Figure 4-2 shows how the current through the RFD900ux varies with the transmit power level. The current during transmission is shown by the 'High Level' plot and that during receive mode is shown by the 'Low Level' plot.

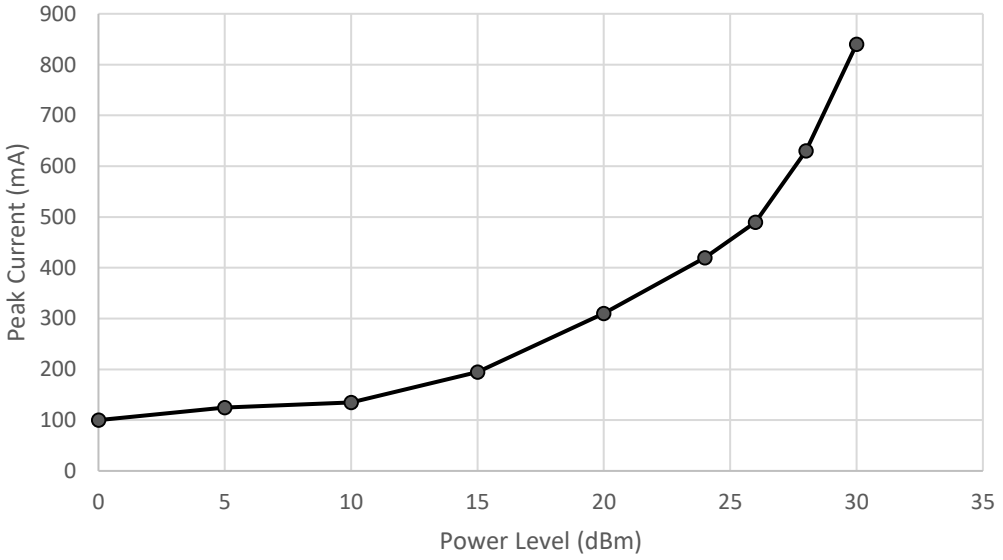


Figure 4-1: Current consumption vs. TX power level

The table below is used to determine the sensitivity of the RFD900ux according to the selected air data rate. The link budget is directly affected by the sensitivity, and therefore the communication range also varies. The sensitivity values in the table are based on a 10^{-5} BER.

Air data rate	Sensitivity @ 10-5 BER
12 kbps	-111 dBm
64 kbps	-104 dBm
125 kbps	-102 dBm
224 kbps	-95 dBm
12 kbps	-111 dBm

6 Pin signals and layout

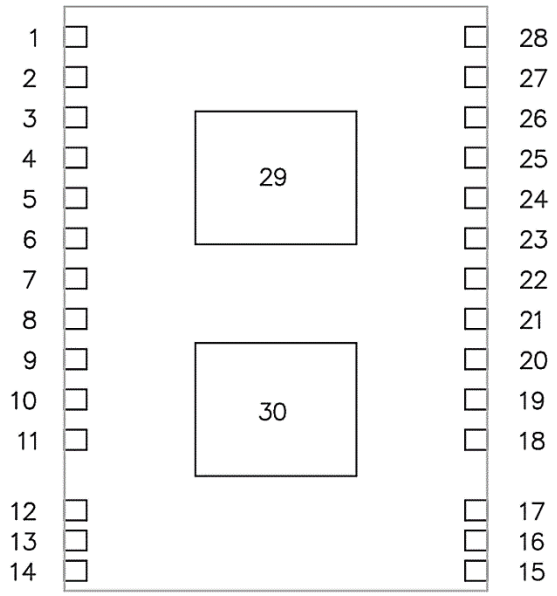


Figure 5-1: Physical pin layout of the RFD900ux Radio Modem

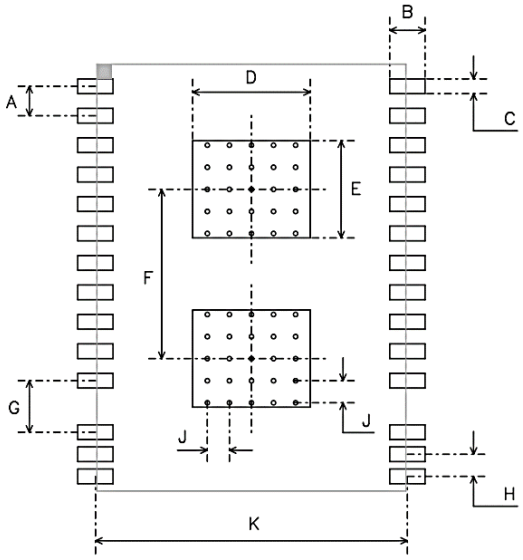
Pin #	Name	Direction	Description	Max Voltage
1	VUSB	Input	Power supply from USB	5V
2	USB_DM		USB Data -	
3	USB_DP		USB Data +	
4	SWO_EXT	Output	SWD debug output	3.3V
5	P3.3_EXT	I/O	Digital I/O	3.3V
6	P3.4_EXT	I/O	Digital I/O	3.3V
7	P3.5_EXT	I/O	Digital I/O	3.3V
8	GND	-	Ground	0V
9	GND	-	Ground	0V
10	+3V3		LDO output	3.3V
11	GND	-	Ground	0V
12	GND	-	Ground	0V
13	ANT1	-	Antenna 1	-
14	GND	-	Ground	0V
15	GND	-	Ground	0V
16	ANT2	-	Antenna 2	-
17	GND	-	Ground	0V
18	GND	-	Ground	0V
19	+5V		Power Supply	5V
20	GND	-	Ground	0V
21	P1.0_EXT	I/O	Digital I/O	3.3V
22	P1.1_EXT	I/O	Digital I/O, PPM I/O	3.3V
23	P1.2_EXT	I/O	Digital I/O	3.3V
24	P1.3_EXT	I/O	Digital I/O	3.3V

25	SIRX_EXT	Input	UART Data In	3.3V
26	SITX_EXT	Output	UART Data Out	3.3V
27	SIRTS_EXT	Output	Request to send	3.3V
28	SICTS_EXT	Input	UART Clear to send	3.3V
29	GND	-	Ground	0V
30	GND	-	Ground	0V

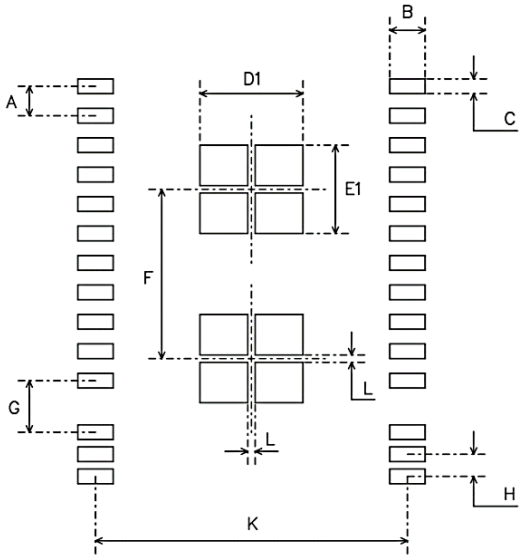
In case there is a need to force the modem into boot mode, pull the SWO pin to the ground while applying power. The on-board LED will become solid red when in bootloader mode.

7 Recommended PCB Design

LAND PATTERN

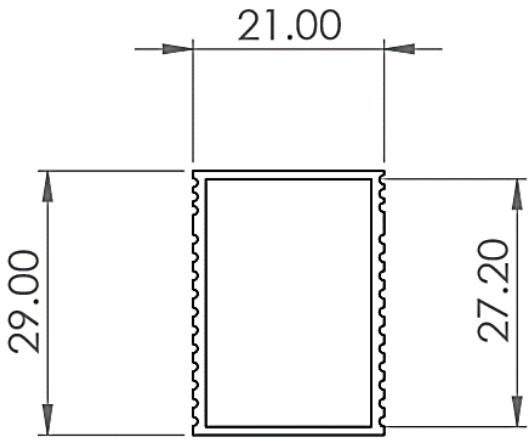


STENCIL DESIGN

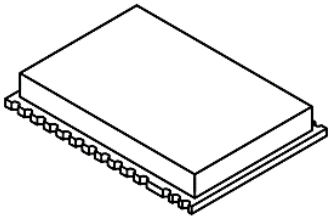


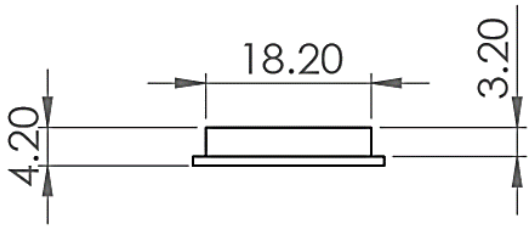
Symbol	Dimension (mm)	Symbol	Dimension (mm)
A	2	F	11.5
B	2.4	G	3.5
C	1	H	1.5
D	8	J	1.5
D1	7	K	21.2
E	6.6	L	0.5
E1	6		

8 Physical dimensions



TOP VIEW





SIDE VIEW

9 Diversity

The RFD900ux has two antenna ports and firmware which supports diversity operation of antennas. During the receive sequence the modem will check both antennas and select the antenna with the best receive signal. The antenna selected during receive is then also used for subsequent transmission. In the case of only one antenna connected, it will automatically select the port with the antenna connected. Testing by Silicon Labs has shown that link budgets can be improved up to the order of 8dB by employing a diversity scheme.

9.1 Spatial diversity

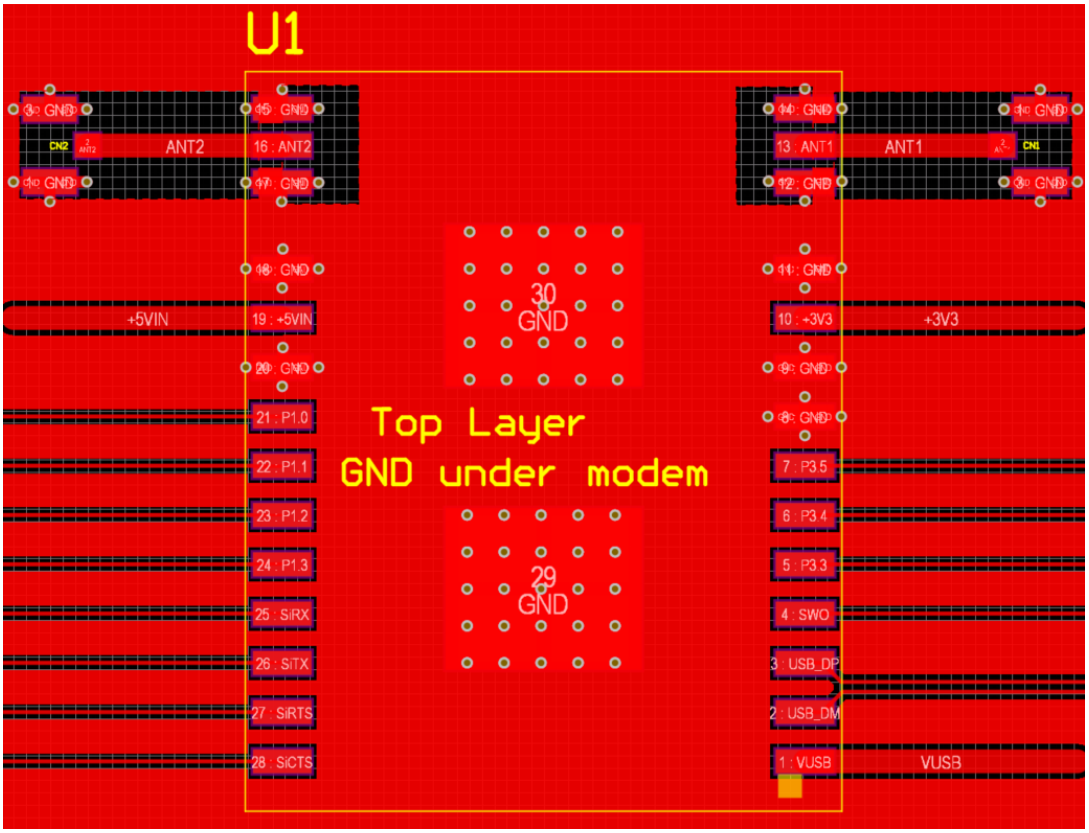
Spatial diversity is the case where the antennas are separated by some distance from one another. It is recommended that two antennas connected to the RDF900ux modem be separated by at least 25cm, more if possible.

9.2 Polarisation diversity

Polarisation diversity is the case where the antennas are perpendicular to each other. i.e. one vertical, and one horizontal. This is effective in reducing multipath effects which affect one or the other polarisation. This scheme also helps to maintain the link between non-static objects such as aircraft performing acrobatics by increasing the likelihood that one antenna will maintain the same polarisation as an antenna on the other side of the link.

10 PCB Design Guidelines

Some guidelines must be followed as to ensure the PCB design meets the RFD900ux thermal dissipation and electromagnetic compatibility requirements. The proposed layout can be used as a starting point and it is not guaranteed to comply with EM immunity and emissions regulations as is. The PCB designer is expected to calculate the RF antenna track widths to be 50Ω outputs, depending on the host PCB layer stack up and dielectric constant.



11 Useful links

RFD900ux Firmware

The RFD900x runs the same firmware as all other radios from the RFD900x family.

http://files.rfdesign.com.au/firmware/

RFD SiK firmware is standard SiK (open source)

RFD Multipoint firmware is multipoint SiK (MP SiK)

RFD900x Flash Programmer

http://files.rfdesign.com.au/tools/

FTDI Cable documentation

http://www.ftdichip.com/Support/Documents/DataSheets/Cables/DS_TTL-232R_CABLES.pdf

12 Document revision history

Version	Date	Changes
1.0	20/08/2019	Release document
1.1	12/09/2019	Amended VBUS pin voltage