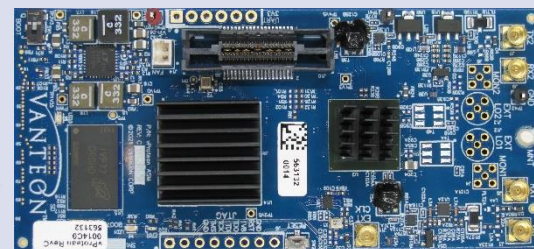# VANTEON®

W I R E L E S S   S O L U T I O N S

USER MANUAL

vPROTEAN™
vPROTEAN+ ™

Ultra-Flexible Software-Defined Radio (SDR)
Evaluation Kit

Accelerate Your Design

Let Vanteon's engineering team help you get your products to market faster with a proven, scalable SDR design.

Call us at 888.506.5677 or email sales@vanteon.com

About Vanteon

Vanteon is a design services company offering complete electronic systems design and engineering solutions with a focus in Wireless and RF design. We offer Analog, Digital, and RF Hardware design, as well as Software and FPGA design services. To learn how Vanteon's expertise can be enlisted to help solve your most pressing challenges, visit the Vanteon website at https://vanteon.com.

Vanteon has been voted one of the "Best Companies to Work for in NY" for more than a decade.

Best Companies to work for **NEW YORK**

Eval Kit Features

The vProtean™/ vProtean+™ Evaluation Kit offers the following key features:

• Convenient Carrier card that mounts directly to the vProtean SDR

• Easy to use menu-based interface running on your host PC

• Ability to independently control both TX and RX channels

• Set the center frequency of each channel

• Toggle both TX and RX channels on/off

• Monitor the RSSI of both RX channels

• Select from a number of pre-defined waveforms to transmit

• Transmit a custom waveform that you load on the SD card

• Trigger and capture a specified number of RX samples to the SD card

• Monitor the FPGA and transceiver temperature

1   Introduction

The Vanteon vProtean™ and vProtean+™ are 2x2 software defined radios (SDR) that targets communications, signal intelligence, and other multi-band processing applications. They are based on the Analog Devices ADRV9004 highly integrated wideband RF transceiver and a Xilinx Zynq System-on-Chip (SoC). The vProtean SDR comes with a Xilinx Zynq-7020 and the vProtean+ comes with a Xilinx Zynq-7045. The SDRs have similar, custom RF front ends that are highly flexible, allowing a SDR's frequency range to be configured from 30 to 6000 MHz.

Each vProtean SDR is pre-loaded with the vProtean SDR Evaluation Kit (VPROKIT-21) firmware and each vProtean+ SDR is pre-loaded with the vProtean+ SDR Evaluation Kit (VPLUSKIT-24-A) firmware. The VPROKIT-21-C firmware includes Vanteon proprietary, programmable logic cores and executable code to perform transmit and receive functions via a menu-based UI over a USB enabled com port from a host computer (host not included).   An encrypted Vivado Project of the VPROKIT-21's FPGA firmware, along with source code of the User Interface (UI) firmware is available under a free license agreement. The vProtean schematic and layout design files and Vanteon-proprietary DSP cores are available with a paid license. Contact Vanteon Sales for more information.

> ⚠️ The vProtean SDR and vProtean+ SDR evaluation kits are sold for evaluation purposes. If you choose to use your vProtean/vProtean+ SDR evaluation kit to transmit using an antenna, it is the user's responsibility to make sure that they are in compliance with all local laws and regulations.

2   Proper Care and Handling

All Vanteon products are thoroughly tested before shipment. The vProtean/vProtean+ SDR is guaranteed to be functional at the time it is received by the customer. Improper use or handling of the vProtean/vProtean+ SDR can easily cause the device to become non-functional. Listed below are some examples of actions which can prevent damage to the unit:

- Never allow metal objects to touch the circuit board while powered.

- Always properly terminate the transmit port with an antenna or 50Ω load.

- Always handle the board with proper anti-static methods.

- Never allow the board to directly or indirectly come into contact with any voltage spikes.

- Never allow any water, or condensing moisture, to come into contact with the boards.

- Never apply more than 0 dBm of power into any RF input.

- Always use at least 30dB attenuation if operating in a loopback configuration.

> ⚠️ The vProtean/vProtean+ SDR evaluation kit is supplied with heatsinks of the FPGA and transceiver IC. Under heavy processing and/or high output power levels additional airflow may be required to ensure the components remain in the specified operating temperature range to prevent damage.
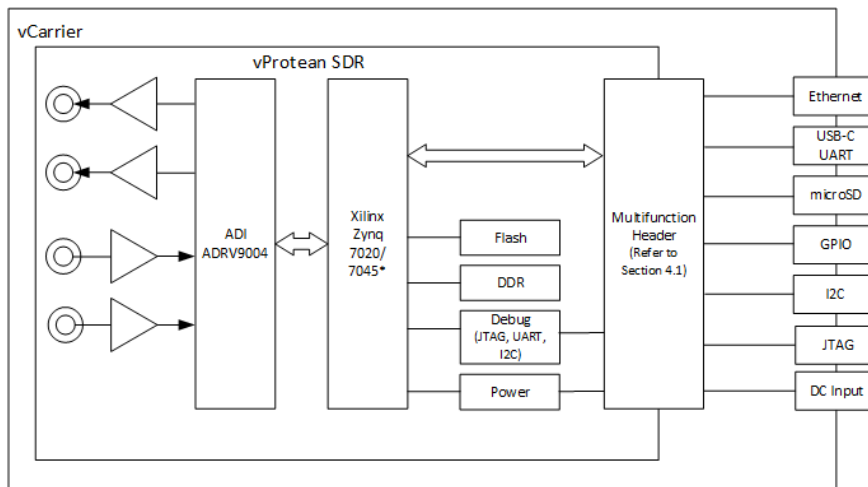
3 Evaluation Kit Contents

The SDR Evaluation Kit (VPROKIT-21-C or VPLUSKIT-24-A) contains the following items:

- vProtean/vProtean+ Software-Defined Radio
- vProtean Carrier (vCarrier) with mounting hardware
- 120VAC power supply
- USB cable (Type A to Type C)
- 16GB microSD card with SD card adapter

4 Technical Overview

4.1 Block Diagram

The vProtean comes with a Xilinx Zynq 7020 FPGA.

The vProtean+ comes with a Xilinx Zynq 7045 FPGA.

4.2 vProtean/vProtean+ Evaluation Kit Specifications

Frequency Band 1	30 to 6000 MHz
Instantaneous Bandwidth	12 kHz to 40 MHz
Number of transmitters	2
Number of receivers	2
Maximum Transmit Power	+19 dBm
Maximum Input Receive Power	0 dBm
Antenna connections	50Ω MMCX RF connectors
Power control	Wide range of output power from –20 dBm to +19 dBm
Flash	512 Mb
DDR SDRAM	4 Gb

vCarrier Input Voltage	6-30 VDC

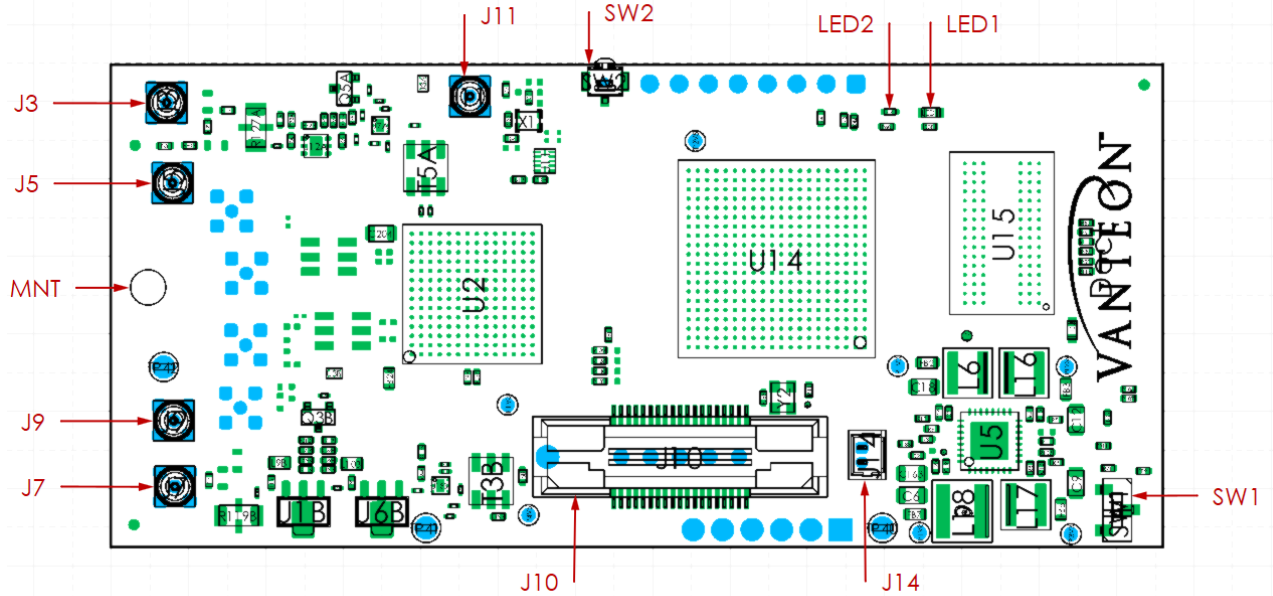# 5   Interfaces

5.1   vProtean Interfaces

Figure 1: vProtean RevC, Top View

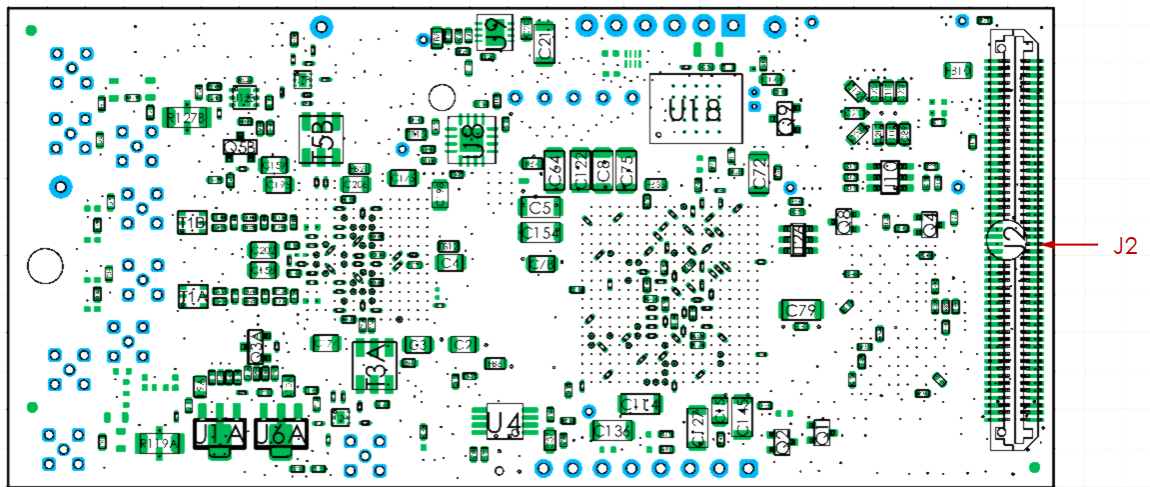**Figure 2: vProtean RevC, Bottom View**
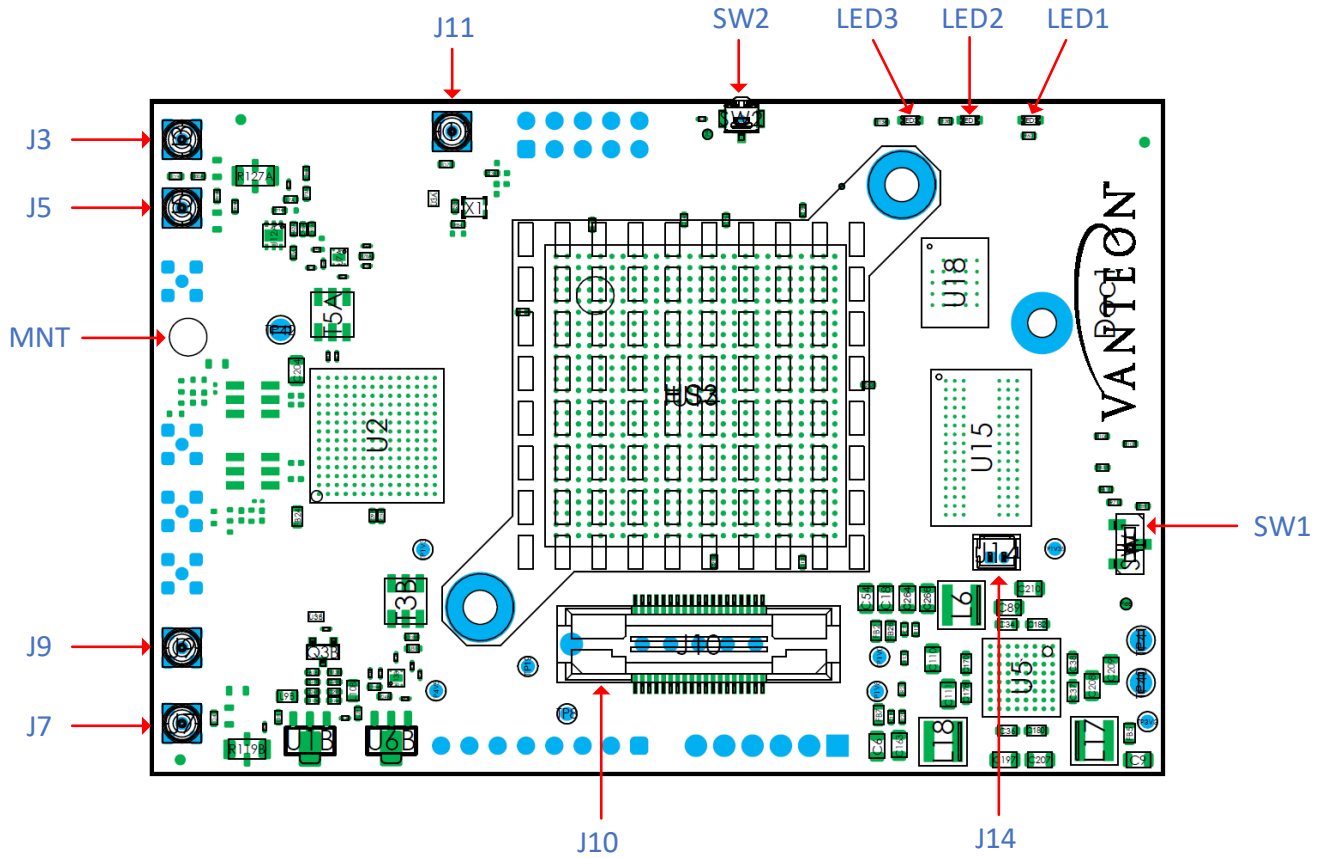
5.2   vProtean+ Interfaces

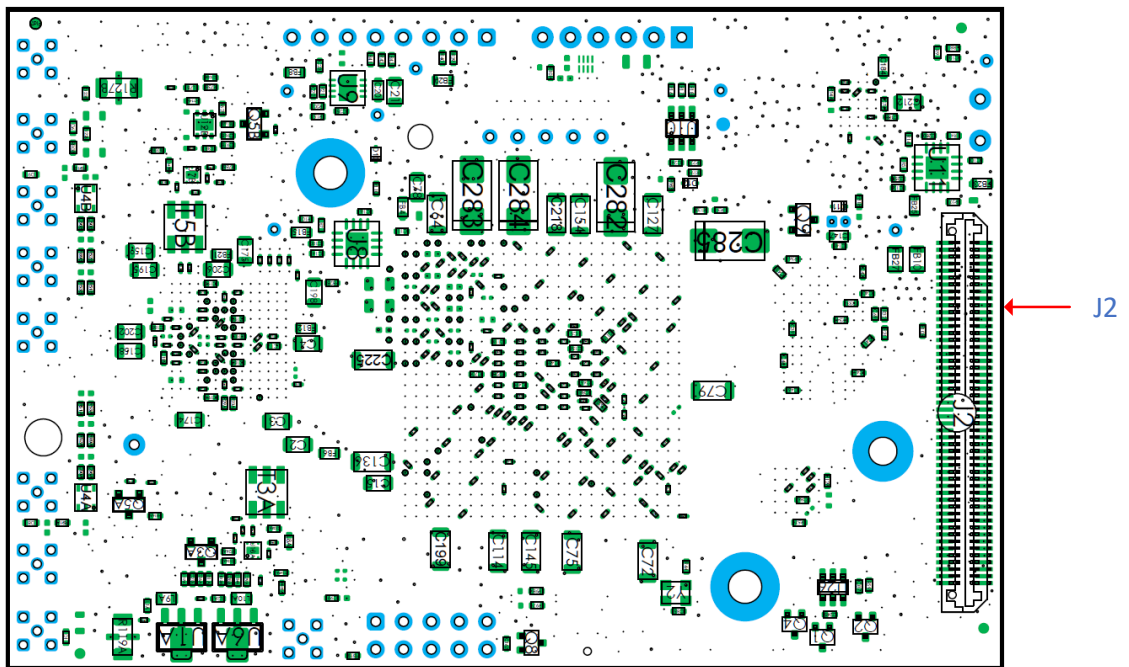**Figure 3: vProtean+ RevA, Top View**

Figure 4: vProtean+ RevA, Bottom View

5.3   vProtean/vProtean+ Connectors

The vProtean/vProtean+ SDR has a number of connectors that allow it to be interfaced to the vCarrier board, as well as connectors for external antennas. The table below lists all of the connectors and their associated functions. Refer to Figure 1 and Figure 2 for vProtean connector locations. Refer to Figure 3 and Figure 4 for vProtean+ connector locations.

Connector	Type	Function
J2	2x50 100 pin header	JTAG, UART, Boot Mode, Power, Reset, USB, Ethernet, SD Card, I2C, GPIO **Contact Vanteon for additional information**
J3	MMCX	Transmit 1
J5	MMCX	Receive 1
J7	MMCX	Transmit 2
J9	MMCX	Receive 2
J10	MICTOR	Debug
J11	MMCX	External Clock
J14	2-pin PicoBlade header	Fan Connector

5.3.1 J14 Connector

The J14 connector is a fan connector that can be used to provide cooling for the evaluation kit. It can deliver 5V up to 200mA. Connect a suitable fan using a Molex PicoBlade connector (for example, Molex part number 15134-0200).

Pin	Description
1	FAN -
2	FAN +

5.4   Switches

The vProtean/vProtean+ SDR has two switches, whose function is described in the table below.

SW1	Switch	Boot Mode. Move to position J (towards Vanteon logo) for JTAG boot mode, position Q for QSPI or SD card booting. Can be overridden by carrier jumpers.
SW2	Pushbutton	Reset. Can also be driven from carrier board.

5.5   LEDs

The vProtean/vProtean+ SDR has two LEDs, whose function is described in the table below.

LED1	Blue	On when Zynq 7020 programmable logic has been programmed
LED2	Green	Software control

5.6   Mounts

The vProtean/vProtean+ SDR has one mounting point. In the standard configuration, it is designed for a standoff height from a carrier PCB of 9.5mm (3/8").

MNT	Standoff	Use threaded spacer, screws and locking washer (supplied in kit). The smaller head screw is intended for the top side, to avoid collision with RF connectors

6 vCarrier Interfaces
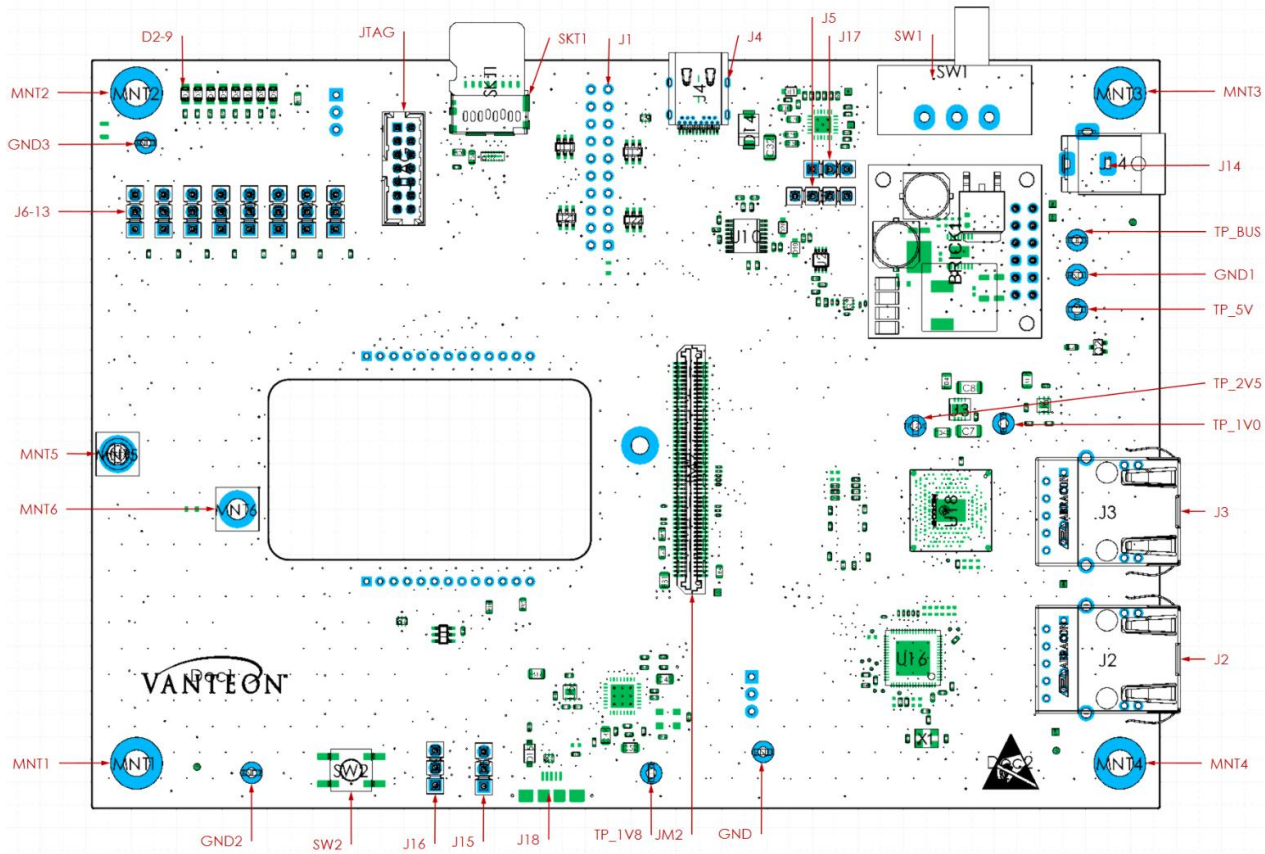
6.1 vCarrier Connectors (Revision D)

Connector	Type	Function
JM2	100 pin header	JTAG, UART, Boot Mode, Power, Reset, USB, Ethernet, SD Card, I2C, GPIO **Contact Vanteon for additional information**
J1	Header	User Defined Differential IO (optional, if fitted)
J2	RJ45	Ethernet 1 interface (Not supported)
J3	RJ45	Ethernet 0 interface
J4	USB-C	USB – UART serial interface
J5	Header	I2C 3.3V interface
J6-13	Header	2.5V GPIO. Jumpers may be used to set input levels, or removed to use center pins as outputs. **Contact Vanteon for additional information**
J14	DC Jack	2.5mm DC barrel jack for system power input. 6-30VDC, 20W
J15-16	Header	Boot mode jumper select. May be used to override vProtean boot mode switch, otherwise leave off. **Contact Vanteon for additional information**
J17	Header	USB power enable. Unused with DC supply.
J18	USB-Micro	USB-OTG host/device interface (Not supported)
SKT1	microSD	microSD card connector for storage of system firmware and TX/RX data.

6.2   Test Points

The vCarrier has 9 test points for measuring system voltages, whose function is described in the table below.

GND0-3	Test Hook	System ground
TP_1V0	Test Hook	Carrier 1.0V
TP_1V8	Test Hook	Carrier 1.8V
TP_2V5	Test Hook	Carrier 2.5V
TP_5V	Test Hook	Carrier 5.0V
TP_BUS	Test Hook	System input supply voltage

6.3   Switches

The vCarrier has two switches, whose function is described in the table below.

SW1	Slider	System power switch. Slide right to enable power from DC jack.
SW2	Pushbutton	System Reset

6.4   LEDs

The vCarrier has eight LEDs, whose function is described in the table below.

D2-9	Green	Displays the status of GPIO0-7

6.5   Mounts

The vProtean SDR has mounting points for the system and for the vProtean SDR. In the standard configuration, it is designed for a standoff height from a carrier PCB of 9.5mm (3/8").

MNT1-4	Foot	vCarrier mounting points. Fitted with rubber feet as default
MNT5	Standoff	Use threaded spacer, screws and locking washer (supplied in kit). The smaller head screw is intended for the top side, to avoid collision with RF connectors

7   Evaluation Kit Assembly

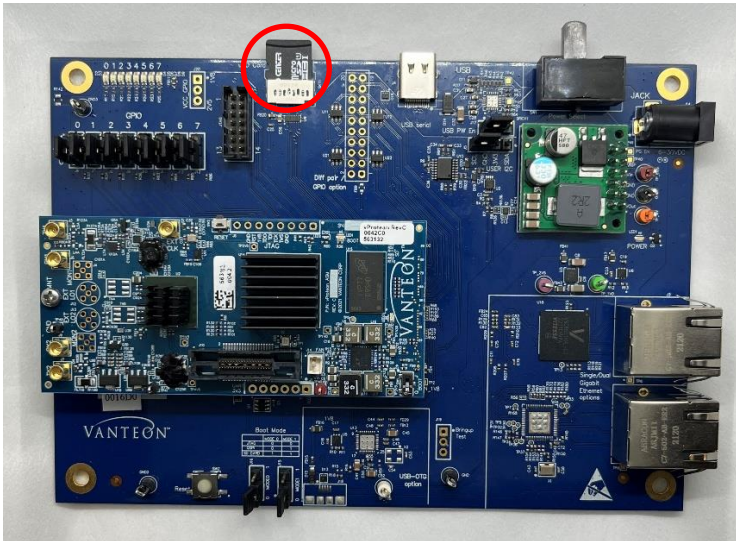Follow the step by step instructions below to assemble your vProtean/vProtean+ SDR evaluation kit.

> ⚠️   Please refer to Section 2 for proper care and handling

> 📋   For more information view our setup video here, or visit our website at
> https://vanteon.com/vprotean/

1.   Install the provided microSD card into the microSD socket (SKT1) on the vCarrier.

2.   Connect the vCarrier USB-C port (J4) to a customer provided PC using the provided cable.

3.   Connect the supplied AC power supply to the DC Jack (J14) on the vCarrier.

4.   Connect the AC power supply to an AC outlet.

5.   Turn on the evaluation kit by sliding the switch (SW1) on the vCarrier towards the DC Jack (J14).

8   User Console

The vProtean/vProtean+ SDR evaluation kit is preloaded with a menu-based application that allows a user to perform transmit and receive functions through the USB interface. This section explains how to use the evaluation application. The examples in this section refer to software version 3.5. Older versions may not support some of the features listed.

To access the preloaded evaluation application connect the vProtean/vProtean+ SDR evaluation kit USB port to a PC using the appropriate USB cable. Use a terminal emulator program (for example, PuTTY or HyperTerminal) on the PC to open a terminal session using the virtual COM port associated with the vProtean/vProtean+ SDR evaluation kit.

To determine the appropriate virtual COM port, open Device Manager and find the associated USB Serial Port. In the example below COM4 should be used.
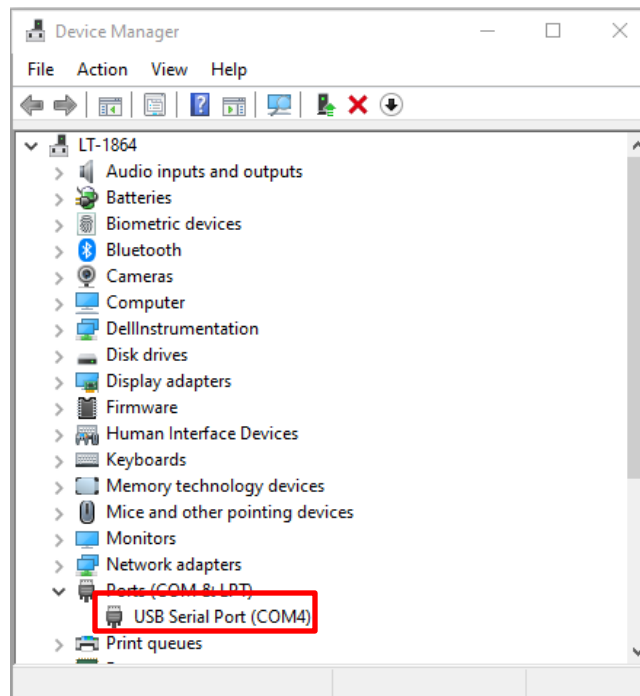
Configure the virtual serial port in the terminal emulator as 115200 baud-8-N-1. See example below.
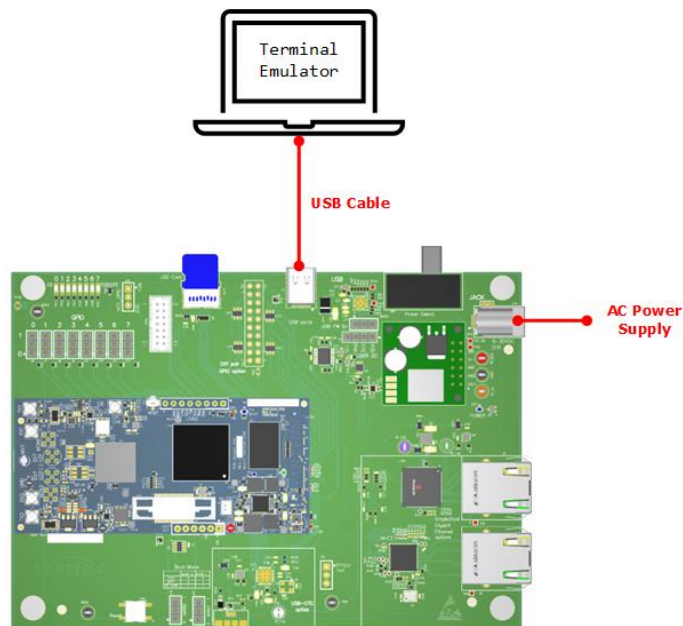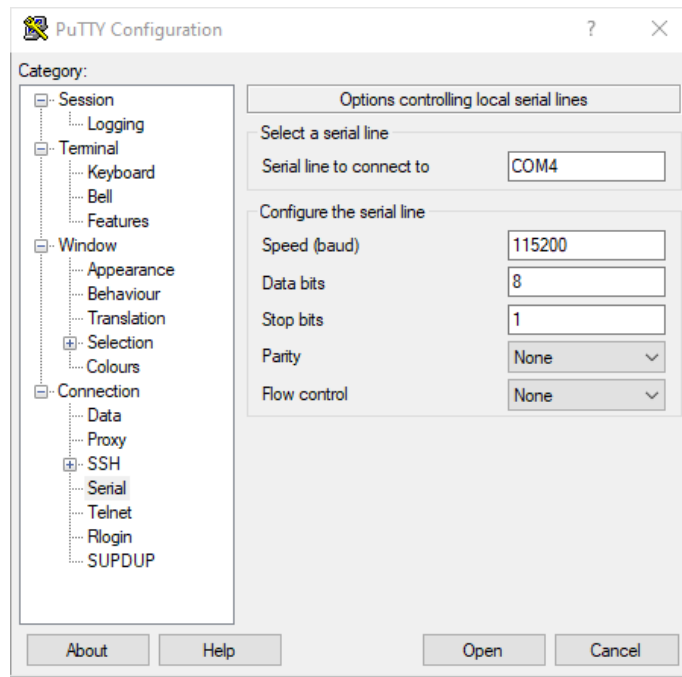
The evaluation kit application does not provide access to the full capabilities of the vProtean/vProtean+ SDR platform.

To explore additional options and functionality call us at 888.506.5677 or email us at sales@vanteon.com.

8.1 Main Menu

The vProtean SDR evaluation application has a hierarchical menu structure that allows you to configure the radio and to transmit and receive test waveforms. The main menu consists of the following status and commands:

Item	Name	Function
-	TX RX Sample Rate	Display of the pre-configured sample rate
-	FPGA Temperature	Display of the FPGA temperature
-	ADRV Temperature	Display of the ADRV IC temperature
-	RX1 RSSI	Display of RX1 receive signal strength indicator (RSSI) in dB relative to full scale
-	RX2 RSSI	Display of RX2 receive signal strength indicator (RSSI) in dB relative to full scale
-	TX1	State of the transmit (Primed/Enabled)
-	TX2	State of the transmit (Primed/Enabled)
1	TX1 RX1 Settings	Configure TX1 and RX1
2	TX2 RX2 Settings	Configure TX2 and RX2
3	Capture RX	Displays the number of samples to be captured. Selecting the option initiates RX capture according to RX capture settings.

Item	Name	Function
4	RX Waveform Capture Settings	Displays the current Capture settings. Selecting the option allows configuration of the RX capture parameter.
5	Recalibrate System	Force a transceiver recalibration
6	Sample Rate Menu	Change the sample rate
C	Switch to CLI	Switch to the command line interface

> Please contact Vanteon for more information on the command line interface.
>
> Type **menu** in the CLI to return to the menu-based application.

8.1.1 TX1/RX1 and TX2/RX2 Settings Menu

There are two submenus for configuring the TX1/RX1 and TX2/RX2 pairs. This section covers both submenus and refers to TX1 and TX2 as a generic TX_, and RX1 and RX2 as a generic RX_.

Item	Name	Function
-	RX RSSI	Display of RX receive signal strength indicator (RSSI) in dB relative to full scale
1	TX_/RX_ Frequency	Set the TX_/RX_ frequency (30 MHz to 6000 MHz)
2	Toggle TX_	Toggles transmit for TX_ on/off PRIMED – Transmit disabled ENABLED – Transmit enabled
3	TX_ Waveform Select	Go to TX_ waveform select menu
4	Digital Attenuation (dB)	Attenuation that is applied digitally to the transmit waveform (0 to 100 dB)
5	TX_ Front End Atten (dB)	Sets the attenuation in the ADRV9004 (0 to 41.5 dB), value can only be changed when TX is disabled
6	TX_ BOOST	Adds an additional 3 dB to the transmit
7	Toggle RX_	Toggles receive for RX_ on/off PRIMED – Receive disabled ENABLED – Receive enabled

> ⚠ The vProtean/vProtean+ SDR evaluation kit is supplied with heatsinks on the FPGA and transceiver IC. Under heavy processing and/or high output power levels additional airflow may be required to ensure the components remain in the specified operating temperature range to prevent damage.
>
> The FPGA and ADRV temperatures displayed on the main menu should be monitored by the user, and external cooling (for example, directed fan) should be applied as needed to prevent damage.

The TX Waveform Select Menu configures the waveform that is transmitted when the TX is toggled on. When the transmit is enabled, the selected waveform is transmitted repeatedly.

Item	Name	Function
-	Current Waveform	Display the current selected waveform
1	Zeros	Fills transmit buffer with zero waveform
2	CW	Single tone at carrier frequency
3	USB Tone, Offset=FS/32	Upper side band waveform, FS=sample rate
4	Dual Tone, Offset=FS/32+FS/8	Dual tone waveform, FS=sample rate
5	File	Go to file select menu to load waveform file from SD card
6	Ramp	Transmits a waveform whose amplitude increases overtime
7	Chirp	Transmits a linear FM signal

8.1.2 TX1 and TX2 File Select Menu

The File Menu allows the user to select a user defined file from the SD card that specifies the transmit waveform. Use the UP and DOWN arrows on your keyboard to highlight the file you want to select and press Enter.

The format of the filename must have a ".iq" extension to show up in the file list.

The format of a transmit waveform is a .CSV file with one sample (2 IQ pairs) per line with I and Q values separated by a comma. Columns 1 and 2 contain the Channel 1 data and columns 3 and 4 contain the Channel 2 data . Values must be within the range of -32768 to 32767, inclusive. See below for an example file format.

TX1-I, TX1-Q, TX2-I, TX2-Q

```
twoChannel.IQ ☒
    1      -13393,5151,-14134,3787
    2      -14150,2459,-14618,978
    3      -14342,-357,-14520,-1890
    4      -13982,-3163,-13856,-4695
    5      -13108,-5818,-12676,-7301
    6      -11739,-8254,-11019,-9632
    7      -9896,-10406,-8920,-11613
    8      -7657,-12152,-6472,-13141
    9      -5139,-13402,-3793,-14144
   10      -2432,-14144,-964,-14613
   11      383,-14374,1926,-14547
   12      3179,-14051,4725,-13917
   13      5840,-13150,7315,-12716
   14      8299,-11731,9655,-11013
   15      10455,-9897,11654,-8929
   16      12173,-7713,13167,-6541
```

The TX waveform file must contain between a minimum of 512 samples and a maximum of 2,097,152 samples, inclusive. The number of samples should be a multiple of 512. If the number of samples is not a multiple of 512, the TX waveform will be zero padded to the next multiple of 512.

If the TX waveform file contains less than 4 columns the missing columns will be interpreted as zeros. If the TX waveform file contains more than 4 columns the extra columns will be ignored.

The '#' character can be used at the start of a line to indicate a comment.

> The evaluation kit should be powered down whenever mounting or removing the microSD card.
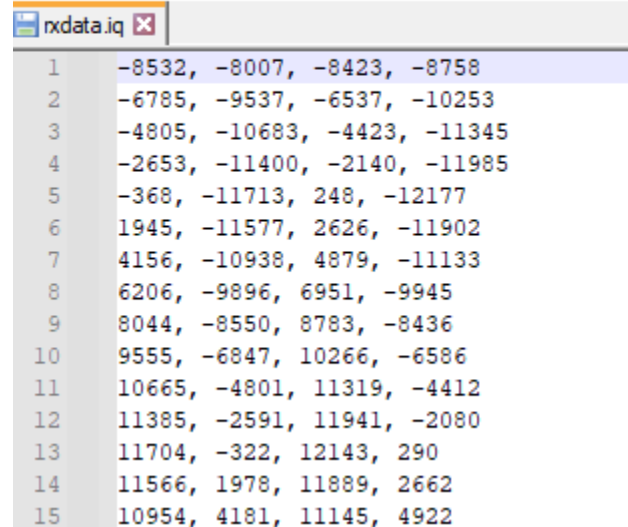
8.1.3 RX Waveform Capture Settings Menu

The RX Waveform Capture Settings Menu allows the user to setup the data capture. Option 1 allows the user to change the filename if the destination is the SDCard, if the destination is UDP, "UDP" will be listed as the file name. Option2 allows the user to set the number of samples captured. Option 3 allows the user to select the destination of the captured data, either a file on the SDCard or Send the data over ethernet as UDP packets.

Item	Name	Function
1	Filename	The name of the file to save the RX samples to. The filename can be up to 9 characters. The filename extension can be up to 2 characters. It is recommended that the filename extension be ".iq". If UDP is selected as the destination then "---UDP---" will be displayed.
2	Samples	The number of samples to capture. Must be a multiple of 512 IQ samples.
3	Toggle UDP/SD Card	Toggles between saving RX capture data to SD card or to send the RX capture data over UDP

8.1.3.1 SDCard Capture format

The format of a captured waveform is a .CSV file with one sample (2 IQ pairs) per line with I and Q values separated by a comma. The RX capture file will have 4 columns. Columns 1 and 2 contain the I and Q data for Channel 1 and columns 3 and 4 contain the I and Q data for Channel 2. See below for an example.

RX1-I, RX1-Q, RX2-I, RX2-Q

```
rxdata.iq
 1   -8532, -8007, -8423, -8758
 2   -6785, -9537, -6537, -10253
 3   -4805, -10683, -4423, -11345
 4   -2653, -11400, -2140, -11985
 5   -368, -11713, 248, -12177
 6   1945, -11577, 2626, -11902
 7   4156, -10938, 4879, -11133
 8   6206, -9896, 6951, -9945
 9   8044, -8550, 8783, -8436
10   9555, -6847, 10266, -6586
11   10665, -4801, 11319, -4412
12   11385, -2591, 11941, -2080
13   11704, -322, 12143, 290
14   11566, 1978, 11889, 2662
15   10954, 4181, 11145, 4922
```

If the captured waveform filename has an ".iq" extension it will show up in the TX waveform list if the capture was successful.

8.1.3.2 Capture over UDP

Both the menu and the CLI support sending RX capture data over the ethernet as UDP packets. When the capture destination is set to UDP the data will be sent over UDP once the capture has been complete. The number of samples requested will be packed into UDP packets and broadcast on the connected ethernet.

The vProtean/vProtean+ IP address is fixed as 192.168.99.200, the UDP packets are broadcast on port 1234 using broadcast address 255.225.225.225.

For UDP packets the four 16-bit values are packed into a 64-bit word as

Bits 63:48 - RX1-I
Bits 47:32 - RX1-Q
Bits 31:16 - RX2-I
Bits 15:00 - RX2-Q

The 64-bit words are packed into the UDP packet data payload in little endian format.

The following Octave Script snippet shows how the UDP packets can be decoded in to RX1 and RX2

```
% read data from the UDP port
% Each sample is 64 bits and contains four 16 bit values
d  = udp_read(u, num_samples*8,10000);
if (length(d) == 0)
  RX1 = [];
  RX2 = [];
  printf("failed to capture UDP data\n");
  return;
endif

% UDP packet read, parse data
% first convert the bytes to 16 bit integers
d0 = d(1:2:end);
d1 = d(2:2:end);
% data in UDP packet is little endian
d2 = [dec2hex(d1), dec2hex(d0)];
d3 = typecast(uint16(hex2dec(d2)), 'int16');
d3 = double(d3);

% Extract the RX1 and RX2 data
% the 64 bit sample is made up as
% Bits 63:48  - RX1-I
% Bits 47:32  - RX1-Q
% Bits 31:16  - RX2-I
% Bits 15:00  - RX2-Q
% The 64 bit sample is stored in the UDO little endian so RX2 Q
is the first value

  RX2 = d3(2:4:end) + i*d3(1:4:end);
  RX1 = d3(4:4:end) + i*d3(3:4:end);
```

8.1.4 Sample Rate Menu

The Sample Rate sub menu allows the user to select the sample rate. Use the menu options to select the desired sample rate. The system's sample rate will be changed to the desired sample rate when the sub menu is exited. A re-calibration will be done when the sample rate has changed.

Item	Name	Function
-	Current Sample Rate	Displays the current sample rate in use
-	Desired Sample Rate	Displays the desired sample rate, will be updated based on selected sample rate
1	Set 1.92 MSPS	Sets the desired Sample Rate to 1.92 MSPS
2	Set 3.84 MSPS	Sets the desired Sample Rate to 3.84 MSPS
3	Set 7.68 MSPS	Sets the desired Sample Rate to 7.68 MSPS
4	Set 15.36 MSPS	Sets the desired Sample Rate to 15.36 MSPS
5	Set 32.72 MSPS	Sets the desired Sample Rate to 32.72 MSPS
6	Set 61.44 MSPS	Sets the desired Sample Rate to 61.44 MSPS

9   Customer Support

If you experience difficulty after reading the manual and/or using the product, please feel free to contact support@vanteon.com for additional assistance.

> ### Need support?
>
> Vanteon offers contract engineering services and can assist you in implementing the vProtean/vProtean+ SDR into your system.
>
> Need short term support?
>
> Purchase a 2, 4, 8, or 40-hour block of engineering support to get access to a team of engineers to support your needs. Engineering support blocks can be purchased directly from our website with any major credit card. For more information visit our website at https://vanteon.com/engineering-support-blocks/.

10 Terms and Conditions of Sale

10.1 General Product Terms

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10.2 One Year Warranty

Vanteon Corporation provides a One-Year Limited Warranty for all products sold. Should this product, in Vanteon Corporation's opinion, fail to be in good working order during the warranty period, Vanteon Corporation will, at its option, repair or replace this product at no charge, provided that the product has not been subject to abuse, misuse, accident or unauthorized modification or repair.

Products returned to Vanteon must be pre-authorized by Vanteon and sent prepaid, insured, and packaged for safe shipment. Vanteon will return this product by prepaid ground shipment service.

Should the product prove to be irreparable, Vanteon reserves the right to substitute an equivalent product if available.

Full warranty details are included in "Vanteon Corporation – Terms and Conditions of Product Sales" available at www.vanteon.com.

The above warranty is the only warranty authorized by Vanteon for this product. Under no circumstances will Vanteon be liable in any way for any damages, including any lost profits, business revenue, special, indirect, incidental, exemplary, punitive, or consequential damages arising out of the use of, or inability to use such product.

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