



LUSWAVE

PUPradar DEVELOPMENT KIT

# USER MANUAL

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# 1 Getting started

## 1.1 Introduction

Luswave Technology develops low-power, low-cost, and easy using radar development kits, which offers great flexibility for applications in academic research, industry automation, public safety, and DIY project.

PUP\_EN24C\_T2R4 is a K-band development platform. This device integrates an RF module and a powerful FPGA-based processor module together. The RF front end consists of two transmitting and four receiving channels, which makes it a multiple in multiple out (MIMO) radar. This device can connect either horn antennas or patch antennas external antennas. When using patch antennas, the device supports direction of arrival (DOA) measuring, which is suitable for target tracking, movement sensing, site surveillance, occupancy sensing, people counting, fall detection, and many other uses. Its FPGA-based micro control unit (MCU) and eight-channel 65Msps pipeline LVDS ADC module offers ultimate design flexibility and accuracy with industry-leading programmable logic.

A user-friendly graphical user interface (GUI) allows great flexibility. Users can easily configure desired center frequency and bandwidth, signal waveform, sampling rates, display parameters, etc. After signal processing, waveform, range-Doppler map and velocity waterfall map are displayed.



Figure 1. PUP\_EN24C\_T2R4

## 1.2 Key Features

- Support both FMCW and CW modulations
- PLL controlled waveform creating
- Reliable Tx channel switching
- Antenna array for beamforming.
- 65MHz eight-channel LVDS pipeline AD converters
- Real-time complex (I & Q) data acquiring
- User-friendly graphical user interface (GUI)
- Re-configurable parameters
- Long recording time for raw data
- USB 2.0 high speed (480Mb/s) interface to host computer

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### 1.3 Kit Contents

The PUP\_EC24C\_T2R4 Development Kit comes with an enclosed radar device and mounting brackets. The complete list of the SDR development kit includes:

- PUP\_EN24C\_T2R4 Development Kit.
- AC/DC power adapter.
- USB 2.0 A to Mini-B cable.
- A USB flash drive with software and documents.

## 2 Hardware Specifications

### 2.1 Functional Block Diagram

Figure 2 is a block diagram of the PUP\_EN24C\_T2R4 MIMO radar development platform. PLL controlled frequency sweep is configured by FPGA-based MCU. Eight channel of IF signals are acquired by a single chip 65MSPS eight-channel LVDS AD converter and then streamed to host computer via a high-speed USB interface (up to 480Mb/s) for further processing. A graphical user interface (PUPradarGUI) is used to control the parameter configuration.

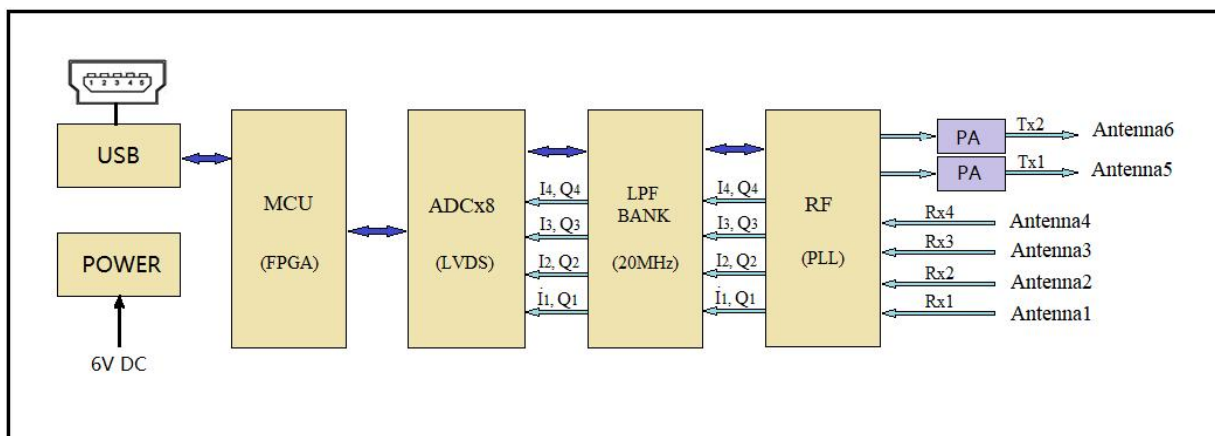


Figure 2. Block Diagram

### 2.2 Specifications

PUP\_EN24C\_T2R4 has two transmitters and four receivers with six SMA connectors for external antennas. Its specifications are shown in Table 1.

Table 1. Specifications of the Multichannel PUP\_EN24C\_T2R4

Model	PUP_EN24C_T2R4
Antennas	6 External Antenna Connectors
RF Channels	2 Transmitters, 4 Receivers
Modulations	FMCW, CW
Typical Frequency	24GHz-25GHz (Expandable to 23.5GHz-26GHz)
Typical Bandwidth	0.25GHz-1GHz (Expandable to 2.5GHz)

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Tx Output Power	19-21dBm
Rx Noise Figure	10dB
Detectable Range	People: 25m, middle sized vehicle: 60m
Supply Voltage	6V
Supply Current	1.2A
Operating Temperature	-40°C - 85°C
Dimensions	L: 130mm, W: 108mm, H: 32mm
Weight	14oz

## 2.3 Antennas

### 2.3.1 Patch Antenna

Six channel patch antenna (Figure 3) can be configured as a MIMO beamforming array (Figure 4).

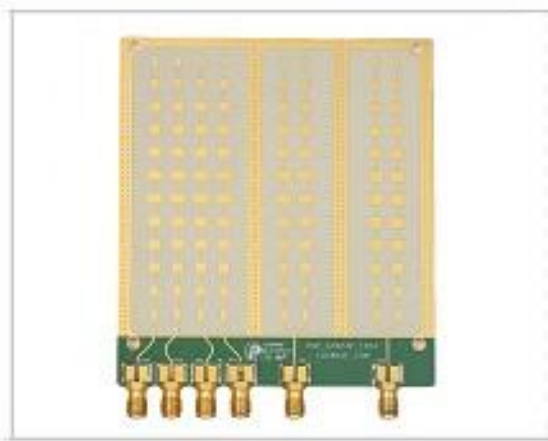


Figure 3. Patch antennas

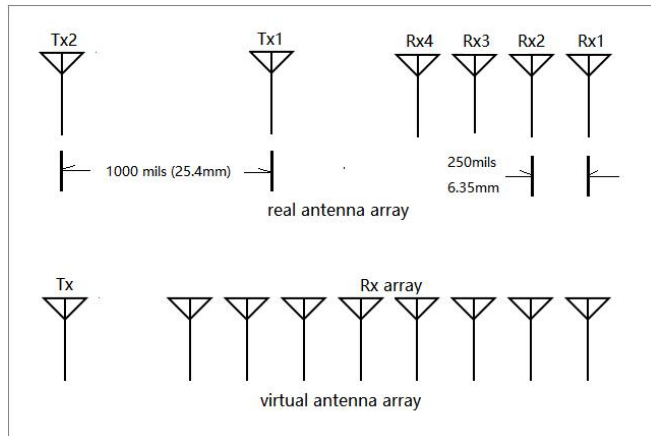


Figure 4. Antenna array

### 2.3.2 Horn Antenna

External Horn antennas (Figure 5) or other form of antennas (figure 6) can be connected to the device according to user's specific needs. Active transmitters and receivers can be configured by GUI. Due to its bigger size, horn antennas are not easy to be configured as beamforming array.

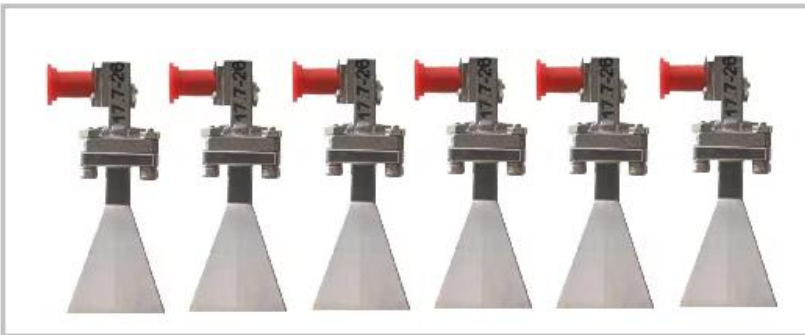


Figure 5. Standard horn antenna



Figure 6. Patch antenna

## 2.4 Data Stream Sequences

The transmitter channel can be configured as one channel or two channels. The receiver channel can be configured as one channel, two channels, and four channels. When only one transmitter is activated, the data stream sequences are illustrated in figure 7.

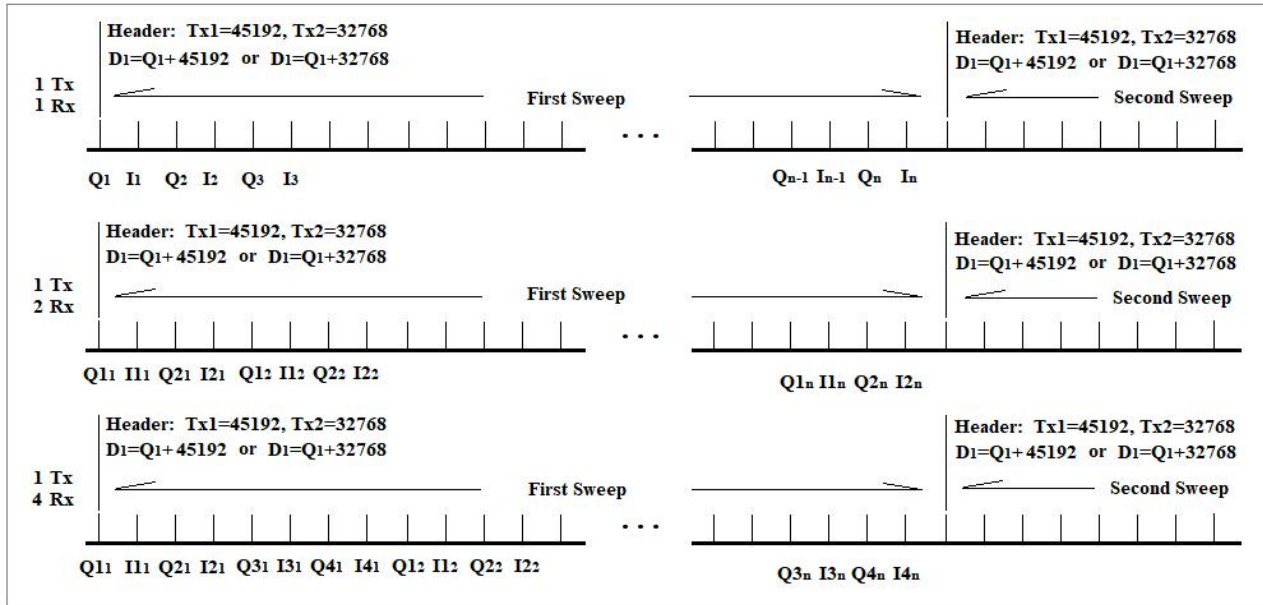


Figure 7. Single Transmitter data stream sequences

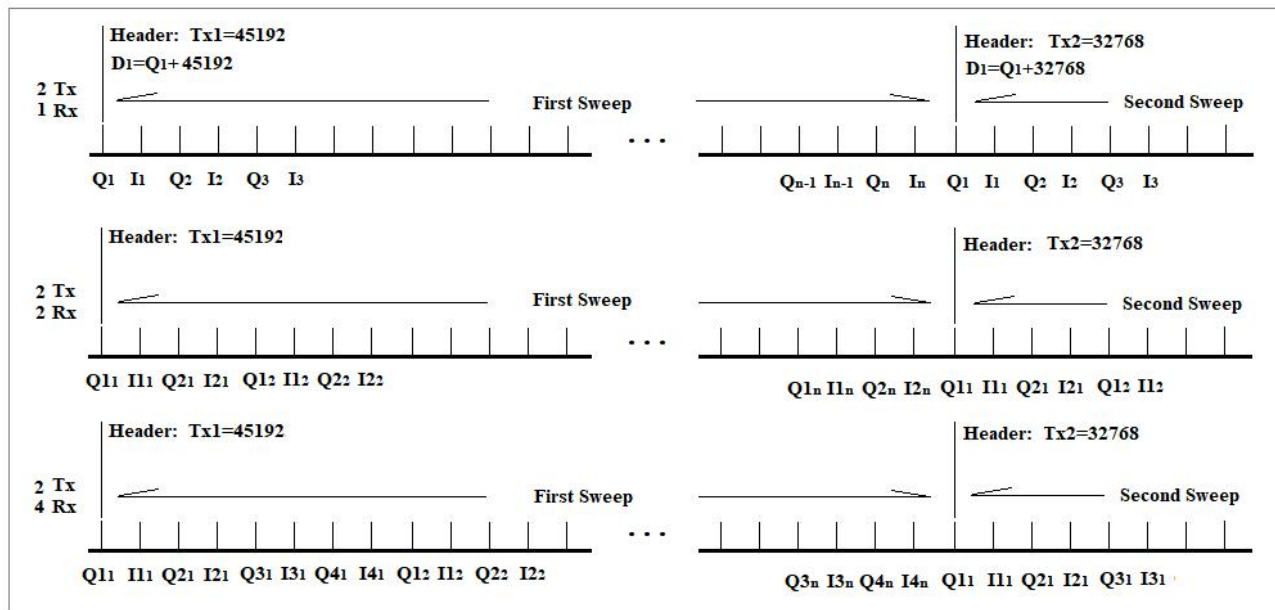


Figure 8. Two transmitter data stream sequences

When the device works in MIMO mode (Tx1.Tx2), both transmitters are alternately activated where only one is activated in each sweep. A header of 45192 (Tx1) or 32768 (Tx2) is always added to the first



sample of each sweep. So when the value of the first sample is greater than 45192, then the data stream of this sweep comes from Tx1. When the value of the first sample is greater than 32768 and less than 45192, then the data stream of this sweep comes from Tx2. Subtracting 45192 or 32768 from the first sample value, the value of Q1 remains. Figure 8 are the two transmitter data stream sequences.

### 3 System Setup

#### 3.1 Panels

The front and back panels of PUP\_EN24C\_T2R4 are shown in Figure 9.



Figure 9. PUP\_EN24C\_T2R4

#### 3.2 USB Driver Setup

Find the Driver folder in the include USB flash drive (Figure 10), and copy it to your computer.

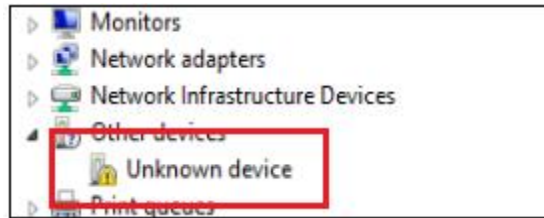


Figure 10. USB Driver

Plug the 6V power into the power socket, slide the power switch towards the socket, and then connect your computer and the device with USB A to USB mini cable.

Open the Device Manager window on your computer, “Unknown Device” is shown (Figure 11) when the device is first connected.





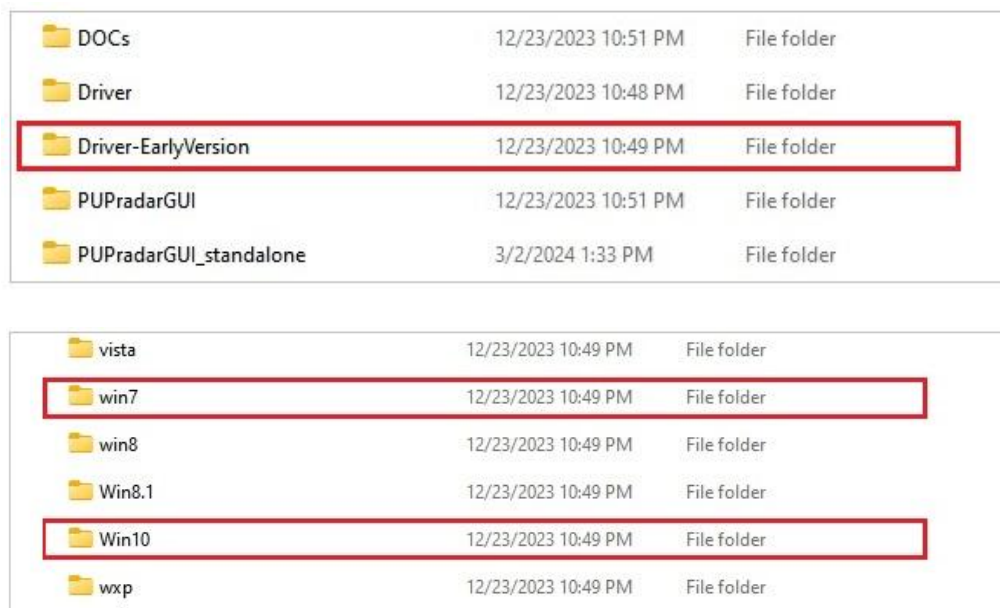
**Figure 11. Device Manager Window.**

When you install the driver for this device using the file in the Driver folder and “Cypress FX2LP No EEPROM Device” is shown, the driver is installed successfully.



**Figure 12. Driver Software Installed Successfully**

In case the USB driver can not be installed, try the earlier version in the folder “ Driver-EarlyVersion”, and try win7 if Win10 won’t work.

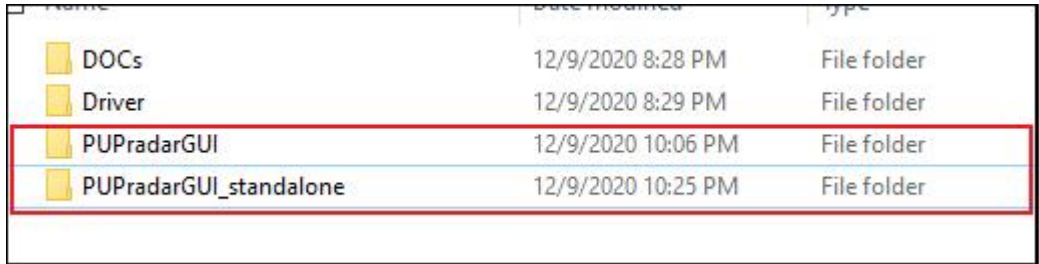


**Figure 13. USB Driver Early Version**

### 3.3 PUPradarGUI Setup

#### 3.3.1 GUI app install

In the USB flash drive, you can find two folders “PUPradarGUI” and “PUPradarGUI\_standalone”.



Name	Date modified	Type
DOCs	12/9/2020 8:28 PM	File folder
Driver	12/9/2020 8:29 PM	File folder
PUPradarGUI	12/9/2020 10:06 PM	File folder
PUPradarGUI_standalone	12/9/2020 10:25 PM	File folder

Figure 14. included documents folders

If you are already a Matlab User, copy the folder “PUPradarGUI” into your Matlab workspace, set the path to this folder, and run PUPradarGUI.m.

If you want to use the standalone version, you can either run PUPradarGUI.exe in the folder “PUPradarGUI\_standalone” When using standalone version, you may need a couple of minutes to start up, please be patient.

#### 3.3.2 PUPradarGUI user’s guide

When running the PUPradarGUI, the GUI window (Figure 15) will appear. First hitting the “Refresh” button, the software will automatically detect the device. When the device is successfully recognized, its model name will show in the message window. you can hit the “start” toggle button to run the software. The GUI gives users access to select modulations and other parameters. Anytime you want to record the raw data, select the record time, and then hit the “record” button to start.

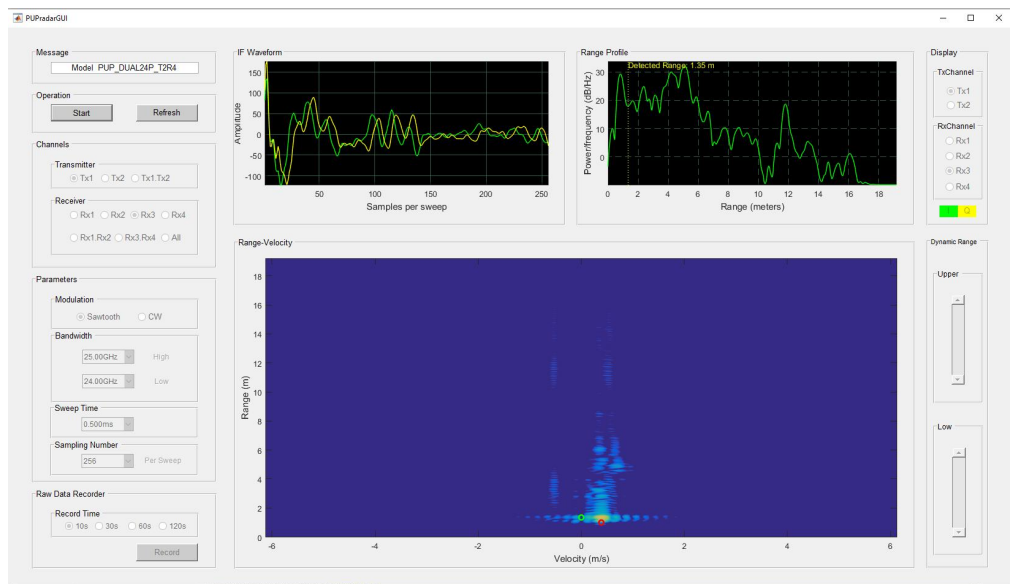


Figure 15. PUPradarGUI

- **Message Window**

When the device is detected, the message window will show the model name, otherwise, it will show an error message or ask you to refresh.

- **Operation Panel**

There are two buttons in the operation panel. The start/stop button is a toggle button. The refresh button resets the software to its default status.

- **Channel Panel**

In the channel panel, you can turn on any Tx channels or Rx channels. When “Tx1.Tx2” is selected, the device automatically works in the MIMO mode. When “Rx1.Rx2” or “Rx3.Rx4” is selected, Rx1 and Rx2 data or Rx3 and Rx4 data are transferred to host PC . When “all” is selected, all Rx channel acquiring data will be transferred to host PC.

- **Parameter Panel**

In the parameter panel, modulations, lower and upper frequencies, sweep time, and sampling number per sweep can be configured.

- **Raw Data Recorder**

When the GUI is running, the buttons in the Raw Data Recorder panel are active.. You can start recording at any time. Push record button to start the recording and a save file window will appear after the recording time is over. The default file format is \*.mat, but you can save the file in \*.txt format. More details can be found in “DataRecordingManual.pdf”.

- **Display Panel**

When one Rx channel is activated, the three display windows are for that channel. When two or more Rx channels are activated, one channel in this panel should be selected for display.

- **Dynamic Range Panel**

The two sliders in the Dynamic Range Panel control the signal threshold in the lower display window. When the slider is lower, it shows more target detail. When the slider is higher, less noise is shown from the image.