



LUSWAVE

**PUPradar--SMART RADAR PLATFORM**

# USER MANUAL

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# 1 Getting started

## 1.1 Introduction

Luswave Technology develops low-power, low-cost, and easy-to-use radar development platforms, which offer great flexibility for applications in academic research, industry automation, public safety, and DIY project.

PUP\_DUAL24P\_T2R4 is a K-band development kit. This model integrates an RF module and a powerful FPGA-based processor module together. The RF front end consists of two transmitters and four receiver channels, which makes it a multiple-input multiple out (MIMO) radar. This supports direction of arrival (DOA) measurement, which is suitable for target tracking, movement sensing, site surveillance, occupancy sensing, people counting, fall detection, and many other uses. Its FPGA-based microcontroller unit (MCU) and eight-channel 65Msps pipeline LVDS ADC module offer ultimate design flexibility and accuracy with industry-leading programmable logic.

A user-friendly graphical user interface (GUI) allows great flexibility. Users can easily select the desired center frequency and bandwidth, signal waveform, sampling rates, display parameters, etc.

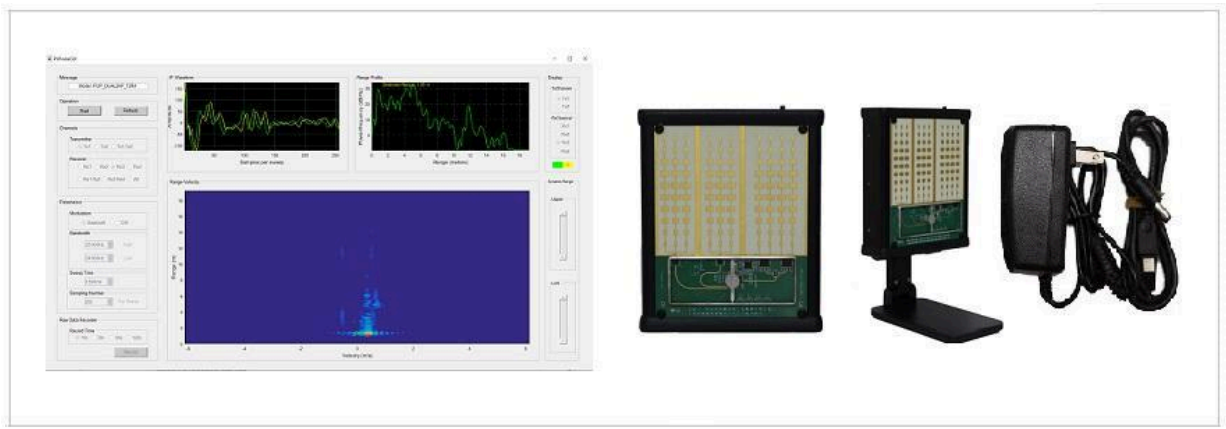


Figure 1. PUP\_DUAL24P\_T2R4

## 1.2 Key Features

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

### 1.3 Kit Contents

The PUP\_DUAL24P\_T2R4 Development Platform comes with an enclosed radar device and a mounting base. The development platform includes:

- PUP\_DUAL24P\_T2R4 Development Platform
- AC/DC power adapter
- USB 2.0 A to Mini-B cable
- Mounting stand
- 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\_DUAL24P\_T2R4 MIMO radar development Kit. PLL controlled frequency sweep is configured by FPGA-based MCU whenever parameter settings are changed. Through a low pass filter bank, eight channels of IF signals are acquired by a 50Mpsps eight-channel single chip 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 of the kit.

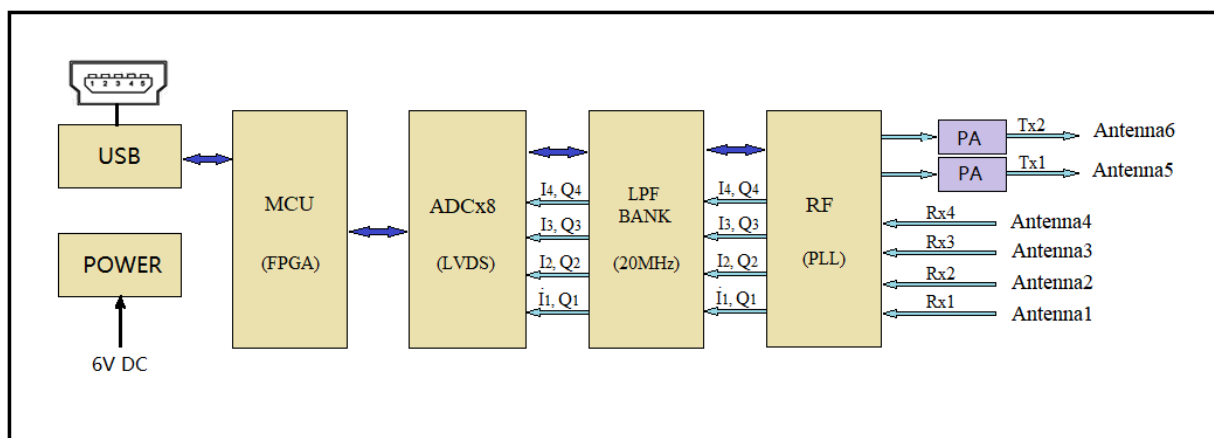


Figure 2. Block Diagram

### 2.2 Specifications

PUP\_DUAL24P\_T2R4 has two transmitters and four receivers with six onboard patch antennas. Its specifications are shown in Table 1.

Table 1. Specifications of the Multichannel PUP\_DUAL24P\_T2R4

Model	PUP_DUAL24P_T2R4
Antennas	6 Onboard Patch Antennas
RF Channels	2 Transmitters, 4 Receivers
Modulations	FMCW, CW

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Typical Frequency	24GHz-25GHz (Expandable to 24GHz-26GHz)
Typical Bandwidth	0.25GHz-1GHz (Expandable to 2GHz)
Tx Output Power	17dBm
Rx Noise Figure	10dB
Detectable Range	People: 15m, middle sized vehicle: 40m
Supply Voltage	6V
Supply Current	1.2A
Operating Temperature	-40°C - 85°C
Dimensions	L: 130mm, W: 108mm, H: 32mm
Weight	12oz

### 2.3 Antennas

The six patch antennas on PUP\_DUAL24P\_T2R4 (Figure 3) are configured as a MIMO beamforming array (Figure 4).

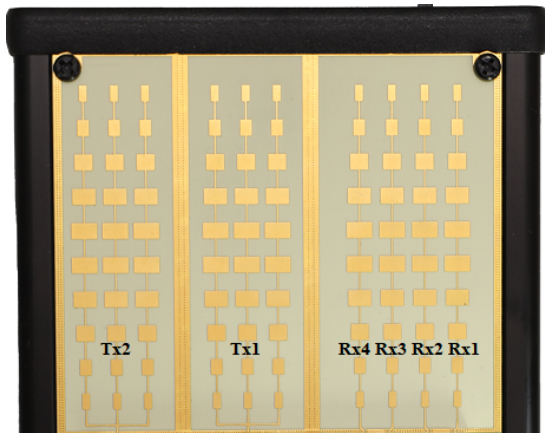


Figure 3. Patch antennas

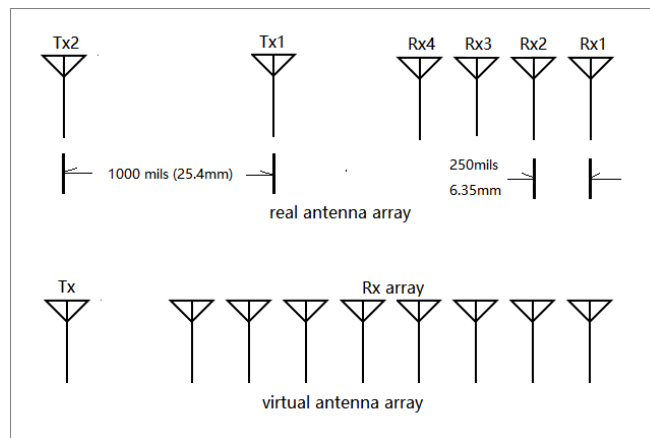
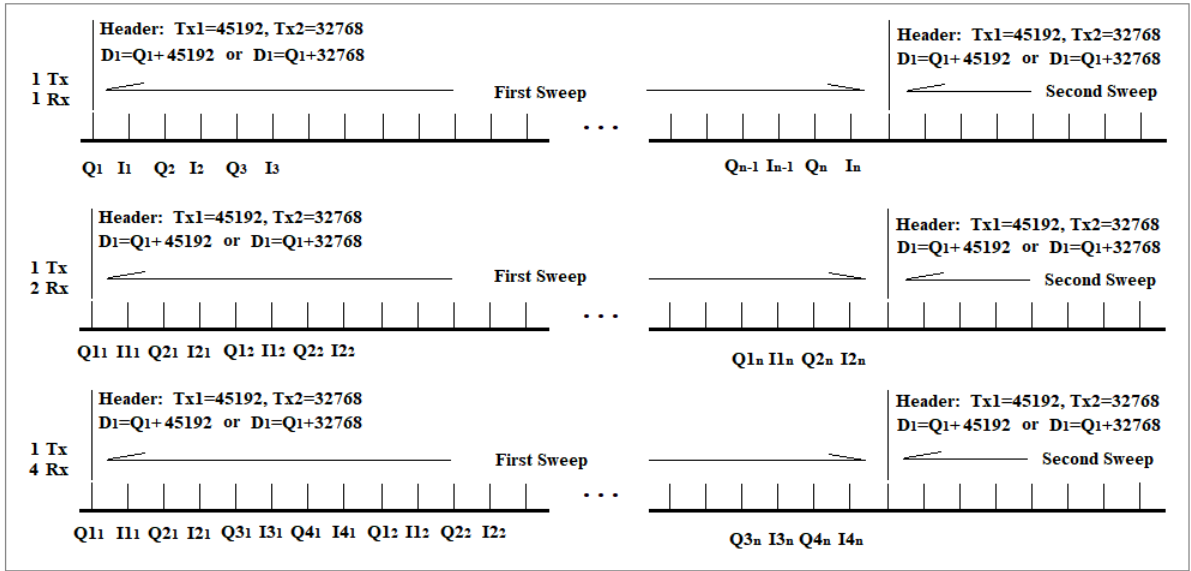


Figure 4. Antenna array

### 2.4 Data Stream Sequences

The transmitter channel can be set as one channel or two channels. . The receiver channel can be set as one channel, two channels, or four channels. When only one transmitter is activated, the data stream sequences are illustrated in Figure 5.



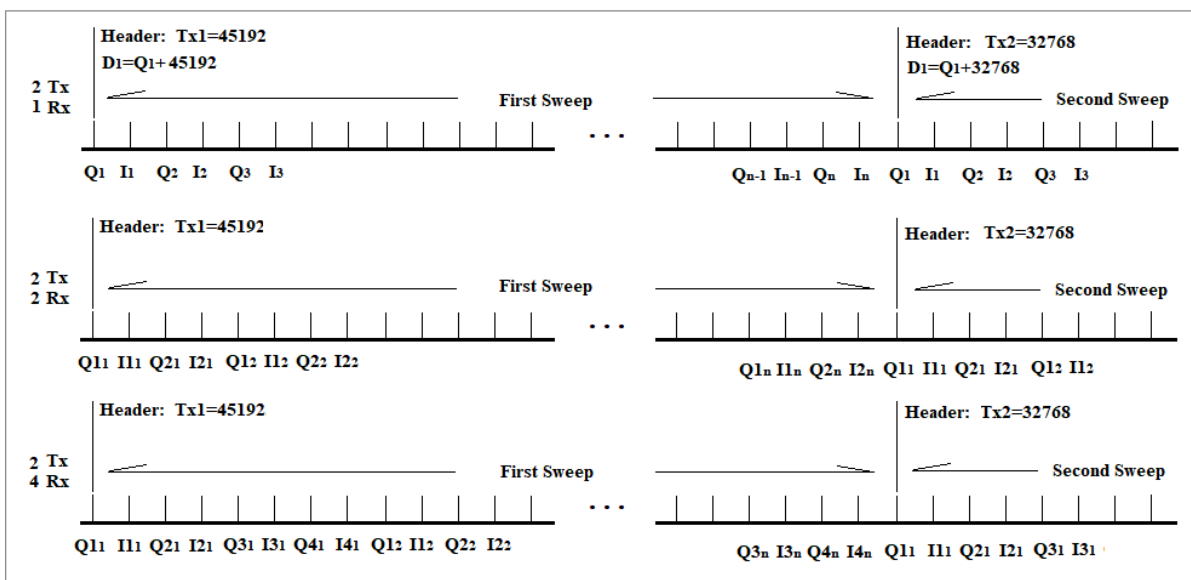
**Figure 5. Single Transmitter data stream sequences**

When the device operates in MIMO mode (Tx1/Tx2), the two transmitters are activated alternately on a sweep-by-sweep basis, with only one transmitter active during each sweep. A header value of 45192 (Tx1) or 32768 (Tx2) is added to the first Q1 sample of every sweep.

If the value of the first sample is greater than 45192, the data stream for that sweep originates from Tx1.

If the value of the first sample is greater than 32768 but less than 45192, the data stream for that sweep originates from Tx2.

By subtracting 45192 or 32768 from the first sample value, the original Q1 value can be recovered. Figure 6 shows the data stream sequences for the two transmitters.



**Figure 6. Two transmitter data stream sequences**

### 3 System Setup

#### 3.1 Mounting Base

The device is mounted on the mounting stand. With the mounting stand, the height and antenna directions are easy to adjust. The power socket and the USB connector is on the top of the device.



Figure 7. Device on stand and top view

#### 3.2 USB Driver Setup

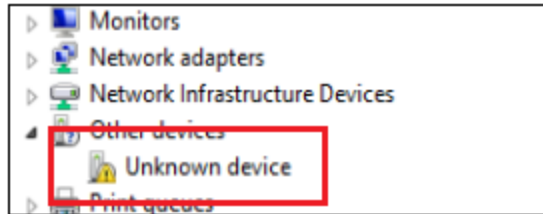
Find the Driver folder in the include USB flash drive (Figure 8), and copy it to your computer.

DOCs	11/9/2024 2:40 PM	File folder
Driver	11/9/2024 2:40 PM	File folder
Driver-EarlyVersion	11/9/2024 2:40 PM	File folder
PUPradarGUI	3/13/2024 9:05 AM	File folder

Figure 8. USB Driver

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

Open the Device Manager window on your computer, “Unknown Device” is shown (Figure 9) when the device is first connected.



**Figure 9. Device Manager Window.**

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



**Figure 10. Driver Software Installed Successfully**

### 3.3 PUPradarGUI Setup

#### 3.3.1 GUI app install

In the USB flash drive, you can find folder “PUPradarGUI”.

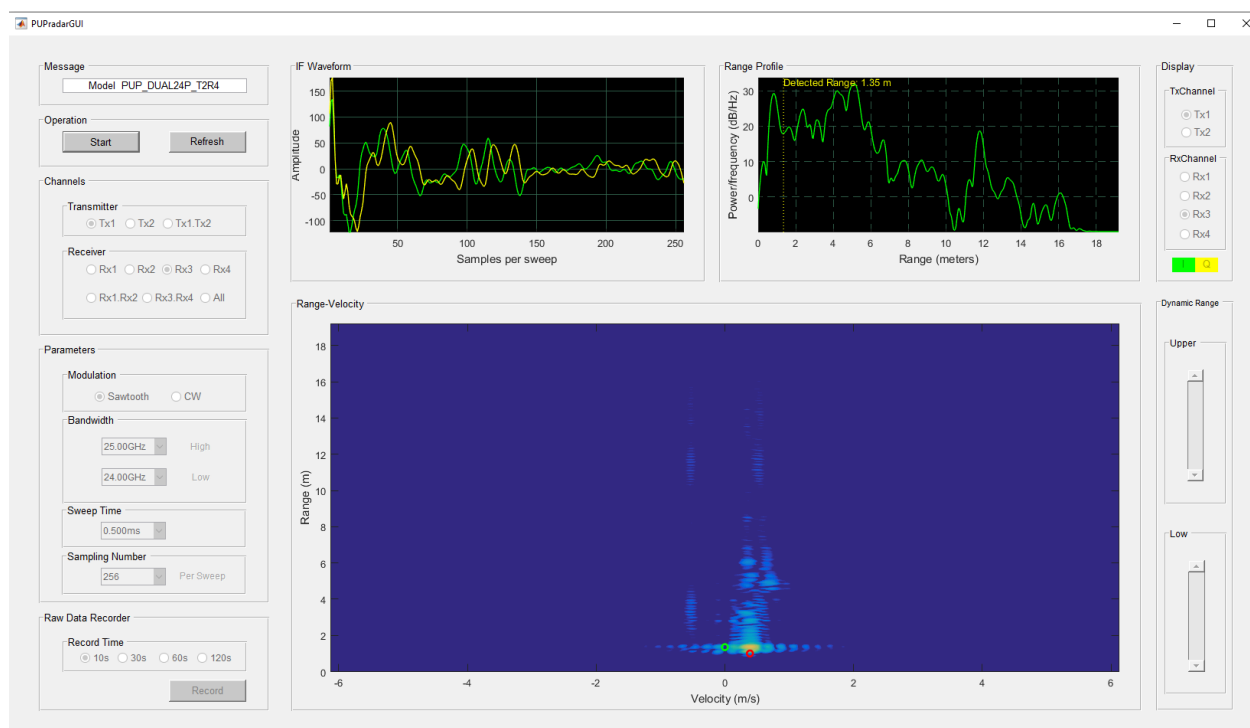
DOCs	11/9/2024 2:40 PM	File folder
Driver	11/9/2024 2:40 PM	File folder
Driver-EarlyVersion	11/9/2024 2:40 PM	File folder
PUPradarGUI	3/13/2024 9:05 AM	File folder

**Figure 11. Included documents folders**

Copy the folder “PUPradarGUI” into your Matlab workspace, set the path to this folder, and run PUPradarGUI.m.

#### 3.3.2 PUPradarGUI user’s guide

When you run the PUPradarGUI, the GUI window (Figure 12) will appear. First push the “Refresh” button, the software will automatically detect the device. When the device is successfully recognized, its model name will appear in the message window. You can then push the “start” toggle button to run the software. The GUI gives users access to selecting modulations and other parameters. At anytime you want to record the raw data, select the record time, and then hit the “record” button to start.



**Figure 12. PUPradarGUI**

- **Message Window**

When the device is detected, the message window will show the device 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 activate 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, the device receives Rx1 and Rx2 signals or Rx3 and Rx4 signals.

- **Parameter Panel**

In the parameter panel, you can select your desired modulations, lower and upper frequencies, sweep time, and sampling number per sweep.

- **Raw Data Recorder**

When the GUI is running, the buttons in the Raw Data Recorder panel are active. You can activate the record function at any time. Push record 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 the.txt format.

- **Display Panel**

When one Rx channel is activated, the three default display windows are for that channel. When both the Tx channels or more than one Rx channels are activated, this panel switches from the three display window to the selected display channel combination.

- **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.