Wearable Trojan Radar System - Instruction

Setup

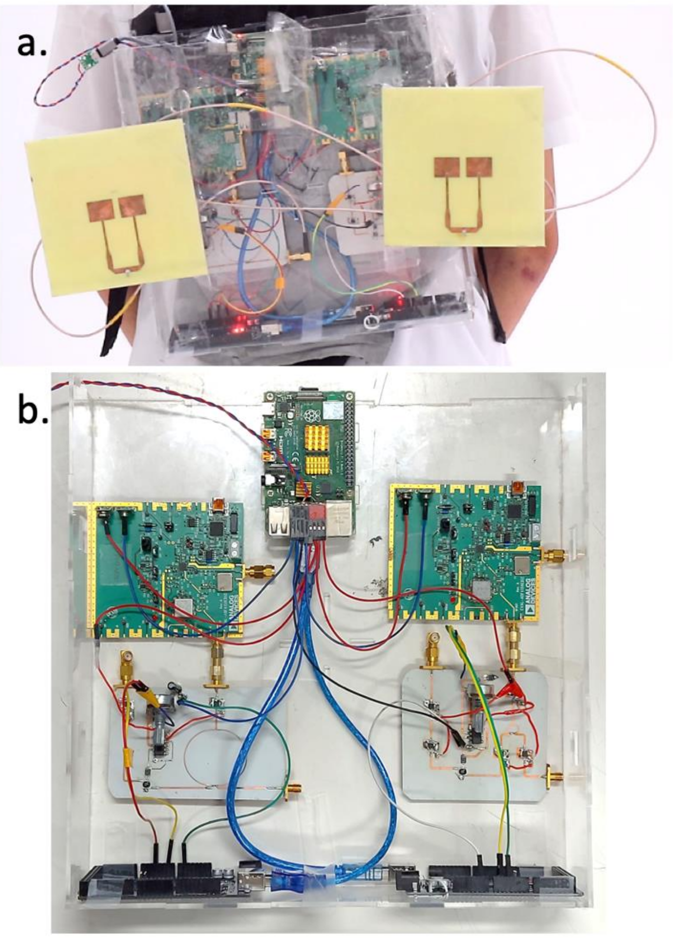


Fig. 1. (a) Overview of Trojan Radar System (b) Close-up look of the circuits.

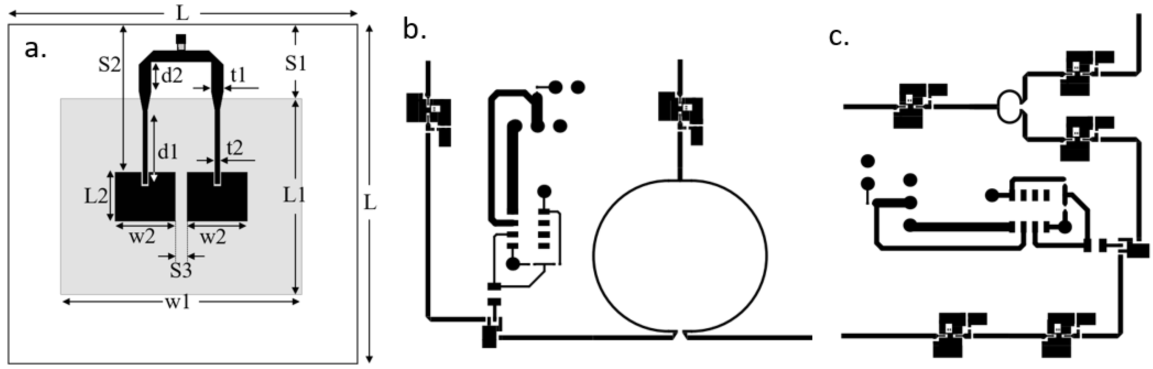
A. Material List:

Item	Usage	Num.	Item	Usage	Num.
Eval-ADF4158	Signal Source	2	Motor	SGen, RCS demo	2
SIM-63LH+	Mixer	2	Arduino UNO	Motor Control	2
PMA3-83LN+	LNA	7	ESP 32	Bluetooth Module	2
Raspberry Pi 4	Control Unit	1	Skywalker ESC	Motor Control	1
Arduino Mega	ADC	2	LM393 Module	Motor Control	1
SMA cable	Connection	4	18650 Battery	Motor Power	8
RO4003C (20mil)	RF Circuits	-	Acrylics	Support	-
RO4003C (60mil)	Antenna	-	Al extrusion	Support	-
FR4 (8mil)	Antenna	-	Foam	SGen	-
SMA connector	RF Connector	10	Power Bank	Power source	1
HA17358	Op Amp.		Variable R	IF Amplification	
0402 R/L/C	Lump Component	-	Motor	SGen, RCS demo	2
Variable R	IF Amplification				

B. Hardware Setup

1. PCB Fabrication (Circuits and Antenna)

With simple wet etching equipment, we could DIY the circuits and antenna. Parameters of the antenna and layout files are attached, and the following PCB substrates are needed.



d.

Design Parameters for Antenna (Unit: mm)					
L	L1	w1	S1	t1	t2
150	85	100	32.5	5	2
L2	w2	S2	S3	d1	d2
19	24	65.5	6	33	12

e.

Substrates	Usage	size
RO4003C 60mil	Antenna	300×300mm
FR4 8mil	Antenna	300×300mm
RO4003C 20mil	Circuits	100x200mm

Fig. 2. The PCB Layout of (a) Trojan antenna, (b) 915MHz circuits, and (c) 5.8GHz circuits. Important parameters of antenna design are listed in (d). The required substrates are listed in (e).

2. Soldering

According to the schematic files, solder all the components, including LNA ICs, mixer ICs, resistors, capacitors, inductors, variable resistors, SMAs and 5V power lines.

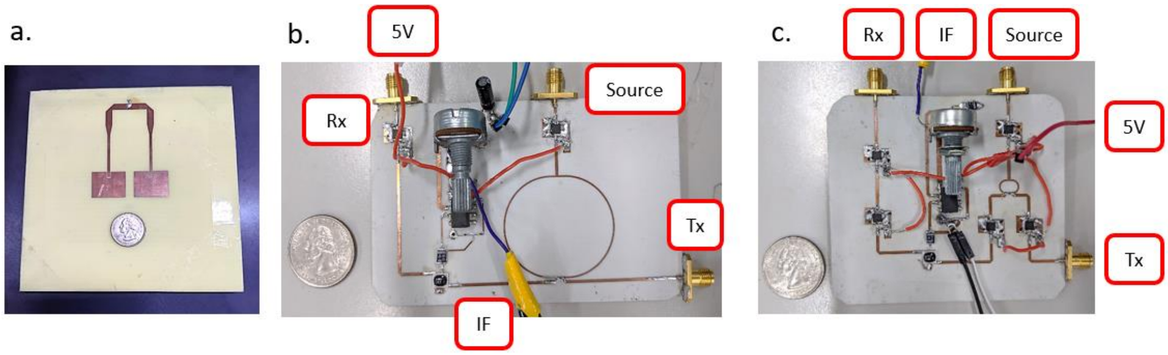


Fig. 3. The finished product of (a) Trojan antenna, (b) 915MHz circuits, and (c) 5.8GHz circuits.

3. Assembling

Using cables or connectors to connect signal from ADF4158 to source SMA on the circuit, T_x SMA and R_x SMA to T_x and R_x antenna, IF wires to Arduino A1 pin, ground wires to Arduino GND pins. Repeat at the two frequencies band. Last, connect all power lines and ground lines together to the power bank.

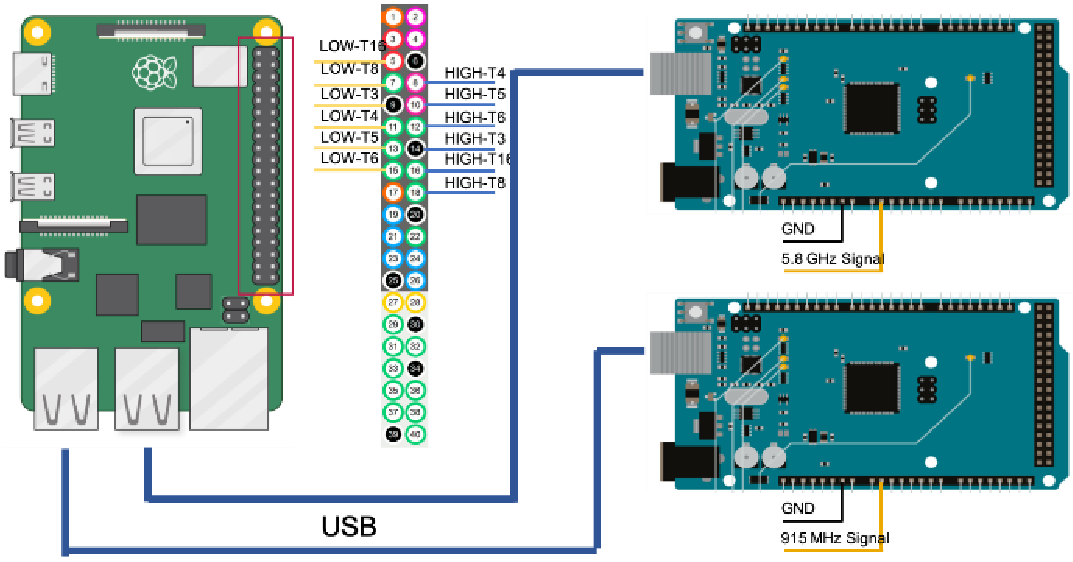


Fig. 4. Connection of Eval-ADF4158, Arduino Mega 2560, and Raspberry Pi 4.

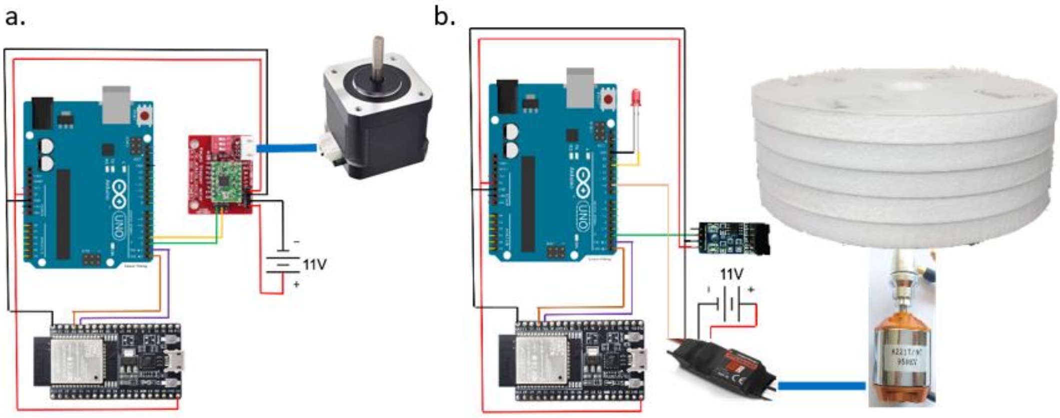


Fig. 5. Connection of (a) Rotation Platform and (b) SGen

C. Software Setup

Raspberry Pi

All source codes are available at GitHub. Because the codes are implemented by Python 3, Python 3.7 or higher version must be installed on Raspberry Pi. Please check the library dependency by typing the following commands:

```
$ cd Wearable-Trojan-Radar-System

$ python3 -m pip install -r requirements.txt
```

Arduino Mega 2560

Arduino Mega 2560 is the ADC of Trojan radar. There are 2 files, ADC_915MHz.ino and ADC_5800MHz.ino, which should be installed on 2 Arduino Mega boards.

Arduino UNO

SGen and Rotation Platform are controlled by 2 Arduino UNO boards. Install SGen.ino and Rotation_Platform.ino on the 2 boards.

ESP-32 (Bluetooth Module)

ESP-32 serves as the Bluetooth Serial controlling SGen and Rotation Platform. Please install BT_Serial.ino to ESP-32 Boards by micro-USB cables.

Getting Start

To start Trojan radar, please type the following command in the terminal.

```
$ python3 main_control.py
```

The command line interface (CLI) of Trojan supports the following commands:

Command	Function
`read / stop`	Start / stop loading IF signal
`setbg / resetbg`	Set the current signal as background signal
`obj`	Open the object detection view
`sig`	Open the oscilloscope view
`close`	Close all views
`quit`	Close the program

Demonstration

A. Distance Measurement

The range resolution and max. detection range of the 2 bands of radar would be compared in this demo.

i. Read Signal

Type the following commands to start reading the signal.

```
>>> Command: read
>>> Command: sig
>>> Command: obj
```

The view would look like Fig. 6a, which includes 3 plots: 1. IF signal waveform; 2. IF signal spectrum, and 3. post-processed spectrum of IF signal. The green line represents the signal of the 5.8GHz and the red represents the 915MHz.

ii. Remove background signal

To remove the background IF signal, direct Trojan radar to an open space and type the following command:

```
>>> Command: setbg
```

After the command, the view would look like Fig. 6b. The Fig. 6b-1 and Fig. 6b-2 shows the realtime signal, which would not be affected. Fig. 6b-3 would be suppressed to zero.

iii. Move radar to 2m

Direct the radar to the wall and move to 2m away from the wall, the view would look like Fig. 6c. The peak frequency on Fig. 6c-3 indicates the distance between the wall and Trojan radar.

iv. Move radar to 4m

As shown in Fig. 6d-3, the peak frequency of 5.8GHz radar goes higher while that of the 915MHz radar remain at the same point. The different reaction of the spectrum indicates that the range resolution of 5.8GHz radar is better than 915MHz.

v. Move radar to 12m

As shown in Fig. 6e-3, the power of the peak frequency of 5.8GHz radar is not strong enough for distance detection. However, the peak the power of the peak frequency of 915MHz radar doesn’t change a lot. It suggests that the max. detection range of 915MHz radar is farther than 5.8GHz.

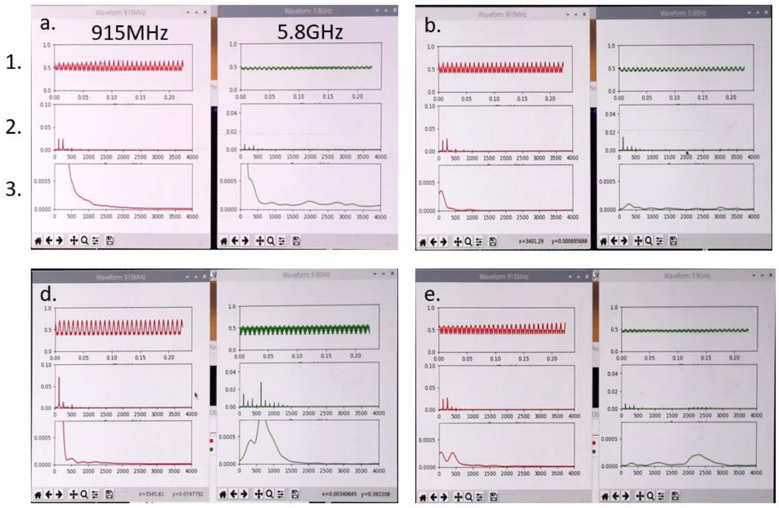


Fig. 6. Measurement results of distance demo.

B. Speed Measurement

Doppler frequency shift would be observed in this demonstration.

i. Follow step i and ii in part A to remove background signal.

ii. Initialize SGen

Put the SGen at 2m, and connect SGen to the Smartphone with Bluetooth module.

iii. Observe the stationary SGen

Because the SGen doesn't rotate, the spectrum in Fig. 7a looks like the spectrum Fig. 6b.

iv. Observe the rotating SGen

The rotation of SGen would result in a pair of peak frequency (Fig. 7b, 7c), which are caused by Doppler effect. The faster SGen rotates, the frequency difference between the two peaks increases.

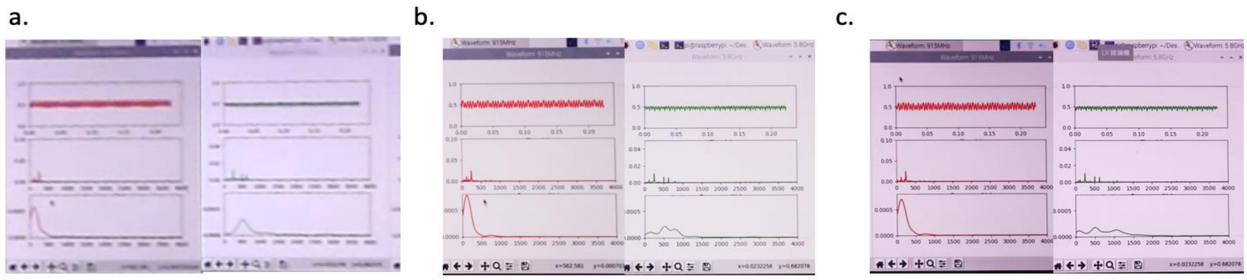


Fig. 7. Measurement results of speed demo.

C. Radar Cross Section (RCS)

i. Follow step i and ii in part A to remove background signal.

ii. Initialize rotation platform

iii. Rotate the aluminum Board

The reflected power of aluminum board is related to the observation angle of Trojan radar. Rotate the board 360 degree with 5 degrees step and record the reflected power, it could be shown that the board reflected power reach its peak when the board face to the radar.

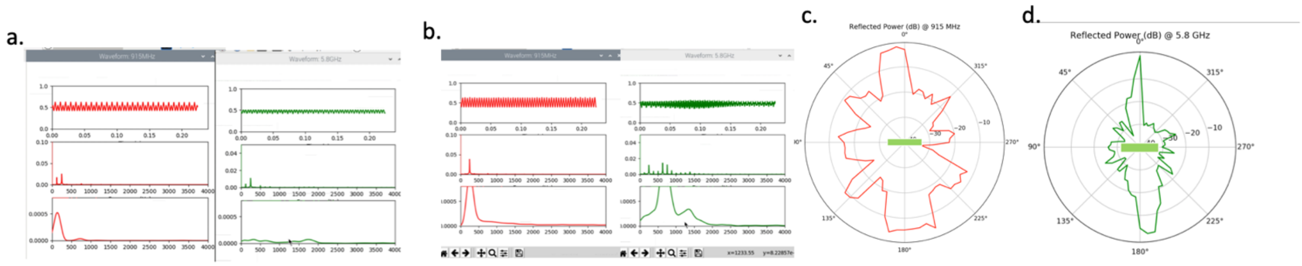


Fig. 8. Measurement results of speed demo.