# Radio Recovery Guide:

Last edited: David Dobbie 17/10/17

There are two methods of utilising the radio system on the rocket after launch to ascertain its location:

- using the transmitted GPS coordinates of the rocket, and
- signal strength detection with a high power, directional antenna and a software defined radio (SDR)

These two methods detailed in this document are to be used when the location of the rocket is not known and out of eyesight. The radio system continuously transmits the GPS coordinates with a time stamp. The methods here use radio receivers to pick this up. The radio operates at 434 MHz.

## GPS Coordinate Recovery

### Equipment required:

1. a) A preassembled rocket PCB from the avionics package OR:
   b)
   i) Teensy 3.6 micro-controller
   ii) RFM96W radio breakout
   iii) Yagi ('fox hunting') antenna or whip (quarter wavelength 17.3cm wire) antenna soldered to the radio module
   iv) Breadboard and solid core connection wires

2. The rocket radio transmitter system (build in a PCB)

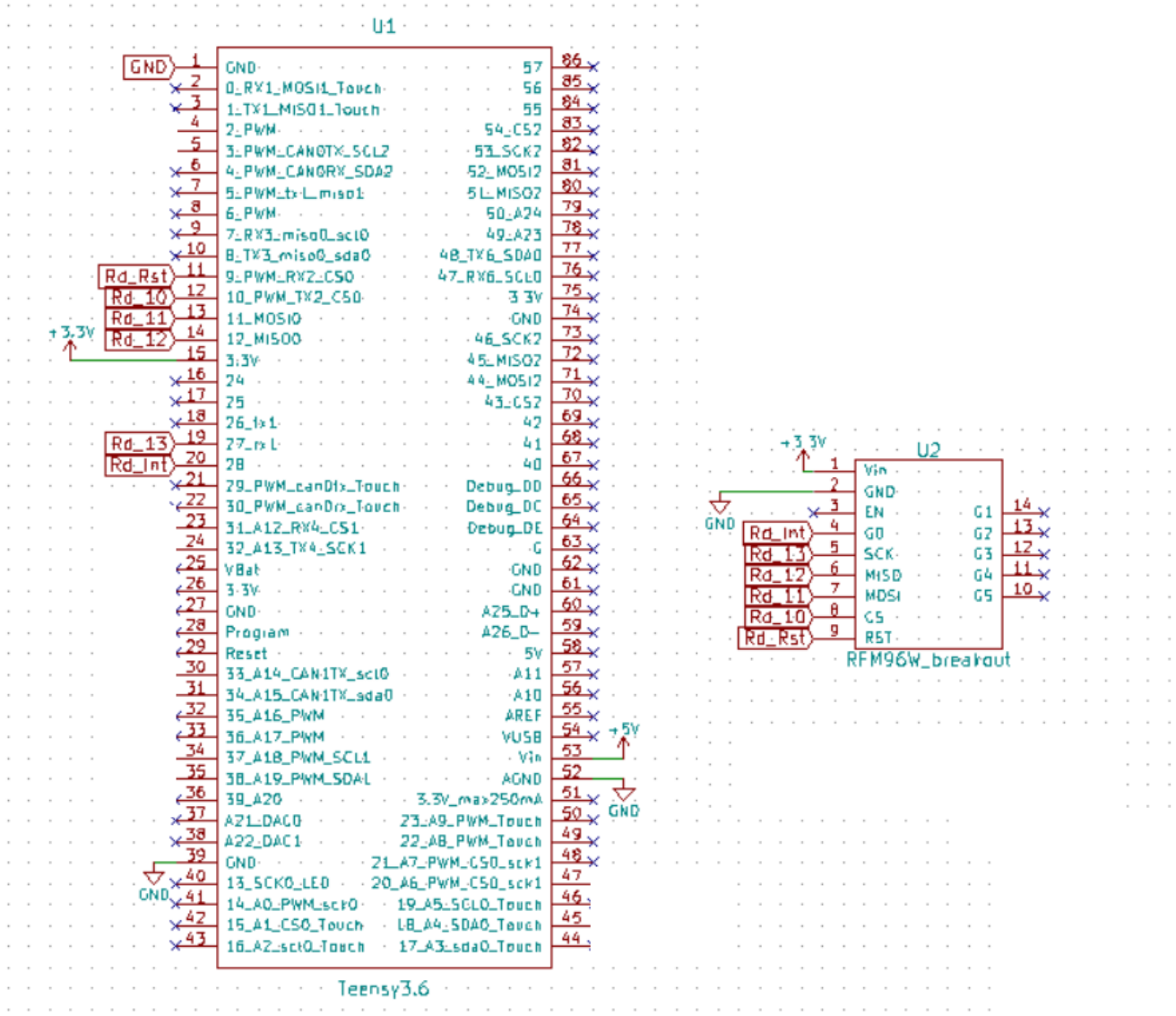
3. Micro USB cable

4. Computer - preferably a laptop for mobility - with

    - Installations of Arduino IDE (https://www.arduino.cc/en/main/software (https://www.arduino.cc/en/main/software)) and TeensyDuino for the Teensy microcontroller (https://www.pjrc.com/teensy/teensyduino.html (https://www.pjrc.com/teensy/teensyduino.html))
    - Installation of PuTTY (http://www.putty.org/ (http://www.putty.org/)) - to allow for serial communication with the home base device.
    - GPS coordinate converter to map position - e.g. http://boulter.com/gps/ (http://boulter.com/gps/)

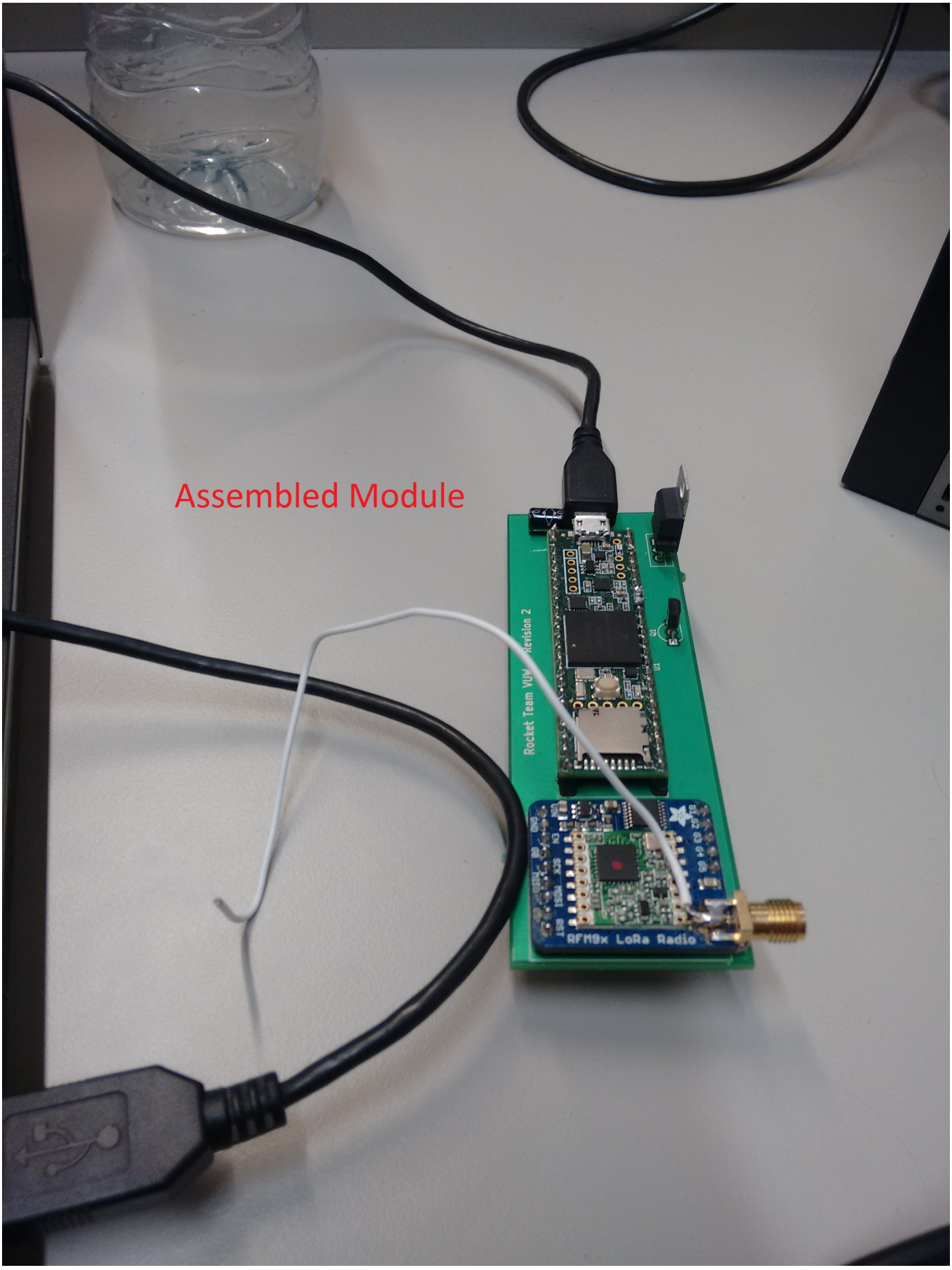
### Setup Method:

**Step 1.** We can skip towards step two if we are using an assembled electronics board of the radio system (PCB revision 2 or 3).
Wire up the receiver radio, and the Teensy according to the PCB wiring diagram below. (**NOTE:** the pin number is in the name inside the box, not on the red connection lines). The antenna is connected directly to the radio module with the golden SMA (SubMiniature version A) connector.

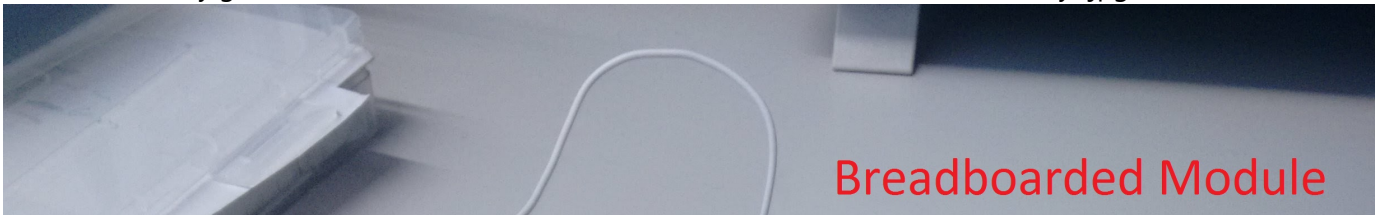


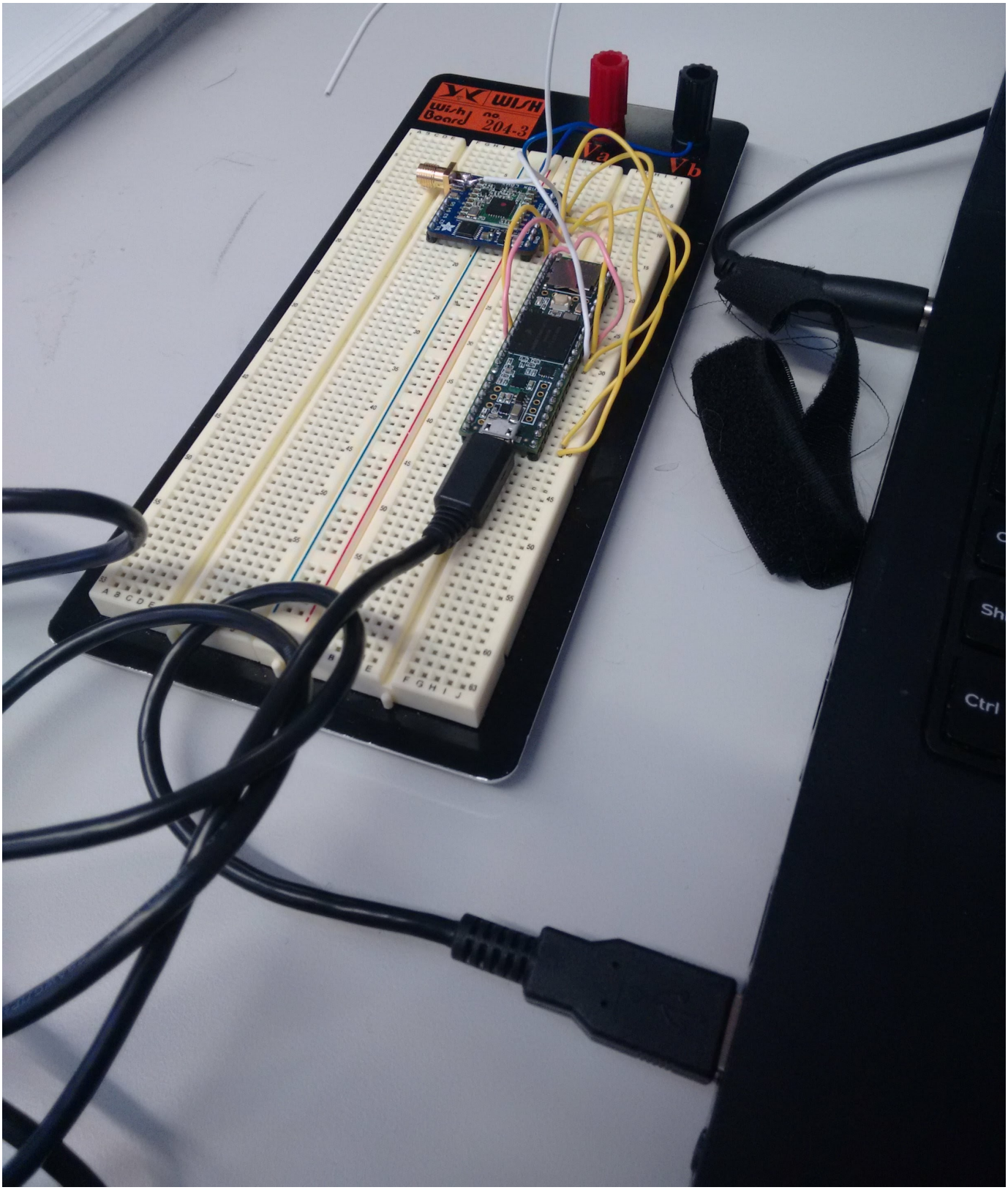

(./Radio recovery guide · Wiki · David Dobbie _ team-rocket · GitLab_files/radioWireUp.png)

**Step 2.** Connect the laptop to the Teensy with the micro USB cable.



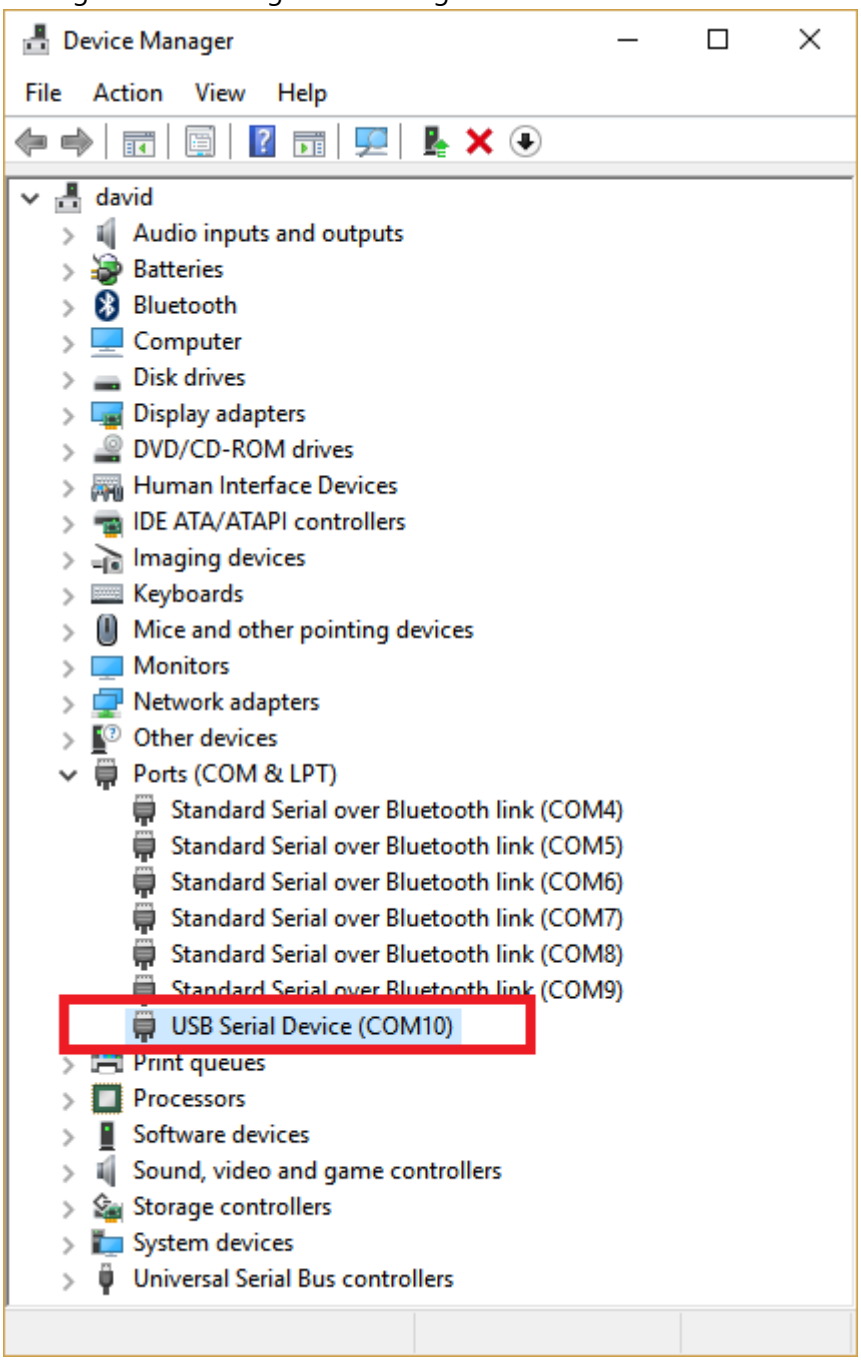

(./Radio recovery guide · Wiki · David Dobbie _ team-rocket · GitLab_files/assembled_sys.jpg)






(./Radio recovery guide · Wiki · David Dobbie _ team-rocket · GitLab_files/connectedRadioSystem.jpg)

**Step 3.** Find the COM port for the receiver module. This can be achieved in Windows by searching for Device Manager in the settings and looking for the new USB device added. It should be from COM 4 to COM 15.



(./Radio recovery guide · Wiki · David Dobbie _ team-rocket · GitLab_files/device_manager.PNG)

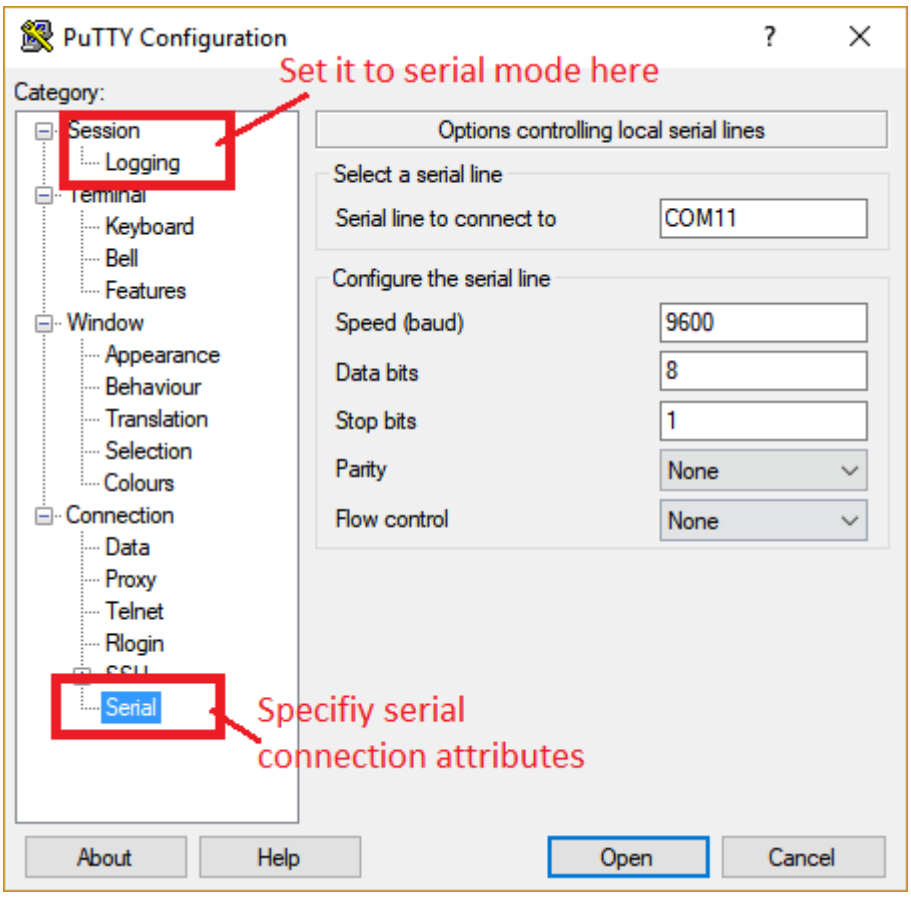
**Step 4.** If the breadboarded module is being used, upload the home_base_rev2.ino code onto the Teensy.

**Step 5.** To monitor the receiving module, open up PuTTY. Set the 'Connection Type' to 'Serial'.

Go to Serial connection settings and specify:

- Serial line to connect to = COMXX
- Speed = 9600
- Data bits = 8
- Stop bits = 1
- Parity = None
- Flow Control = None

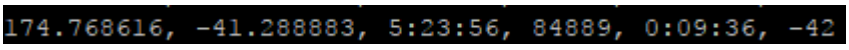
Click open to begin communication.



(./Radio recovery guide · Wiki · David Dobbie _ team-rocket · GitLab_files/putty_settings.PNG)

**Step 6.** If the rocket system is transmitting, there should be regular messages showing up on the serial monitor. They have the following comma separated format:

> LONGITUDE, LATITUDE, GPS TIME, GPS CHARS PROCESSED, BASE MODULE TIME ELAPSED, RADIO SIGNAL STRENGTH

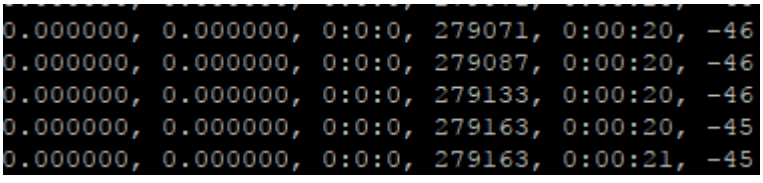


(./Radio recovery guide · Wiki · David Dobbie _ team-rocket · GitLab_files/gps_locked.PNG)

Radio signal strength (RSSI), indicates how close to the transmitter i.e how far the rocket is from the base station. This can be used to get an idea of the location of the rocket module. Once it goes below -120dB, communication fails.

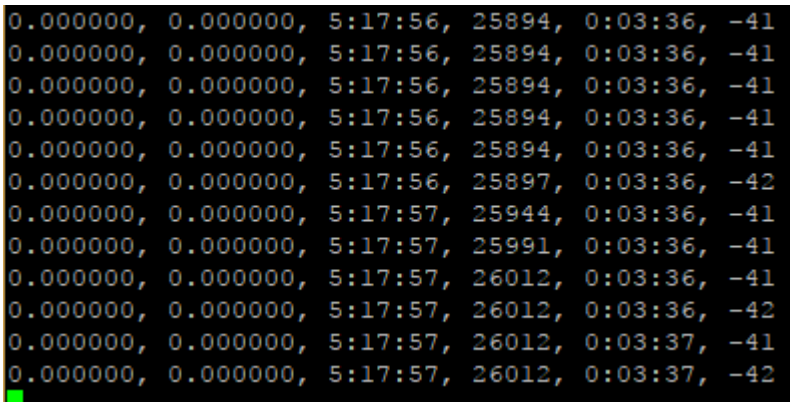
**Step 7.** Achieving a GPS lock:
a) The rocket module initially has no GPS data at startup. The 'LONGITUDE', 'LATITUDE', and 'GPS TIME' (first, second, third columns) are initialised as zeros.

b) The first sign that indicates the GPS system is working is that the 'GPS CHARS PROCESSED' value (fourth column). It increases over time during operation. This indicates that the GPS module is communicating with the Teensy micro-controller



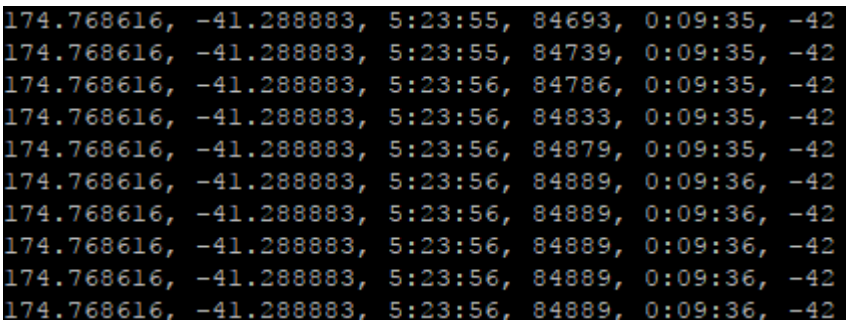
(./Radio recovery guide · Wiki · David Dobbie _ team-rocket · GitLab_files/system_.PNG)

c) The next part that becomes non-zero is 'GPS TIME'. If it comes up as Greenwich Mean Time (GMT), then communication with a satellite has been achieved. More satellites need to have communication picked up before the positional information becomes valid.



(./Radio recovery guide · Wiki · David Dobbie _ team-rocket · GitLab_files/time_locked.PNG)

d) After approximately 5 to 15 minutes - depending on the overhead coverage - positional lock will be achieved. After a minute, the position will have been calibrated to be within 30 metres from the location.



(./Radio recovery guide · Wiki · David Dobbie _ team-rocket · GitLab_files/gps_locked(1).PNG)

### How to use this:

The GPS coordinates that are shown in the serial port give us an indication of the position of the rocket. However, if the GPS has 'lost lock' on its specific position or has been damaged it may be an unreliable indicator. In which case, the SDR directional strength direction technique would be more suitable. The GPS may especially be incorrect if the GPS deactivates after going too fast.

### GPS Troubleshooting:

- If CHARS PROCESSED is not increasing, the GPS is not on and may not have been activated
- If no positional lock has been achieved: reorient the GPS antennas (beige squares on the PCB) to point upwards towards the sky. They are typically very directional.
- If no new messages are coming to the receiver, check the antennae on the transmitter and the recovery module. They may be broken or disconnected.
- A typical strength from the radio signal with whip antennae next to each other is -41 RSSI. Obviously, this varies with different antenna designs. It loses signal at -120 dB RSSI.
- Simple whip antenna to whip antenna communication is able to achieve at least 600-metre communication with significant obstructions.
- GPS coordinate data is not as effective in steep areas or in heavy obstruction. An error of 100m has been measured due to this. Directional strength testing would be advantageous in this scenario.

## SDR Directional Strength Detection

## Equipment required:

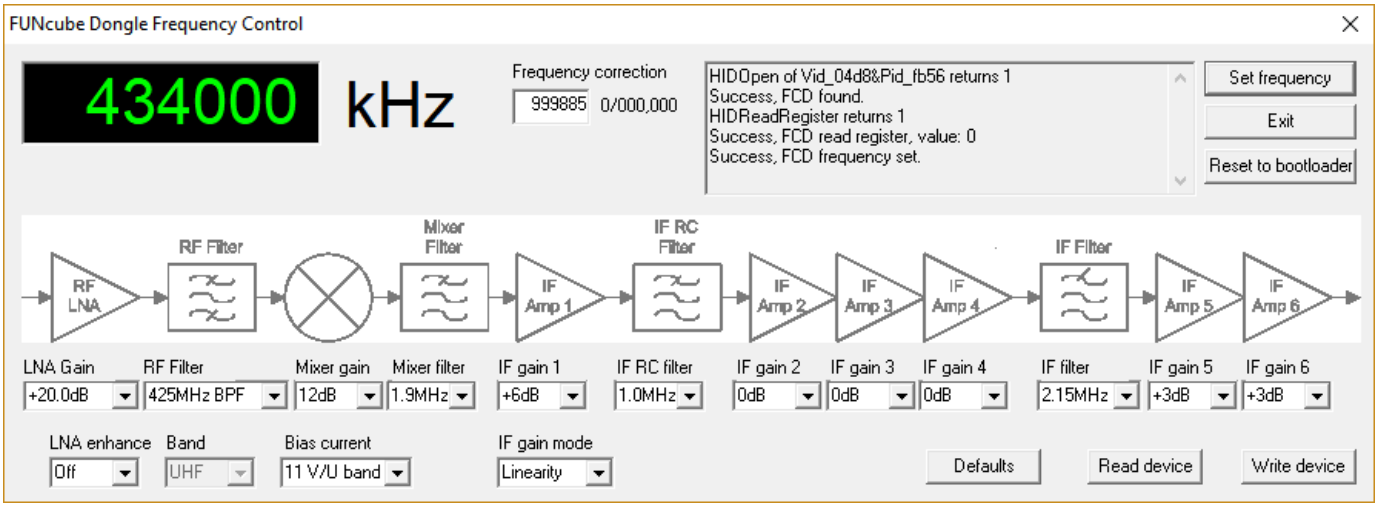
1. FCD Pro V1.1 SDR
2. Yagi 433 MHz 'fox hunting' antenna
3. Computer - preferably a laptop for mobility
    - SpectraVue 3.39 (http://www.rfspace.com/RFSPACE/SpectraVue.html (http://www.rfspace.com/RFSPACE/SpectraVue.html)) - spectrum analyser to monitor transmitter signal strength
    - FUNcube Dongle Frequency Control (http://www.funcubedongle.com/?page_id=1225 (http://www.funcubedongle.com/?page_id=1225)) - to control the SDR receiver settings
4. Connecting coaxial cable with male to male SMA connectors

## Setup Method:

**Step 1:** Plug in the FunCube SDR dongle and connect it to the directional antenna


(./Radio recovery guide · Wiki · David Dobbie _ team-rocket · GitLab_files/1-pluggedIn.jpg)

**Step 2:** Open the FCHid.exe frequency control program and set up the specific frequency the SDR to 434,000 kHz (434 MHz).

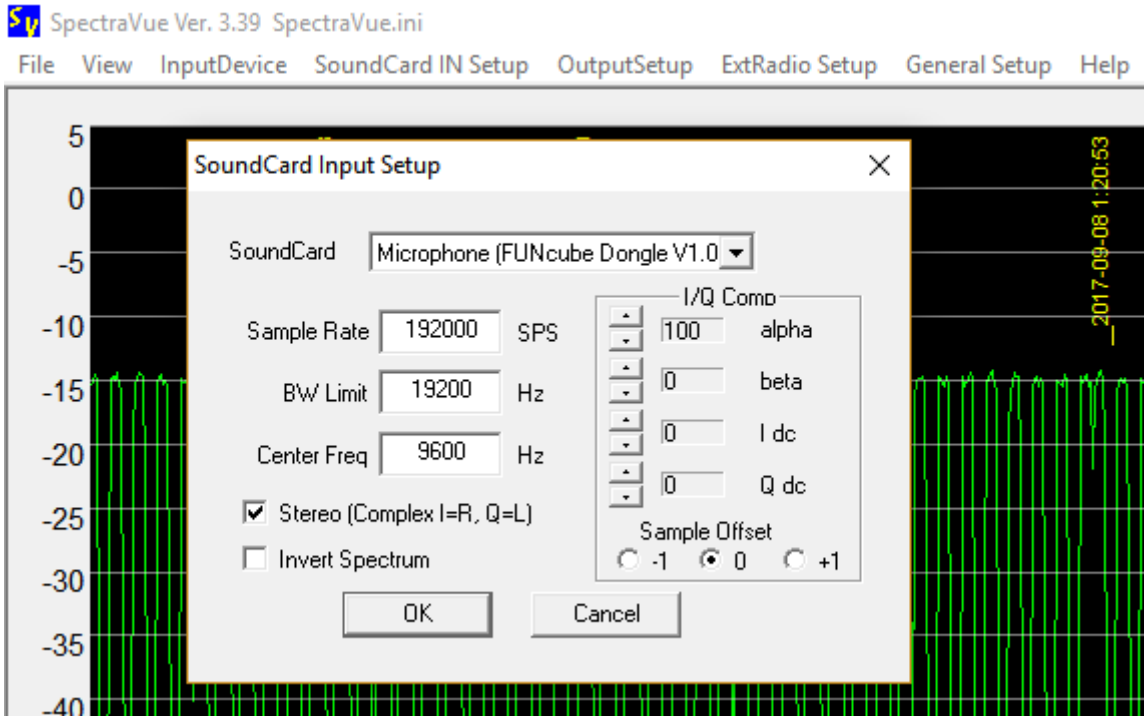



(./Radio recovery guide · Wiki · David Dobbie _ team-rocket · GitLab_files/2-setFrequency.PNG)

**Step 3:** Open SpectraVue

**Step 4:** Go to SoundCard IN Setup and specify the SDR dongle as the 'Sound card'. Additionally set:

- the Sample Rate to 192000 SPS,
- BW Limit to 19200 Hz, and
- the Center Freq to 9600 HZ

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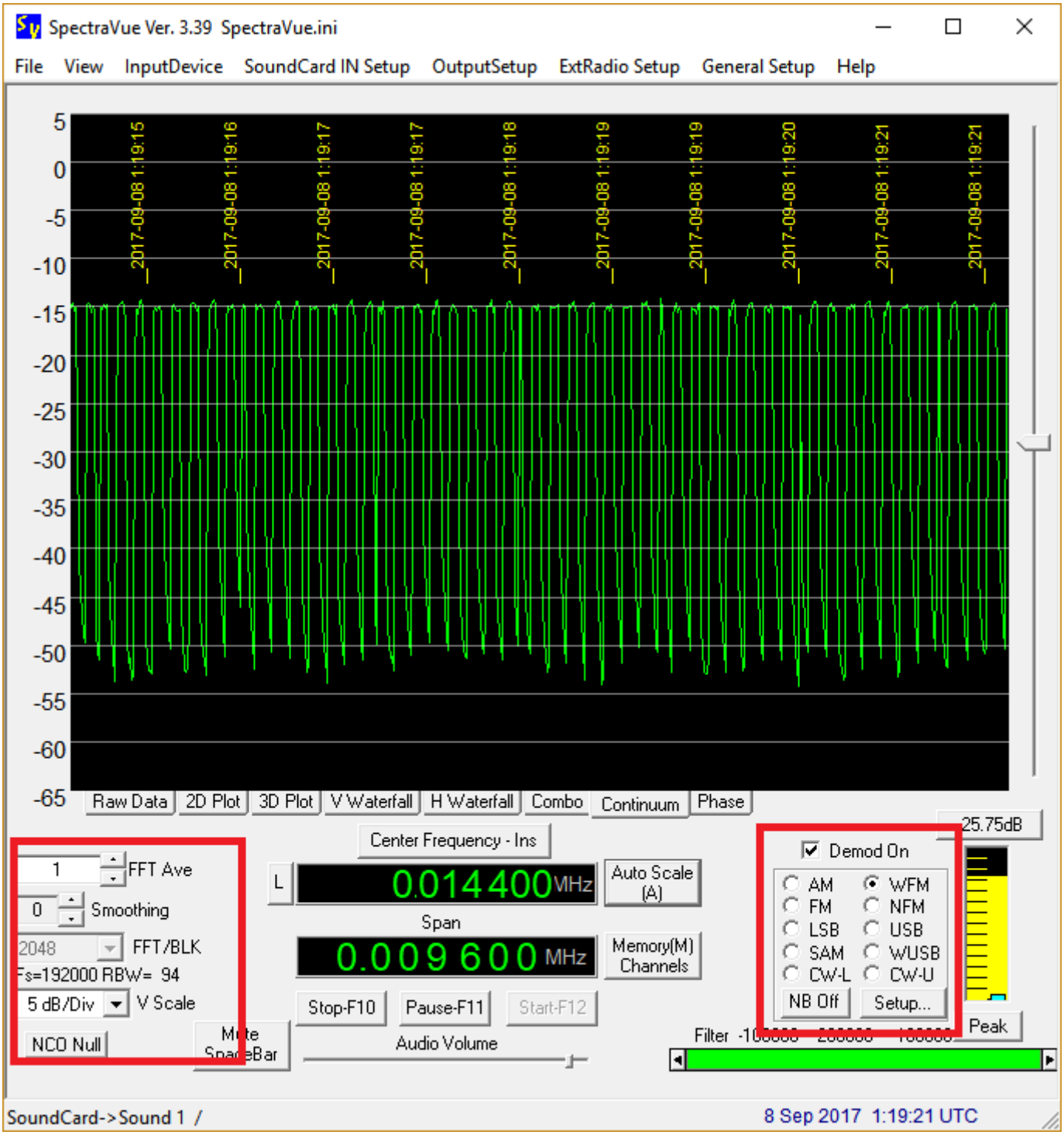
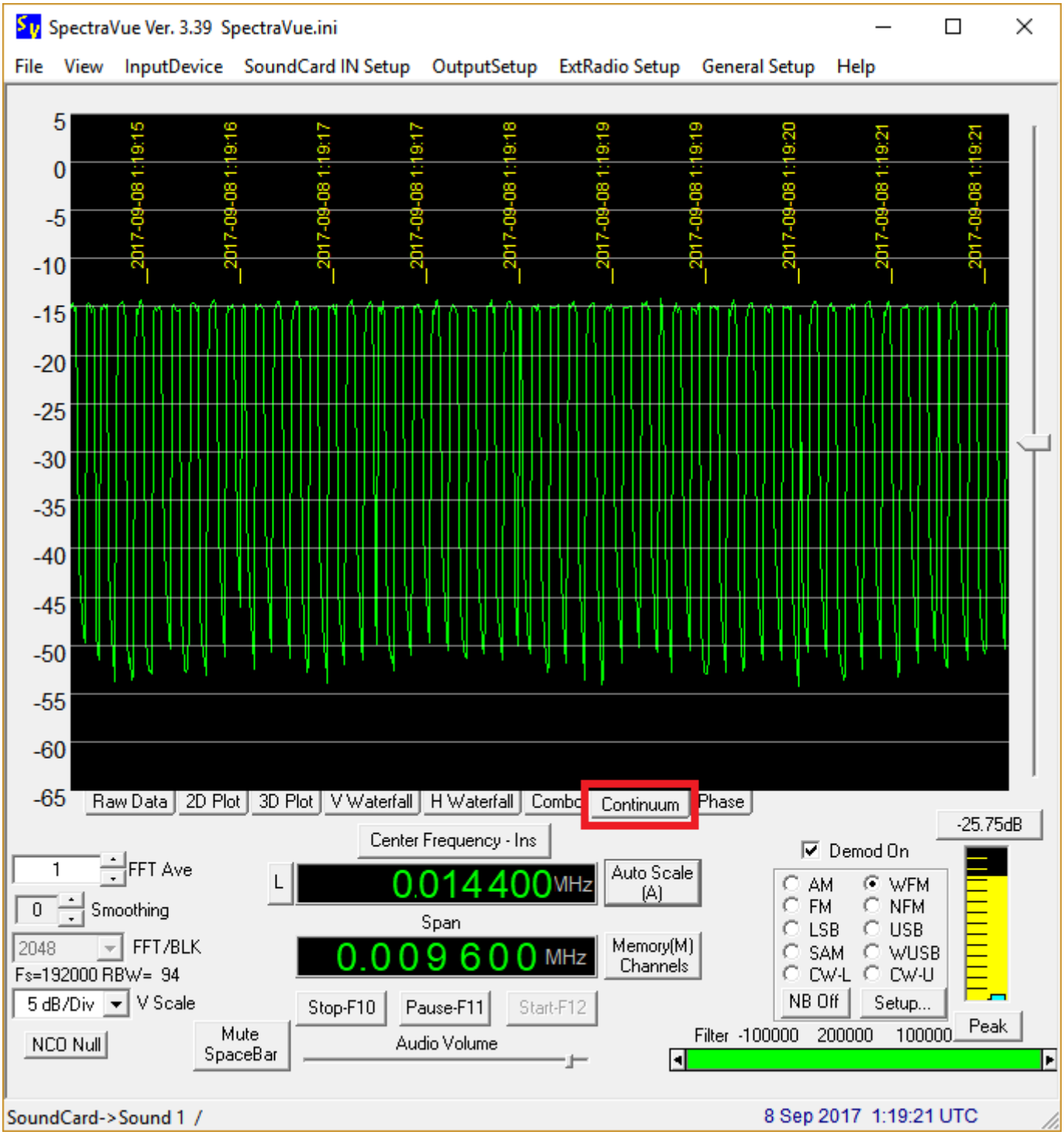
**Step 5:** Set the display settings as demonstrated in the bottom left corner of the screen. Set the demodulation in the bottom right corner to WFM (to give consistent and reproducible signal readings)



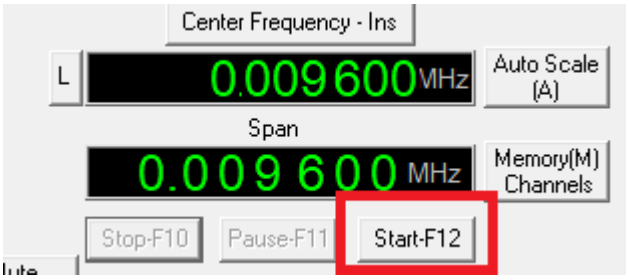

(./Radio recovery guide · Wiki · David Dobbie _ team-rocket · GitLab_files/5-scaleAndDisplaySettings.PNG)

**Step 6:** Set the signal display to 'Continuum'. This gives a signal strength relative to the specific time it was measured.




(./Radio recovery guide · Wiki · David Dobbie _ team-rocket · GitLab_files/6-continumm.PNG)

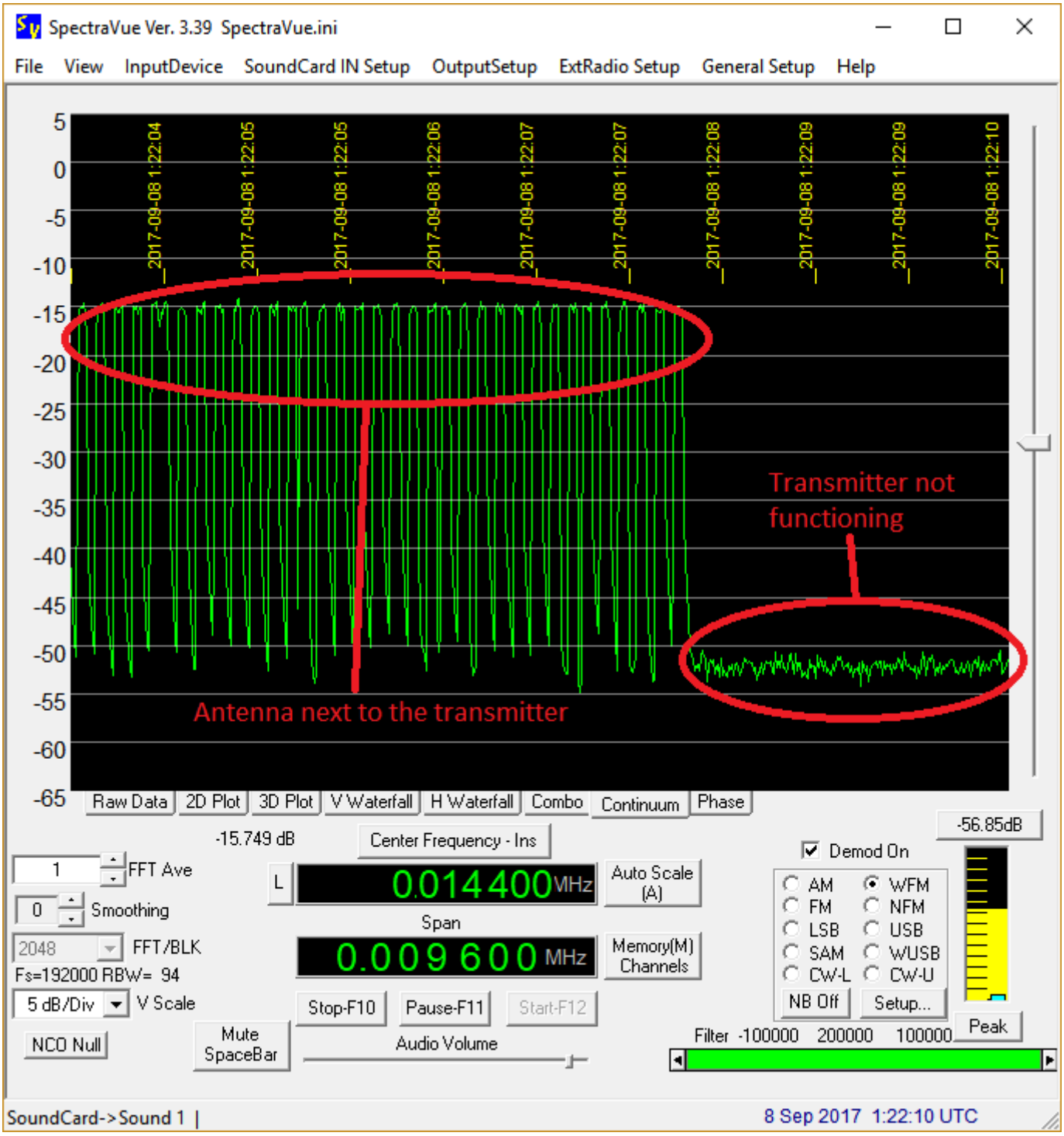
**Step 7:** Press Start-F12 to begin gathering signal readings




(./Radio recovery guide · Wiki · David Dobbie _ team-rocket · GitLab_files/6-startButton.PNG)

## How to use this:

The transmitter broadcasts a spike signal continuously. This causes a spike in the antenna readings. The larger the spike, the stronger the signal is in the specific direction the antenna is pointed. This method gives a graphical version of the RSSI in the GPS coordinate recovery with a more intuitive method of detection. The antenna next to the transmitter will give a 35 dB spike size.




(./Radio recovery guide · Wiki · David Dobbie _ team-rocket · GitLab_files/8-signalExampleON-OFF.PNG)

When utilising this the user must be stationary as moving while picking up readings affects the magnitude of the signals being picked up. The user needs to be stationary for at least two seconds before inferring the signal readings.

**NOTE:** the decrease in signal strength compared with distance is not *necessarily* consistently proportional. Obstructions such as trees, buildings, and noise can cause interference with the readings of this device.