

# Introduction to the Generation 1 Grape Personal Space Weather Station

Explanation and DIY\* guide to sourcing components, assembling the system and collecting Time Standard Station frequency data

\*DIY = 'Do It Yourself'. HamSCI offers this information for those who may want to independently construct the Gen 1 Grape PSWS. HamSCI offers no 'official' support as the Gen 1 Grape was designed as a proof of concept instrument. However, a user community dedicated to the Gen 1 Grape has been formed - details later in this document.

Please understand that development of the Gen 2 Grape is well underway, and all efforts of the designers/developers are focused on Gen 2.

# Background

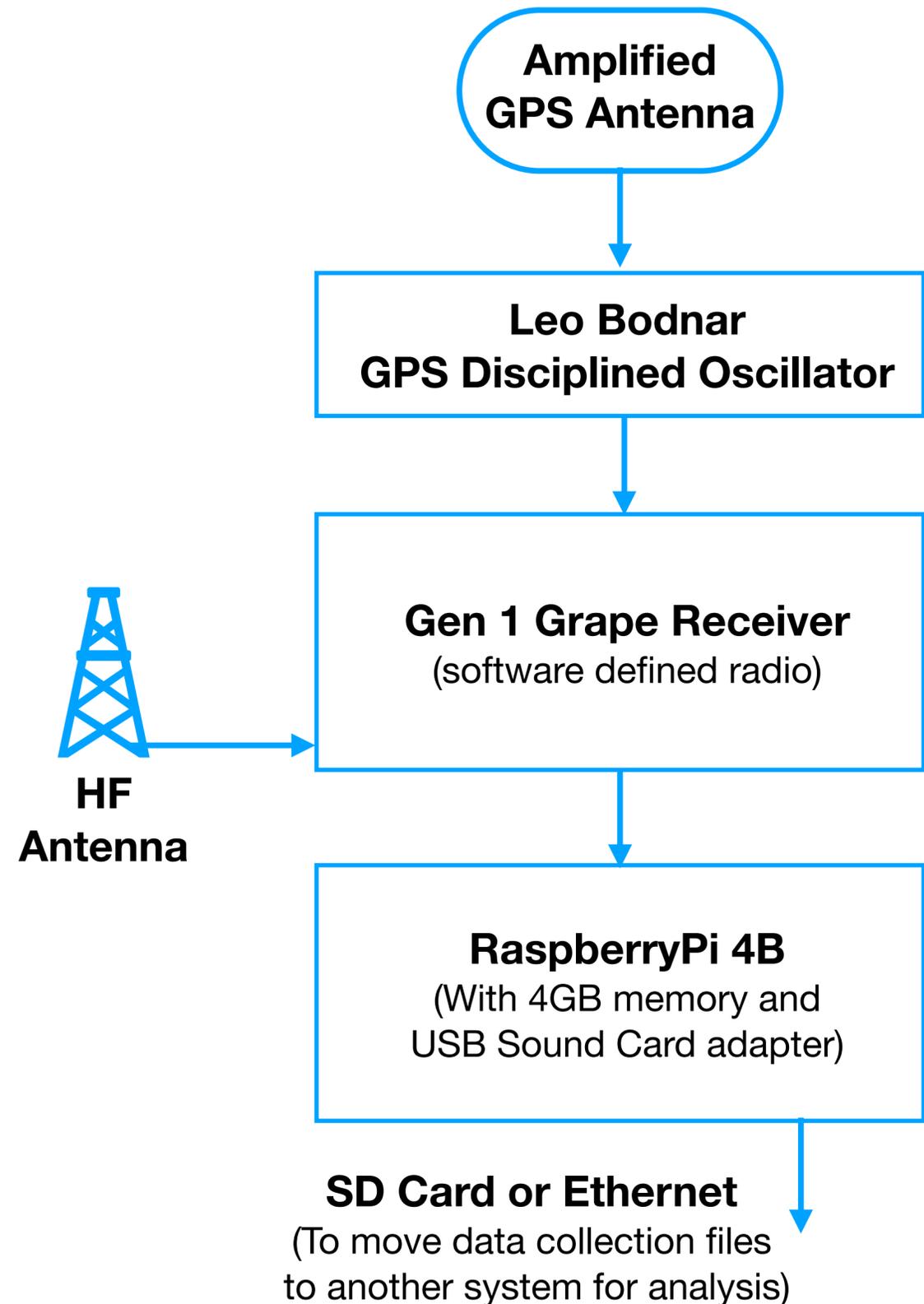
- ▶ Current information on HamSCI, the Personal Space Weather Station (PSWS) project, the organizations involved, the contributors and much more can be found at <https://HamSCI.org>
- ▶ Under the HamSCI umbrella, TAPR and Case Western Reserve University are each developing independent versions of PSWS hardware. TAPR's version, the Tangerine SDR, is expected to be commercially available some time in year 2022. The CWRU version of the PSWS, the Grape (Generation 2), is expected in the same time frame. Other organizations are developing the data gathering and archiving software.
- ▶ Some individuals have asked to be be 'early adopters' of the PSWS technology, expressing an interest in building a Gen 1 Grape PSWS. The hardware and software are fairly mature. Those with the proper skills may want to assemble a Gen 1 Grape, program it using the public-domain software image, obtain the ancillary hardware, resulting in a complete Gen 1 Grape system. Take note that this is a 'bleeding edge' approach, as builders will be on their own for the most part. HamSCI is not able to provide kits or detailed technical support.
- ▶ An online community of Grape builders is slowly building. Such groups have proven invaluable to many projects; it will be up to the community to initiate, maintain and support the effort. They can be found at <https://groups.google.com/g/hamsci-grape>

# Gen 1 Grape Functionality

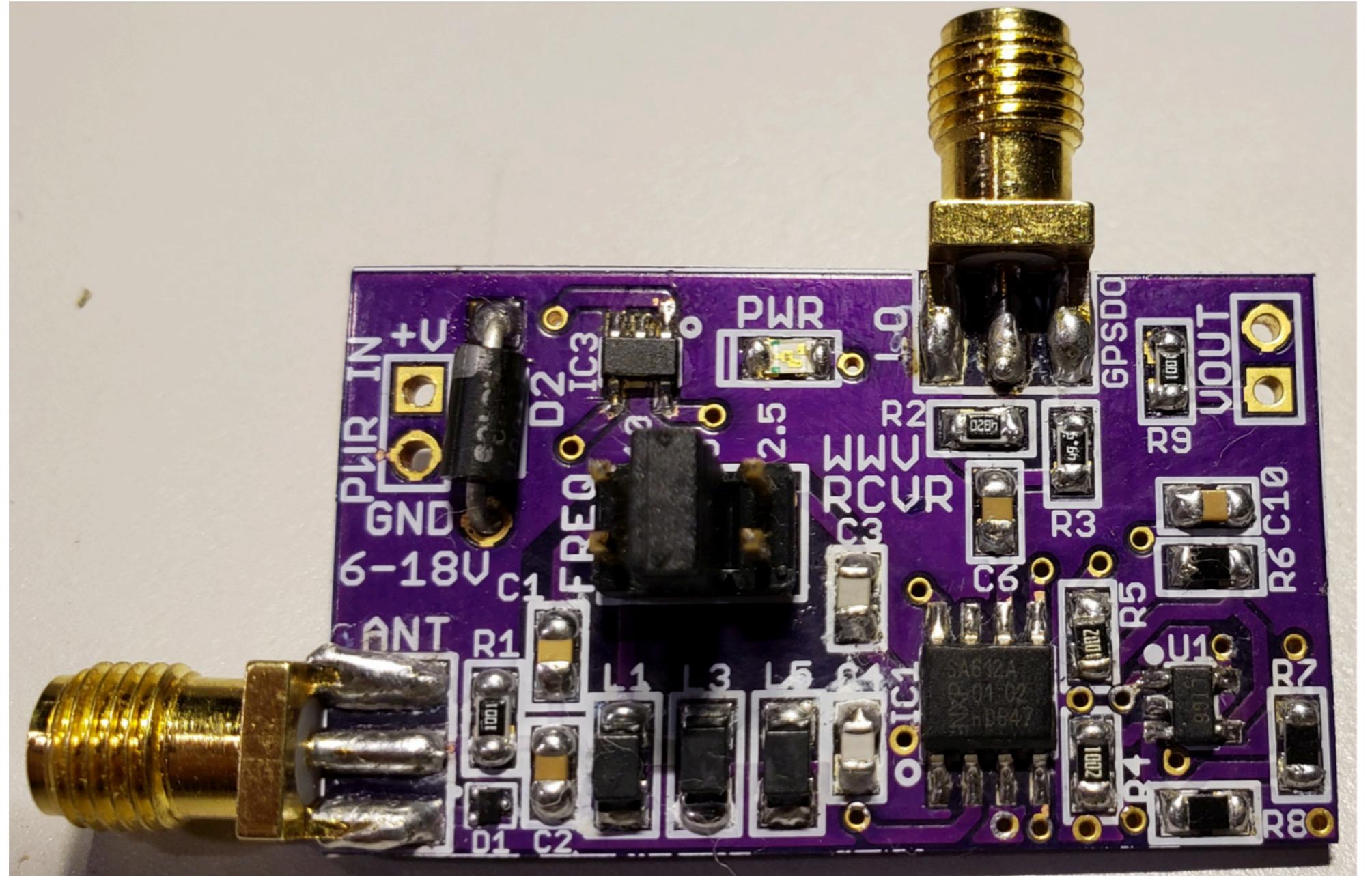
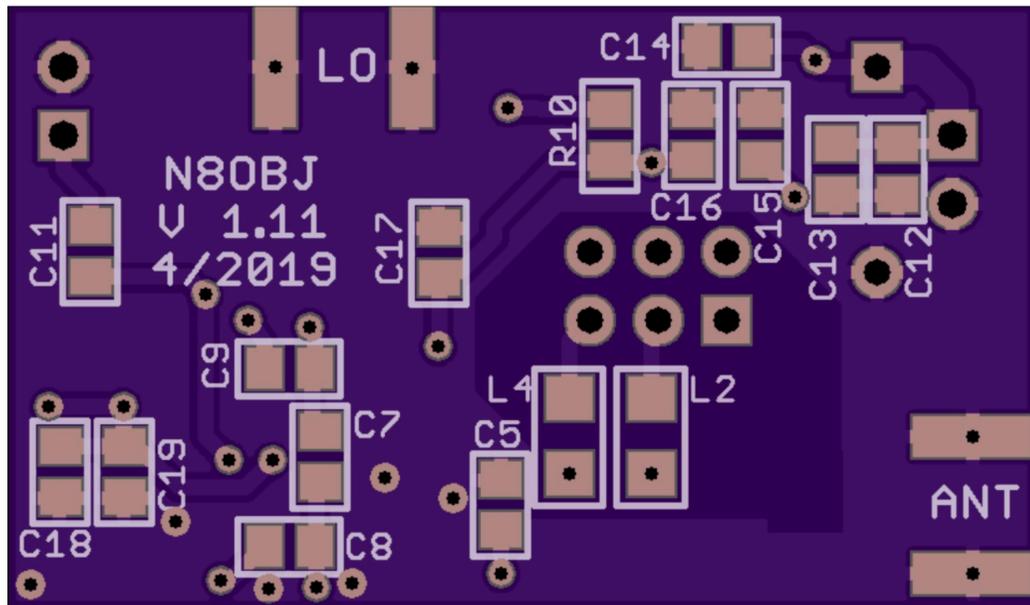
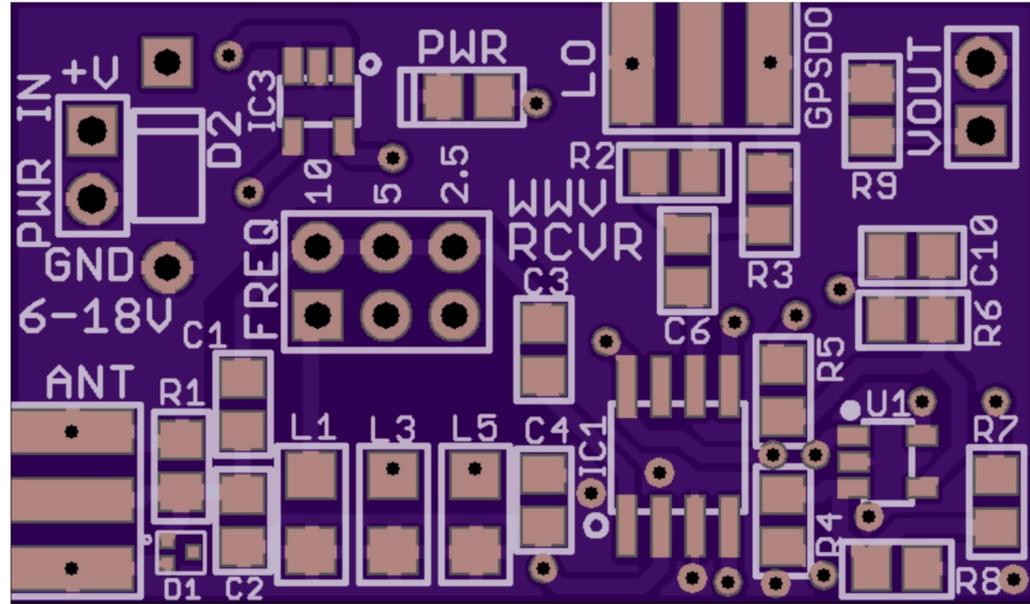
- ▶ The Grape 'system' primarily consists of 4 components, as shown in subsequent slides.
- ▶ The Grape receiver is best characterized as a 'low IF SDR'. It is designed to receive a single frequency, one used by an AM modulated time standard station (ie WWV, BPM, LOL). In conjunction with the GPSDO, it downconverts the carrier to a 1 kHz audio stream.
- ▶ The single received frequency can be changed by reprogramming the GSDO and moving an on-board jumper. The Grape can receive these frequencies: 2.5, 3.33, 5.0, 7.85 or 10.0 MHz.
- ▶ The RaspberryPi, utilizing a USB Sound Card adapter and a program called fldigi, samples the audio signal, records amplitude and frequency data with very high precision, storing that data on an SD card for later export and analysis.

# Grape Gen 1 PSWS Block Diagram

- ▶ The GPS antenna, GPSSDO and the RPi are commercially available.
- ▶ The Grape receiver is an SMT PC board and must be built by the user. A board blank and all components are available from sources in the US.
- ▶ Directions to find the the complete RPi image are available on GitHub (to be installed on the RPi via SD card).



# Gen 1 Grape PCB



# Complete\* Gen 1 Grape PSWS

**A - RaspberryPi 4B, with case and fan**

**B - USB Sound Card interface**

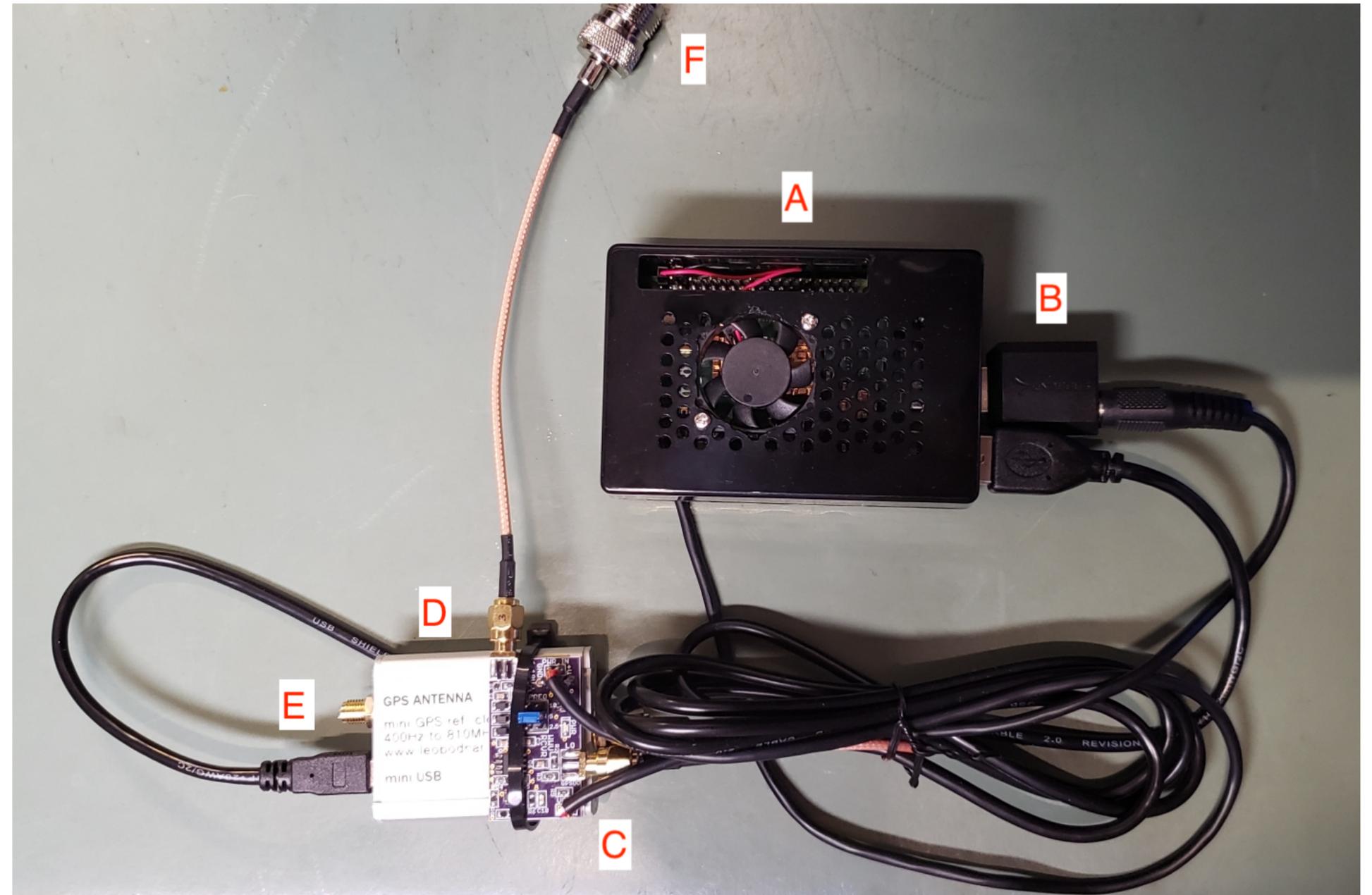
**C - Gen 1 Grape Receiver**

**D- Leo Bodnar GPS Disciplined Oscillator**

**E - SMA Connector for GPS Antenna\***

**F - SO-239 Connector for receive antenna\***

\*These components not shown



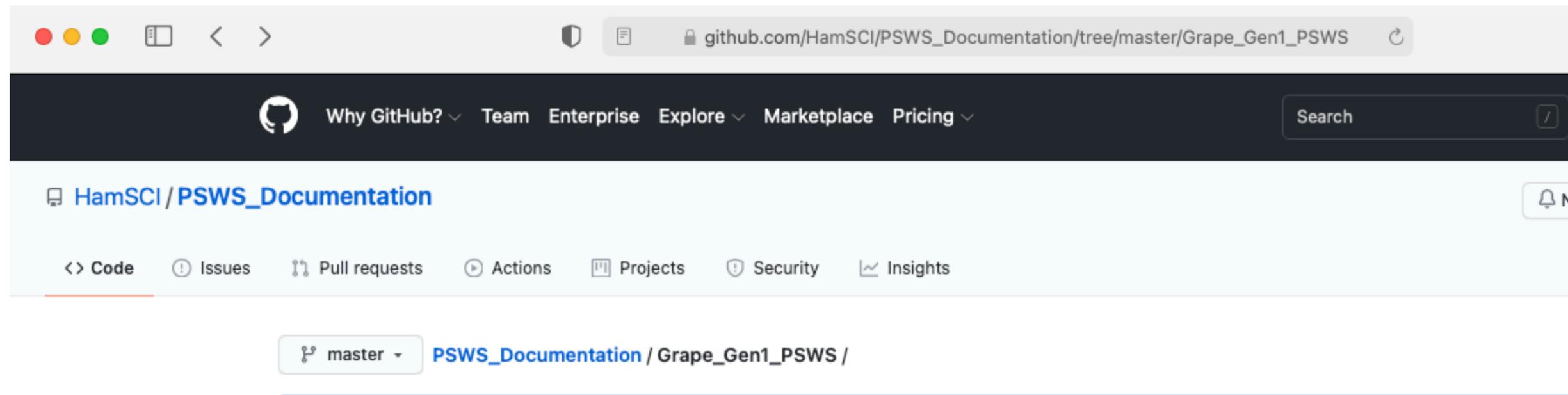
# Considerations

The developer of the Grape Gen 1 hardware and software suggests that anyone wishing to construct this version of the PSWS have these skills:

- ▶ Familiarity with the RaspberryPi and at a least cursory experience with Raspbian Linux
- ▶ Ability to read and understand schematics, download and manipulate files from GitHub
- ▶ Construction of SMT PC boards, from blank and component ordering through final assembly. The Gen 1 Grape receiver mostly consists of medium-pitch components (0805, 1206, SOT-23 packages) though one passive is a fine pitch (0.80mm) SOT-723 device
- ▶ Familiarity with loading images and file manipulations in the Linux environment, on a RaspberryPi
- ▶ Familiarity with the fl-suite of radio-based digital communications software, specifically, fldigi

# Hardware Bill of Material - 1

- ▶ The most current documentation, including all schematics, PCB Bill of Material, details on the RaspberryPi (including the recommended case, fan, sound card adapter), links for purchasing the GPSSDO/GPS antenna, location of the Gen 1 Grape ISO image, and so on...can be found on GitHub.com. Search GitHub for 'HamSCI/PSWS'
- ▶ Also noted there is the Creative Commons license for the documentation. Please open and review as thoroughly as you would any end user agreement!



# Hardware Bill of Material - 2

- ▶ The Gen 1 Grape PC Board blank can be purchased from [oshpark.com](https://oshpark.com)
- ▶ Go to their Sharing page, and search for 'HamSCI'

oshpark.com/shared\_projects?utf8=✓&search%5Bquery%5D=hamsci&search%5Bfilters%5D

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## Shared Projects

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*There is 1 project matching your search criteria.* Board types ▾

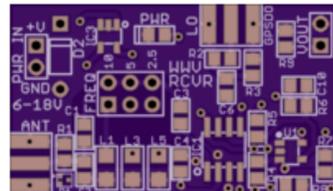
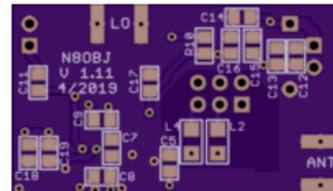
Sort: Newest first Projects per page: 20

All shared projects

### WWV\_Radio\_V1\_11 author: N8OBJ

2 layer board of 1.50 x 0.88 inches (38.1 x 22.4 mm)  
Uploaded: April 17th 2019  
Shared: March 2nd 2021  
Total Price: \$6.60  
HAMSCI Grape Gen 1 WWV 3 band Receiver Ver 1.11

Actions ⚙

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# Additional Documentation

The early Gen 1 Grape PSWS enthusiasts plan to share their experiences from building and programming their own Grapes. Additional documentation - such as *Gen 1 Grape Builders Hints and Hacks*, will likely be written and published in the future.

All who build a Gen 1 Grape are encouraged to contribute their experiences to the community. Posting your questions, successes, and, even your failures (we often learn more from failing, stepping back and going forward again) to the HamSCI-Grape Google Group forum will be most appreciated.

<https://groups.google.com/g/hamsci-grape>

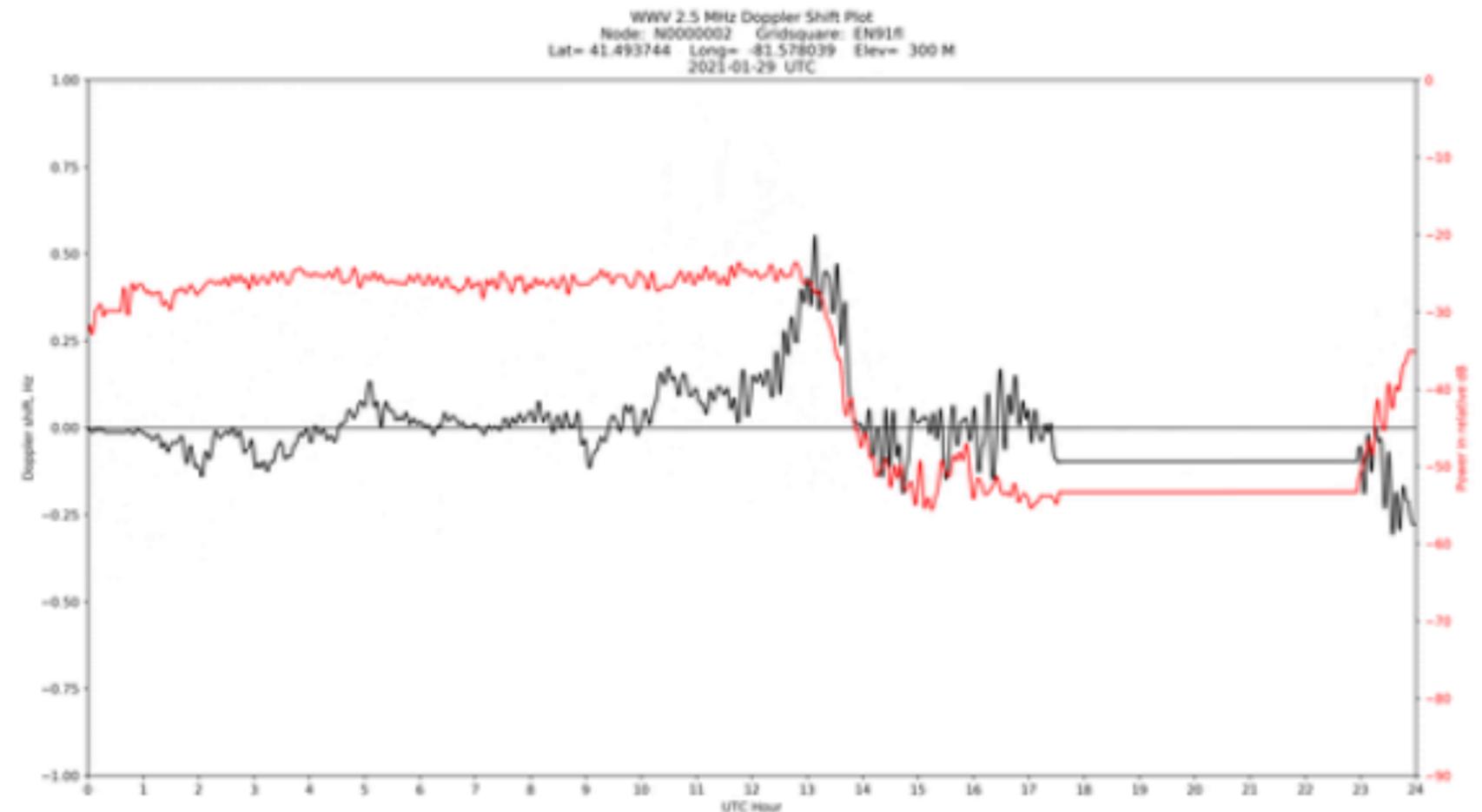
# Appendix 1 - Gen 1 Grape Output

Shown below is the output from a Gen 1 Grape system.

fldigi, running on the RaspberryPi, will generate a large data file - containing time stamps, frequency and signal strength data.

Shown are typical results when the data is exported from the RPi and graphed accordingly. See Appendix 2 for more details.

| UTC      | Freq         | Freq Err | Vpk      | dBV(Vpk) |
|----------|--------------|----------|----------|----------|
| 17:41:13 | 10001500.315 | 0.315    | 0.000055 | -85.15   |
| 17:41:14 | 10001499.959 | -0.041   | 0.000093 | -80.58   |
| 17:41:15 | 10001500.171 | 0.171    | 0.000133 | -77.55   |
| 17:41:16 | 10001499.905 | -0.095   | 0.000148 | -76.60   |
| 17:41:17 | 10001499.355 | -0.645   | 0.000143 | -76.91   |
| 17:41:18 | 10001499.700 | -0.300   | 0.000139 | -77.14   |
| 17:41:19 | 10001499.358 | -0.642   | 0.000141 | -76.99   |
| 17:41:21 | 10001499.710 | -0.290   | 0.000147 | -76.63   |
| 17:41:22 | 10001500.083 | 0.083    | 0.000146 | -76.71   |
| 17:41:23 | 10001500.006 | 0.006    | 0.000154 | -76.28   |
| 17:41:24 | 10001500.572 | 0.572    | 0.000150 | -76.46   |
| 17:41:25 | 10001500.322 | 0.322    | 0.000148 | -76.58   |
| 17:41:26 | 10001499.784 | -0.216   | 0.000158 | -76.03   |
| 17:41:27 | 10001499.094 | -0.906   | 0.000159 | -75.99   |
| 17:41:28 | 10001499.133 | -0.867   | 0.000148 | -76.60   |



# Appendix 2 - Gen 1 Grape Output

- ▶ The graph is a plot of time (X-axis) and the red line is the received frequency (with respect to the nominal carrier frequency) of, in this case, the 2.5 MHz WWV signal.
- ▶ The change in frequency (left Y-axis) is due to Doppler shift introduced by the changing height of the ionosphere with solar radiation. The black line is signal strength (right Y-axis). A time span of 24 hours is illustrated.
- ▶ During the early part of the recording period, the received frequency is high as a result of the ionosphere height dropping. This reduces the total path length, resulting in positive Doppler shift. In the latter part of the plot the ionosphere is rising, producing a longer path and negative Doppler shift. For a good bit of the period the signal is lost due to normal propagation during a 24 hour cycle.
- ▶ From this data ionospheric scientists can deduce a good bit about the characteristics of the ionosphere. Ultimately the project will allow correlation of ionospheric data with solar winds and other factors, some known, some yet to be discovered.

# Acknowledgments

- ▶ The designer of the Gen 1 Grape receiver is John C. Gibbons (N8OBJ), Director - Sears Undergraduate Design Laboratory, Dept. of Electrical Engineering and Computer Science, Case Western Reserve University
- ▶ HamSCI gratefully acknowledges the support of NSF Grants AGS-2002278, AGS-1932997, and AGS-1932972
- ▶ Author of this document: Gary Mikitin (AF8A), member of the HamSCI Community

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