March 30, 2024
Version 1.20

Dear Grape2 Host,

Thank you for volunteering to host a Grape receiver! The Grape Team is excited to help you to get your receiver set up and ready for its first light.

The Grape Team meets virtually on Thursday mornings (14:00 UTC). Please join our google group to get a Wednesday evening reminder email and zoom link. You may also join the Grape weekly telecon through the calendar.

Google Group URL: https://**groups.google.com/g/hamsci-grape**
HamSCI Calendar URL: https://**hamsci.org/get-involved#Calendar**

In the next few weeks, deployment is the main priority for these meetings, so please bring any questions or concerns. You are the priority, so don't feel shy about posting your questions in the minutes or asking questions on the call. If you cannot make the meeting in person, the meetings are recorded and available on YouTube. You can email questions to the google group, or me personally (ac8xy@case.edu).

More setup documentation will be sent out soon by Gary Mikitin, AF8A (available at the Grape 2 Web Page https://hamsci.org/grape2), but I wanted to include enough information to reconnect the grape after it has been shipped. Note that the Grape2 is not wifi enabled, and it must have ethernet. Additionally, the magnetometer port must **not** be used for anything other than the magnetometer. The port will be taped over. Please do not remove the tape unless you are installing a magnetometer.

Thank you and 73,
Rachel Boedicker AC8XY

GRAPE2 SETUP INSTRUCTIONS

PARTS INCLUDED

Grape2 Receiver
Grape2 Linear Unregulated Power Supply
USB Pico Connection Cable
Leo Bodnar GPS Disciplined Oscillator w/ USB cable (**LB GPSDO**)
Leo Bodnar to Grape2 RF Connection Cables (2)
GPS Antenna
Western Digital 4TB Hard Drive (**HDD**) in modified case
StarTech Hard Disk Drive Controller w/USB3 cable and Power Supply
Dummy HDMI module and uHDMI - HDMI adapter (if have @ shipping time)
Antenna Connector Cable (SMA to HF SO-239)
Magnetometer Board (Upon Request ONLY)

PARTS NOT INCLUDED

Grape2 RF Antenna
Computer Monitor
Micro-HDMI to HDMI Video Cable
Keyboard / Mouse and USB Hub (if needed)
Magnetometer Housing

1 Checking the Contents

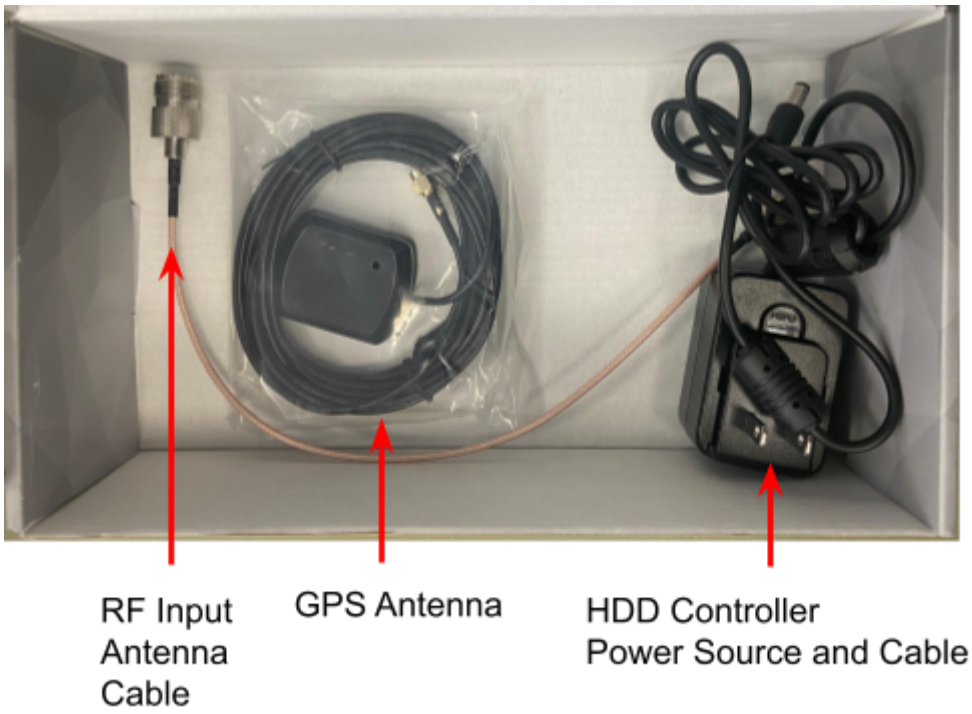
Your grape has been disconnected for transport. When it arrives you should have the pieces depicted below; if you do not or if something is damaged, please email AC8XY (ac8xy@case.edu) as soon as possible.

First, remove the tape holding the Grape2 to the sabrent box and discard it.

Inside the power supply box you will find the power supply for the Grape2.

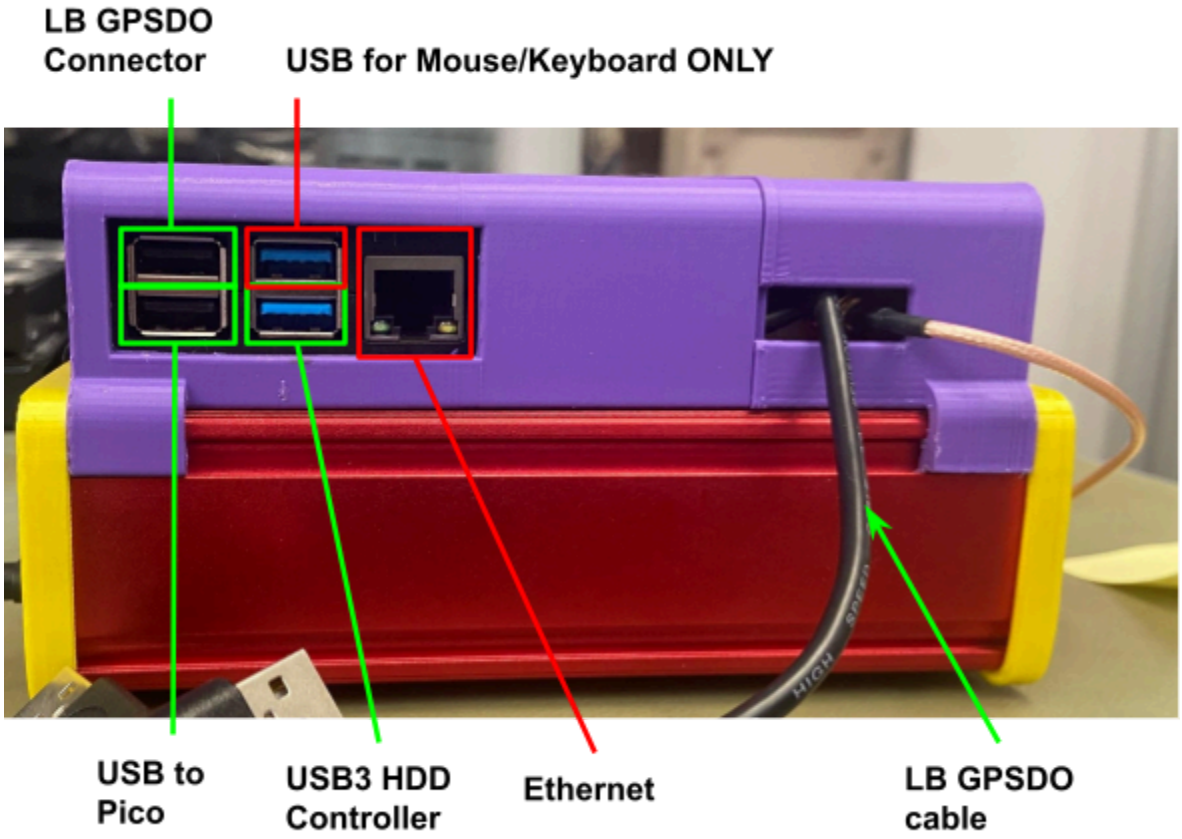
Inside the hard drive box are the 4TB Hard Drive (**HDD**) in its case, as well as the attached HDD controller, the HDD controller power supply, a GPS antenna and an RF cable to connect an RF antenna.

Under the cardboard layer is the antenna cable, the GPS antenna for the Leo Bodnar (**LB**), and the hard drive power cable:

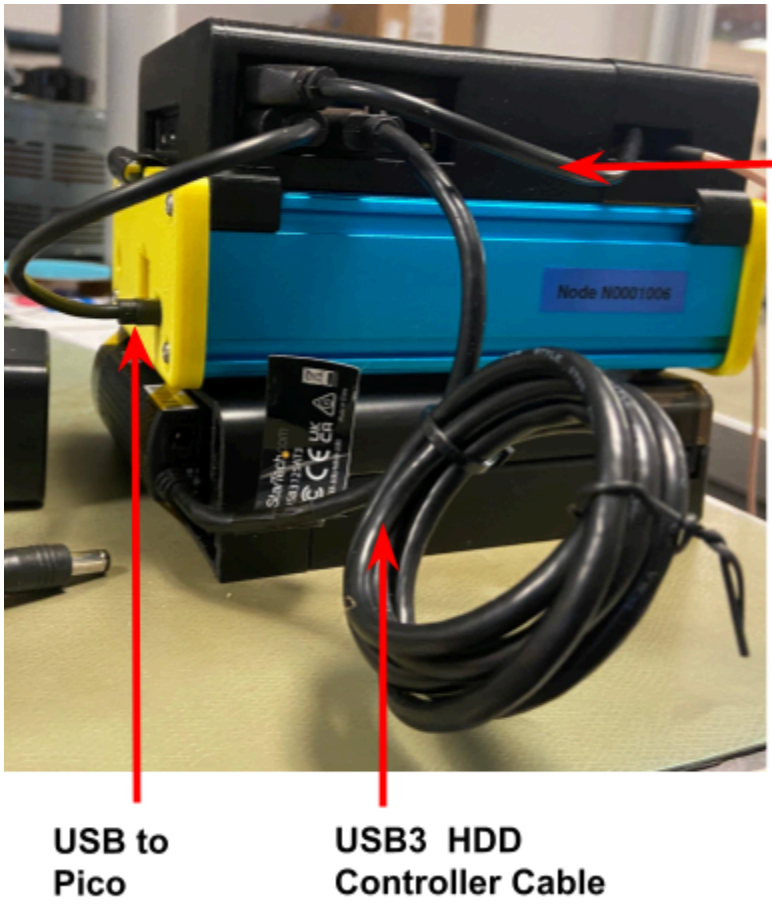


2 Connecting the Grape2

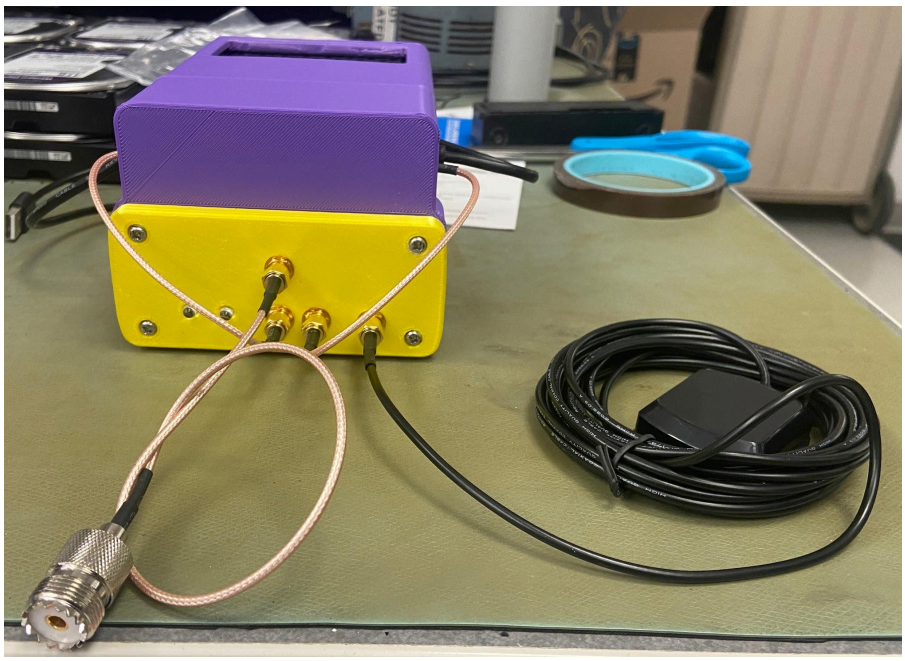
The grape cables have been unplugged for transport. You will need to plug them back in. Note the available side ports:



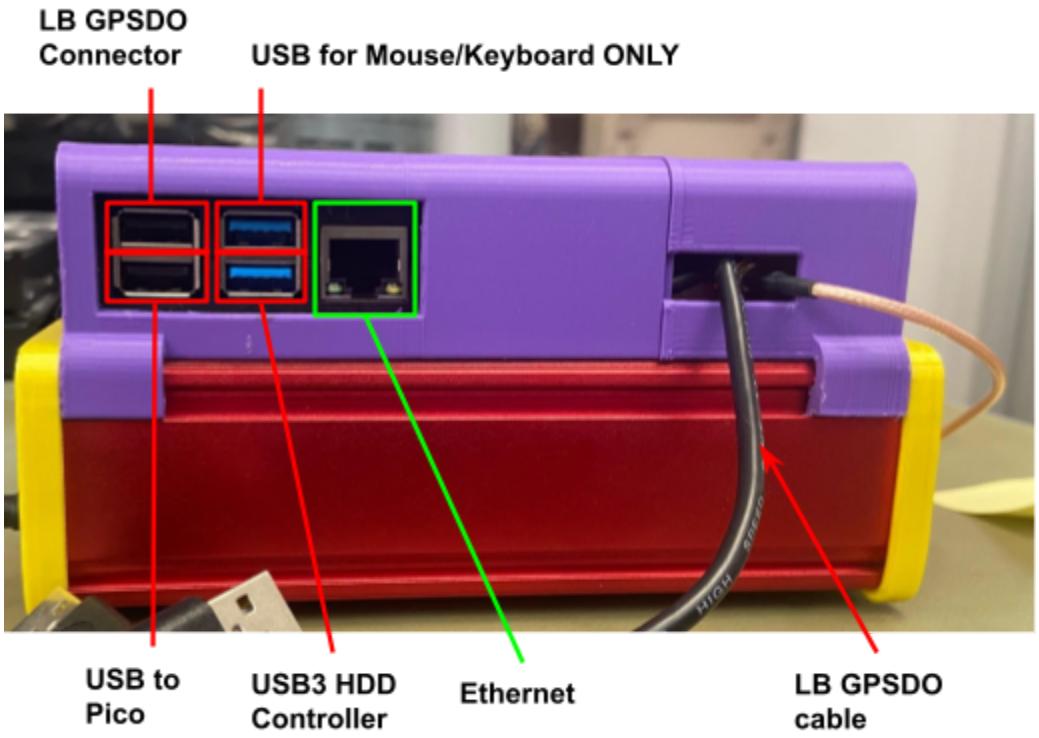
There should be three black cables physically attached to the unit, but not plugged in: the Leo Bodnar GPSDO connector (from the top box), pico connector (from the middle case), and hard drive connector (from the bottom hard drive controller). This is what it will look like connected:



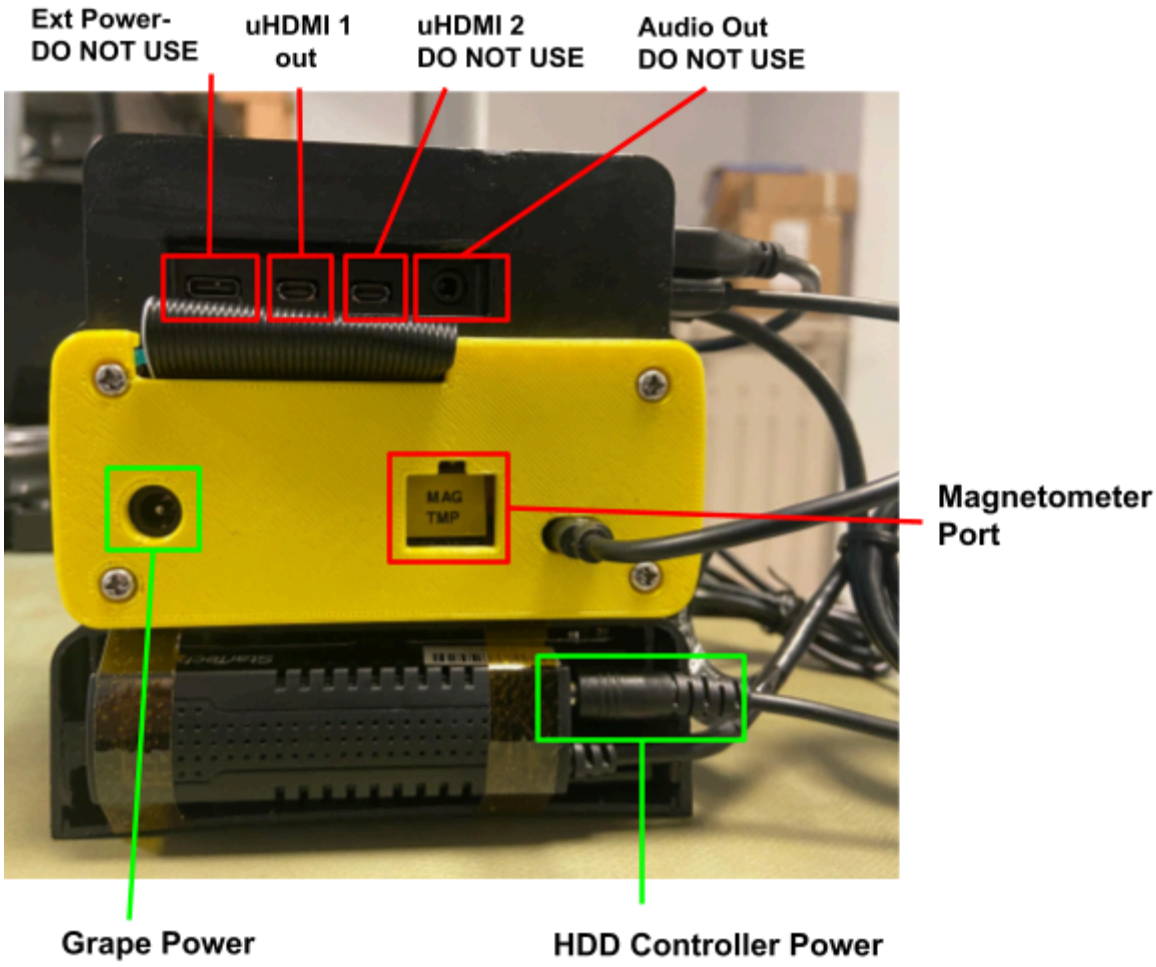
On the antenna port side, you will need to connect the antenna connector cable and GPS antenna as shown:



Then connect the ethernet cable.



Finally, connect the power cables to the Grape2 and HDD controller:



If possible it is highly recommended to run the system on an uninterruptible power supply (**UPS**) since the April 8th event is a once-in-a-lifetime event. If you have reliable power you can skip this but this decision will be left up to the user.

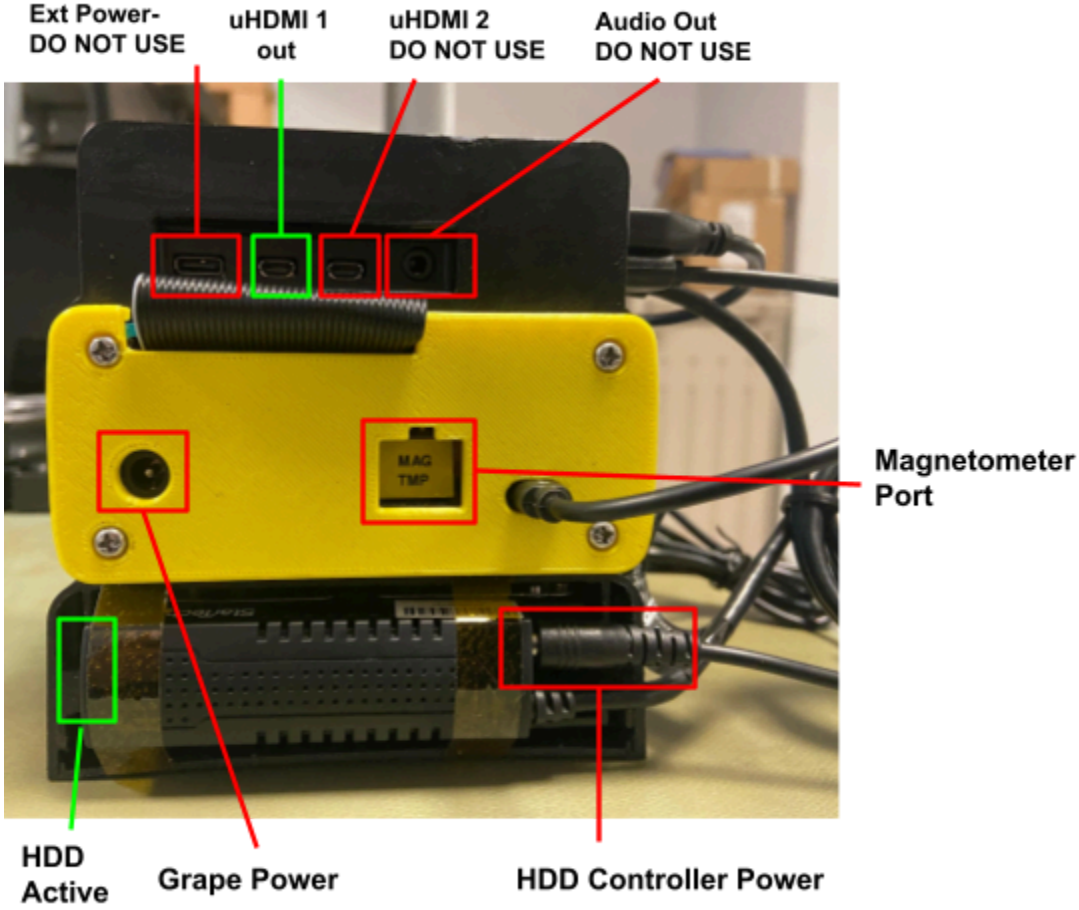
Also, the Grape 2 power input can be unregulated between 12VDC and 24 VDC.

The disk controller, however, needs 12 VDC regulated @ 2 Amps.

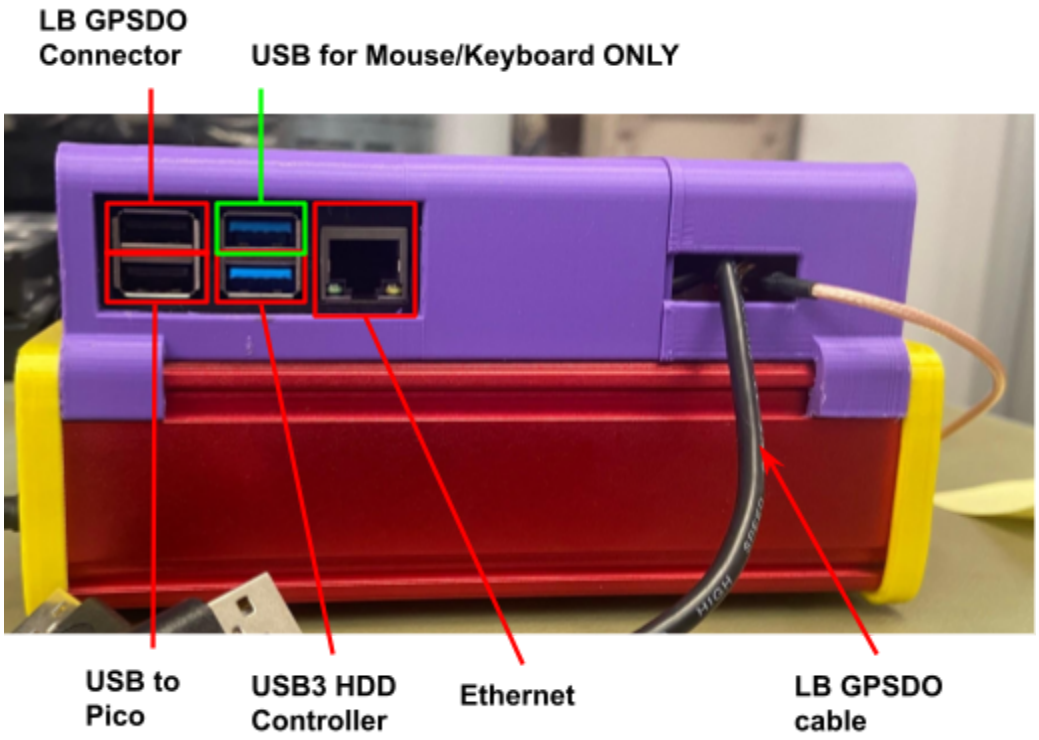
3 Connecting to a Monitor

Your grape will need a monitor capable of 1920 x 1080 resolution, as well as a keyboard/mouse for initial setup. After setup, the monitor will not be needed if you choose to use Virtual Network Computing (**VNC**) with a dummy HDMI module connected. The VNC server is turned on by default. We are supplying a dummy HDMI unit to fake the presence of a monitor [but not all were available at shipping time]. If you need one to run the unit headless please contact us and we will ship you one.

Connect the monitor using a micro-HDMI to HDMI cable. Note this component is **not included** in the package. Failure to have a monitor the HDMI port may result in a screen resolution of 320x480 (not usable - especially over VNC). We will be supplying a dummy HDMI plug into this in the future. For now, always boot the system with a monitor (which can be removed after boot finishes).



Connect either a wireless controller for a keyboard and mouse, or a USB dongle for a wired keyboard and mouse, to the last available USB3 port:

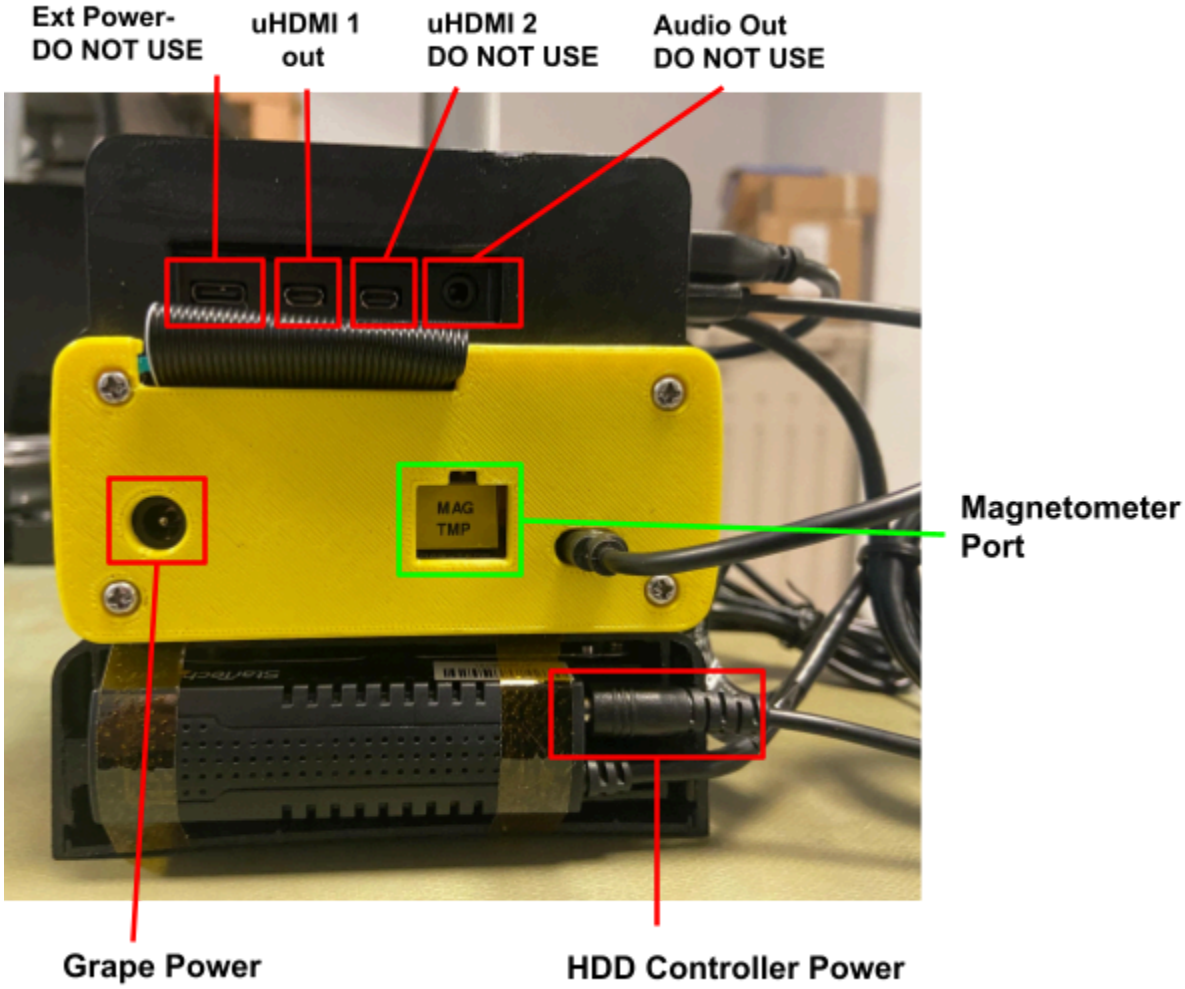


Note that the Raspberry Pi (**RasPi4B**) doesn't always see the HDD on boot and, since it is mounted in the filesystem, this will stop the boot process. If the Grape2 does not boot and you see a message on the screen asking to hit return to continue, do the following:

1. Disconnect the HDD controller cable from the USB3 port
2. Wait 5 seconds
3. Replug the HDD cable back into the same USB3 position
4. Now press enter and the boot should complete

4 (Optional) Connecting the Magnetometer

If you are going to run a magnetometer you must install it before running the PSWSsetup program as it is automatically detected and will not be operated if not present during setup. Begin by removing the tape (shown here labeled 'MAG TMP') covering the magnetometer port - then plug the cable into the port.



To see if the system sees the magnetometer, type:

```
qi2c
```

And hit **<enter>.** This will scan the I^2C bus for the magnetometer. If the magnetometer is found you will see:

```
pi@G2DevSystm:/home/pi$ qi2c
     0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00:                          -- -- -- -- -- -- -- --
10: -- -- -- -- -- -- -- -- 18 19 -- -- -- -- -- --
20: 20 -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
30: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
40: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
50: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
60: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
70: -- -- -- -- -- -- -- --
```

If not found you will see:

```
pi@G2DevSystm:/home/pi$ qi2c
     0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00:                          -- -- -- -- -- -- -- --
10: -- -- -- -- -- -- -- -- 18 -- -- -- -- -- -- --
20: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
30: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
40: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
50: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
60: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
70: -- -- -- -- -- -- -- --
```

Once you have determined that the magnetometer is seen by the system you will need to align it. The `rmag` program will allow you to do this very easily.

Type:

`rmag`

then press **<enter>**. Your output will look something like this:

```
pi@Grape2N1001:/home/pi/G2User$ rmag

Startup UTC time: Tue Mar 26 02:53:09 2024
Device handle p->i2c_fd:  3
i2c_init OK!
RM3100 Detected Properly: REVID: 22.

In setCycleCountRegs():: Setting NOS register to value: 3C
CycleCounts  - X: 400, Y: 400, Z: 400.
Gains        - X: 148, Y: 148, Z: 148.
NOS Register - 3C.
"time", "rtemp", "ltemp", "x", "y", "z"
"26 Mar 2024 02:53:10", 7.19, 31.25, 47.0716, 0.0457, -24.6870
"26 Mar 2024 02:53:11", 7.25, 31.25, 47.0716, 0.0459, -24.6859
"26 Mar 2024 02:53:12", 7.25, 31.31, 47.0727, 0.0471, -24.6868
"26 Mar 2024 02:53:13", 7.25, 31.25, 47.0723, 0.0474, -24.6895
"26 Mar 2024 02:53:14", 7.25, 31.25, 47.0709, 0.0463, -24.6876
"26 Mar 2024 02:53:15", 7.25, 31.31, 47.0731, 0.0466, -24.6858
"26 Mar 2024 02:53:16", 7.25, 31.25, 47.0725, 0.0437, -24.6886
"26 Mar 2024 02:53:16", 7.25, 31.25, 47.0709, 0.0475, -24.6891
^C
```

To calibrate your unit twist the pipe in the ground to obtain a “y” value as close to zero as possible. When done type **<ctrl-c>** to exit `rmag`.

Your magnetometer unit is now calibrated.

Note:

The magnetometer has a vertical SMT inductor on the top center of the board that is easy to break off. BE VERY CAREFUL with this as it does break easily (voice of experience…)

5 Connecting to the GPS Constellation

After the cables all have been correctly plugged together, the wired internet connection is set up and the GPS antenna is connected and placed where it will see the sky adequately - apply power to the unit. The Grape2 unit will take a good minute to completely boot. When you see the raspberry on the screen you can proceed.

When the system boots start the terminal window [it's the black box in bottom taskbar with a ">_" in it] and type:

```
gpst
```

then press **<enter>**. This will display what the UBLOX GPS is seeing and you should leave this running for a minimum of 30 minutes - ideally you want the **PDOP** (Position Dilution Of Precision) number to be under 2.0 if possible. Be aware that it takes 20 minutes just to download the ephemeris data for the GPS constellation. The program will not allow a GPS position entry if the PDOP ≥ 4.0. If needed you may have to find a better position for the GPS antenna. This is the purpose of running `gpst` - to make sure you have a good GPS view.

DO NOT PROCEED past this step until you have successfully completed it. Failure to do so will result in system lockup and the end of the universe as we know it.

Once the position is stable, press **<ctrl-c>** to exit the `gpst` program.

Now it's time to set the system up to run. First we need to sync the software to the code repository. After setup is complete, the Grape2 will normally sync automatically every day at 23:30 UTC. To manually do this type:

```
ur
```

then press **<enter>**. Now start the setup program by typing:

`PSWSsetup`

then press **<enter>**. Enter all the info asked for (remember no comma between City and State!)

The setup program will automatically get your latitude (**Lat)**, longitude (**Lon**), and elevation (**Elev**) numbers from the GPS and automatically calculate your grid square from this info.

Keep in mind the PSWSsetup program will retain the pre-existing info if you just keep pressing **<enter>**. So be sure to following the prompts closely and enter the correct info. **When** you mess up an entry don't fret - just run the `PSWSsetup` program again and correct the mistake (and just use **<enter>** for entries you want to keep).

A Word of Caution:

The USB3 HDD controller cable is EXTREMELY SENSITIVE to being moved. There are multiple connections inside the connector that when the cable is bumped, moved up or down, touched or basically just looked at funny will disconnect for a short instant and disconnect the drive. When this happens the drive goes off-line and will require manual intervention to get back online.

This sometimes works:

1 - type: sudo umount /dev/sda1 <enter>
2 - unplug the drive - wait 5 seconds
3 - plug the drive back in
4 - type: sudo mount -a <enter>
5 - verify it's online by: cd /home/pi/G2DATA/ ; ll <enter>
If you see all the S* directories you are good to go.
6 - If this doesn't fix it exit all programs in the terminal windows
7 - type: sd <enter> this shuts the system down. Wait 15 seconds, Cycle power.

6 Running the Grape2

To start the data collection process use the same terminal window and start the Grape2 Console. Note that in the GKRELL monitor on the right side of the screen CPU3 is shut off. This is because it is being dedicated solely to the data collection task. Once the console is started, you should see activity on CPU3.

Start the Grape2 console by typing:

```
g2c
```

then press **<enter>**. When the screen loads now type

```
r
```

You will need to wait a good 7-10 seconds for all of the process intercommunication pipes and structures to get set up and running. Then, you should see numbers printing out on the terminal. If you have a magnetometer attached you will see values there otherwise they will be populated with all 0's

You should see the HDD Active LED (on the side of HDD controller) flicker about once every 3 or so seconds as data is being stored (~432 MB / hour
or ~ 10 GB / Day)

CONGRATULATIONS! YOU ARE NOW COLLECTING DATA!

You can use the command **<ctrl-p>** to toggle between 1 hour max-min values or 24 hour max-min values. Note that the 24 hour mode is a sliding window of the last 24 hours and is **not** reset at 00:00:00 UTC.

7 Testing for the correct RF Gain

The Grape 2 RF front End has been designed to allow the user to better adapt to their specific operating conditions (EVERYONE is different). I designed in 4 different RF gains of 1, 2.5, 4 and 10 via jumper settings on the RF Deck board. These gains apply to all 3 radios so the radio with the largest signal level sets the maximum gain that can be used for all 3 radio channels. I shipped the units with a default gain of 2.5 which will most likely be low for your setup (unless you live in Ft Collins, CO where you don't need a radio to hear WWV, but I digress…). The procedure for setting the RF Gain is as follows:

1 - Run your setup at the gain already set for a full 24 hours - you really DO have to do this as day and night propagation is different and all 3 radios will not show their peak signals at the same time. Be sure to use the <ctrl-p> to toggle to the 24 hour min/max mode of viewing the signal peak levels.

2 - After the 24 hr test, determine the max voltage obtained by the 3 radios. If the max voltage is > 2.0 Vpk on any radio you will need to simply decrease the gain to the next lowest setting and try again for 24 hours.

3 - If it is lower than 2.0 V, use the below equation to determine if you can go to the next highest gain. The voltage must be **below** the listed threshold to go up in gain.

Radio Measured Vpk max * (New RF gain / Existing RF Gain) <= 2.0 Volts

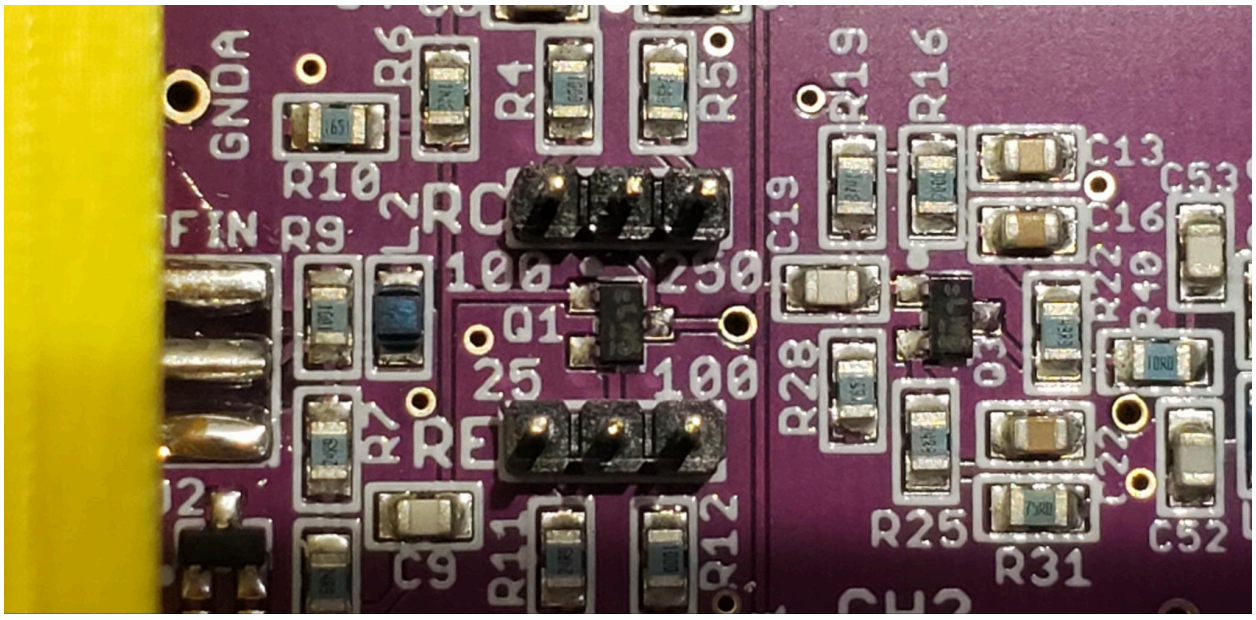
Present Gain Jumper Setting	Incremental RF Gain Increase	Measured Vpk Max Threshold
1	2.5 / 1 = 2.5	<= 0.800 Vpk
2.5	4 / 2.5 = 1.6	<= 1.250 Vpk
4	10 / 4 = 2.5	<= 0.800 Vpk
10	10 / 10 = 1.0	Gain is MAXed out

If you are at a gain of 1.0 and still have too much gain you will need to attenuate your input signal level or use a less efficient antenna.

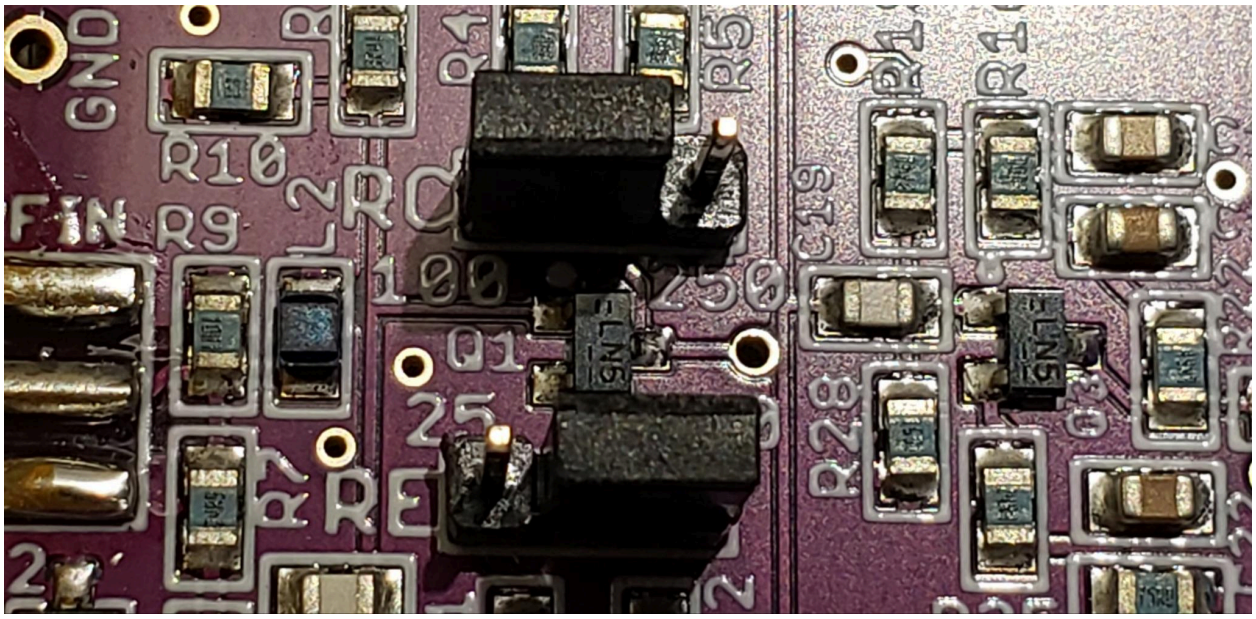
The RF Gain is set by the ratio of the RC / RE resistors in the front end amplifier's common emitter BJT (Q1) gain stage:

RC = 100 or 250
RE = 25 or 100

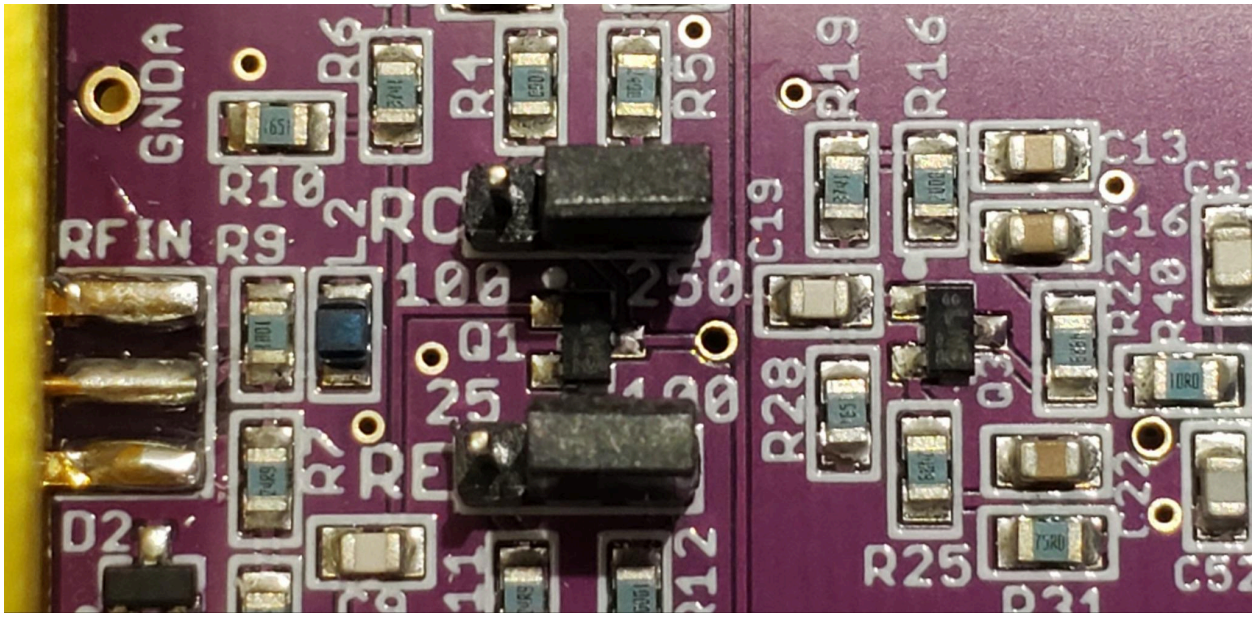
RF Deck Jumper Positions (no Jumpers installed):



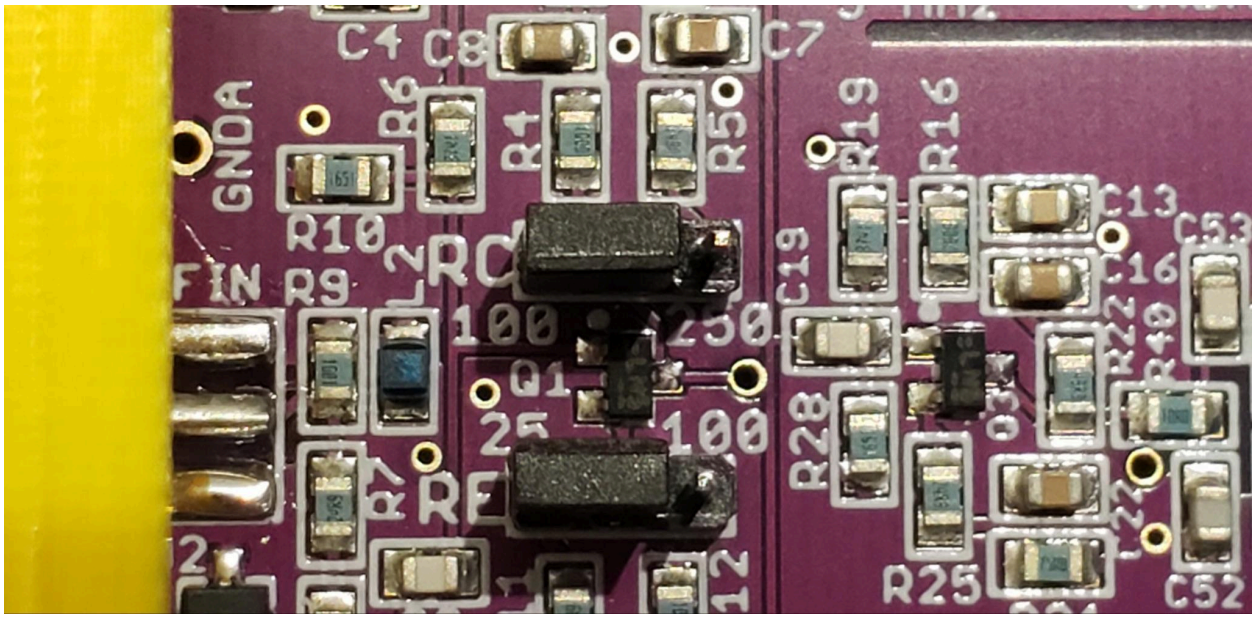
Gain = 1 (RC = 100, RE = 100)



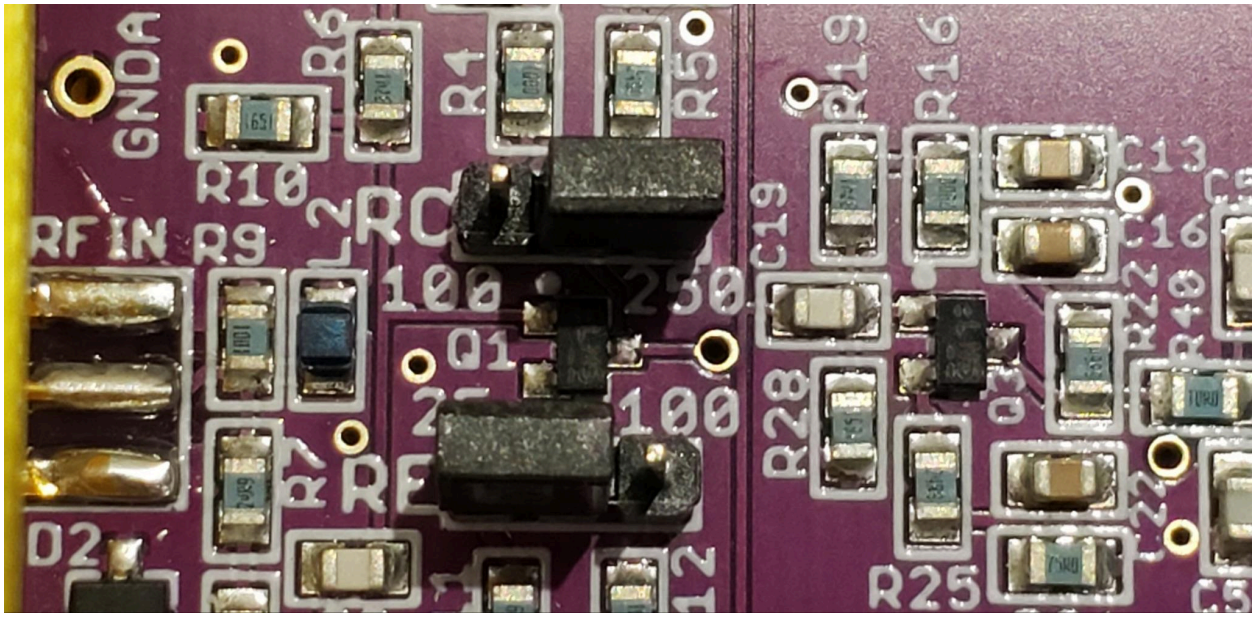
Gain = 2.5 (RC = 250, RE = 100)



Gain = 4 (RC = 100, RE = 25)



Gain = 10 (RC = 250, RE = 25)



8 Setting the RF Gain Jumpers

To change the RG Gain jumper settings exit out of the G2console by typing <ctrl-x>. Once the cmd prompt shows up -

Shut down the system by typing:

sd <ret>

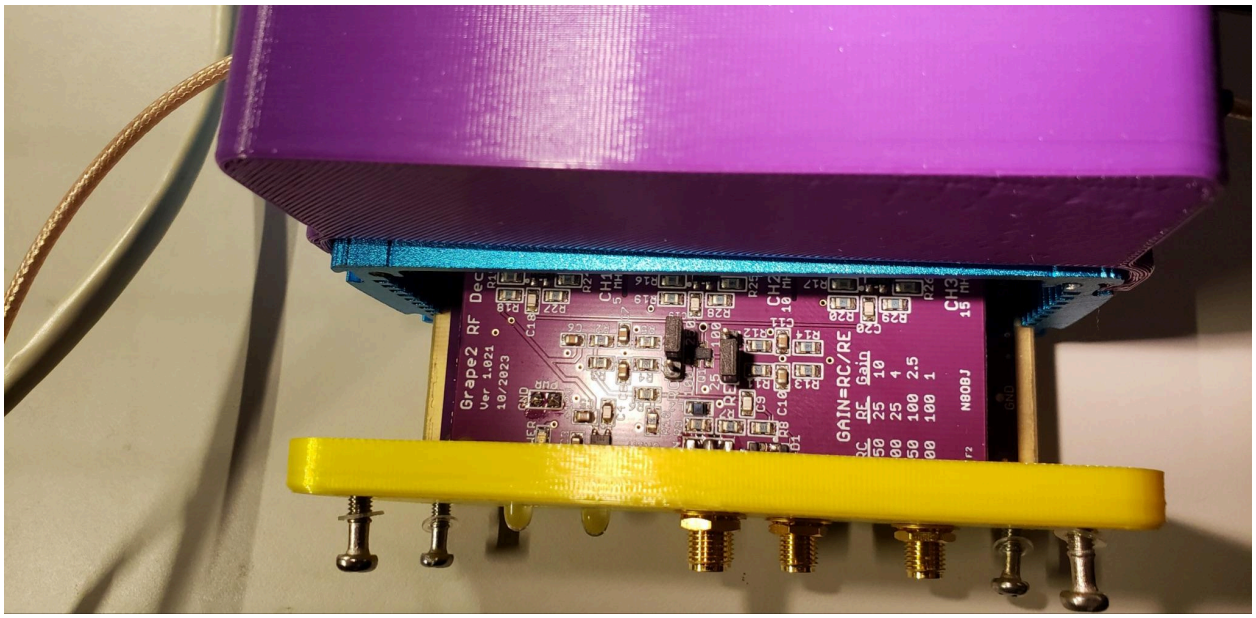
This will take approximately 15 seconds as the disks need to write their cache contents (so don't be too quick to cut power).

Once powered down, turn the Grape2 so the front panel is facing you.

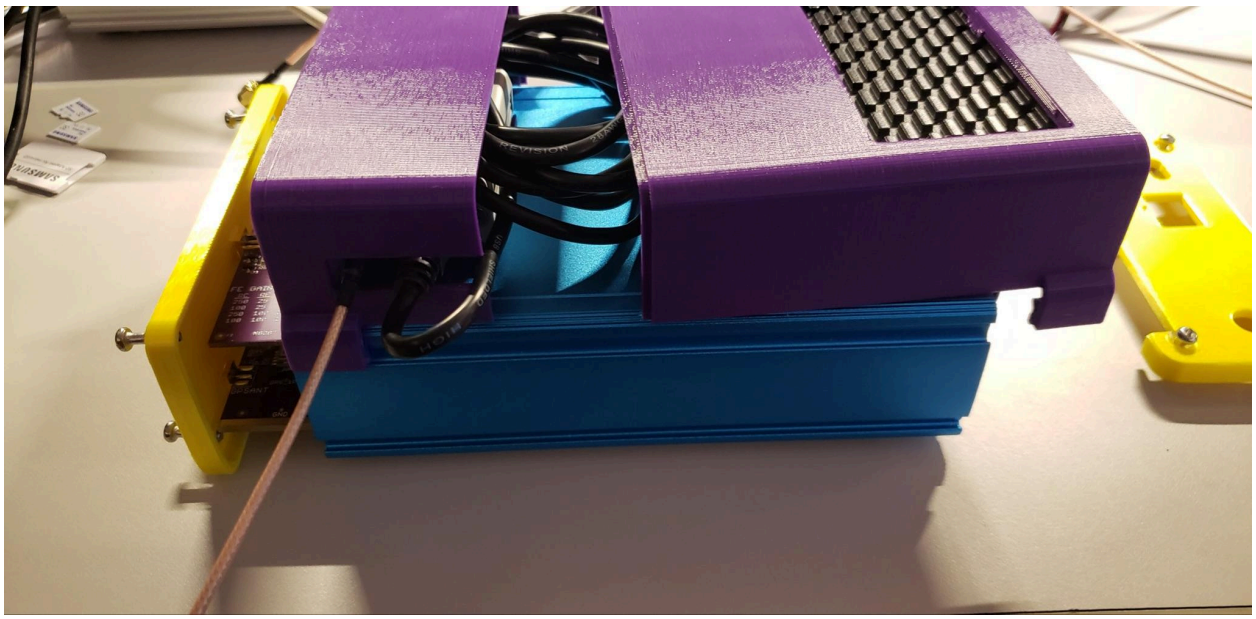
Remove all the RF cables from the front panel (I torqued the 2 cables to the LB GPSDO with a RF SMA torque wrench so you will not be able to loosen them with just your fingers). You can use a 5/16 " wrench [or needle-nose pliers] to loosen the SMA connectors. Once removed, unscrew the 4 front panel screws until they just disengage the aluminum extrusion but don't fall out of the front panel (you may have to back them out incrementally in a rotating progression) or you can live dangerously and just remove them completely.

Now remove the 4 screws from the back panel (as described above) and remove it. You need to do this as the 40 pin ribbon cable isn't quite long enough to allow the board stack to slide out far enough to give you easy access to the jumper headers (it was sooooo close…). Now slide the top rear box (in the rails on the aluminum extrusion - BE CAREFUL - if you twist the top box you will break the feet off). Slide it enough to allow the board assembly to slide out enough to allow easy access to the jumper headers.

Using the needle-nose pliers, change the RF Gain jumpers to the new desired setting. Pics of board stack opened up for RF Gain jumper change procedure:



Position of whole assy during dis-asembly for Gain Jumper change procedure



Once the jumpers are changed, reverse the above procedure and re-assemble the Grape2 unit back to the fully assembled unit. DO NOT overtighten the SMA connectors - they just need to be snug. Too tight will pop the snap ring holding the connector together and destroy it. Finger tight is sufficient for this connector re-torquing. You have been warned…

Apply power to reboot the system and once the Raspberry logo shows up, start a terminal window.

You now MUST run PSWSsetup again and enter the new RF Gain number that you just set the jumpers to. Remember in PSWSsetup it will keep the same entry as before if you just hit the <enter> key. If the PDOP number is lower than the one you saved before, be sure to use the "**n**" command to use the **new** value (as opposed to the default '**s**' to **save** the previous one). Be sure not to accidentally skip past the RF Gain question. If you do, just run the PSWSsetup program again - no harm - no foul…

You can now (assuming everything is reconnected) start the G2console by typing:

g2c <ret>

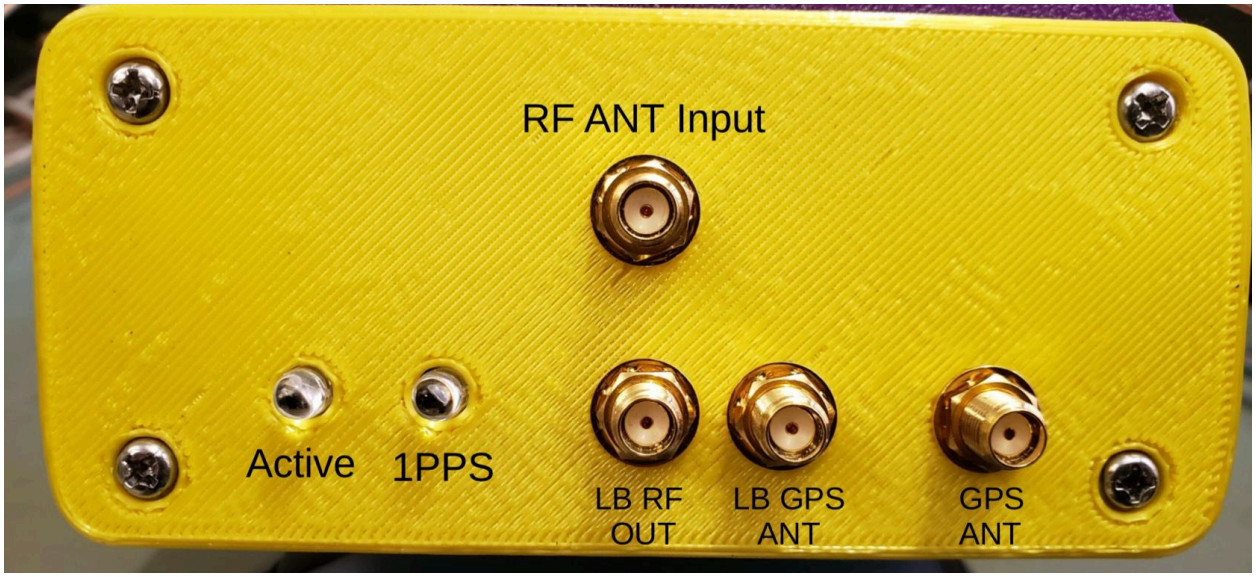
Then enter

r

To start the data collection again.

9 - Front / Rear Panel Connections

Front Panel:



Rear Panel: