

Procedure for Setting Up a 2 Horn Interferometer

These are instructions for how to set up and run a 2 horn interferometer using a Lime SDR with GNURadio. The spectrometer programs write time-stamped data once every integration time. For the adding spectrometer, the data includes horn A spectra, horn B spectra, and the power spectra from the sum of their signals. For the multiplying spectrometer, the data includes horn A spectra, horn B spectra, the magnitude of the interference, and the phase of the interference.

1. List of Equipment

a. Horn

- ◆ horn & can antenna
- ◆ cradle
- ◆ stand
- ◆ bolts for cradle axle
- ◆ clamps - recommended to secure the cradle to the horn after the horn is aligned

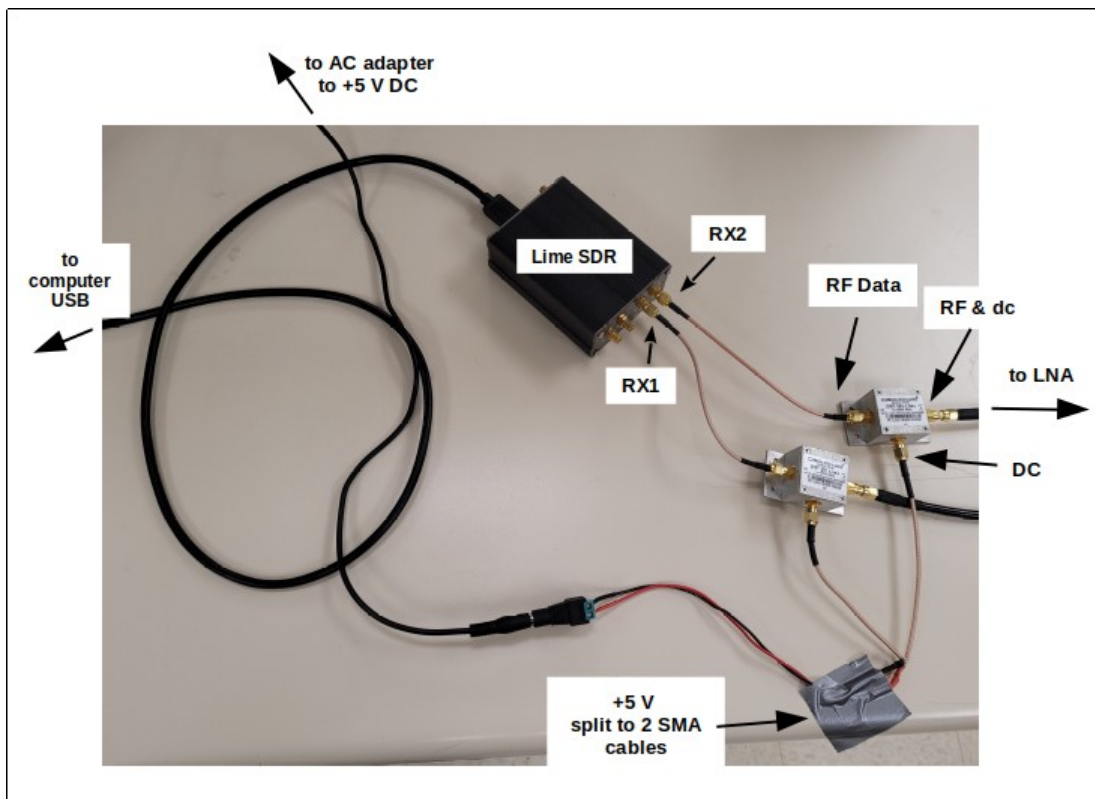
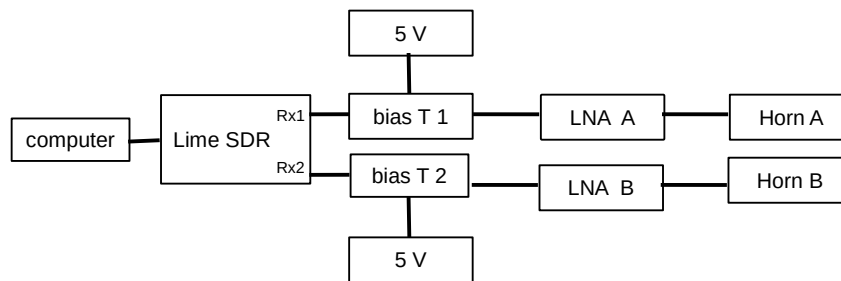
b. Electronics

- ◆ computer with the 2 horn interferometer *GNURadio* spectrometer program on it
Current program: *interferometer_Lime_simpleSpectrometer.grc*
- ◆ Lime SDR with USB cable to connect to a computer
- ◆ 2 bias T's for powering the LNA's
- ◆ 5 V transformer to power the bias T's
- ◆ 2 SMA cables to connect the Lime Rx outputs to the "RF" inputs of the bias T's
- ◆ 2 long SMA cables to connect the "RF+dc" outputs of the bias T's to the LNA's
- ◆ 2 LNA's

c. Set-up aids and other accessories

- ◆ duct tape - recommended for taping the cables in place
- ◆ inclinometer - recommended for setting the telescope angle
- ◆ E-W (N-S) line - critical!
 - best method: determine from the shadow of a vertical pole or string at sun's transit
 - or determine using an accurate compass
- ◆ Large protractor to help orient the telescopes
- ◆ pliers for tightening the horn rotation axis
- ◆ tent in case of rain
- ◆ string - can be useful for aiding the alignment of the horns relative to each other
- ◆ tape measure

2. Schematic Diagram and photo of the electrical connections



3. Setting up the horns

- a. Assemble 2 horns as would be done for a single horn observation.
- b. For horns with a baseline along the east-west direction, set them parallel to each other, pointing at the same spot in the sky (e.g. the sun when it transits).
- c. Here are some tips:
 - ♦ Sometime before doing interferometry, establish the N-S direction marking the shadow of a vertical pole when the sun transits. (See Tad's video.)
 - ♦ If the horns are to be set up with an E-W baseline, use some sort of large compass or square to mark the E-W direction as that perpendicular to the N-S direction. A tape measure or string can be useful for doing this.

4. Setting up the electrical connections - **REFER TO THE PHOTO ABOVE**

- a. Data for "Horn A" is collected on the cable that is plugged in to **RX1** on the Lime SDR; **RX2** is for Horn B.
- b. Be sure that the 5 V dc transformer for powering the bias-T's is plugged in, and check that the power strip is on.
- c. The "RF" terminal of each bias-T is connected to the respective **RX1** and **RX2** on the Lime.
- d. The "RF + dc" terminal of each bias-T is connected to the respective LNA.

5. **For Adding Interferometry:**

- a. Run the spectrometer program *Interferometer_SimpleSpectrometer_Adding.grc*
- b. Plug the Lime SDR into a USB port.
- c. On the computer set up the file directories for data collection:
 - ♦ Create a folder appropriately titled for the data collection, e.g. "Sun_scan_July21". Be sure any folders and filenames have no spaces in them.
 - ♦ Run GNURadio: `$ gnuradio-companion`
 - ♦ On the canvas in the "*Interferometer_Lime_simpleSpectrometer.grc*" program, open the **Variable** boxes described below; these are in the upper left side of the GNURadio canvas:
 - Open the "prefix_hornA" **Variable** block (double-click it). For "Value" type the pathname to the subfolder that will be used to collect the spectrum of Horn A. This must be in quotes. In the example below horn A data is written to the sub-folder "magnitude_july21" that is in the subfolder "sun_july21" which is a subfolder of "interferometer_data", etc.:
"/home/john/dspira_2021/interferometer_data/sun_july21/hornA_july21/"
 - Set up similar file pathnames in the Variable blocks "prefix_hornB" and "prefix_adding" **Variables**.
 - Be sure these sub-folders on the computer have been created.
 - ♦ Start the program. Select "Writing to File" for a few seconds to test if the files are being written to the folders. Stop the program and check the folders.
- d. If all is good, you are ready to go. Delete the test files in each folder (not required but recommended).
- e. Start the program. Select "Long Integration" and "Writing to File". If all is good, the graphs should show signals being collected.

6. For Multiplying Interferometry:

- a. Run the spectrometer program *Interferometer_SimpleSpectrometer_Multiplying.grc*
- b. Plug the Lime SDR into a USB port.
- c. On the computer set up the file directories for data collection:
 - ♦ Create a folder appropriately titled for the data collection, e.g. "Sun_scan_July21". Be sure any folders and filenames have no spaces in them.
 - ♦ Run GNURadio: `$ gnuradio-companion`
 - ♦ On the canvas in the "*Interferometer_Lime_simpleSpectrometer.grc*" program, open the **Variable** boxes described below; these are in the upper left side of the GNURadio canvas:
 - Open the "prefix_mag" **Variable** block (double-click it). For "Value" type the pathname to the subfolder that will be used to collect the spectrum of Horn A. This must be in quotes. In the example below interference magnitude data is written to the sub-folder "magnitude_july21" that is in the subfolder "sun_july21" which is a subfolder of "interferometer_data", etc.:
"/home/john/dspira_2021/interferometer_data/sun_july21/magnitude_july21/"
 - Set up similar file pathnames in the **Variable** blocks "prefix_phase", "prefix_hornA", and "prefix_hornB" **Variables**.
 - Be sure these sub-folders on the computer have been created.
 - ♦ Start the program. Select "Writing to File" for a few seconds to test if the files are being written to the folders. Stop the program and check the folders.
- d. If all is good, you are ready to go. Delete the test files in each folder (not required but recommended).
- e. Start the program. Select "Long Integration" and "Writing to File". If all is good, the graphs should show signals being collected.