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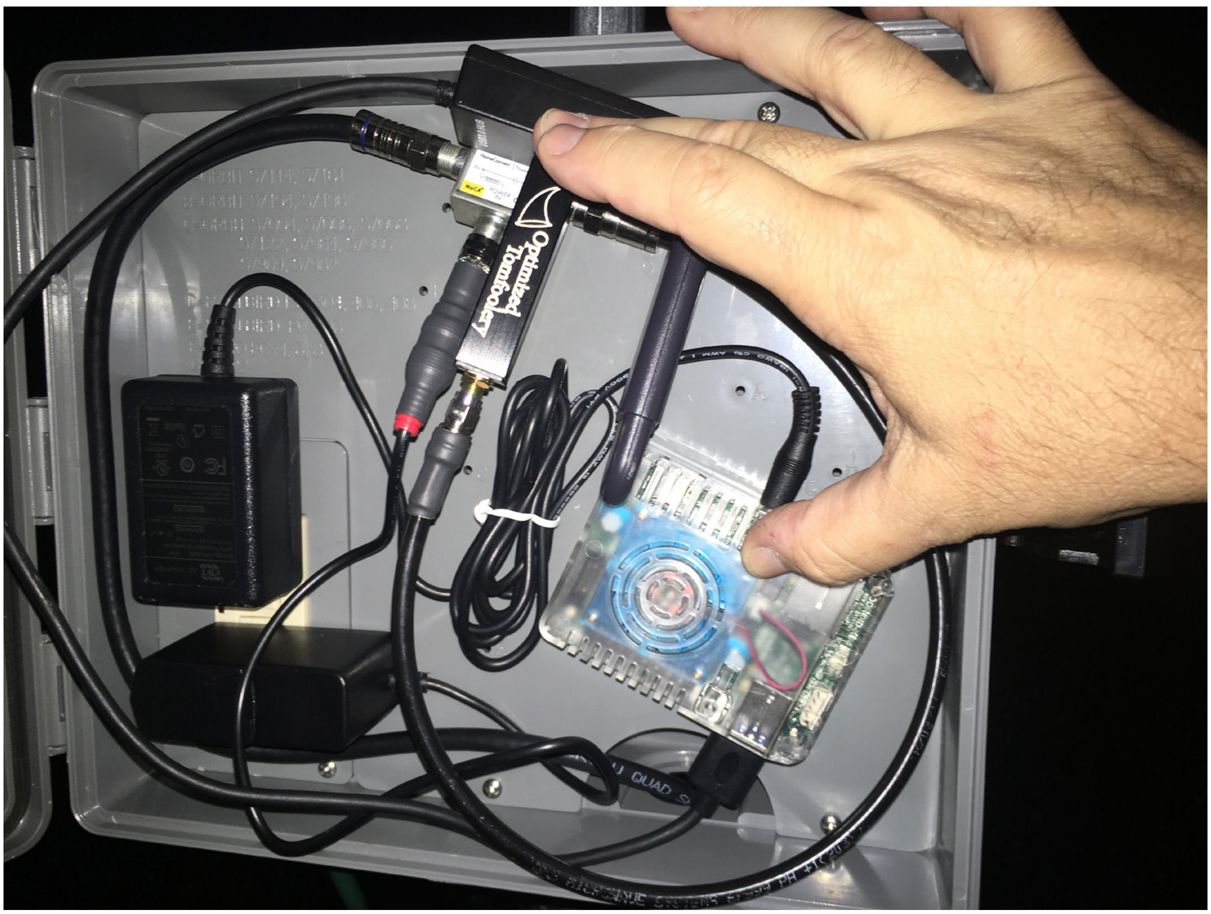
LNB on a Stick

An inexpensive portable 10GHz receive station that is accessible from the internet



The Goal

Phase 4 Ground is an open source amateur radio communications system that implements the DVB-S2/X communications protocol for amateur space and terrestrial use. For more information about Phase 4 Ground and the non-profit that supports it, please visit https://openresearch.institute/

The receiver design is challenging, with up to 10MHz bandwidths, 5GHz uplink, 10GHz downlink, adaptive coding and modulation, Generic Stream Encapsulation, and a price point for the transceiver of less than $1000.

There are many aspcets of this project. This paper discusses some of the ongoing receiver experiments.

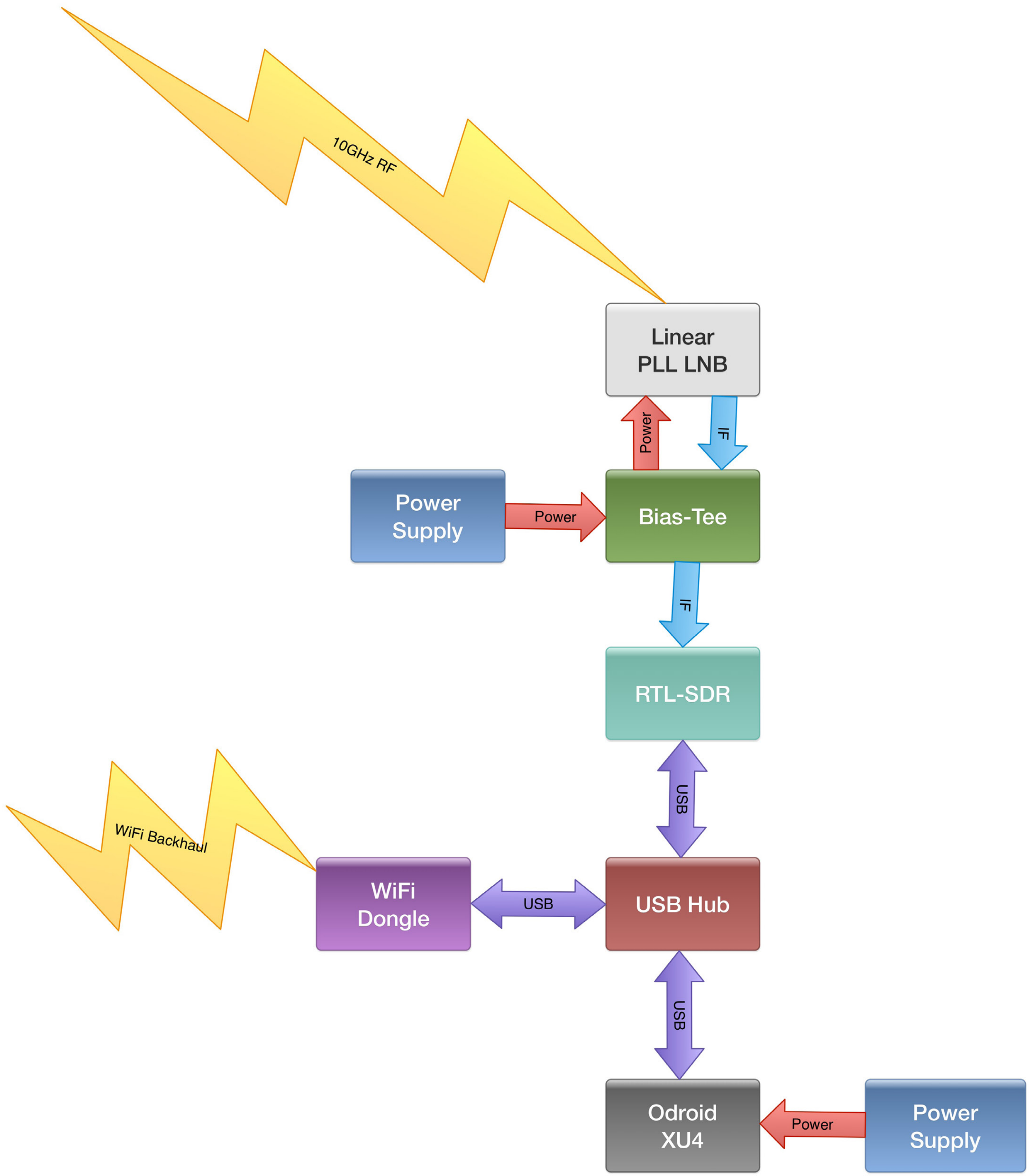
This Experiment

LNB on a Stick is the first set of experiments for a portable, remote, 10GHz receiver that will successfully recover Phase 4 Ground signals. These signals may be terrestrial, from space, or from sources such as balloon launches. With a communications backhaul, these receivers can be easily monitored on the web.

In the photo above are all the components in the equipment box[1]: a processor to run the software, a bias-tee to provide power to the linear PLL-style LNB, an RTL-SDR to receive the intermediate frequency from the LNB, power supply, USB hub, and a WiFi dongle to connect to a local LAN.

1 human hand not included

Block Diagram



Construction, Cost, Software, Performance

Construction requirements for the first revision were minimal as the station was composed of commercial off the shelf (COTS) parts. Bench testing before deployment is highly recommended.

$60	Odroid XU4
$25	Noelec Smart RTLSDR
$0	SDMG loan Bias-T
$35	sprinkler box with outlet
$25	linearly polarized PLL style LNB
$20	wifi dongle
$20	10ft mast
$40	outdoor umbrella stand
$15	USB 3.0 hub
$240	**Total**

An F to SMA cable was contructed to connect the RTL-SDR to the bias-tee. An existing F to F cable was shortened in order to match the length of the mast.

For full bandwidth Phase 4 Ground performance, a quality bias-tee like the MiniCircuits ZABT-2R15G+ is recommended. This can increase the cost by nearly $50.

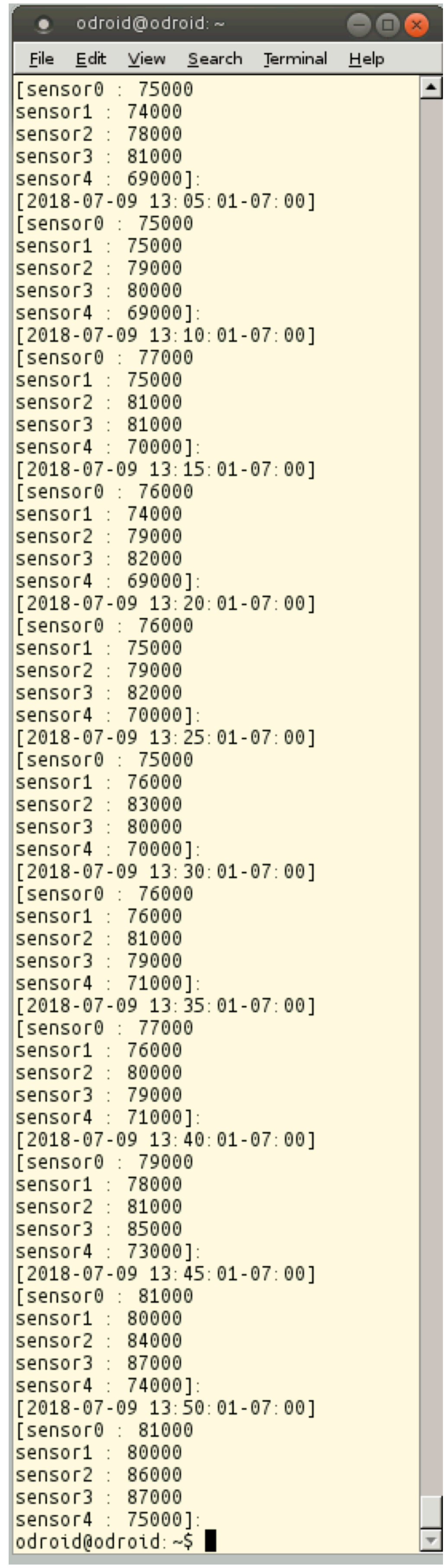
Software used for the first revision was openwebrx available at https://github.com/simonyiszk/openwebrx
The station was placed at the associated software-defined radio (SDR) aggregator website as https://sdr.hu/?q=W5NYV

Openwebrx is open source, multi-user SDR receiver software with a web interface. It takes the output from the RTL-SDR, does a variety of demodulation and presentation tasks, and provides an http server so that the waterfall, control panel, and 3D visualization are presented within any modern browser.

SDR.hu is a website where an openwebrx station can register the reporting station. A simple process for requesting and including a key in the configuration file for openwebrx is necessary. After that is done, the station can be listed at SDR.hu. Obtaining the key and being listed at SDR.hu isn't necessary in order to use openwebrx. Assuming the processor onboard the LNB on a Stick is reachable, it will serve the webpages directly. In fact, the direct internet address of the station is the on information listed at SDR.hu. Being listed at SDR.hu is a convenience, not a requirement, to monitor the station with a browser.

There are several other SDR aggregators that are functionally equivalent to SDR.hu. The selection of openwebrx was driven by the ease of installation and the familiar user interface. Reports and usage were solicited from Phase 4 Ground, San Diego Microwave Group, and San Bernardino Microwave Group. Deployment performance was observed.

The most immediate and pressing problem observed was the **tendency for the Odroid to overheat.** The Odroid is a capable and popular embedded processor, but it runs hot even in indoor environments. Inside a box, even with ventilation holes, in direct sun, caused temperatures as reported by the Odroid's five temperature sensors to exceed the shutdown limits on hot days. This was not unexpected, but it was more severe than anticipated. See a sample of the temperature log at right. Temperatures are in Celsius. Location is San Diego, CA, USA. Ambient temperatures were 25-26 Celsius for the time the sensors were reporting. The Odroid throttles at 95 Celsius

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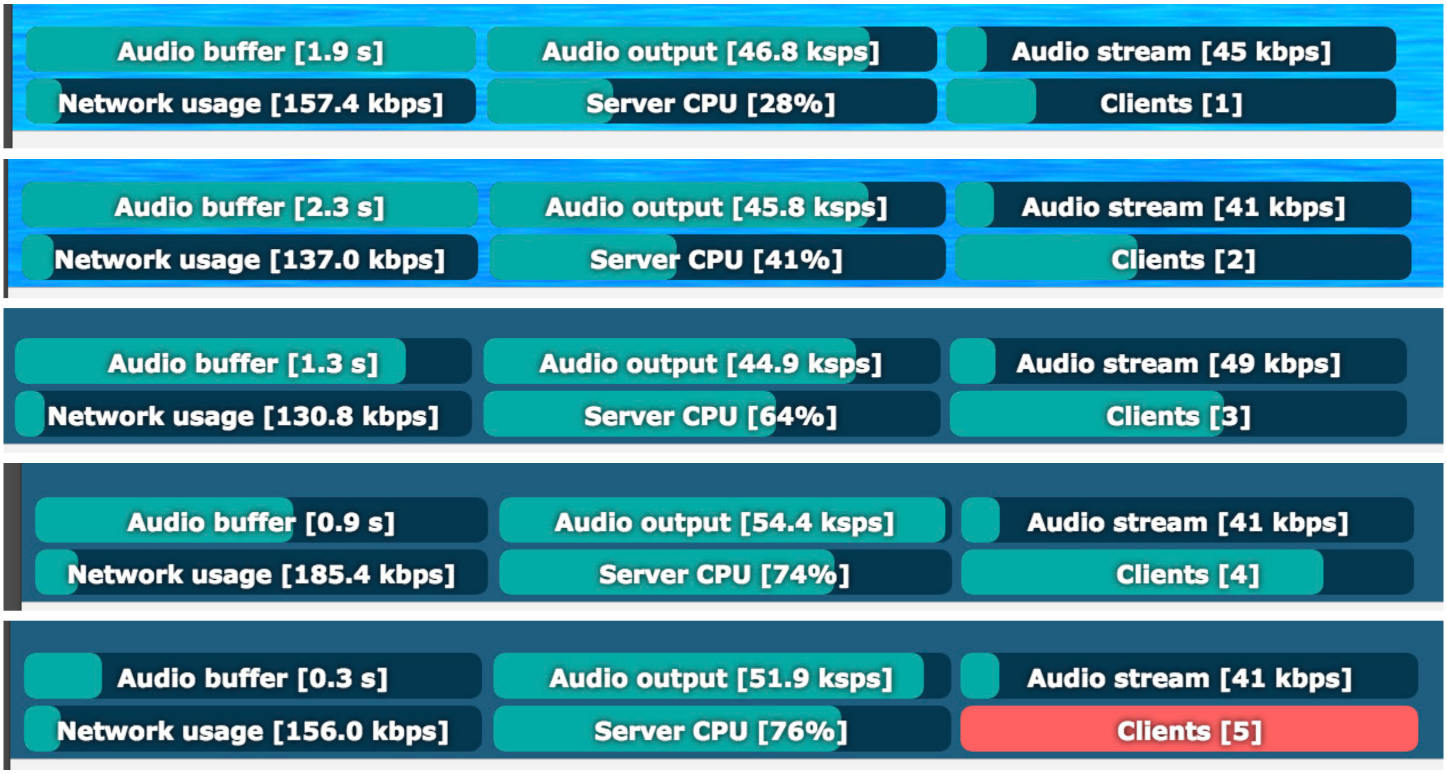

and shuts down at 115 Celsius.

The second problem is one of scale. The Odroid is an http server for openwebrx. Each additional connection consumes additional processor resources. Above are statistics reported by the openwebrx software with respect to number of clients, starting with 1 at the top and ending with 5 at the bottom. The number of clients was limited to 5. Once a limit is reached, the background color changes to red. Audio buffer overruns were observed at all levels.

The linux function `top` was run as each client connection was added. The results agreed with the statistics reported by the browser client (above).

Phase 4 Ground wants to field and support distributed receivers. These receivers need to be able to handle a scaling up of the number of receiver connections. Phase 4 Ground wants to enable an amateur radio operator to have customized receiver deployment scheme. This means that the operator must be able to select a variety of receiver streams. Those streams are routed to the operatng station, where they combine in useful ways without impediment.

In some radio networks, the receivers are individual nodes with a single reporting connection to an aggregator or reporting site. Once the content is reported or uploaded, an operator downloads that receiver content from the single server. This is essentially a star network, with the aggregator or storage server at the center. This model can be thought of like a conference call. All the voices in a telephone conference call are combined and sent out as what is perceived by a listener calling as a single audio stream.

Networks like sdr.hu are not star networks. The individual nodes running openwebrx are listed on the site. Listeners connect directly to a receiver. Each receiver is the central server as soon as the operator selects it. Other operators may start showing up as listeners, and then the receiver becomes the center of a star. The website sdr.hu provides receiver findability, but does not assist with serving receiver data.

The network architecture that Phase 4 Ground wants is neither an aggregated star network (like a telephone conference call) or like a list of receivers that are browsed or searched and then directly connected to. We need another type of network structure.