NOAA GOES-R LRIT/HRIT & EMWIN
Software Radio Receiver

Introduction

The National Oceanographic and Atmospheric Administration (NOAA) Geostationary Operational Environmental Satellite-R Series (GOES-R) satellites transmit real-time environmental sensor data that provides forecasters and the public information they need to improve public safety, protect property, and maintain vital economic activity in the face of critical weather events.

The NOAA GOES-R LRIT/HRIT software radio receiver simplifies retrieving and viewing information pertinent to each user by providing a turn-key radio receiver and product viewing application that operate on low-cost personal computers. The NOAA GOES LiveSDR image is suitable for use on a bootable USB thumb drive or a virtual machine. It is based on the GNURadio LiveSDR Environment.

Getting Started

This manual assumes the user has loaded the image onto a bootable USB drive and booted into the LiveSDR environment. The following screenshot shows the default desktop from the LiveSDR image.

LiveSDR desktop

Double-click the NOAA GOESSDR icon to open the receiver interface. Resize the application window and the window segments to the view shown below.

NOAA GOESSDR Main tab

The main receiver control tab consists of four sub-panels, Receiver Settings, error statistics, and signal visualizations.

Receiver Settings

The Receiver Settings sub-panel defines the operating parameters for the receiver. The interface does not enforce valid entries for receiver parameters, it is up to the user to understand the limits of their hardware. A brief description of the Basic Settings sub-panel parameters are as follows:

- Center Frequency (MHz) – sets the RF front-end tuner of the receiver hardware
- Sample rate (MHz) – sets the maximum sample rate of the receiver
- Symbol rate (Hz) – sets the nominal symbol rate of the received signal

- Decimation factor – sets the digital decimation factor. Digital decimation is applied immediately after the ADC to reduce the processing load downstream and remove noise outside the desired passband
- Frequency Offset (Hz) – sets the residual frequency offset from the center frequency which is compensated by the decimation filter (regardless of the decimation factor), e.g. if the center frequency is 1.5 GHz and the frequency offset is set to 500 kHz then the effective tuned frequency is 1.5005 GHz
- AFC – sets the automatic frequency compensation. When checked, the app will periodically measure the residual frequency offset and set the Frequency Offset parameter to compensate. The AFC will only search the frequency spanned by Sample rate / Decimation factor about the center frequency
- RRC Roll-Off – sets the root-raised cosine pulse shape roll-off factor [0, 1)

The Source Selection sub-panel parameters set the signal source and signal type for the receiver.

- Source – sets the signal source
  - FILE – obtain samples from a file, a binary list of interleaved in-phase and quadrature float32 samples. Represented graphically: `[I0 | Q0 | I1 | Q1 | ...]` where each I (in-phase) and Q (quadrature) sample is a single-precision (32 bits) float at each time index
  - RTL – obtain samples from a connected RTL-SDR USB dongle
  - UHD – obtain samples from a connected Ettus Research UHD compatible SDR
- Loop file – file will repeat continuously if checked, set file name in dialog
- Device addr – specifies the address of the connected RTL or UHD device (only required when multiple devices connected)
- Start (Stop) – press to start and stop processing

Error Statistics

The Error Statistics sub-panel displays some basic error rate statistics and receiver state along with a signal-to-noise (SNR) estimate and symbol rate measurement.

- TOT FER – total frame error rate, includes missed frames
- RS FER – Reed-Solomon frame errors, excludes missed frames
- VIT_BER – Bit error rate estimate at the output of the Viterbi decoder, computed only from error-free frames output from the Reed-Solomon decoder
- VCDU Miss – unprocessed VCDUs (due to missed detection), a VCDU consists of four Reed-Solomon frames
- TOT VCDU – estimated total number of VCDUs (including missed)
- Lock lvl – 0 = unlocked, 3 = strong lock (consistent frame synchronization)

Signal Visualizations

The Signal Visualizations sub-panel has two plots: the left plots signals prior to synchronization with sample rate Sample rate / Decimation factor, the right plots signals after synchronization with sample rate equal to the symbol rate. The digital noise level can be adjusted to test error rate performance with the provided noiseless test file.

Configuration

The receiver parameters can be set individually through the GUI, but repeating this procedure for every signal of interest be tedious. Alternatively, all of the configuration parameters in the GUI can be saved to a configuration file and restored later. From the File menu select "Save Config" or press ctrl-s to open the save configuration dialog. To restore a saved configuration from the File menu select "Load Config" or press ctrl-o to open the load configuration dialog. Select a saved configuration file and press OK to load the parameters. The configuration files are text files following the INI file format and can be modified in any text editor.

Hello World

The receiver application can be tested with the included noiseless test input. A configuration file for the test input is also included. Open the Load Config dialog and navigate to `/usr/local/share/gr-goessdr/examples/config`. Select `default_file_test.conf` and press OK. The receiver parameters should now all be set appropriately for the noiseless test input file. Press Start and you should observe the signal spectrum in the left signal visualization plot and the time-domain symbols in the right signal visualization plot.
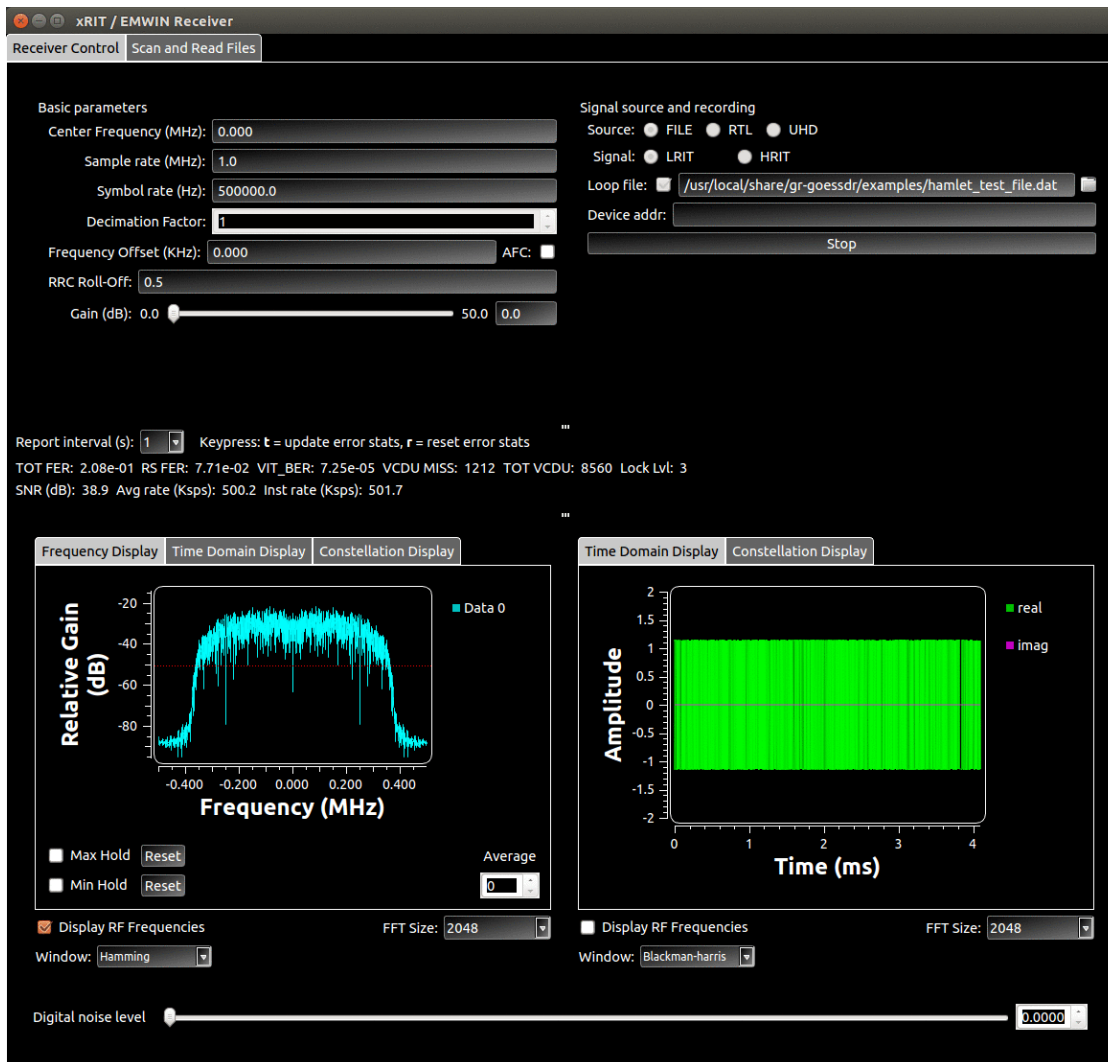

NOAA GOESSDR Main tab

Troubleshooting

Received Files Disappear

The operating system of the Live USB drive (Ubuntu 14.04) does not allow the creation of LiveUSB flash drives with persistent storage. This implies that if the computer is shutdown or restarted, all received HRIT / EMWIN files will disappear from the boot drive. In order to preserve this files, an additional drive for persistent storage needs to be used to store received files.

NOAA GOESSDR Nominal Operation

Nominal Operation

When receiving the GOES signal under normal conditions, the signal diagnositics panels should look something like the images shown below. In order to check if your receiver is working properly, it may be helpful to look for the some of following features:

- In the "Frequency Display" tab of the input signal, you should see something resembling a plateau. A flat frequency response (between +-400 kHz) raised above surrounding frequency bands. This indicates a strong input signal and a clear receiving channel.
- In the "Time Domain Display" tab of the Post-Sync Signal Visuals, the amplitude of the signal should be flat- you should see a clean rectangle of received signal. This indicates that the receiver can properly track the input signal.
- In the "Constellation Display" tab of the Post-Sync Signal Visuals, you should see two small dots near +-1. Tighter dots means less noise in the input signal.

We will now go over some common issues with receiver systems and how to remedy these problems.
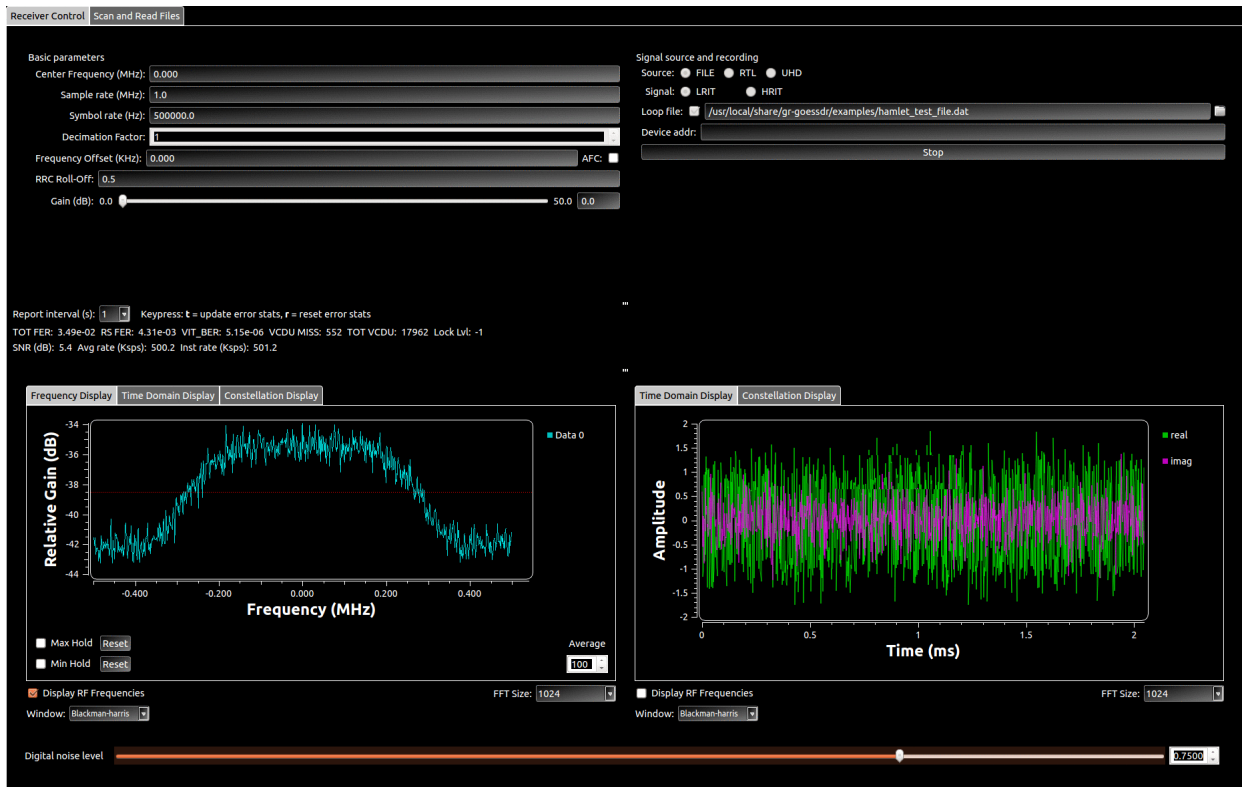
Weak Signal Strength

If your received signal is too weak, the receiver may not be able to properly demodulate the signal. Some signs of low signal strength are:

- In the "Frequency Display" tab, the plateau mentioned in the Nominal Operation section is too low, not raised above the surrounding frequency bands. In the example below, our input signal (the plateau) has a Relative gain of about -34dB, while the noise floor (the surrounding frequency bands) is at -42dB. This means that our signal has about 8dB of gain relative to the noise floor, which may be too low to properly receive GOES products without errors.
- In the "Time Domain Display" tab of the Post-Sync Signal Visuals, the amplitude of the signal will not be flat, but uneven and jagged.
- In the "Constellation Display" tab of the Post-Sync Signal Visuals, the two dots will be clouds of dots instead. If these clouds appear to have significant overlap, that is a good indicator of too much noise in the input signal.

If you see these indicators in your GOESSDR receiver, try the following steps:

1. Double check that the "Digital noise level" slider is at 0. This slider is a debugging feature to test receiver performance and should not be used in normal operation.
2. Adjust or move your antenna to receive a higher strength signal. Outdoor antennas with an unobstructed view of the sky are best.
3. Check all connections in your receiver system, from your antenna to the RTL dongle or USRP you are using to receive and process the signal. Any loose connections can cause significant losses in signal power.
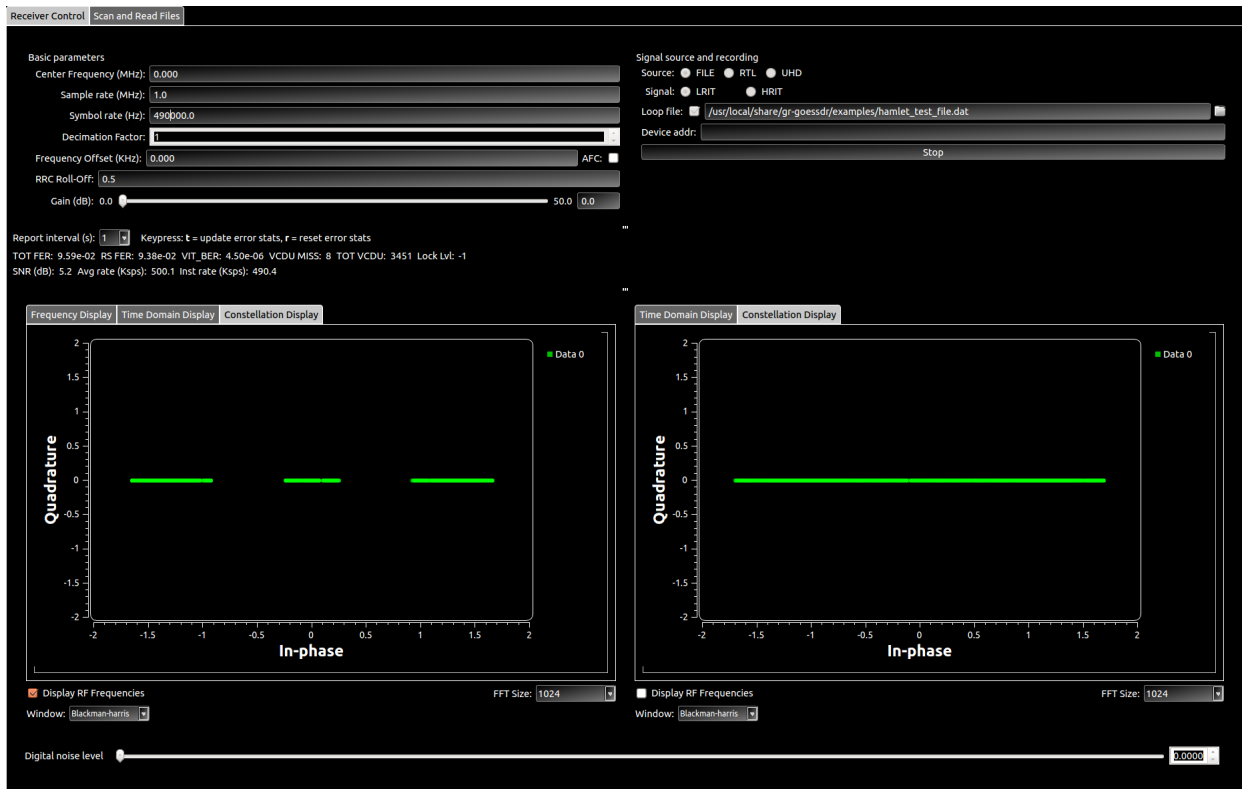
NOAA GOESSDR Low Signal Power
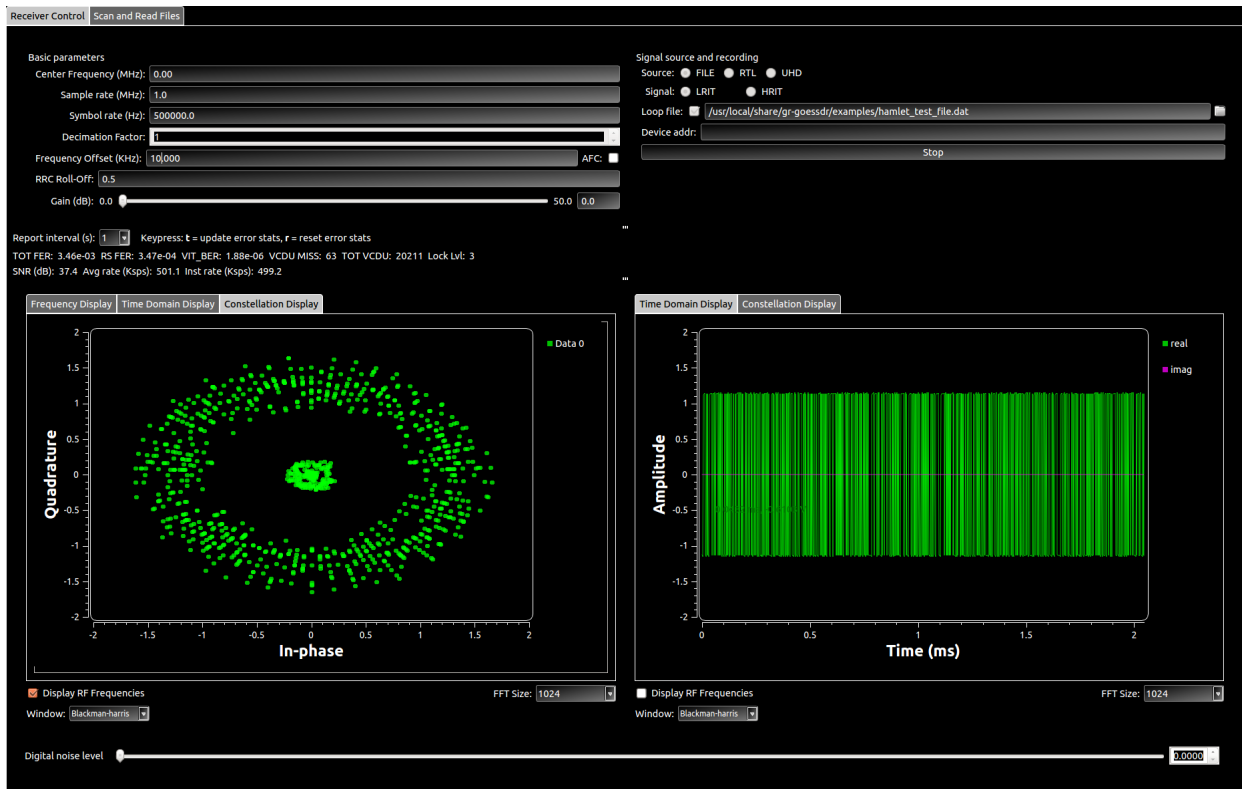
Configuration Errors

There may be other problems with the configuration of your GOESSDR receiver. One common issue is to have the wrong symbol rate in the Basic Parameters section. Double check all parameters in this section to ensure that the receiver is configured properly.

In the example below, we can tell that the symbol rate has not been properly set because we do not see the two clean dots in the "Constellation Display" of the Post-Sync Signal Visuals. Unlike the low signal power situation, we do not see clouds of dots either. Instead, there is a clean line, which indicates that the receiver has not been configured to properly track the input signal.

NOAA GOESSDR Wrong Symbol Rate

Another common configuration issue can be seen in the image below. The circular pattern seen in the "Constellation Display" tab of the Pre-Sync Signal Visuals often manifests when the receiver tries to track the wrong center frequency of the input signal. Again, to fix this issue, double check your receiver's configuration, especially the Center Frequency, to make sure it matches the GOES signal parameters. Enabling Automatic Frequency Correction with the AFC checkbox (to the right of Frequency Offset in the Basic Parameters portion of the GUI) can also allow the receiver to better track

NOAA GOESSDR Wrong Symbol Rate

Signal Clipping

In some cases, some component in your receiver system may be overdriven; that is, the signal amplitude is too high for some component to handle. This can cause the signal to be clip, and can be a tricky issue to diagnose. If your signal looks distorted and your amplifiers are near their upper limits, trying lowering the gain of the amplifiers and see if the distortion lessens.