Modulation – Demodulation Software Radio

Running the RF-Seismograph on Raspberry Pi3+

Groups.io user group: https://groups.io/g/MDSRadio

MDSR website: http://users.skynet.be/myspace/mdsr

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Build and configure your Space Weather Station
with RF-Seismograph
on a Raspberry Pi 3+
and
Installing a LIF port into the
TS-590 Transceiver

Intro:

The MDSR and the RF-Seismograph are very stable and well established amateur radio software packages enabling users to extend the capability of their analog radios to SDR. The MDSR software provides a real time spectrum analyzer and IF DSP filtering with extremely clean RX audio and high dynamic range. The RF-Seismograph is a propagation scanner that monitors and records up to 6 different bands for long term propagation monitoring of 24h (6h are displayed). This software checks the NOAA Space Weather alert system every 10min for updates. It also includes a FTP upload service that allows the user to upload the measurement graphics to a web-server, for usage in websites to display real time propagation on the web. Individual propagation events are also listed in the Propagation Tracker. This creates an HTML page for additional on-line propagation updates.

Linux versus Windows:

I got my first PC running Win3.1 and DOS in the early 90. This was the heyday for PCs and it seemed as if there was no limit to what could be done with it. Microsoft enabled a lot of small computer and peripheral manufacturers to grow and become market leaders. Spreading this knowledge allowed everyone to create the internet and the web as we know it today.

For over 20 years Windows had a vision that was supporting well-paying jobs, not only for Microsoft, but for the whole Tech sector integrating more and more products with MS software and computers.

This is why we started to develop the MDSR and the RF-Seismograph software for Windows. With the market success of Smartphone and iPods the technology landscape changed. In order to survive, Windows adapted to become a Cell Phone and Gaming company, abandoning a lot of their legacy, customers and businesses. A lot of companies spent billions developing software for PC's, and now it is all in jeopardy!

Luckily, the MDSR Team was doing the bulk of its development in JAVA. This allows us to re-use most of the coded software by modifying it slightly to work on Linux. But the price of Linux computers is also affected by the sales numbers of motherboards and processors. Both devices are highly complicated and only a large demand for them can guarantee low cost. So if we adapt our software to run on Linux, the future availability is still not very promising. Because the bulk of the hardware was used in PCs, lower demand for them will raise the prices for all computer hardware across all platforms.

Raspberry Pi to the Rescue!

This is the second time the MDSR team has looked into the use of the Raspberry Pi computers. The first time we tested using a Pi 2, without success in 2015. But the new 4 core Pi 3+ is now fast enough and that is why we decided to move all software over to Linux (Raspbian). Unfortunately the CAT control, OmniRig and MDSR Spectrum Analyzer (SA) where written only for Windows and needed to be abandoned.

The RF-Seismograph also contains a spectrum analyzer, but it runs a bit slowly on the Pi3+, so there is still room for improvement. For the RF-Seismograph, which also utilizes the Fourier transform indirectly, it is fast enough. Nothing changes fast when it comes to changes in propagation; the Pi3+ is just perfect, especially considering the price of the unit.

fl-rig - the new CAT software for the RF-Seismograph (Standalone)

fl-rig was developed and is maintained as an open source project by David H. Freese (W1HKJ). Dave and his associates maintain a whole set of interesting programs that can run on Linux, Mac and Windows. In this write-up we also want to thank Dave and his colleagues for the great Amateur Software which they have made available for free. We also appreciate the fast response to our inquiries with regard to the fl-rig XML-RPC data exchange system. This was definitely a learning curve for us.

In the old software we used config files to communicate cross-platform. The data exchange between fl-rig and the RF-Seismograph is now done via XML-RPC calls. The XML setup utilizes a web server and a web client. Depending on the setup of fl-rig's XML server, the data can be exchanged locally or/and across the Internet. This also works point to multipoint, so that the fl-rig and the connected transceiver can be controlled via multiple software packages at the same time. It eliminates the need of more than one CAT cable (RS-232 is only point to point), to control one radio with multiple programs.

We have not modified the MDSR software to run on Linux yet. As of now, fl-rig and the RF-Seismograph communicate directly, eliminating the need to have MDSR running on the system. Once MDSR is moved over, the RF-Seismograph will have the capability to select which device (MDSR or fl-rig) will be queried to keep its data current and in sync with the connected transceiver.
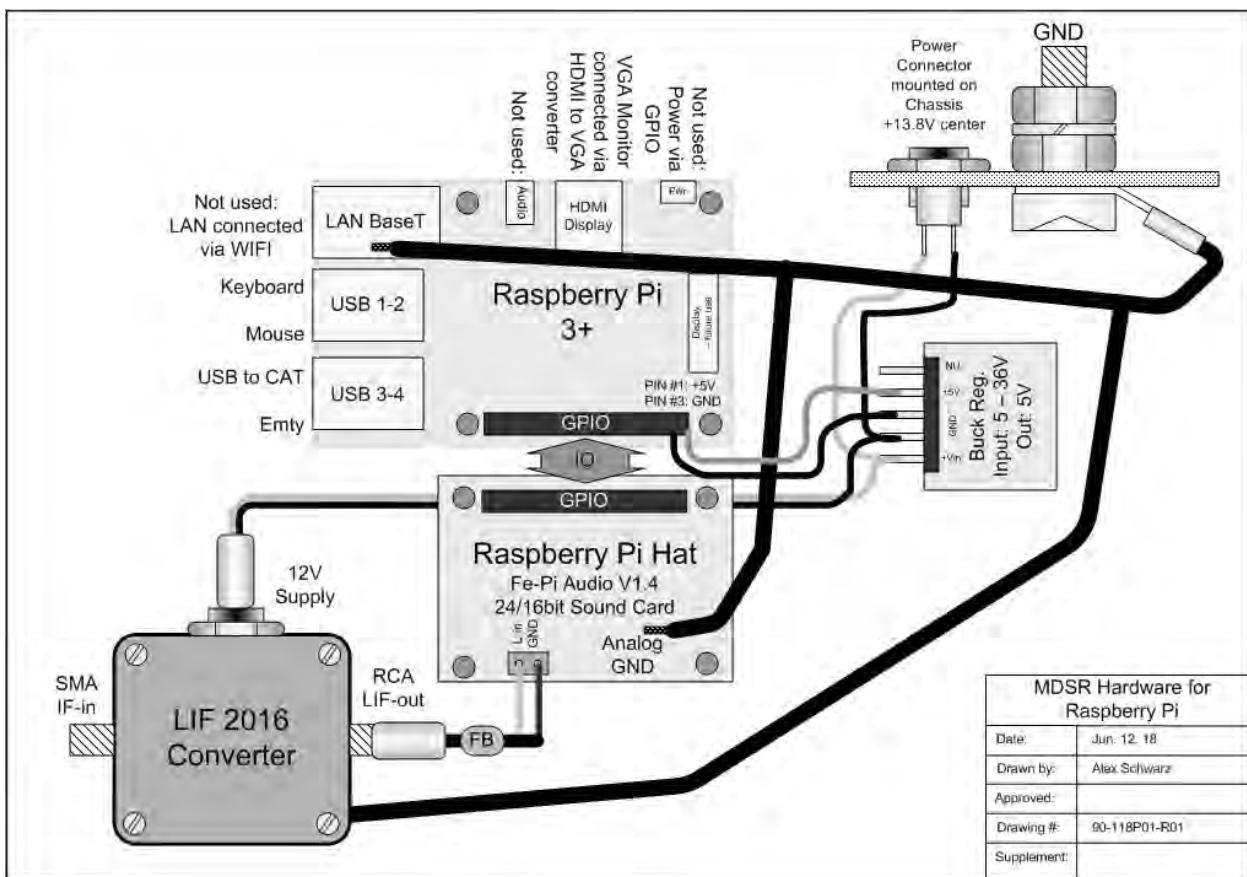
The MDSR software for Windows is still supported for all current Windows platforms using the Java RTE environment. The setup can be downloaded from our website.
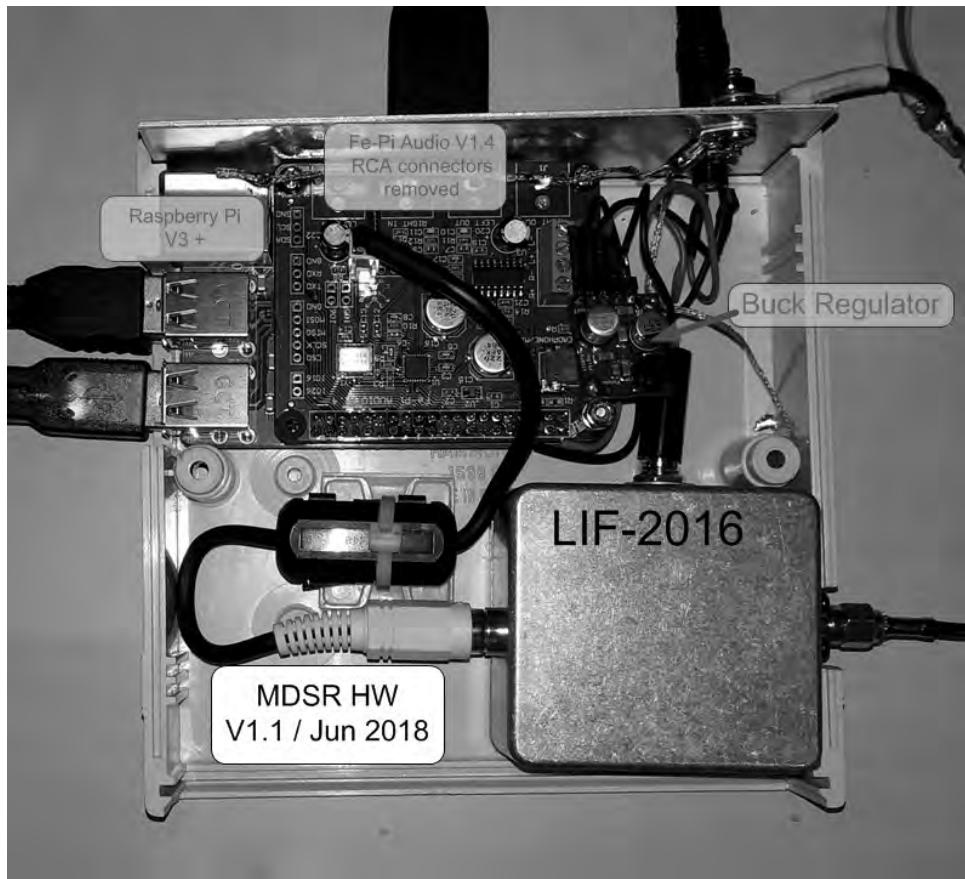
Hardware Implementation

Introduction

The hardware design of the Raspberry Pi setup to run the RF-Seismograph has to include a sound-card with stereo line level output and input. The higher the quality of the sound-card input the better the results for the received and demodulated signal. The Raspberry Pi unit requires 5V and draws up to 2A of power. This is different from all the amateur equipment that usually requires 13.8V. To simplify the setup of the unit a Buck power regulator is implemented to reduce the 13.8V to 5V for the Pi. Since this is done internally the PI power connector remains empty. The connection between the LIF-2016 and the left audio line input is wired with high quality shielded audio cable. To reduce inductive RF currents on the shield, a clamp-on ferrite bead is placed over the cable. Grounding is required to reduce the induction of noise generated by the microprocessors and other digital circuits. For best grounding results, follow the schematics for grounding points.
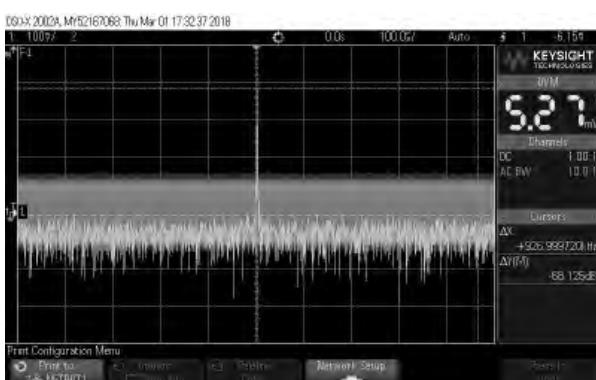
Schematics

Future Upgrades:

To make the MDSR hardware truly portable the Raspberry Pi 7" touch screen will be added to the Pi.Assembled MDSR Hardware

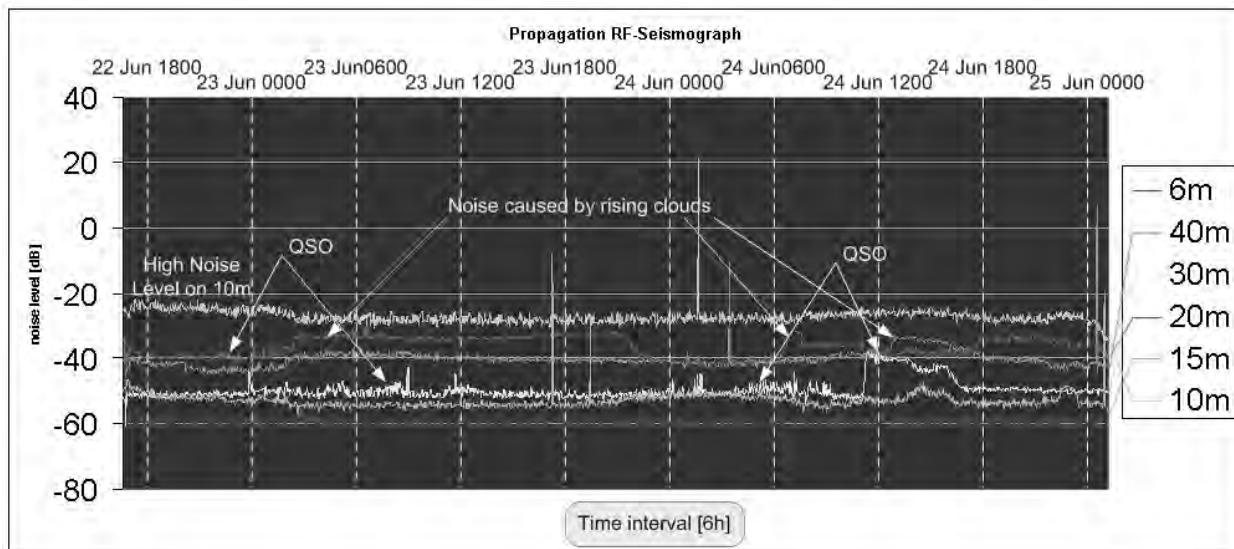## Why use a simple crystal-controlled Downconverter?

The frequency stability and the phase noise of a crystal cannot be duplicated without some major expenses in DDS and time base circuitry. A lot of the cost-effective and commercially available oscillators have severe phase noise and stability issues. Crystal oscillators allow us to keep the budget low and the quality of the LIF high. The flexibility of the variable IF that DDS allows for, has now been programmed into the software running on the Pi.

The measurement to the left shows the 10.707MHz crystal LO of the SA-612 mixer. With a span of 2MHz, the very flat noise floor is down by -68dB. The peak of the carrier is very steep and at the -68dB mark it is only 20Hz wide! Custom crystals can still be made by www.quartslab.com in England.

Trial by Radio Wave: Field Day test of the new Raspberry Pi RF-Seismograph

During Field Day 2018 the MDSR team was recording the noise and propagation at the NSARC annual outing on Cypress Mountain (loc: 49.358292, -123.210771) at about 700m elevation. This is a great site and the view is spectacular. The only problem is that there is a steep hill down to the ocean and when the clouds are rising, the generated RF noise (S9+ at times) makes it impossible to receive anything. Fortunately there are always other bands that open up… **Note:** the antenna used was not really ideal for 6m so there is only a base line visible (see measurement at the bottom).

How to set up the Raspberry with the RF-Seismograph

Note: Before attempting this, the sound-card has to be configured and working. Depending on what sound hat is used, these instructions vary. Please follow the manufacturer's instructions for the driver installation and confirm that it is working properly before continuing. Any sound-card will work that has a line level input. A good sound-card can make all the difference. The minimum ADC bit count is 16 running at a data rate of 48kHz.

The sound-card used for the prototype is the **Fe-Pi Audio V 1.4**. It is a very versatile sound-card which has a lot of options such as a 2W PA for the MDSR audio output, headset with mic input plug. For easier installation, the RCA connectors were removed. The 0.1" strip connector was soldered instead and it provides the input for the LINE IN signal.

Find instructions on the Fe-Pi website:

https://fe-pi.com/p/support-and-setup

Setting up the Audio Volume Controls on Pi

After the audio card has been installed the volume controls have to be enabled manually.

In Raspbian click on the Raspberry Icon at the top left, select Preferences and then Audio Device Settings. Set the Fe-Pi Device that is listed besides the bcm2835 ALSA as the default device. To gain access the volume controls press the "Select Controls" button and then select the controls as shown in the picture left. Set all the "Capture" devices to max for the RF-Seismograph setup.

This only has to be done once and for the next time it will remember the settings and the selected controls will be visible. **Note:** The RF-Seismograph will always use the default audio device.

Set up Raspberry Pi so that it will run Java jar files (Loading RTE)

- **Use a minimum SD size of 8GB without IDE**
  (if there is not enough space consider deleting some of the bundled software on Raspberian, such as Wolfram, Office and Google Chrome. Check the web on how this is done using the command line interface.)

NOTE: the **sudo** command invokes the super user privileges and is required for most commands.

Install Java RTE the fast way:

$sudo apt-get install openjdk-8-jre

$sudo apt-get install openjdk-8-jdk

$sudo apt-get update

Verify with the commands with -version option.

$ java -version
$ javac –version

If this did not work:

Visit **http://www.oracle.com/technetwork/java/javase/downloads/jdk8-downloads-2133151.html**, click the download button of Java Platform (JDK) 8. Click to Accept License Agreement, download **jdk-8-linux-arm32-vfp-hflt.tar.gz** for Linux ARM v6/v7 Hard Float ABI 32bit OS.

Open command line, enter the command to extract jdk-8-linux-arm-vfp-hflt.tar.gz to /opt directory.

$ **sudo tar zxvf jdk-8-linux-arm32-vfp-hflt.tar.gz -C /opt**

Set default java and javac to the new installed jdk8.
$ **sudo update-alternatives --install /usr/bin/javac javac /opt/jdk1.8.0/bin/javac 1**
$ **sudo update-alternatives --install /usr/bin/java java /opt/jdk1.8.0/bin/java 1**

$ **sudo update-alternatives --config javac**
$ **sudo update-alternatives --config java**

After all, verify with the commands with -version option.
$ **java -version**
$ **javac –version**

The next step is only required it you want to edit the Java NetBeans Software. If you want to run the IDE a 16GB SD is needed.

Download Netbeans IDE for Raspberry PI (any OS)

Unzip downloaded file; `unzip filename.zip`

Change directory to ~/Downloads/netbeans/bin

Run IDE installation for Platform-Independent Package

To run the installation:

1. After the download of the platform-independent ZIP file completes, extract it to any folder on your system.

2. Run the executable file located in the `netbeans/bin` directory.

   $chmod +x netbeans //make file executable

   in directory type: "**./netbeans**" //installer will launch

3. Accept the License Agreement.

4. Click Next. The NetBeans IDE installation starts.

Note: If a compatible JDK installation cannot be found, you might need to manually add a path to the JDK installation directory by doing the following: (it did not require this step for me)

a. Open the `netbeans.conf` file located in the `netbeans/etc` directory in a text editor.

b. Enter the location of a compatible JDK installation for the `netbeans_jdkhome` option. The default location in Windows is `C:\Program Files\Java\jdk1.8.0` or similar.

c. Save the `netbeans.conf` file and run the executable file in the `netbeans/bin` directory.

Once it has been installed launch the IDE with:

   in directory type: "**./netbeans**" //application will launch

Download MDSR_SA software from MDSR ftp server

Open a command line, go to the Pi directory

//to download the MDSR_SA archive

$ wget http://www3.telus.net/public/bc237/MDSR/MDSR_SA_Archive.tar

$tar -xvf MDSR_SA_Archive.tar //to create and extract the files into MDSR_SA

To change directory type **cd /MDSR_SA.**

$sudo chmod +x SpectrumAnalyzer.jar //make file executable

To run the SpectrumAnalyzer.jar in the directory it's in**: /home/pi/MDSR_SA/.**

Type **"$java –jar SpectrumAnalyzer.jar"**

Desktop Shortcut to start the RF-Seismograph from the desktop
In the MDSR_SA folder there is a shortcut file called MDSR_SA which has an oscilloscope icon. This file can be copied and placed on the desktop to easily start the RF-Seismograph by double-clicking it.

Installation Instructions for flrig on Raspberry Pi
Before installing flrig the FLTK and X11 Libraries have to be installed.

$sudo apt-get install libx11-dev //install X11 libraries

Download the FLTK tar from: http://www.fltk.org

fltk-1.3.4-2-source.tar.gz

place in the Pi directory

$**tar -xvf fltk-1.3.4-2-source.tar.gz** //unzip

Install FLTK by running the following commands:

$ sed -i -e '/cat./d' documentation/Makefile   &&

**> ./configure --prefix=/usr   **

> --enable-shared &&

> sudo make   //will take about 20 min

$ sudo make docdir=/usr/share/doc/fltk-1.3.4 install   //will take about 5 min

Installing fl rig

http://www.w1hkj.com/ download FL Rig 1.3.39.tar.gz. After download the file will be in the "Download" directory. To unzip, double click the file in the file editor. As destination give the Pi directory.

Open a command line:

1. `cd' to the directory containing the package's source (fe: /Pi/ FL Rig 1.3.39/)

$sudo ./configure

Might take a while, while running, it prints some messages telling which features it is checking for.

2. Compile the package.

$sudo make   //this will take about 30 min

3. Type to install the programs and any data files and documentation.

$ sudo make install //this will take about 2 min

The executable is in the data directory and called Flrig. If you are using the file browser double clicking will launch the program. By copying and pasting this file to the desktop you can launch the program by double clicking on the desktop.

Note: All the modified radios on our website have using the OmniRig for doing the CAT setup. FL-rig the new software will work with the same CAT control settings as OmniRig. The only difference is that in Linux there are no COM ports. They are called TTY ports.

How to set up the Serial device for the CAT Control interface:

Connect USB to serial converter,

Open command line editor and type

$Dmesg | grep tty

Return should state that the ttyUSBx is now attached to the RPB Pi.

Note: Manny of the USB to serial and USB to CAT interfaces will work besides Windows also on Linux. The above test is designed to help with discovering which devices are not capable to run on the Pi. Personally I have tested the USB-RTS-01 and the USB-RS232 Converter (Model SP-880). Both work like a charm. There are a lot of other converters that can work with Linux. When more users use the Pi and Linux, radio manufacturers will be required to provide drivers for their units.

Receiving Space Weather Bulletins and Propagation Alerts

The RF-Seismograph is a real time Space Weather Station that records the background noise of your station and connected antennas. Some of the changes in noise level are caused by meteorological events such as thunderstorms and rising air. The bulk of the changes are the effect of solar wind, earth's magnetic field and events which the Space Weather Department of NOAA monitors. When NOAA puts out a space weather alert, it has an immediate effect on the noise level heard in a HF receiver.

In order to allow everyone to learn what noise changes occur when a certain space weather condition persist, the MDSR IO Groups sends out Space Weather alerts to its members. These alerts will also include special propagation alerts for unusual propagation such as Sporadic E.

Please register with www.Groups.io and become a member of the groups.io/g/MDSRadio group if you wish to receive these alerts.

Conclusion

Spending the time and effort to the RF-Seismograph over to Linux was a very rewarding experience. It was also a steep learning curve to understand the differences and the similarities between Windows and Linux. After all, they are both computers and, once the program is running the user experience is the same.

If you want to set up the RF-Seismograph for your station, this is the time to do it. The new platform of the Raspberry Pi offers a very affordable way to get started in setting up your own monitoring of you local RF weather conditions. The installation instructions are made for people that had minimal experience with the Pi and Linux. If you get stuck you can always ask our group members for help!

Buying the LIF units

Go to our website at http://users.skynet.be/myspace/mdsr and find the documentation for one your rigs. On our website also allows ordering the kit there. We accept PayPal.

The RF-Seismograph can be downloaded for free from the Web and works now for Windows as well as Linux. Only the Windows version is available on our website. The Linux version is downloaded during the setup procedure, which is included in this publication.

LIF SMD kits are available for the following IF: 450kHz, 455kHz, 9.015MHz, 10.695MHz

Units are shipped from inside Europe, the USA and Canada for fast delivery and to avoid lengthy customs delays. Canada also ships to Commonwealth countries and the rest of the world.