Modulation – Demodulation Software Radio

Yahoo user group: https://groups.yahoo.com/neo/groups/mdsradio/info

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

Build your own IF SDR
Introduction of MDSR V3.1
and the
Scanning RF-Seismograph V1.4

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Introduction: Why MDSR and the LIF (BiLIF)?

Today's analog receivers have excellent dynamic range. Even lower-end analog radios will have a dynamic range of 80dB or more at a very affordable price. Transceivers built before 2000 are very nice to operate; they are great workhorses and get the job done.

A lot of Hams love their old rigs and would keep them if were it not for all the new modes or the “bells and whistles” which the new ones offer.

The MDSR system allows these old, perfectly functional rigs to get a second lease on life. The LIF concept uses the 455kHz IF and down-converts it to 12kHz where it can be processed by the soundcard. Once it is digitized the DSP engine of the MDSR software can provide sharp IF filters, notch filters and a whole range of neat SDR-like features that most analog rigs lack. The MDSR software also adds a real-time spectrum analyzer for fast tuning and a remote control feature that is easy to use and to set-up. At the cost of a LIF converter PCB and the time spent to connect the transceiver and the computer together, the MDSR system outperforms any SDR available on the market today. Combined with a 24-bit sound card which has a dynamic range of about 120dB, the receiver opens up a whole new world of reception.

The weakest link on the SDR development is the lack of high speed A/D converters with 20 or more bits. By not being able to use 24-bit converters, the reception is severely limited by the noise floor of the analog to digital conversion process. In the worst case, the lack of dynamic range masks all the weak signals that today's contesters want.

Connect ability

The MDSR system can be set up to use two sound cards. One high end 24-bit card to do the IF demodulation and a lower 16-bit (onboard) sound card for decoding baseband digital systems such as WSPR, JT-65 and JT-9.

The MDSR setup is a free program. It also includes **fldigi** with its extensive choice of digital modes.

Programs included in the MDSR setup

- **MDSR:** provides the graphic user interface that controls the transceiver via the OmniRig CAT translator and the DSP engine for audio processing.
- **MDSR-SA:** provides a fast spectrum analyzer, the OmniRig setup utility and preset frequency banks.
- **PM Manager:** the Profile Manger is a backup utility that also stores profiles for different setups such as digital setup or analog setup. It can also be used to store profiles to control different transceivers. Once profile is established it can easily be recalled.
- **OmniRig:** translates the CAT protocols of over 100 different radio makes and models so that MDSR can remote control them.
- **fldigi:** developed by Dave (W1HKJ) for modulating and de-modulating a vast variety of digital base band audio modes.
- **VLC:** for recording and playing audio, and streaming audio during remote operations.
- **Dream V1.1:** DRM demodulator for digital DRM shortwave radio reception.
- **Java SA:**
    - Amplitude correcting real time spectrum analyzer: uses band noise to calibrate the filter response curve for a flat spectral display without filter flanks
    - Scanning RF-Seismograph for RX long term monitoring up to 6 bands; can be engaged to monitor passively while the user is not at the station

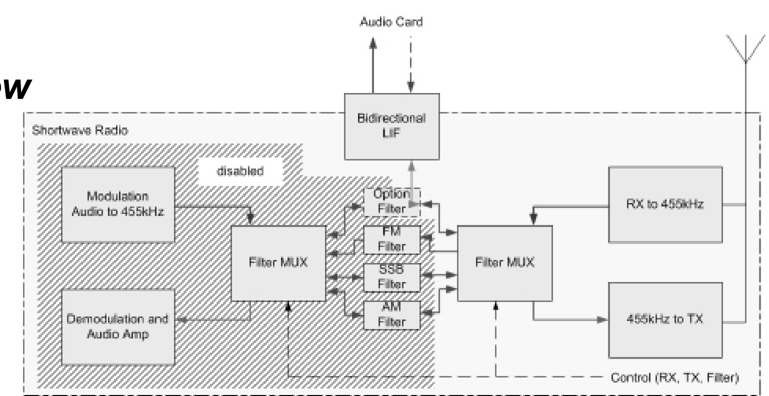
Documentation and User Help

The MDSR development is extremely well documented and accessible to everybody. All the documentation on our website is free and can be used for any amateur radio purpose. Each program has its own easy to follow PDF help file for reference.

For issues that can not be resolved by the user, MDSR has a Yahoo user group and online knowledge base that can be searched for answers.

LIF (BiLIF) and MDSR Overview

The LIF concept utilizes an existing transceiver and extends the option filter port via a converter so that its signal can be processed by a sound card.



By processing the IF and not base audio, the MDSR software can perform a lot of the functions which most transceivers lack. As a second connection, the CAT cable is required to allow control of all functions of the host transceiver via the MDSR software. Thus, MDSR so completely controls the transceiver that it can be out of reach while operating.

The most important tools for tuning in weak signals are a real-time spectrum analyzer and on-screen IF-DSP filters that eliminate even the most severe interference.

The MDSR offers both - and 2 notch filters in addition.

The MDSR software puts any analog RIG on “steroids” without changing the way the connected radio works. The modifications to the transceiver are minimally invasive - in most cases even reversible - allowing it to change from MDSR to stand-alone operation in minutes.

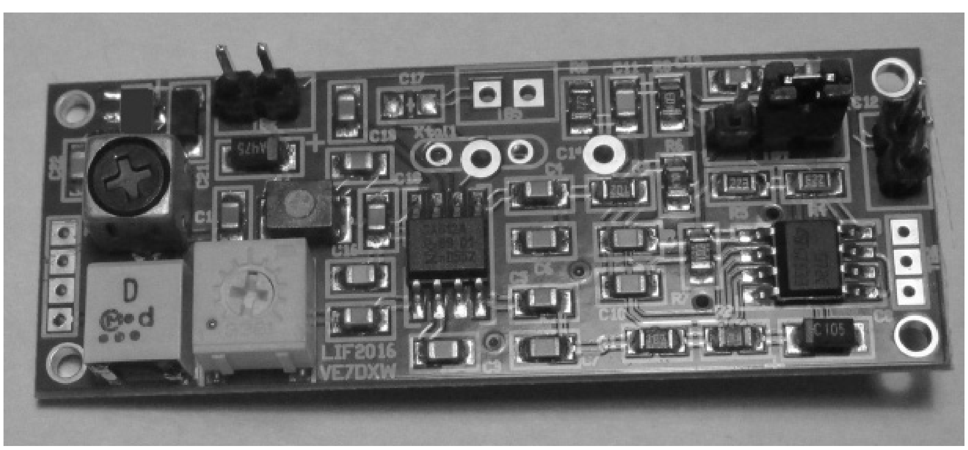
Accomplishments since the last publication (TAPR 34th.)

- Development and manufacture of the LIF2016 PCB
- Improvements on the spectral amplitude correcting spectrum analyzer, released updates as Java SA V1.2
- Added a single channel long-term noise level time graph: **RF-Seismograph**; released as Java SA V1.3
- Implemented a scanner to monitor long term noise levels on 6 different bands: **Scanning RF-Seismograph**; released as Java SA V1.4 on June 6, 2016

Previous videos and presentations can be found on-line at You-Tube and at the MDSR website. The Power Point presentation and the white papers at the MDSRadio Yahoo user group. Previously published white papers are also available in the TAPR archives.

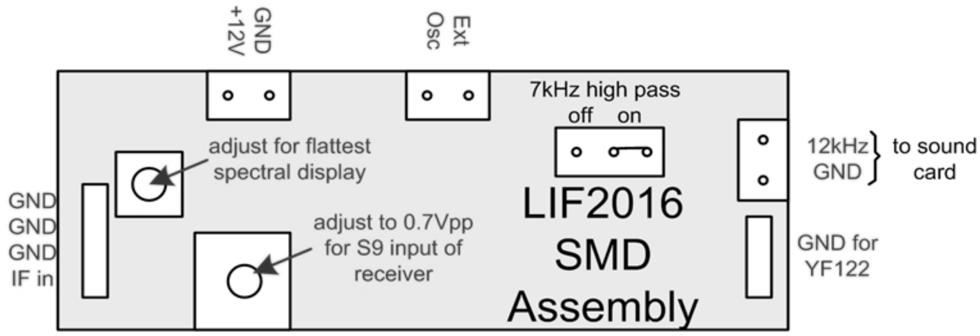
Development of the LIF2016 SMD PCB (RX only)

The development of the LIF-2016 PCB was the next step in making the MDSR development appeal to more amateur radio operators. It is mostly SMD and is assembled by robot. The design consists of two layers, and has over 95% ground plane coverage. Now the down-converter hardware is small enough to fit into most transceivers internally. It is actually pin-compatible with the YF-122 crystal filter that fits into the option filter space of many Yaesu transceivers. Modifying the radios for MDSR becomes now a very neat and fast endeavor. (shipped version not exactly as shown - LO crystal is on the other side)



LIF2016 Block Diagram and Pin Out

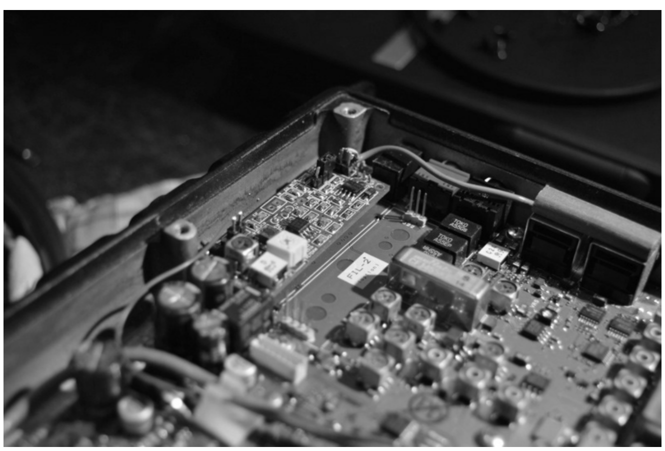
The schematics of the LIF have not changed, because it has proven, excellent performance. Its frequency stability and signal purity make receiving JT-65 and JT-9 signals a breeze.

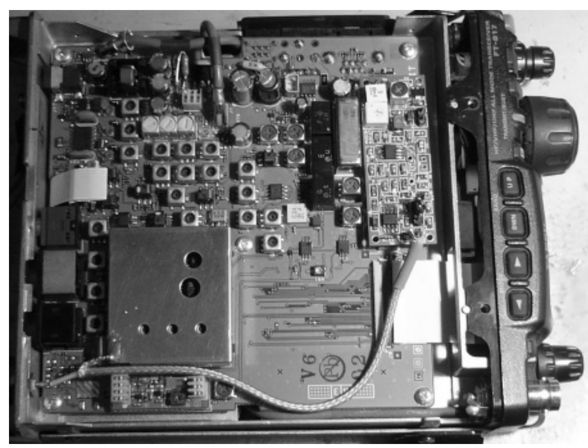


If the unit is placed in a transceiver with a YF-122 option filter, the pin header of the radio fits easily into the left and right PCB holes and slides down for a snug fit. For other receivers, the IF connection has to be made with a jumper. The +12V supply has to be picked off from a suitable spot inside the enclosure.

The LIF-2016 has all the components to allow for a LINE level input of a 16- or 24-bit soundcard. There is also an additional 7 kHz high-pass filter that can be selected. It is set "on" by default. Its purpose is to protect the soundcard from low frequency rumble that can overload the ADC circuit on the sound card.

LIF2016 installed into FT-897 and FT-817





8 transceivers are documented by the MDSR Team (available on the website)

- Installing a LIF port in the IC703.pdf
- Installing a LIF port in the IC7000.pdf
- Installing a LIF port the FT857 - 897.pdf
- Installing a LIF port in the FT817.pdf
- 12kHz port output Kenwood TS-2000.pdf
- Installing LIF port in a Yaesu FT-950.pdf
- Installing LIF port in a IC-756.pdf

Receivers / Scanners

- Installing LIF port in a BCD996P2.pdf
- Installing LIF port in a Panasonic RF4900/RF4800.pdf

Available in our Yahoo support group only

IC-7100, IC7200, IC-735, IC-746, IC-706, FT-736, TS-850 and many more

The LIF2016 makes the conversion of an analog radio very simple. All that is required is the installation of a LIF port as per instructions.

The additional CAT control cable is controlled by OmniRig. OmniRig translates each CAT control command so they can be read by over 100 different transceivers, scanners and receivers.

This makes MDSR very versatile and flexible as a as a computer controlled radio interface, with the additional benefits of digital signal processing via the LIF interface.

Your current radio can be upgraded to and SDR at a very low cost. The MDSR software is free and the cost of the LIF-2016 is only $50. The LIF and the BiLiF are also available on line.

The development of the RF-Seismograph

Why do we need the RF-Seismograph to monitor local propagation?

The origin of this idea has several starting points. I used to have a weather station which was connected to the Weather Underground. This is a brilliant concept which uses private weather stations linked via the internet to display the weather readings all over the world. This concept is efficient and very cost-effective. It shares the information and makes it accessible to everyone. Everyone benefits from it and it is free.

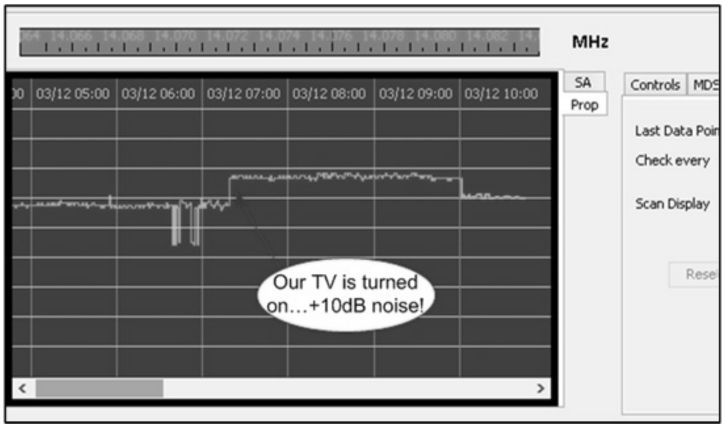
The solar flux graph which is shared over the internet is also a neat way to determine how good propagation will be. Unfortunately there is not a lot of variation throughout the world when we correct the intensity depending on radiation angle. It is a bit like taking the average temperature of the planet and then stating: "It is 4°C in Florida". As matter of fact, it is 4°C everywhere else too.

Another interesting model is the D-Region Absorption prediction. It takes the amount of the solar flux and the angle of radiation into account. It is a negative indicator that shows which areas and bands cannot be reached during high solar activity. This model makes the assumption that the D-Layer is uniform. It also neglects the fact that when solar radiation hits the D-Layer at a shallow angle (sunrise and sunset) the energy exchange into the D-Layer is stronger.

There are a large number of indices which can help to determine where an HF signal is supposed to go and end up and why it goes there. Most of them are based on solar activity. But where does the propagation come from in the absence of the sun, low solar flux or during a solar eclipse? What other phenomena can excite the D-Layer and provide impressive DX-coverage for shortwave bands?

There is always propagation but it changes and if someone says: "The conditions are terrible!" they should actually say, "The bands have shifted - I wonder which ones are open now?"

Eliminating local noise sources

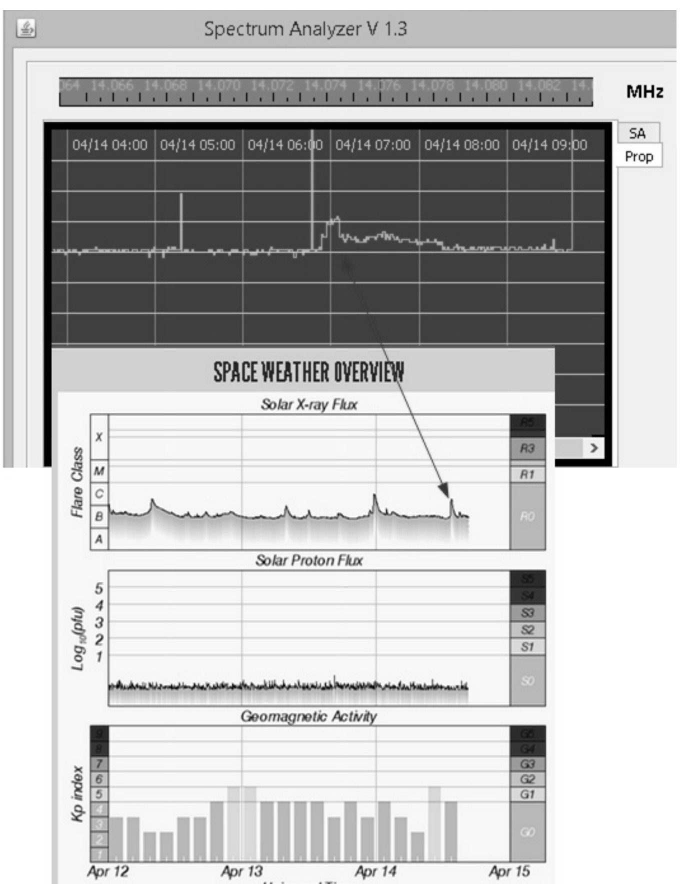


Measuring noise in the environment that surrounds the station is the first task of setting up an RF Propagation monitor. One of the biggest contributors of RF noise is the flat-screen TV. By monitoring the time noise occurs and vanishes one can pinpoint the location of offending units.

The remedy is an AC RF-line filter and choke cores on the antenna input. The graph to the left shows the interference caused by a TV and the noise reduction after applying filters.

Another noise source can be fluorescent lighting and electric motors. Electric motors can be cleaned up by putting an RF line filter in series with the AC power cord. One can replace noisy fluorescent lights with RF-quiet, efficient LED's.
There are many man-made noise sources that are very hard to get rid of. By doing this initial work, one can improve DX reception dramatically. Lowering the noise floor is the best antenna upgrade, because noise hides all the weak signals.

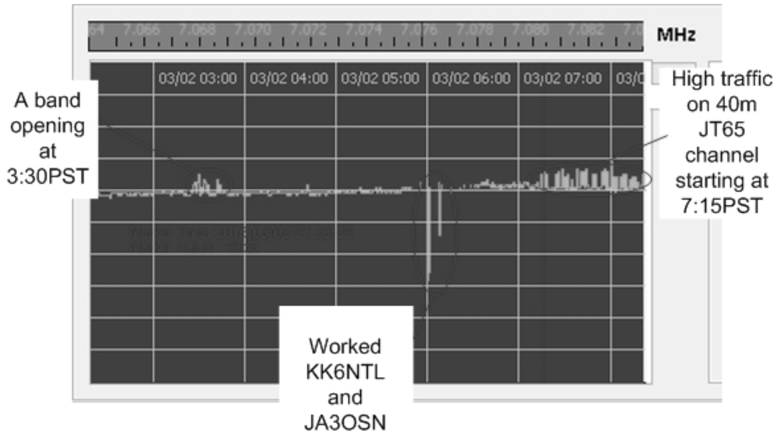
The single-channel RF-Seismograph confirms the standard model



X-Ray Solar Flux hits the ionosphere and causes vibrations in the D-Layer. These changes can be measured and monitored with the single channel RF-Seismograph. In matter of fact the Solar Flux graph on the NOAA website even corroborates the measurement and the time.

But here the similarities end. Where as the solar flux indicates a sharp spike, the local measurement is quite different. Because the local time is 7AM on April 14th, the sun is very low in the sky. The radiation hits the D-Layer at a very shallow angle. This lengthens the path and the time the radiation energy has to excite the local D-Layer. More energy is transferred into the ionosphere. In the graph at 6:50AM the noise level goes up, spikes and after 20 min it drops to a level still higher than the noise level before. It stays there for about an hour, drops abruptly again just above the regular noise level and then sits there for another hour. Another short spike and then the noise level returns to normal.

Follow the Gray line



A good strategy for finding propagation is following the gray line between day and night. It means to operate DX during the morning and the early evening hours. This works especially well on 40 and 20m; making worldwide contacts is not unusual.

The picture on the left shows exactly that behavior. At about 4:30AM local time the band starts to open and stations from the Far East and Australia are starting to come in. At 6:30AM the JT-65 frequency is packed with DX stations. At 7:15AM the rest of the continent wakes up and the frequency is jammed with North American stations.

The opening at 3:30AM is also interesting; is it a sleepless local Ham?

What happens to propagation when the Sun "flatlines"?

This solar cycle has been very unusual. Even before the peak in 2014/15 we saw a long period of very low solar flux. When the sun finally took off, it only lasted for about 1 year and now it has basically flat-lined again! These are frustrating times for a Ham operator, or are they? If X-Ray flux is the only contributor to propagation, right now, the bands should be dead. But they are not, so what is happening?

Bands still open up but at different times and in unexpected ways. We have to relearn how propagation redistributes RF energy, and change our operating times and methods.

In order to do this we need a receiver that monitors the local RF conditions 24/7, like a weather station that monitors air pressure and temperature, or a seismograph that records RF signals instead of tremors. It needs to do this over a very long time (≥ 6h), and it must scan all frequencies of interest. This is where the "Scanning RF-Seismograph" comes in.

Changing old habits

To be more successful in finding RF propagation, our operating procedures and setup have to change. The antenna system needs to be hardened against lighting and static discharges, and the operator has to be comfortable leaving the station running and connected to the antenna at all times, even when he is not present.

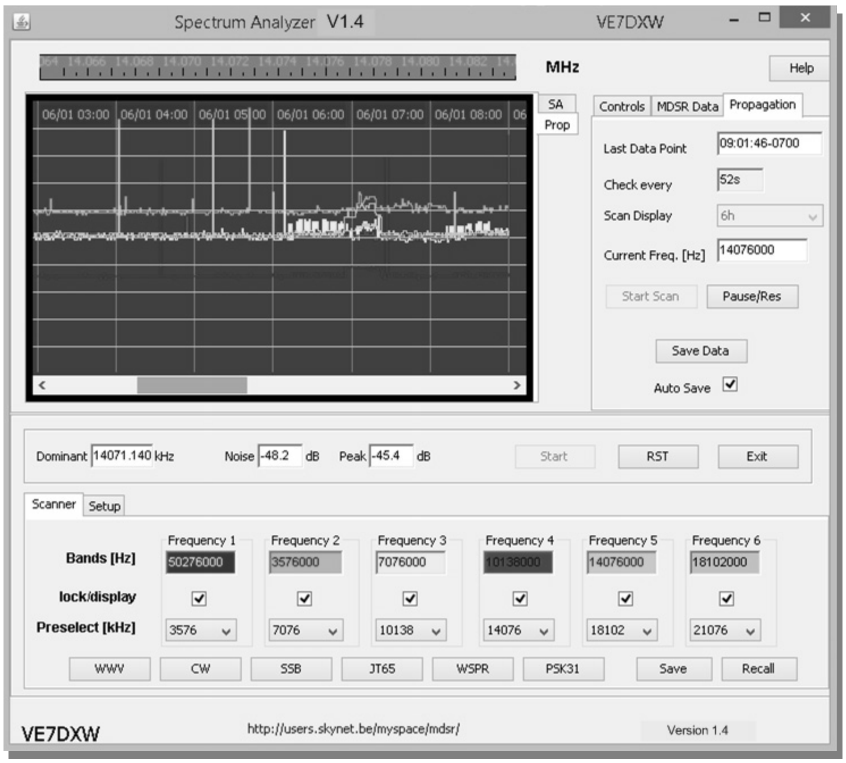
It is too late to turn on a seismograph after the earthquake, and since we cannot predict the time when an event will occur, it has to be on at all times.

The Scanning RF-Seismograph - Spectrum Analyzer V1.4

Why use a Scanning RF-Seismograph?

Noise sources do not create noise that is evenly distributed through the radio spectrum. Neither do radio operators stick to only one frequency or band. With the 6-channel scanner and RF level recorder it is possible to record six different frequencies of interest. This is almost like having 6 radios receiving at one time. It will do that even while the operator is busy with other chores.

Java Spectrum Analyzer and Scanning RF-Seismograph V1.4



The scanning RF-Seismograph is the latest release in the development program of the MDSR group.

The computer interface separates the scanner setup from the display. All the functionality of the amplitude-correcting spectrum analyzer is still there, but hidden in this window display. For more details on how to set this program up and how to install it on the computer, go to the MDSR website. Also consult the included PDF Help document.

You may also join the MDSRadio Yahoo user group and post a message.

Using the "Scanning RF-Seismograph" or "How to find Propagation"

The setup of the is very simple, because it offers easy to use presets for the frequencies most Hams should or want to monitor. Especially if the operator is using digital modes or merely wishes to observe WWV. Once the frequencies are set, pressing "Start Scan" launches the scanner and the recorder. The scanner is designed to run indefinitely, but also has a "Pause/Res" button so that the scan can be stopped if the operator decides to use the transceiver for TX/RX operations.

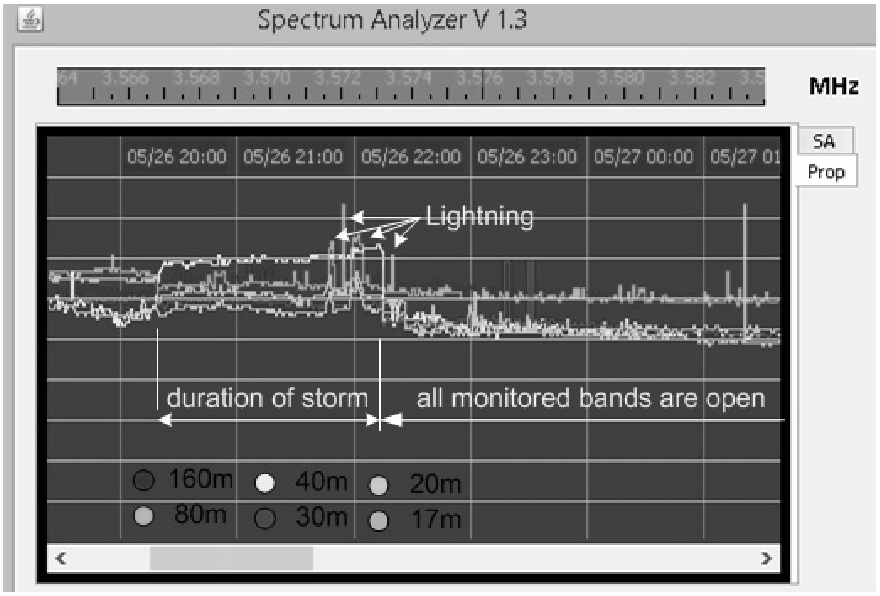
Interesting finds during the operation of the "Scanning RF-Seismograph"

All the events recorded for this paper were recorded during the standard operation of the station. Any antenna can be used to monitor RF conditions. The MDSR uses a *Hy-Gain* 18HTjr omni-directional multiband antenna.

Warning: Leaving the station connected during a thunderstorm without proper lightning protection can be hazardous to your life and property. It is not safe to operate any equipment connected to an aerial while a thunderstorm is within 10 miles (16 km)!

Measuring the effects of a passing Thunderstorm

Early in the evening of May 26 the Greater Vancouver area was treated to a rare thunderstorm. Vancouver gets about 2 or 3 thunderstorms a year. The MDSR team got lucky and the RF-Seismograph was running automatically while nobody was there to operate the station.



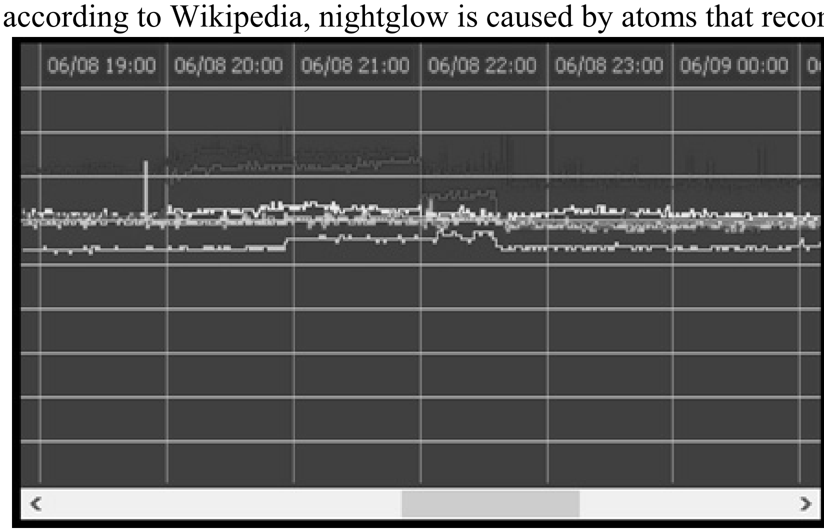
The buildup of energy in the troposphere was visible at least 2 hours before the storm hit (left of the "duration of the storm" marker). During the 2h storm the noise level of the 40m band jumped way up. In this particular storm the lightning passed last, mostly seen in the green spikes (80m). Just after 22:00 a big lightning strike makes even the 17m band jump. At 22:15 the noise of the 40m band drops almost immediately even though the storm was only a few miles away. And then something happened that was rather unexpected; stations from all over the world were heard on all the monitored bands!

<u>Can Thunderstorm affect the D-Layer?</u>

There are several explanations on how this is possible. My favorite theory is that the sprite discharge on top of the storm causes the ionosphere to ionize.

10m Propagation caused by "Nightglow"

Nightglow (airglow) is a phenomenon that causes a green glow in a dark cloudless sky. It looks similar to soft green aurora borealis, but is more uniform and lacks the streaming nature of auroras. Also, according to Wikipedia, nightglow is caused by atoms that recombine after being photo-ionized by UV radiation from the sun during the day. Nightglow is mostly visible during the summer months around the solstice.

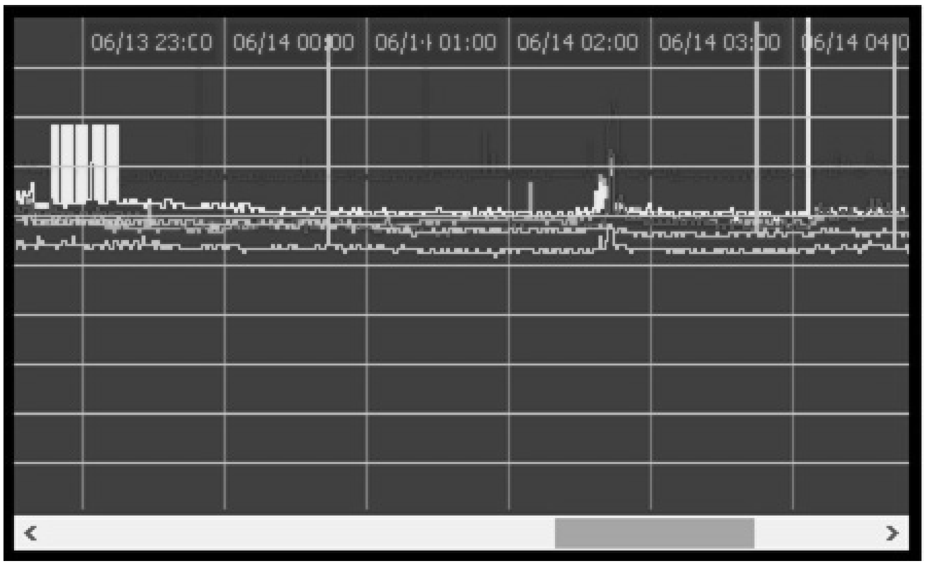


The pink (bottom graph) represents the 10m noise level; just before 21:00 the band noise increases slightly. After 22:00 the band opens to allow for 30 minutes of band activity. Also interesting is the effect on the noise level on 80m (red-top) and 20m (purple - 2nd from top). During the time of the 10m opening there were reports of strong nightglow sightings in Texas. The solar flux reading for this particular day was 92 and the geomagnetic activity very low.

We also have run the RF-Seismograph on 6m but due to the lack of a good antenna we have abandoned the attempt. With the right antenna though, the RF-Seismograph would be ideal to monitor the 6m band.

Propagation caused by Meteor Scatter

Most Meteors are usual very small, and their ion trails get lost in all the other events during the day. At night time, when the bands are quiet a meteorite trail can cause quite some propagation.

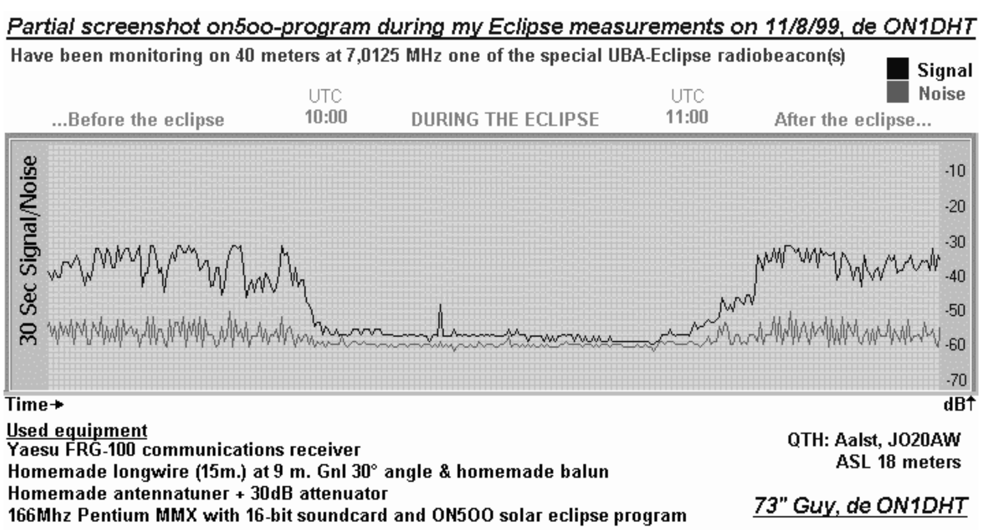


This particular event happened at 2:40AM local time. It starts out by increasing propagation on 40 and 30m. As the propagation drops after about 5 minutes, the noise level of the remaining bands also spikes for another 5 minutes.

Now that we know what a meteorite looks like on the RF-Seismograph we will spot more, even during the day.

Monitoring a Solar Eclipse (Aug. 21. 2017)

This story begins in Belgium on Aug 11. 1999 when Guy Roels (ON1DHT at that time) was watching and recording the total solar eclipse on his computer using a audio card and a converter on his FRG-100 receiver, very similar to the one we are using today.



The big difference today is that we can use the LIF-2016 and a universal CAT interface to connect the receiver to the computer. The MDSR software, together with the Scanning RF-Seismograph, can monitor the changes on 6 different bands. The data can be saved in a data format that is compatible with Excel. The implementation of a file upload utility will make it easy to share the collected data with scientific organizations such as NASA, NOAA and DRAO.

Coverage of the total Solar Eclipse in North America Aug 21, 2017

The totality map of the event shows an epicenter line that goes across North America. In southern Alberta and BC the coverage of the sun will still be over 90%.

The event will start at the east coast of America at 17:00UTC (1PM local time) and then work it way across the continent in a north western direction. It will exit the US on the West coast of Oregon north of Newport at around 20:00UTC (12AM local time). The total time of the eclipse from start to finish is about 2h30m. Adding the time it takes the sun to pass North America the time of the total event could be more than 6h for RF propagation effects.

Monitoring the Solar Eclipse with the "Scanning RF-Seismograph"

The current version of the software is fully capable of monitoring such an event and to record it. There will be additional functionality in the version planned for this event.

The bands being monitored will have to be synchronized with all the users; in addition local information such as the grid square and the call sign will have to be entered.

If there are new scientific discoveries, the person(s) who submits the data of the event will be credited with the discovery.

Summary

The development of the RF-Seismograph and then the scanning RF-Seismograph was a very worthwhile undertaking. It gives us the opportunity to share propagation reports among many uses and makes use of the transceivers that sit idle in an unoccupied shack.

We were already developing the RF-Seismograph when we found out that there will be a solar eclipse in a year from now in North America. At this time Guy also sent us the link and described what he and the amateurs in Europe (Belgium) were doing in 1999.

During the development we were able to observe and confirm the standard model of propagation and the role the sun plays in it. But we were also able to extend the propagation model by showing how different phenomena can create workable propagation even when the solar flux is low.

With the outreach program and our Yahoo user group we like to invite all amateurs to participate in the "Solar Eclipse 2017" experiment and then to forward the recorded data to solar scientists.

Acknowledgement:

Guy Roels (ON6MU); for the continued support of the MDSR-SA, maintenance of the website and the creation of MDSR setup files.

Special thanks go to Phil Burk for providing the Jsyn FFT sound interface free of charge for this project.

We also want to thank Alex Shovkoplyas (VE3NEA) for the use of the OmniRig CAT interface.

Adam Farson (VA7OJ) for the continued support of his test lab and of a sounding-board for ideas.

Dr. Ken Tapping (currently working for DRAO). He is responsible for the solar flux monitor station in Penticton, BC.

NOAA for their great website and the solar monitoring tools.

Wikipedia for being such a great repository of information and easy explanations of even the most abstruse subjects.