The INSPIRE Journal

Volume 16 December 2007

The INSPIRE Journal's New Editor

The new editor of *The INSPIRE Journal* is Kathleen Franzen, the president of The INSPIRE Project, Inc. The plan at this time is for the *Journal* to continue as in the past. Check the INSPIRE web site (http://image.gsfc.nasa.gov/poetry/inspire/) for all INSPIRE news including the latest edition of the *Journal.*

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Volume 16 December 2007

The INSPIRE Journal is a publication of The INSPIRE Project, Inc., a nonprofit educational/scientific corporation of the State of California. The purpose of the INSPIRE Project, Inc., is to promote and support the involvement of students in space science research. All officers and directors of the corporation serve as volunteers with no financial compensation. The INSPIRE Project, Inc., has received both federal and state tax-exempt status (FEIN 95-4418628). The *Journal* is published once per year in December.
Submission deadline: December 1

Contributions to the *Journal* may be sent to:

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Washington, DC 20003

email: kathleen@womanfriday.com

INSPIRE Co-Founder, Treasurer, *Journal* Editor, Kit Distributor Retires

In June 2005, my wife and I retired from our jobs: she as a school nurse in Rancho Cucamonga, CA, and I as physics teacher at Chaffey High School in Ontario, CA. Since that time we have made four car trips across the country. Last summer we drove to Central New York and spent six months at our newly purchased (but not new!) lake cottage on Cayuga Lake, one of the Finger Lakes. Our plan is now to spend from May to November in New York and from November to May at our home in California.

During these busy times it has proven to be increasingly difficult to meet my responsibilities to INSPIRE – especially while on the road. Last summer I reached the difficult decision to step down from my involvement with INSPIRE. It has been a wonderful 19 years. I have made many friends at NASA, at Goddard Space Flight Center, in Washington, DC, and across the country. Many people I have considered friends for years I have never even met - except via email! The loyal readers and contributors to the *Journal* are very special to me.

I consider it a compliment that it will take three people to handle my INSPIRE responsibilities! They are all good people, serving as volunteers and excited about the future of INSPIRE. It is clear to me that INSPIRE is strong and will continue to prosper. The legacy of my friend, Bill Taylor, is in good hands.

I will still remain involved, but mostly from the sidelines. I wish you all a fond farewell.

billpine@roadrunner.com

The INSPIRE Journal Online

This issue of *The INSPIRE Journal* will appear online as soon as possible. Click on "The INSPIRE Journal" button to find the latest online version and an archive of all previous *Journals*.

An important feature of the online version of the *Journal* is the inclusion of sound files for each data session and for any additional analysis that is done. All photos will also appear in color online.

Subscriptions to the paper version of the *Journal* are no longer being sold. The online version ix the only one available. A big advantage is that it is free!

Write for *The INSPIRE Journal*

The procedure for contributing articles for *The INSPIRE Journal* could not be simpler! Just send it in! Any format is acceptable. Electronic format is easier to work with. A Word file on disk for either the PC or Mac platform is preferred. An email message will work, too. If that does not work for you, a paper copy will do. Any diagrams or figures can be scanned in.

What about topics? Anything that interests you will probably interest most INSPIRE participants. As long as the topic is related to natural radio or the equipment used, it will get printed. The deadline for submissions is December 1. Don't worry about the deadlines though. If you miss a deadline, you will just be very early for the next edition!

We at INSPIRE are looking forward to hearing from you!

INITIAL ASSESSMENT OF THE L600S ELF/VLF H-FIELD RECEIVER

Robert Bennett, Las Cruces, NM

BACKGROUND

For several years I have attempted to acquire an H-Field (e.g. magnetic loop) receiver for use as a companion to my INSPIRE E-Field receivers. I made several attempts to build one by modifying older E-Field receivers. However, my attempts were never fully successful. In early 2007 I did a careful search of the INTERNET to determine what was available in commercial H-Field receivers. I found many receivers but only a few were within my price range and covered the VLF/ELF bands. After reviewing the specifications and prices I decided to buy a mid-priced unit that looked like it would make a good Whistler receiver. I chose the L600S ELF/VLF receiver system made by LF Engineering Co.[1]

RECEIVER DESCRIPTION

The L600S is a complete ELF/VLF receiving system consisting of a loop antenna and a receiver. The loop antenna consists of a coil of number 26 wire mounted on a 2-foot square PVC frame. The loop has about 100 turns. The Receiver electronics are housed in a small box that also holds the 9-Volt battery. The major specifications for the system are:

LOOP

Size:	24 Inches Square (Includes an attached shielded 10-foot cable)
DC Resistance:	50 Ohms Unbalanced
Inductance:	28 mH
Sensitivity:	0.23 uV √Hz

RECEIVER

Frequency Response:	300 Hz to 30 kHz -3dB points are 1.5 kHz and 30 kHz Broadband and High Pass modes (specified when ordering) Response at 60 HZ down 35 DB
Audio Output:	300 mW into earphones
Recorder output:	Provided
Power:	Internal 9V DC battery

[1] LF Engineering Company, 17 Jeffery Road 'East Haven, MA 06513
860-526-4759 'WWW.LFENGINEERING.COM

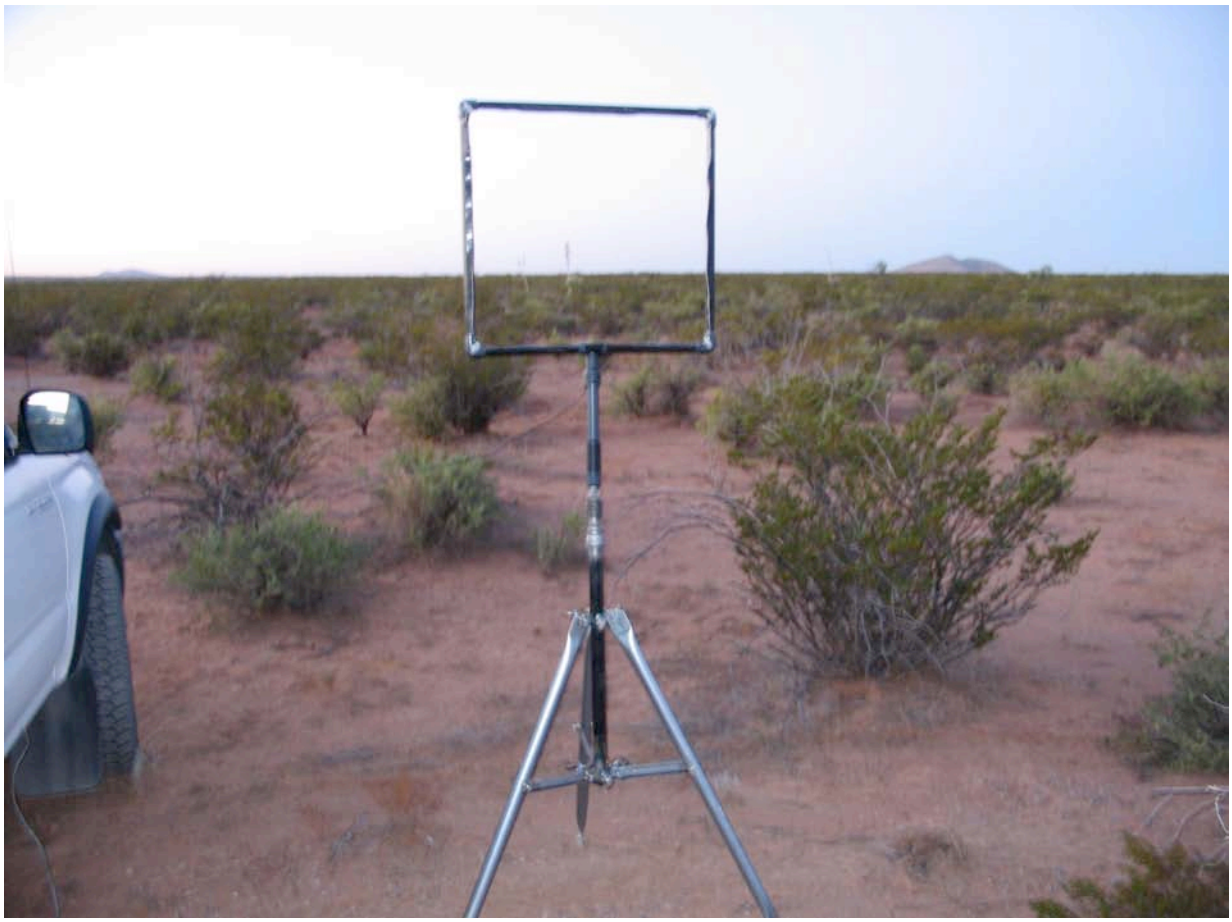


Figure-1. The L600 Loop Antenna shown is mounted on a homemade tripod. This photo also shows the terrain around one of the monitoring sites I used.

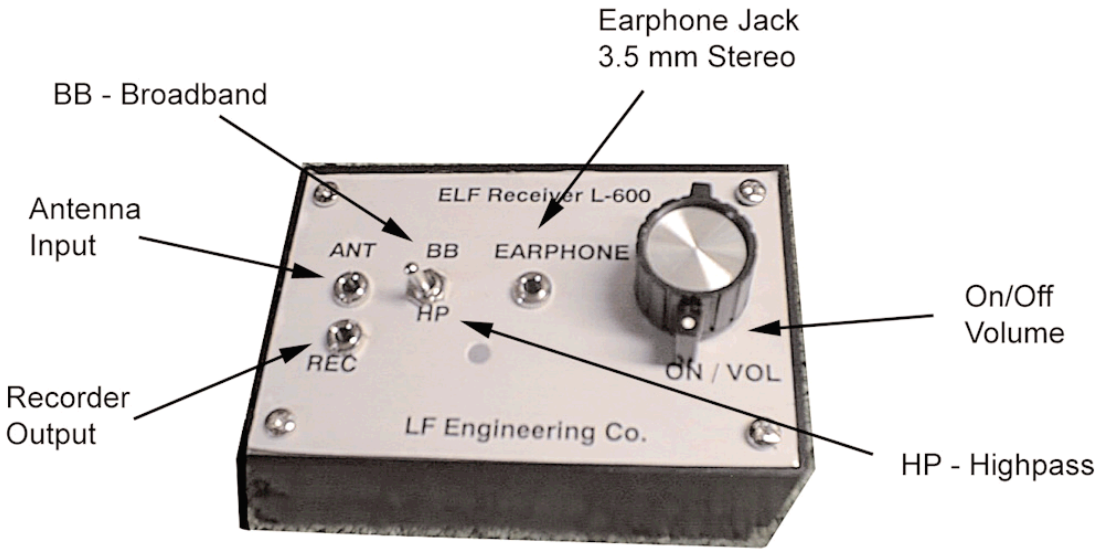


Figure-2. The L600 receiver.

THE RECEIVER ELECTRONICS

The schematic for the receiver is available on the LF Engineering WEB Site. Functionally, the receiver consists of a loop antenna connection followed by a switch selectable coupling capacitor. The switch allows either broadband operation or high pass operation. The high pass position is useful for attenuating power line harmonics. The purchaser can specify the desired broadband and high pass bandwidths when the receiver is ordered. I selected the stock values (300 Hz to 30 kHz for broadband and 1.5 kHz to 30 kHz for high pass).

The first active circuit is an active filter and impedance matching circuit using the LF356 IC. This is followed by two internal adjustments to set the levels for the audio amp which follows and the output to the recorder. The last stage is an audio amp using the LF386 IC.

EVALUATION TECHNIQUE

I decided that the best way to assess the utility of the L600 was to perform field experiments and compare the L600 performance with the INSPIRE VLF-3 receiver. Due to time constraints, I was not able to journey far from home and had to conduct my tests at less than desirable locations.

I chose two areas for the field tests. **Site One** was at the center of a large expanse of undeveloped desert within the city limits of Las Cruces. The area is roughly rectangular, about 3-miles in the east-west direction and about 5-miles in the north-south direction. There are no buildings in the area. Unfortunately several power lines cross the area, including a 375 kV transmission line and two 200 kV transmission lines. **Site Two** is north of my home in a remote location along the historic trail "El Camino Real de Tierra Adentro" ("The Royal Road of the Interior").

I made measurements at each site three times in the early morning hours (0500 to 0700 MDT) and once in the early evening hours (2000 to 2100 MDT). I conducted the test as follows:

a. I set up two complete receiving stations. The first used the VLF-3 with a 6-foot vertical whip antenna and the receiver output was fed into a stereo recorder. Natural radio signals were recorded on one channel and WWV timing markers along with voice notes were placed on the other track. The second receiver was the L600 using its loop antenna. I placed the loop as far from the receiver as the built in lead would allow. I conducted all monitoring from the cab of my truck. The setup I used is shown in Figure-3.
b. I recorded 15 minutes of VLF-3 output on a new tape then recorded 15 minutes of L600 output. The recorder was a Marantz model CP430 professional stereo portable.
c. To determine if the recorder had an impact on receiver performance, I repeated the experiment using a SONY TCD-D8 DAT recorder.
d. When I returned home I transferred the recordings to audio files (WAV format) using the computer sound card. I saved a 2-minute segment from the beginning and end of each session for detail analysis.
e. I analyzed the 2-minute segments using both the SPECTRAGRAM[2] and Spectra Plus[3] programs.

[2] Visualization Software LLC
[3] Pioneer Hill Software

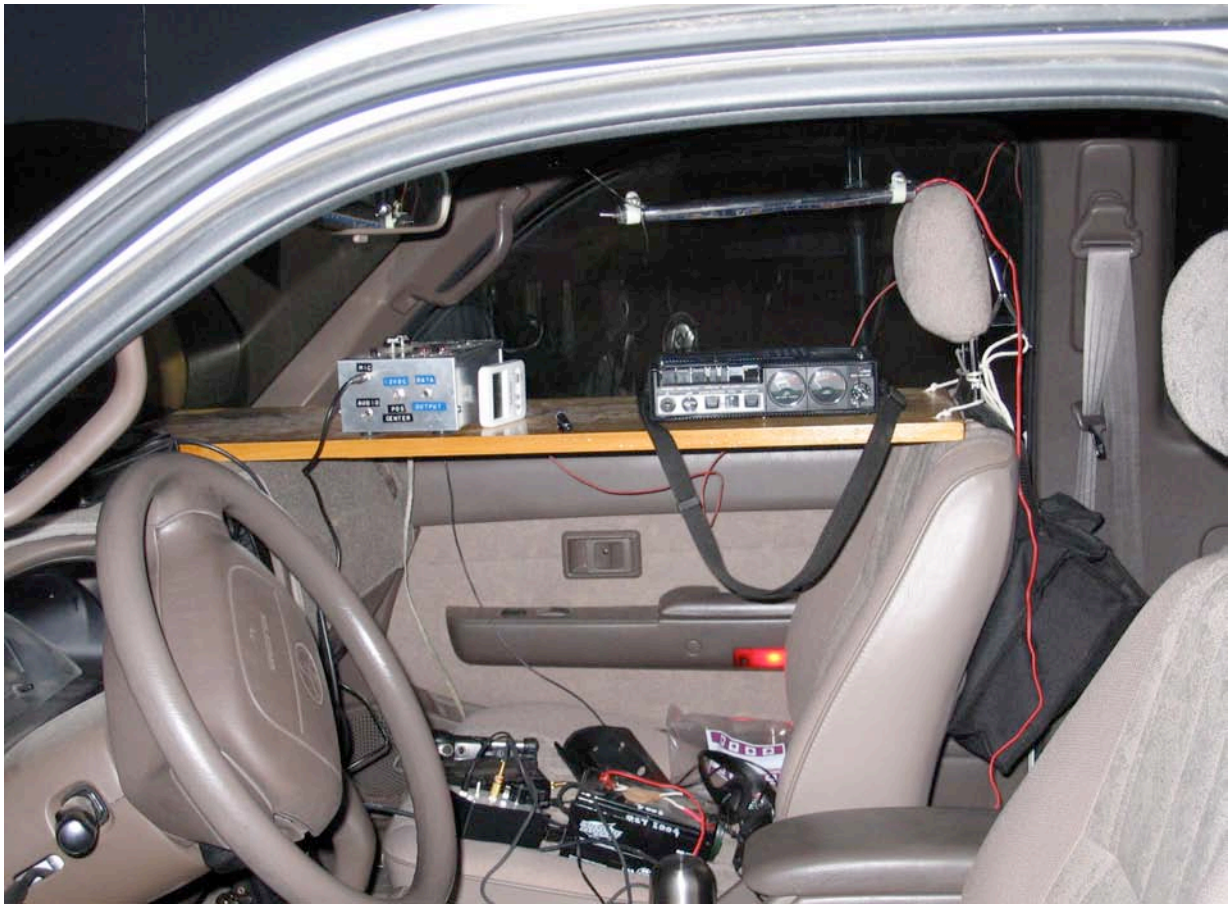


Figure-3. The figure shows my monitoring setup. The Marantz recorder and VLF-3 receiver are mounted on the board that is wedged between the seat and the windshield. The L600 receiver and Sony DAT recorder are visible on the seat. The cylindrical object above the seat's headrest is an LED light.

RESULTS

The results of the field measurements are shown in the spectrum plots that follow. The images are computer screen dumps. The first five were produced by SpectraPlus and show receiver response comparisons for the VLF-3 and L600S. The reader is cautioned that the results are specific to the area, the date and time the measurements were made. These results are believed to be typical; however, measurements made at different times and places might be significantly different.

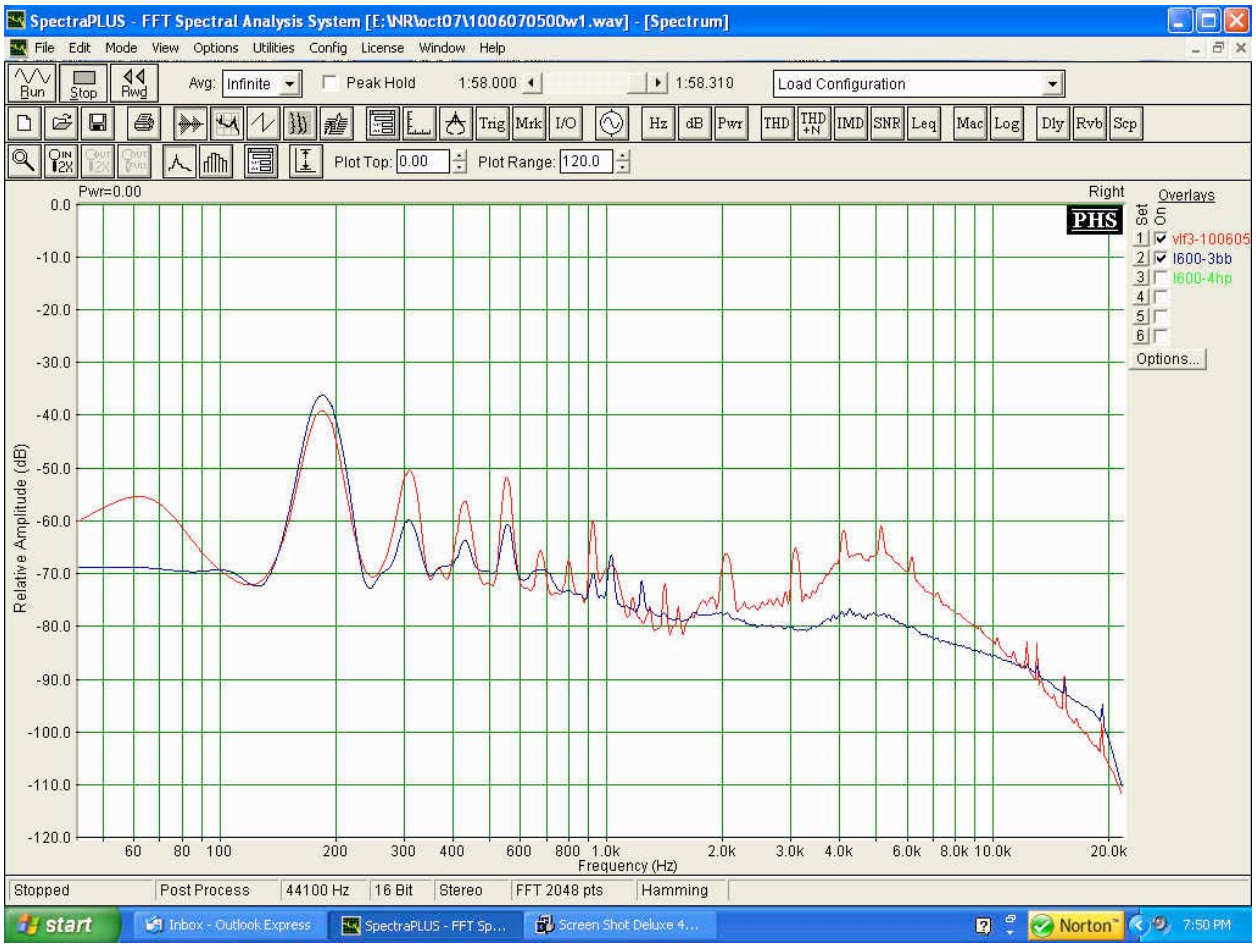


Figure-4. This Spectra Plus screen dump shows the response of the VLF-3 receiver (upper red trace) versus the L600S (blue). The data was captured using the Marantz recorder at **Site One**. The data was recorded at 0600 MDT. **Site One** has severe 60-cycle and Loran interference problems.

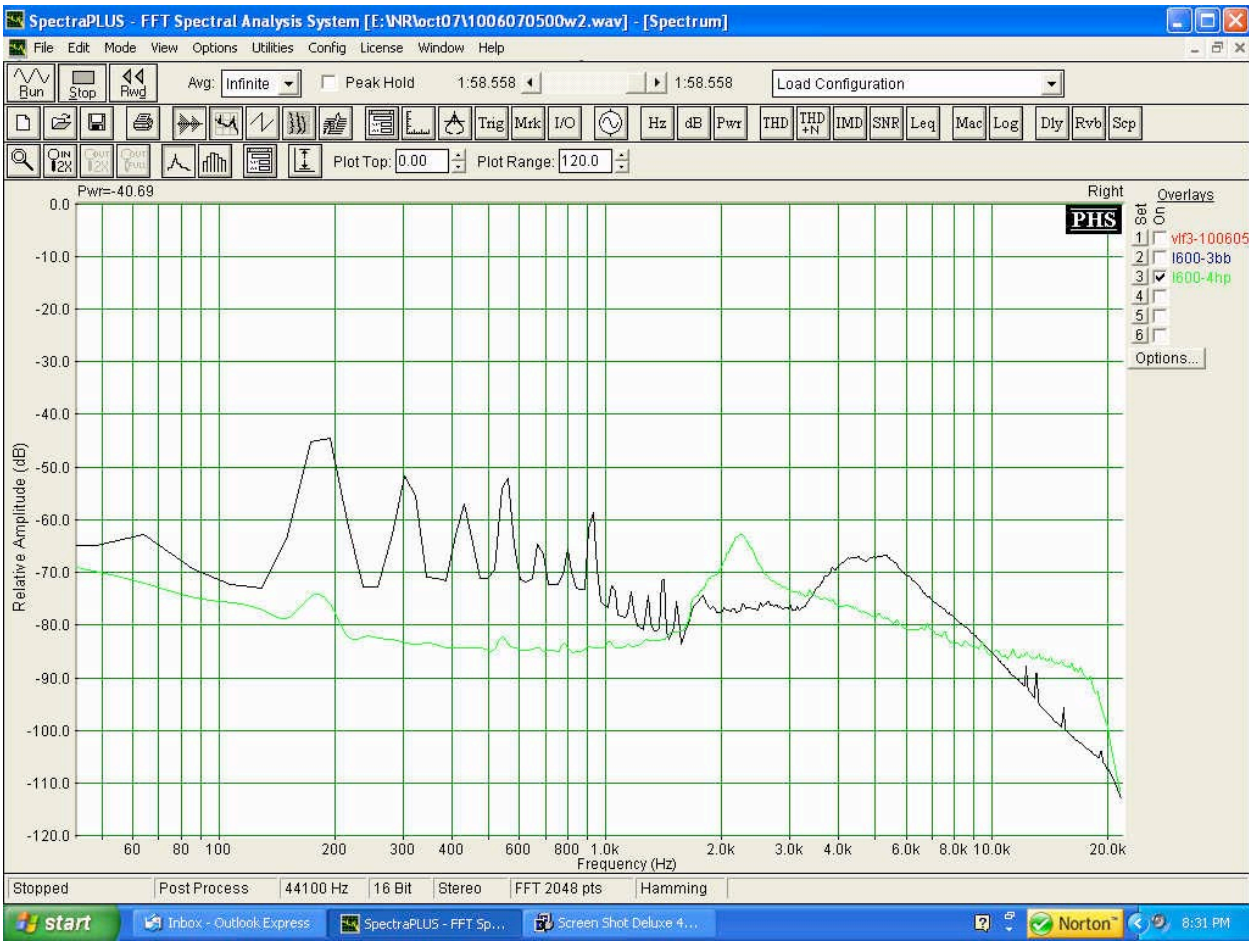


Figure-5. Spectra Plus comparison of the VLF-3 and L600S in noisy area **one** at 0630 MDT. The upper (black) trace is for the VLF-3 while the lower (green) trace is for the L600S. The VLF-3 was operated with the LORAN filter engaged (note the absence of Loran spikes at multiples of 1 kHz). The L600S was operated in the high pass (HP) mode. Note that the L600 filter effectively removed most 60 Hz harmonics while the VLF-3 is still receiving all the harmonics. Both the VLF-3 and the L600S were operated in the broadband mode. The above figure shows that both receivers experienced similar significant 60 Hz interference as can be seen by the many 60 Hz harmonic spikes on the spectra plot between the frequencies of 60 Hz and 1.5 kHz. However, the L600S performed significantly better in the presence of LORAN. The upper trace in the figure shows LORAN interference between the frequencies of 2 and 6 kHz. The lower trace shows that the L600S did not respond to the Loran Signal.

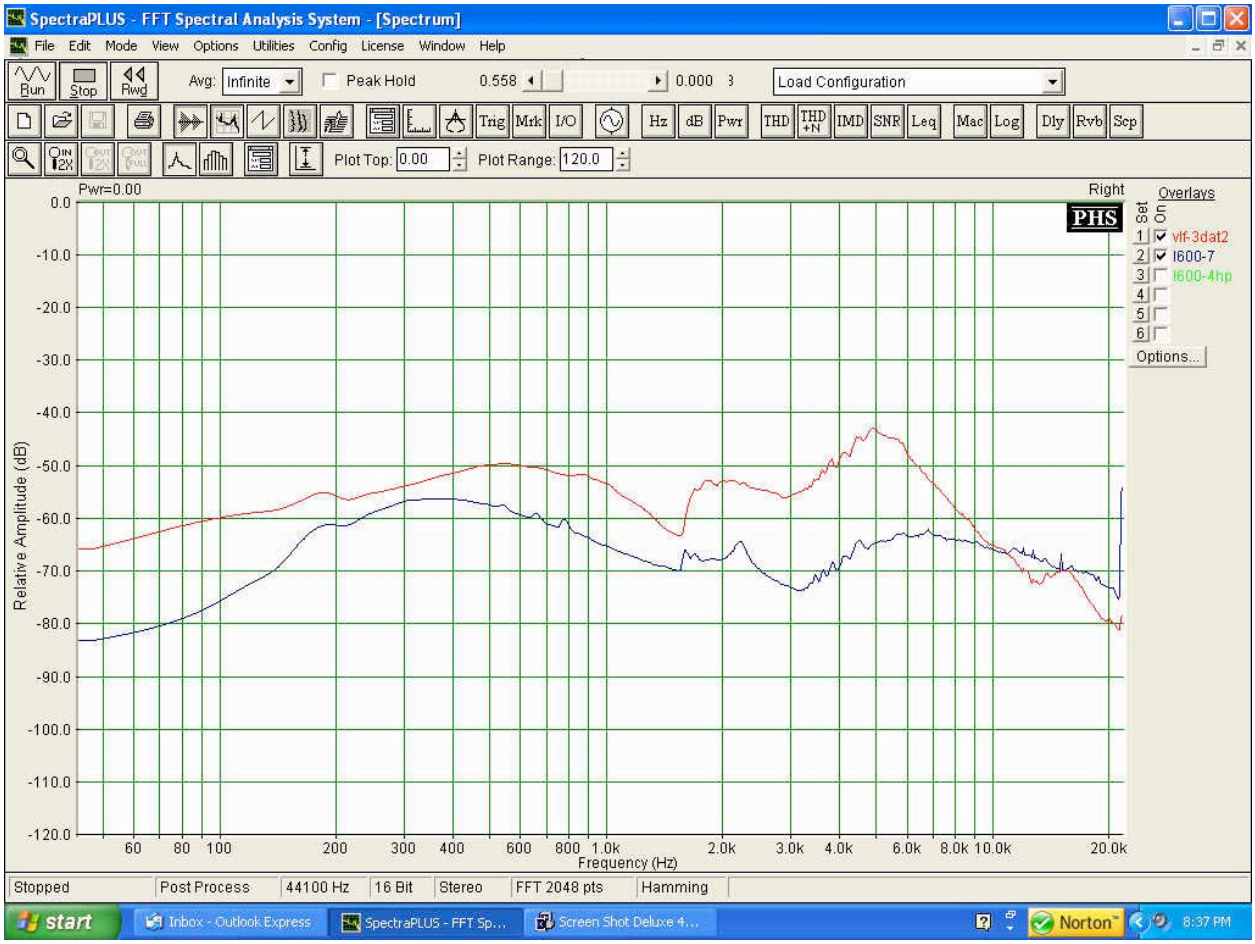


Figure-6. This figure presents data taken at the remote site number two about 5 miles from the nearest power line. The data was recorded at 0600 MDT. The top trace (red) is for the VLF-3 while the lower (blue) trace is for the L600S. Both receivers were operated in the broadband mode. Both receivers have similar frequency response characteristics except that the VLF-3 was designed to attenuate frequencies above about 8 kHz while the L600S frequency response continues to well above 20 kHz. The VLF-3 has one more stage of amplification than the L600S. This results in the VLF-3 being more sensitive than the L600 across much of the band.

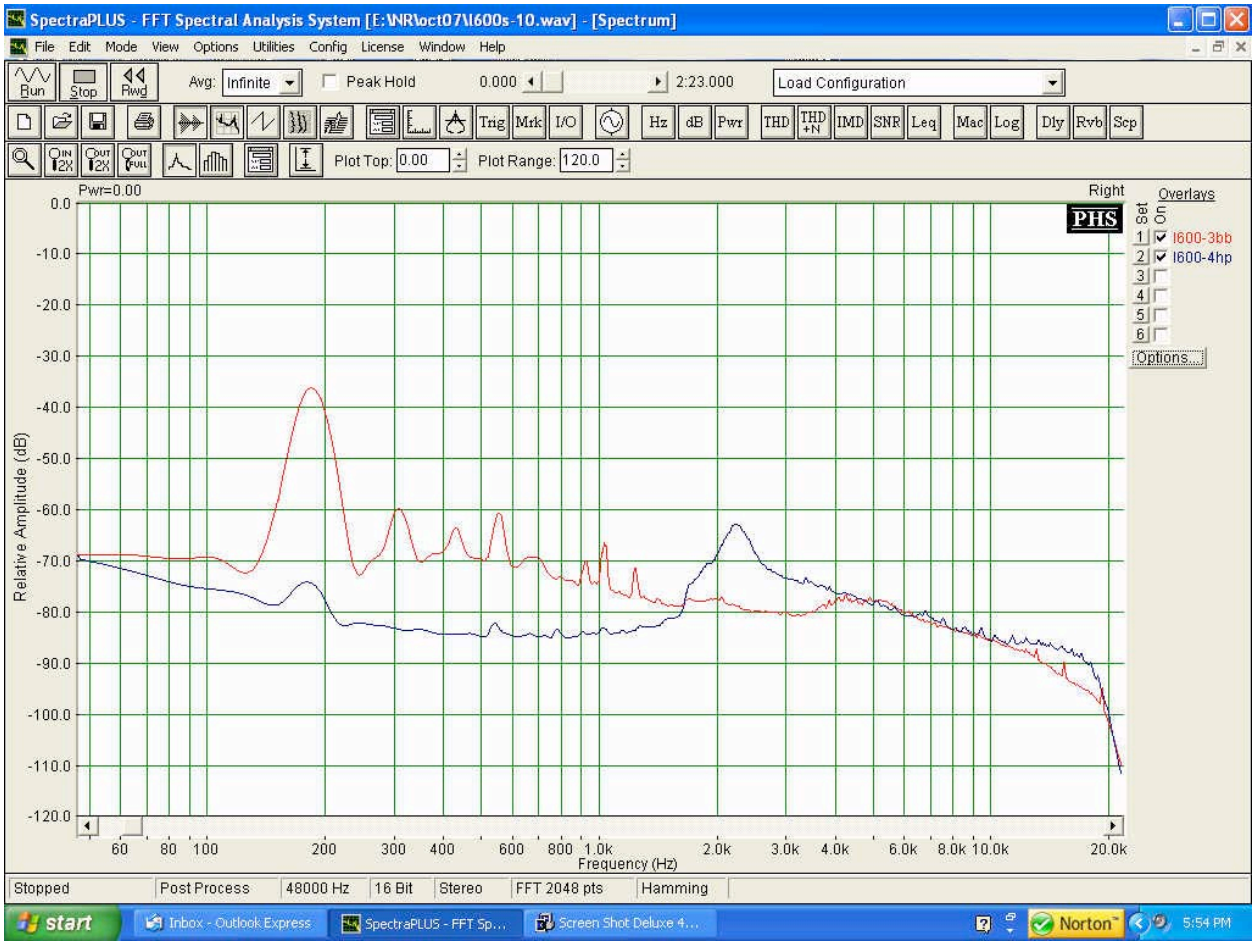


Figure-7. This chart shows the response of the L600S for the broadband mode (upper red trace) and the high pass mode (lower blue trace). The data was recorded at **Site One** at about 2000 MDT using a Sony DAT recorder. The upper trace clearly shows the 60 Hz interference. The interference is greatly reduced in the second trace (high pass mode).

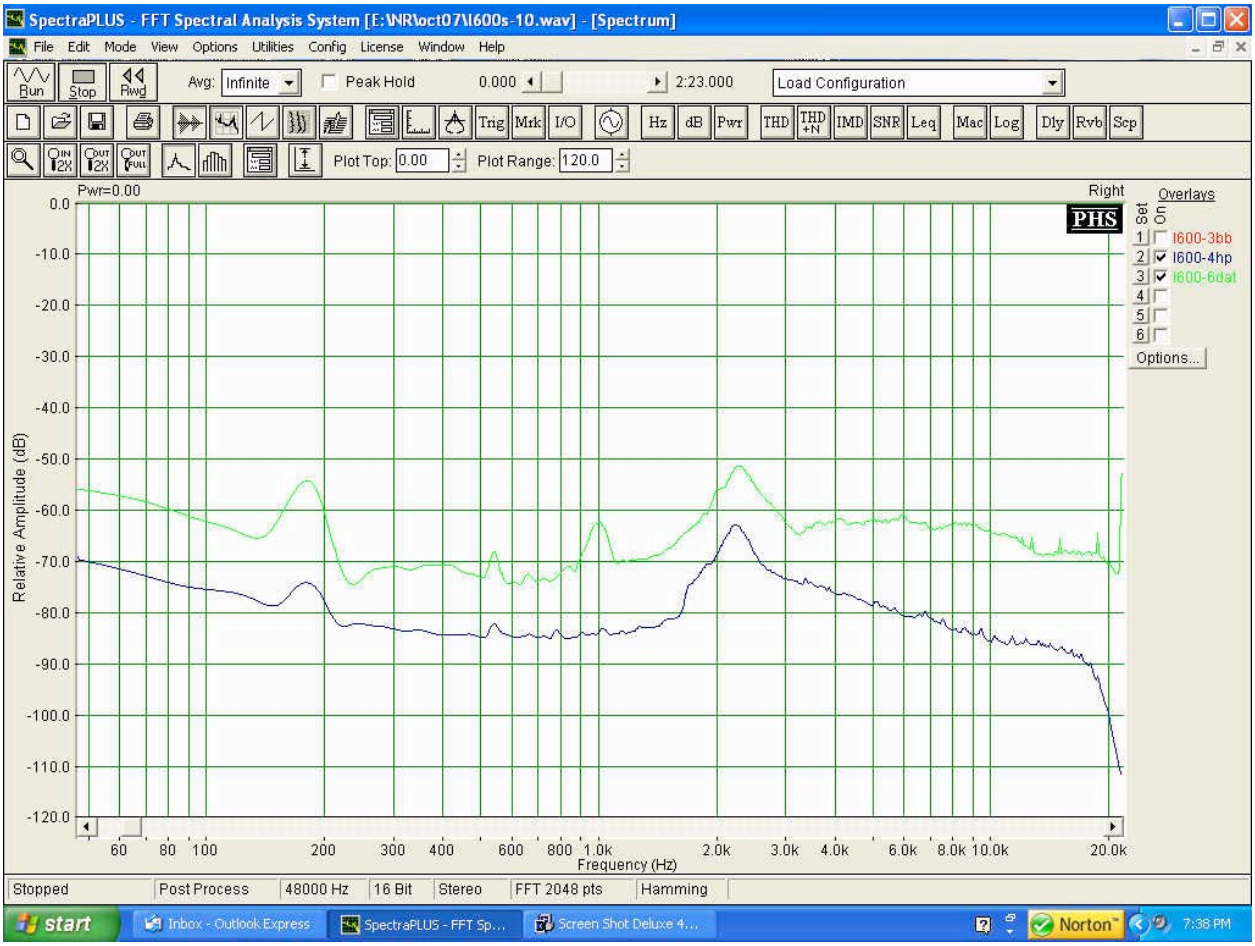


Figure-8. This chart shows the effect of different recorders. The upper trace was produced by the SONY TCD-D8 DAT recorder while the lower trace was produced by the Marantz CP430 cassette recorder. The L600S provided the input to both recorders. I performed this comparison to see if the recorder was introducing any bias into the recorded data. The separation between the traces should be ignored; the CP430 gain was deliberately reduced during playback to separate the two traces. The only significant feature on the chart is that the CP430's frequency response starts to decrease significantly at about 10 kHz and has no response above about 18 kHz while the DAT recorder is flat to over 24 kHz.

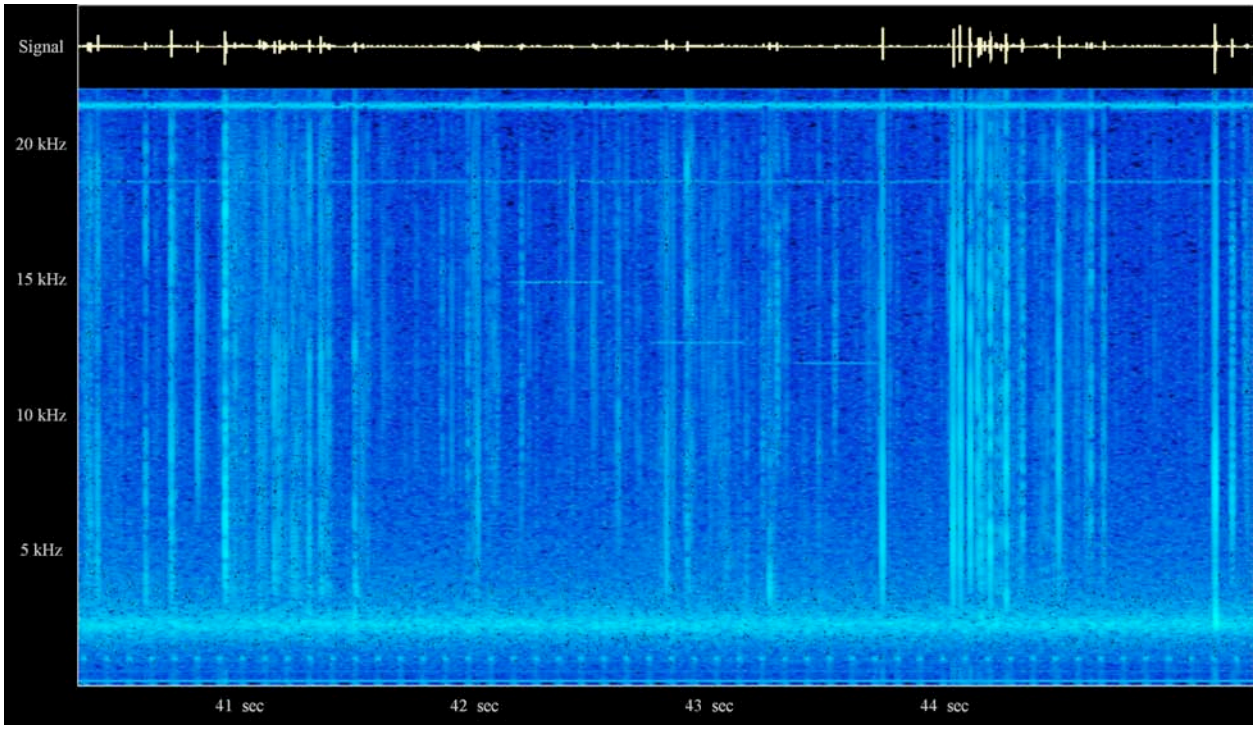


Figure-9. This figure is a screen dump of the Spectrogram program. The program provides a time versus frequency display of the recorder output. The data is for the L600S in the broad-band mode and was recorded at 0700 MDT at the quieter **Site Two**. This spectrogram clearly shows several sferics (the vertical lines), two communications signals (horizontal lines) at 18.6 kHz and 21.4 kHz, and the Russian Alpha navigation signals (the three short horizontal lines in the center of the display). At the bottom of the chart the two lower horizontal lines are 60 Hz harmonics and the fuzzy line at about 2.4 kHz is of unknown origin. The 2.4 kHz signal disappeared when the loop antenna was disconnected; however, it was not observed on the VLF-3 receiver that was operating at the same time. It is possible that this noise like signal is being generated by some feedback mechanism in the L600S, the recorder and/or interconnecting cables, but more investigation is needed to determine what it is.

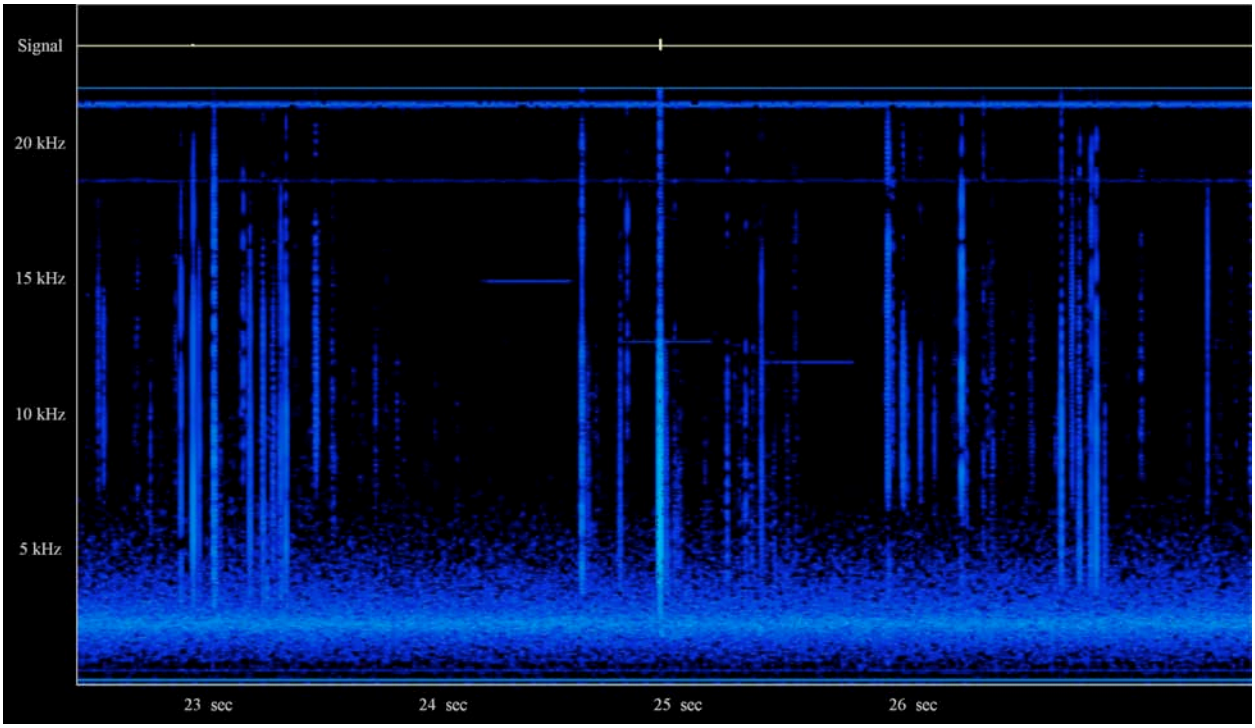


Figure-10. This data was recorded a few seconds after the recording in Figure-9. The only difference is that the L600 has been placed in the high pass mode. Most of the features on this chart are identical to the ones in Figure-9, including the unknown noise-like signal at 2.4 kHz. However, a new strange signal appeared - the series of short vertical lines at the bottom of the chart. The signal lasted for about five minutes then suddenly disappeared. The pattern is indicative of a pulsed signal. The measured parameters of the pulse signal are: center frequency = 1011 Hz, PD = 28.0 ms and PRI = 96.4 ms.

OTHER OBSERVATIONS

During three days of field testing, several other problems, shortfalls and items of interest were noted.

a. DF Performance of the L600. I tried several times to obtain lines of bearing (LOB) on prominent signals, mostly communication and 60 Hz interference without much success. First, rotating the loop proved to be a problem. I had to disconnect the L600 receiver from the recorder, plug in headphones and leave my truck to rotate the loop. I had difficulty finding a null by headphones alone, mostly due to wind noise and my poor hearing. A signal strength meter on the L600 would help a lot. The first site seems to be surrounded by 60 Hz sources; rotating the loop had little effect on their amplitude. However, I was able to correctly determine the direction to the worst 60 Hz offender, a 375 kV transmission line. I was unable to determine a LOB to the two mystery signals described in the previous paragraph. In order to obtain a LOB, the desired signal must clearly stand out against the natural radio background. Except for some 60 Hz harmonics, this rarely happened.

b. The L600 recorder output has two problems. First, the preset level was not sufficient to drive the line-in on the DAT recorder. I had to open the receiver case and set the internal adjustment for maximum output to get sufficient drive for the recorder. Second, some additional circuitry needs to be added. The recorder output uses a stereo jack but only one channel is connected. A switch and another input jack needs to be added. This will allow either the same natural radio signal on both recorder channels or timing markers on one channel and natural radio signals to the other channel, as is done in the VLF-3 receiver.

c. Care needs to be exercised in selecting a tripod for the loop antenna. I initially used a lightweight tripod designed for a digital camera and it was not strong enough. The first gust of wind blew the tripod and loop over bending the tripod leg. On my next trip out I used a 3-foot tall TV antenna roof mount with a 3-foot tall. 1.5-inch diameter steel pipe as the mast. I welded a #10 bolt to the end of the pipe, which screwed into the base of the loop antenna. This made a sturdy rigid mount for the loop antenna.

d. I found the internally mounted battery to be inconvenient. I prefer to mount the battery external to the case for two reasons. First, on equipment that is used only a few times a year, I like to remove the battery after each use to prevent potential leakage. If I forget whether I removed the battery or not, a simple look at the external holder will answer the question. Second, if a battery fails in the field, it is much simpler to replace an externally mounted battery than to open the receiver case and take a chance on dropping the small screws.

CONCLUSIONS

I believe these initial tests show the following:

1. The L600S is a worthwhile addition to the tool kit for natural radio observation and INSPIRE Project work.

2. The L600S is clearly superior to the VLF-3 at reducing 60 Hz interference and the L600S does not respond to LORAN.

3. The VLF-3 is more sensitive than the L600S and is the better Whistler receiver for use at “quiet sites”, e.g. sites free of 60 Hz interference.

4. For INSPIRE use, the L600S should have its recorder output modified to allow stereo recording of both the L600 output and WWV timing markers.

How to Do VLF Recording With Low Cost Equipment

Peder Skogaas
Hessdalen, Norway

This was done in Hessdalen, Norway.

Hessdalen is a small valley in the middle of Norway and is known for the strange atmospheric lights occurring here since the beginning of the 1980s.

I was born in Hessdalen and lived there until I was 18 and had to leave the valley for education and later work. But I always went back to the valley for holidays. When my mother and brother passed away in 1996 I inherited the farm. In 2003 I moved back to the farm with my wife and mother in law where I am now working as a distance-learning instructor in computing. For many years I have housed scientists at the farm and helped them with practical problems like translations.

Ever since the Hessdalen Phenomena (HP) started to be seen in the fall of 1982 I have taken interest in the HP and inhabitants asked me for help. This was not easy. Unfortunately serious scientists kept their hands off because the media described people of Hessdalen like some kind of hillbillies drinking too much moonshine and hallucinating the sightings. But, fortunately, some stubborn inhabitants had the ability to not care about what the media wrote or said and slowly the attitude changed.

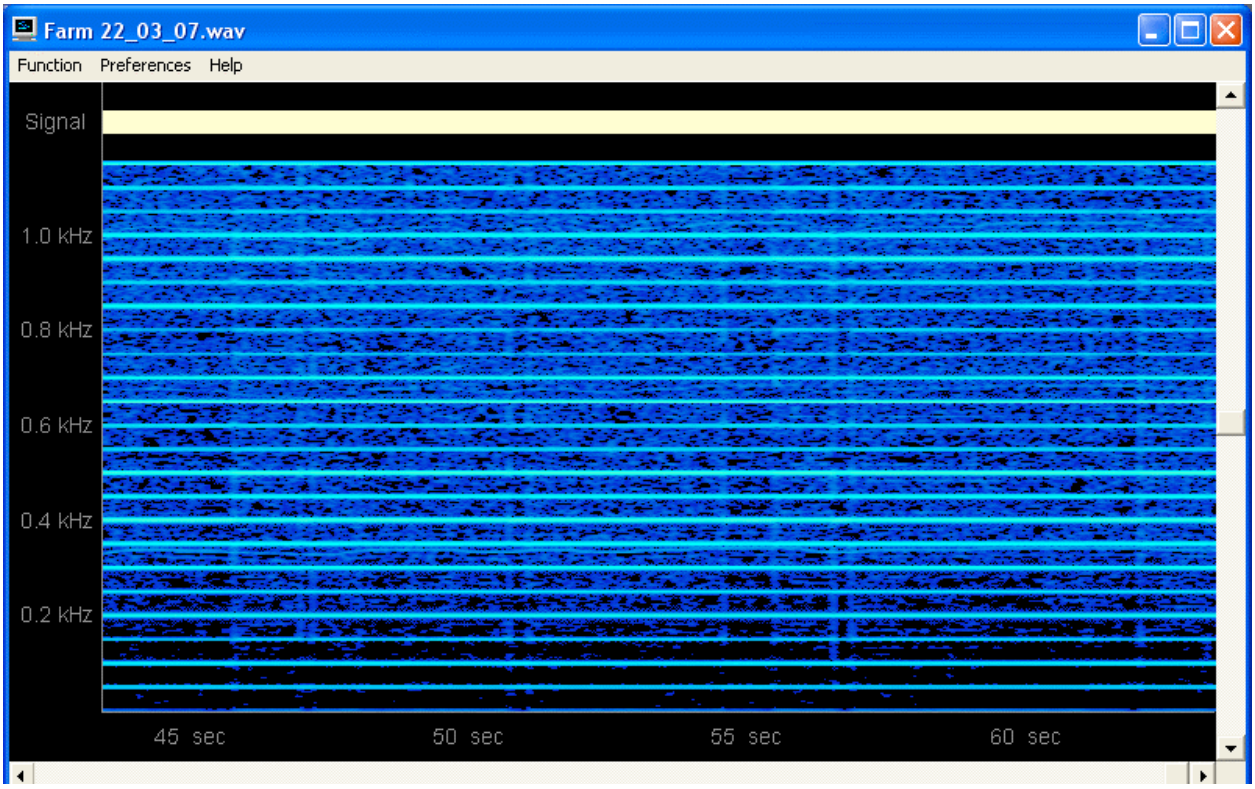
The first serious research was done by assistant professor Erling Strand at the Ostfold College of Engineering and he started Project Hessdalen. The next step was when the AMS was set up and people around the world could go on the net and see automatically recorded pictures of the phenomena. More on this can be found at www.hessdalen.org.

The next turning point came in 1997 when Dr. Stelio Montebugnoli from the Institute of Radioastronomia, University of Bologna, visited Hessdalen for the first time with his wife, Carla, and assistant professor Bjorn Gitle Hauge from the Ostfold College of Engineering.
They stayed at the farm for one week and saw the HP several times – a great puzzle for Mr. Montebugnoli! Since then several Italian scientists have visited in Hessdalen.

In July 2001, the Inspire Project European Coordinator, Flavio Gori, came for the first time, and I started to learn about VLF from him. Than he came back in 2002 and made some interesting recordings at the same time as Dr. Montebugnoli did on his radar. This was the time when I realized how important VLF recording would be to get further into the investigation of the HP occurrence.

As in other parts of the world there is lots of man made noise in the valley itself as you may see from this spectrogram:

Spectrogram:



Here an INSPIRE receiver and antenna are used.

Antenna

Unique places

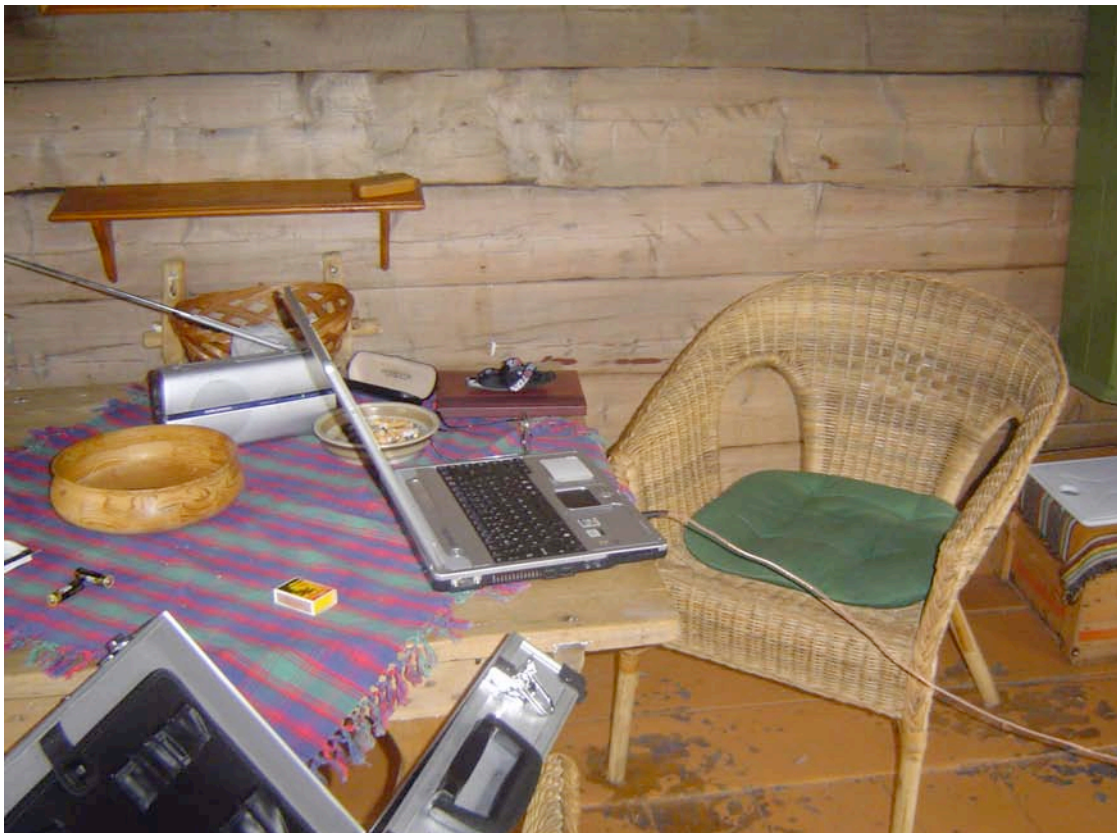
For centuries mountain areas have been used for summer farming. Here houses were built and are still used as cabins. Better roads were also constructed so today it is easy to go to these places by car during the summer. The great advantage for our work is the complete lack of manmade noise. The disadvantage is the closing of the roads during winter seasons due to snow.

I have a place like this about 18 kilometers driving from my farm and about 10 kilometers from the power lines. It is often referred to as “Peder Summer Farm” (62.43’13.90 N 10.59’58.43 E).

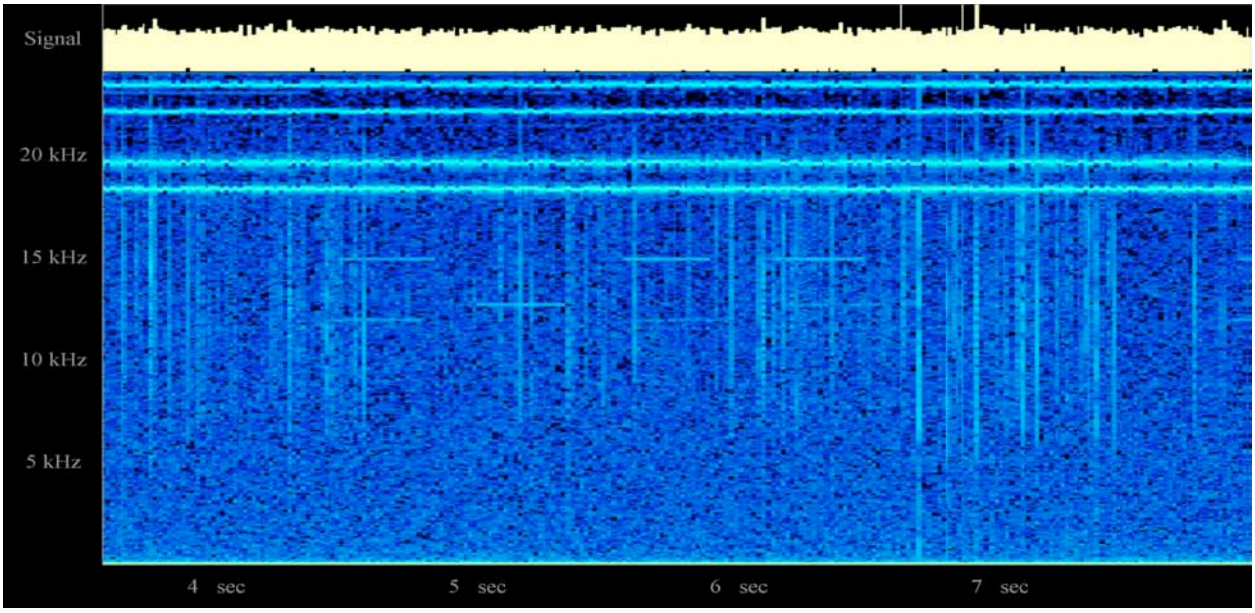
When Mr. Gori visited Hessdalen last summer, we did not have any receiver, so we tried out some very low cost equipment:

1) 50 meters of loudspeaker wire which we split so we had 100 meters of wire.
2) At one end we soldered a minijack which fits the Mic input on my Laptop and alligator clips at the other ends.
3) Five broom sticks and some leftover wood to make bases for the sticks. (see photo)
4) A Packard Bell laptop with an AMD 2600 /656 MHz/224 MB RAM.(Later upgraded to 1 GB RAM)
5) As software we used Spectrogram version 14.1 from Visualization Software. (Thanks to Mr. Horne)

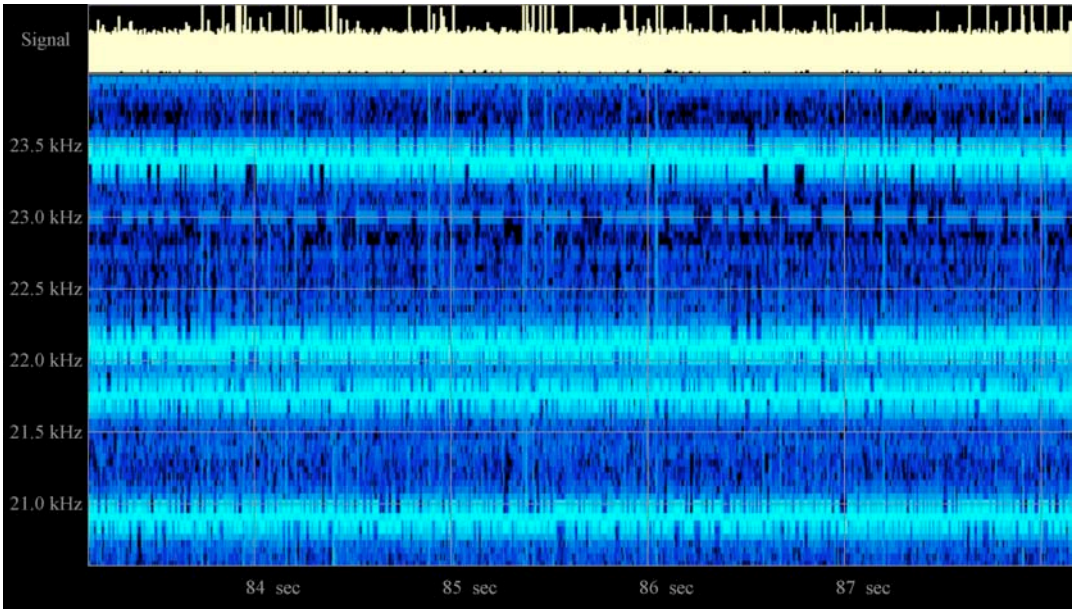
The first 50 meters of antenna was stretched out north/south and the next west/east. The Laptop was placed inside the summer farm cabin.



During the first recordings we got the Alpha Radio Navigational System very clear. All recordings are analyzed by Mr. Gori.



After he left I made some other recordings at 0505 UTC where we found the Beta system.



Once I also connected the antenna to 50 meters of barbed wire at the top of the fence.

The main problem with the laptop was the battery capacity - it lasts for only one hour recording and very little memory. The memory is upgraded to 1 GB, and we will make an adapter so a car battery can be used and then charged by a small windmill.

The summer of 2007

Even if we had a short test period last summer we know that the equipment works.

During the summer of 2007 I intend to organize recordings at different places away from manmade noise and where HP has been seen. I hope this can be done in cooperation with the local school. Maybe some of you readers would like to visit Hessdalen this summer so we can do something together?

Please e-mail me: Peder.Skogaas@Gauldalen.No

New Mexico Field Observations
6 – 7 October 2007

Field Notes and Data Recording: Robert Bennett, Las Cruces, NM
Data Analysis and Spectrograms: Bill Pine, Upland, CA

NOTE: Text in italics is contributed by the analyst (Pine); regular font is contributed by the observer (Bennett).

Due to family illness, I was not able to journey to my favorite quiet natural radio monitoring site. I had to stay close to home and be ready to return on short notice.

I spent a day searching maps and using MAPQUEST® to locate potential electrically quiet areas within about a 30 minute drive of my home. I found only two possibilities.

Site One is at the center of a large expanse of undeveloped desert within the city limits of Las Cruces. The area is roughly rectangular, about 3-miles in the East-West direction and about 5-miles in the North-South direction. There are no buildings in the area. Unfortunately I did not realize until too late that several power lines cross the area, including a 375KV and two 200KV transmission lines.

Site Two is north of my home in at a remote desert location along the historic trail "El Camino Real de Tierra Adentro" (royal road of the interior). This site is about 5-miles away from the nearest power line along a seldom-used dirt road.

5 October Monitoring.

As it had been over a year since I last monitored natural radio signals and used my monitoring equipment, I decided it would be wise to conduct a "dry run" monitoring session. So on Thursday evening, 4 Oct 2007, I loaded all my equipment in the truck and traveled to a location near the center of **Site One**. Just about everything that could go wrong did! The following are some of the highlights.

a. While setting up my equipment, I realized that I did not bring an adapter needed to connect the WWV receiver to the antenna. I tried to improvise an antenna and feed line from insulated wire but never got it to work. The end result was that I could not insert timing markers into the recording.

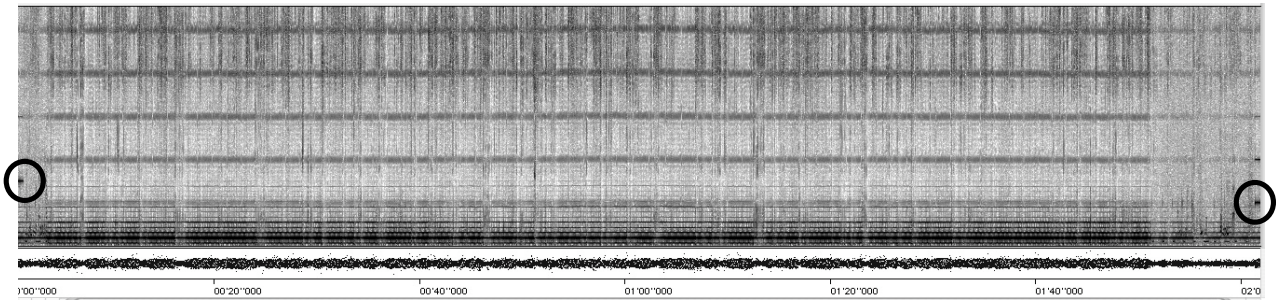
b. When I started to record, I discovered that I left my box of blank cassette tapes at home. I had to recycle a used tape. I finally started recording at 2040 local (MDT) time (0240Z 5 October 2007).

c. The worst problem was the extremely high levels of power line hum. The 60 Hz interference was so bad that it seemed to overload the VLF-3 receiver. I quickly concluded that **Site One** was not suitable for natural radio monitoring. Next morning I drove around the selected area and discovered the transmission lines.

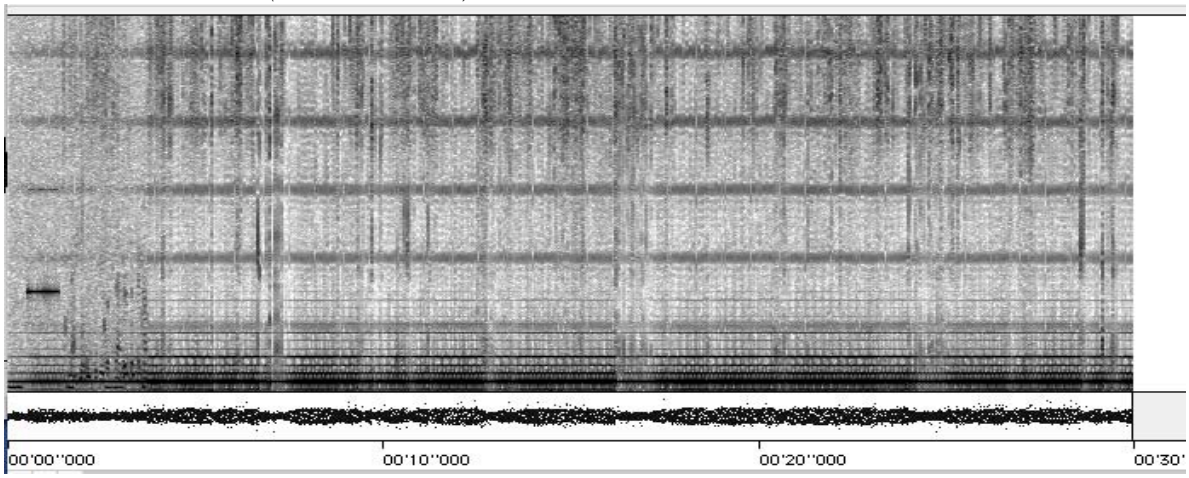
I recorded for about 30-minutes then tore down my monitoring post and returned home. I reviewed the recording and confirmed that there was nothing on the tape of interest.

6 October Monitoring.

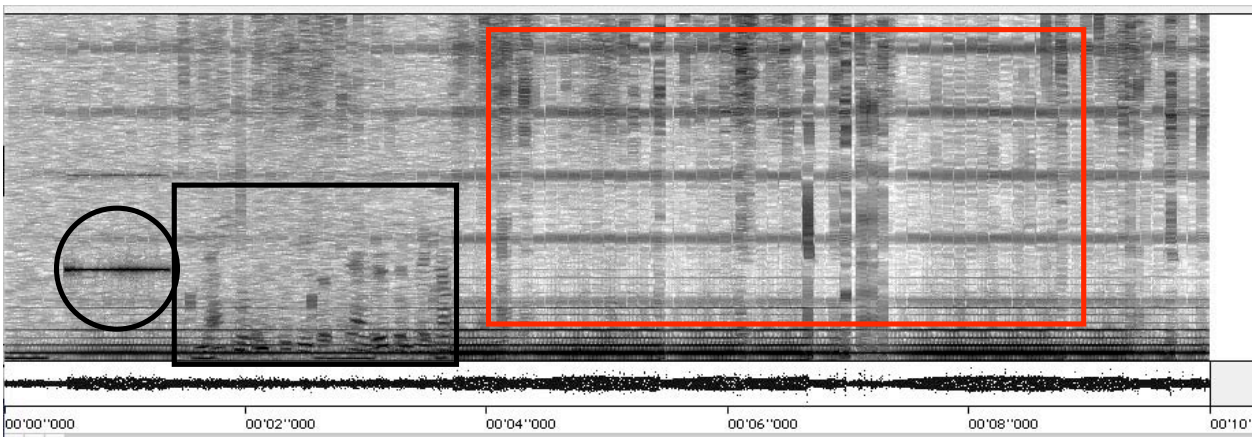
I decided to try monitoring from **Site One** again. I hoped that the power grid noise levels would be less in the early morning hours as we had a brief rainstorm earlier in the evening. I have actually observed this effect in the past. I arrived at my selected site at 0400 local time and setup my equipment. I monitored at 0500, 0600, and 0700 MDT. During all three sessions, I observed very strong 60 cycle related interference, strong LORAN interference, intense and frequent tweeks and sferics. I switched the VLF-3 LORAN filter on and this eliminated the interference from LORAN. The only interesting signal I detected was a single weak Whistler that occurred at 06:01:47 MDT (12:01:47 UTC)



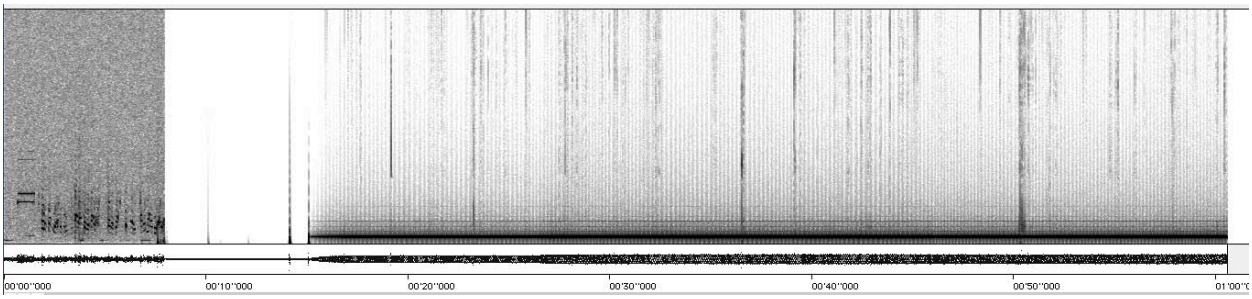
10/06/2007 0500 MDT 1100 UT (2 minutes) Sound file: btrack1.wav
Dense sferics and tweeks appear as closely spaced vertical lines and sound like crackling and short ringing noises. Power line 60 Hz interference appears as dark horizontal bars near the bottom of the spectrogram and sounds like a steady low humming tone. LORAN shows up as horizontal bars, evenly spaced to the top of the spectrogram and sound like a steady clicking noise. The short tones (circled dashes) are the WWV tones at 1100 UT and 1102 UT.



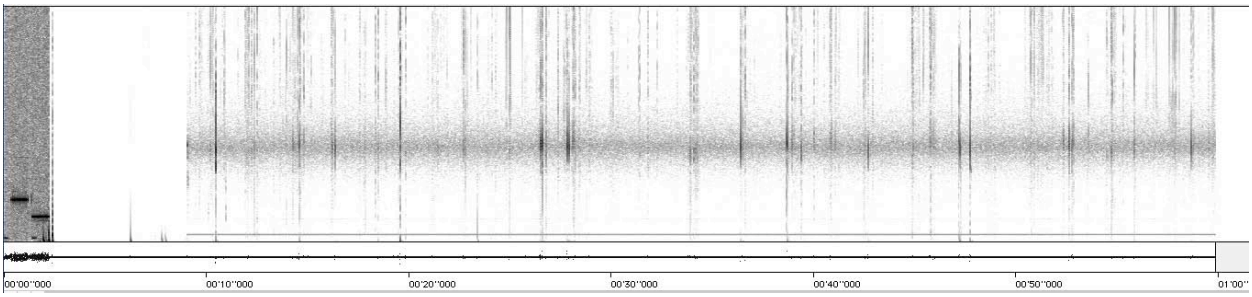
The first 30 seconds of the above session.



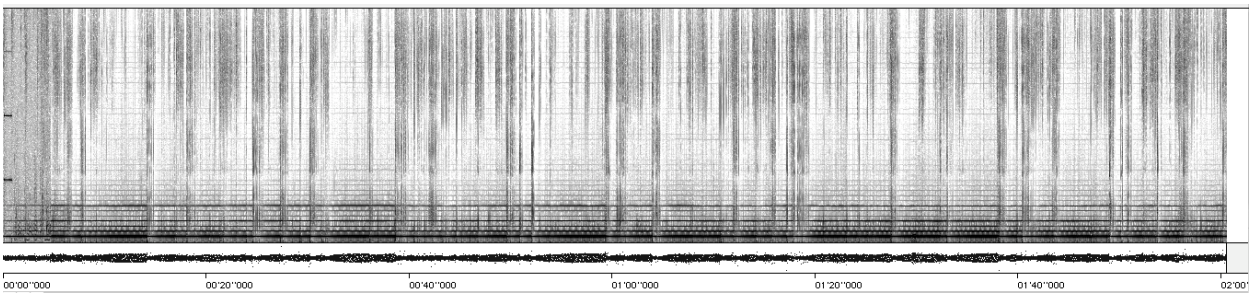
The first 10 seconds of the session. The WWV tone is circled. In the box is the voiceprint of the WWV announcer. The red box encloses the LORAN bands.



10/06/2007 0516 MDT 1116 UT (1 minute) Sound file: btrack2.wav
This was a test of the L600S B-field receiver. The file starts with WWV tone and voiceprint followed by a brief gap while the receiver was being connected. The signal shows the strong 60 Hz signal at the bottom. Notice the complete absence of LORAN signals.



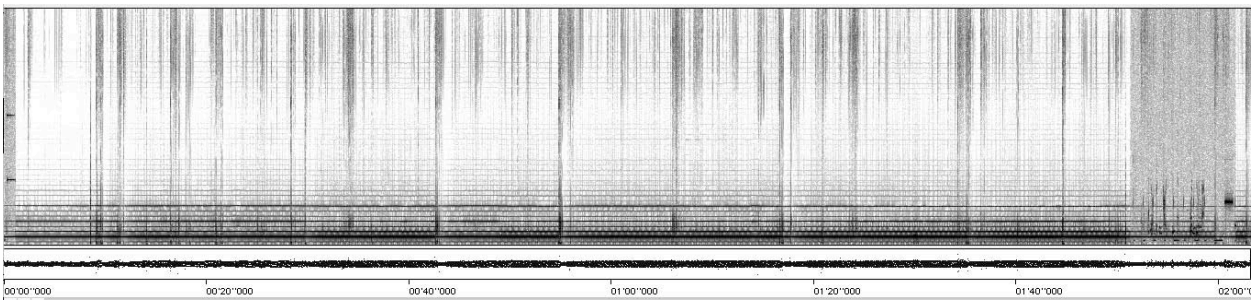
10/06/2007 0526 MDT 1126 UT (1 minute) Sound file: btrack3.wav
The next test of the L600S receiver was with the high pass switch on. Note the complete lack of 60 Hz signal. Comparing this file with the VLF-3 performance shows that the filter brings with it a drop in sensitivity. The strongest sferics and tweeks are audible, but the density is way down.



10/06/2007 0600 MDT 1200 UT (2 minutes) *Sound file: btrack4.wav*
This file was created with the INSPIRE VLF-3 receiver with the LORAN filter in.

Field notes: General Observations:

1. Temp at 0615 has dropped to 60º F.
2. 60 Hz interference seems stronger than at 0500.
3. Sferic/tweek seem less frequent and weaker than at 0500.



10/06/2007 0700 MDT 1300 UT (2 minutes) *Sound file: btrack5.wav*

When I returned home, I reviewed the tapes and analyzed a short segment with an FFT program. I noticed that the Russian Alpha navigation signals were much stronger that I normally observe. I was surprised to note the absence of the communication signals that I normally detect between 10 and 20 KHZ.

The recording is a good example of what happens when one tries to monitor too close to power lines!