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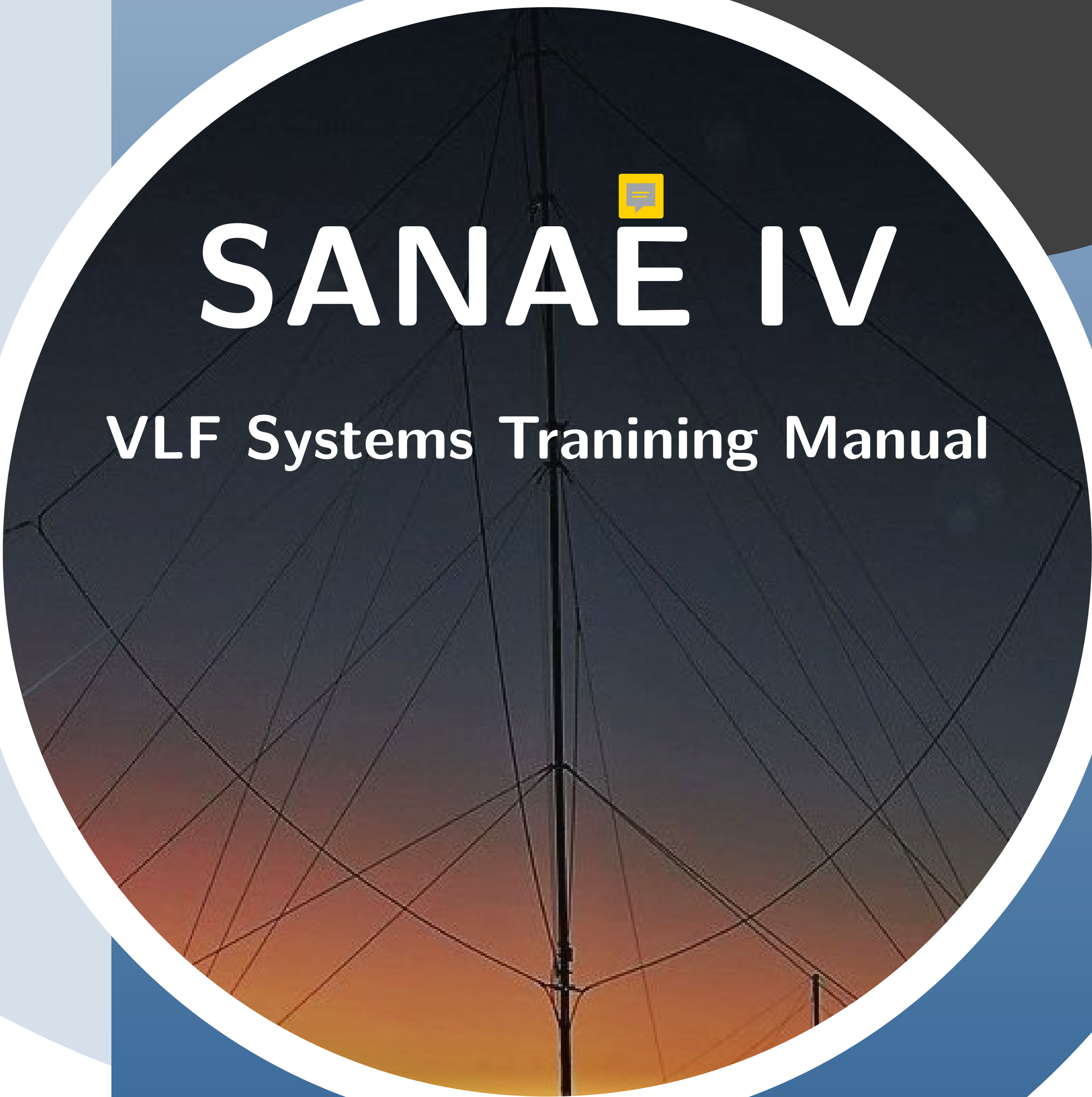
## Space Science



# SANAE IV

## VLF Systems Tranining Manual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**CLASSIFICATION:**
**Internal Use Only**

# APPROVAL PAGE

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# 1 Introduction

Very low frequency (3 kHz – 30 kHz) radio waves propagate thousands of kilometers in the Earth-Ionosphere Waveguide (EIWG) formed between the conducting Earth and the ionosphere. During daytime, the ionospheric D-region (at an altitude of 60 km – 90 km) acts as the upper boundary of the EIWG, whilst at night the D-region becomes much weaker and the boundary moves to higher altitudes. Diurnal and seasonal changes in the ionosphere cause the reflection height of the EIWG to change in a predictable way, whereas space weather events produce seemingly random modifications of the ionosphere, which affect the characteristics of the EIWG and therefore also VLF propagation.

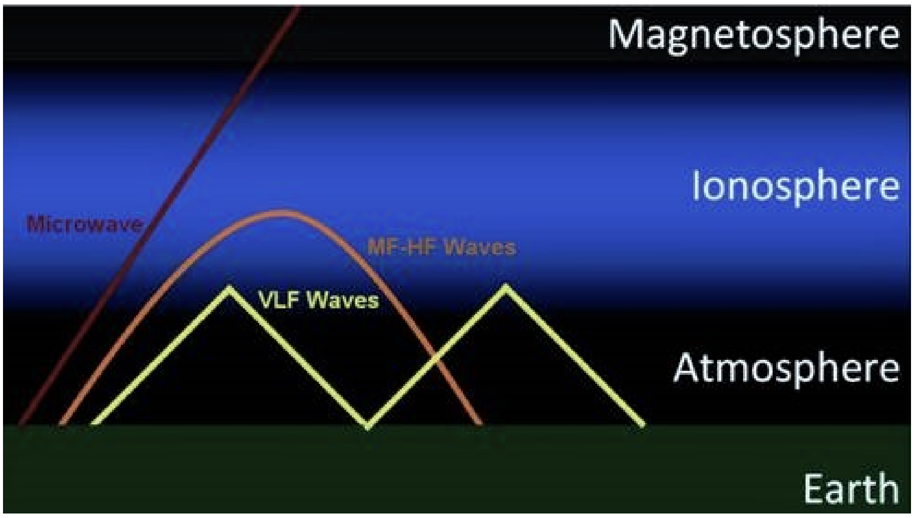


Figure 1.1: Atmospheric Layers

From a scientific perspective, though, the reflectivity of the D region at these frequencies make ELF/VLF a unique tool for remote sensing of the D region, which responds to a variety of inputs like solar activity, lightning energy, electron precipitation from the radiation belts, cosmic gamma-rays, and earthquakes. Measurements of properties of the D region are extremely difficult, since those altitudes are too high for balloons, yet too low for satellites, so this is a useful ability.

**The Space Physics Research Institute (SPRI)** from the University of KwaZulu Natal (UKZN) historically conducted various Very Low Frequency (VLF) projects at the Base. However, management of the projects was handed over to SANSA. Since then, several other international research institutions, such as the University of Washington, Stanford University, etc., have collaborated with SANSA to expand the scope of VLF projects and produce world class research.

**The Space Weather engineer is responsible for the following VLF Systems:**

- World Wide Lightening Location Network (WWLLN).
- UltraMSK
- Digital Very Low Frequency Recording and Analysis System (DVRAS)
- AWD - PLASMON.

The Space Weather and RADAR engineer has a combined responsibility for both the Scientist Data Server and the Grafana Live Monitoring systems.

# 2 Standard Operating Procedure

## 2.1 DVRAS - Digital Very Low Frequency Recording and Analysis System

The analysis of VLF wave data recorded at high latitudes is a powerful tool for remote sensing of processes in the magnetosphere, providing data complementary to other techniques which, for example, monitor particle precipitation and magnetic field variations. This manual describes the Digitised VLF Recording and Analysis System (DVRAS) developed at the Space Physics Research Institute (SPRI).

The DVRAS system is comprised of the following components: antenna, pre-amplifier, goniometer, programmable power supply, signal attenuator, GPS and a workstation, arranged as indicated in Figure 2.1. Broadband VLF signals from the pair of orthogonal vertical loop antennae pass through the preamplifier (located at the antenna site). The Digital Very Low Frequency (VLF) Recording and Analysis System (DVRAS) is used to collect this VLF wave data.

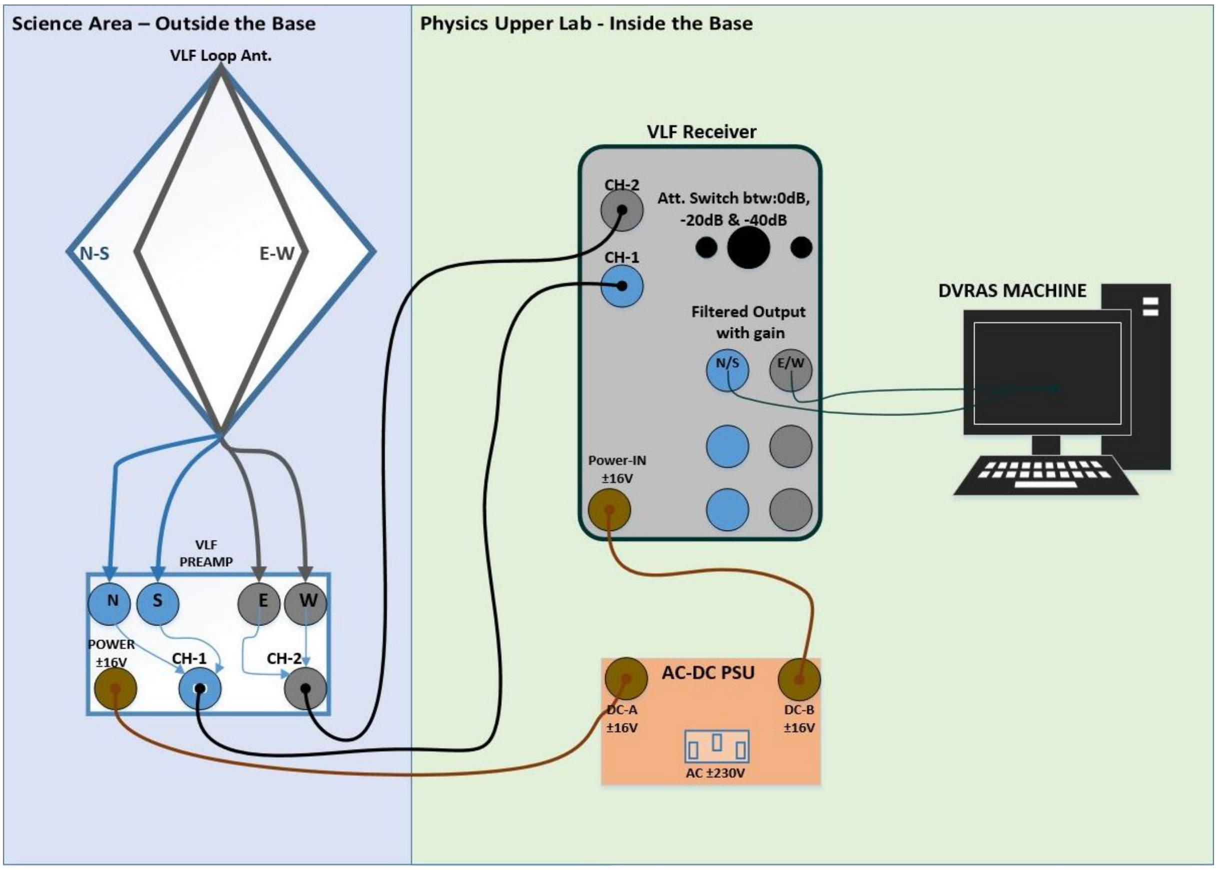


Figure 2.1: Diagram of the connections to the DVRAS system.

The signal acquired at the antenna is boosted by the pre-amplifier before passing via a pair of lengthy coaxial cables to the control unit where it is anti-alias filtered before being digitised through the workstation's sound card.The signal conditioner(VLF Receiver) simply scales the input signal to a range suitable for input to the sound card.The time source (GPS or radio clock) is used to accurately time-stamp the digitised data.The workstation's parallel port interface is used to periodically activate a module in the control unit which generates a set of calibration tones which are fed back into the system through a small coil mounted at the center of the antenna.

### Dvrecord

The capature of digitised data is carried out by dvrec script.An executing dvrec is comprised of three concurrent processes implemented as separate threads of execution:

- sampling /dev/dsp and inserting samples into data queue;
- popping samples from data queue and writing to disk;
- monitoring process of other threads and updating database.

### Dvreport

A report documenting the status of the various software components of DVRAS may be produced using dvreport.Should there be sufficient new samples, then quicklooks are generated. dvreport supports the following options:

- –max-quicklook limit the number of quicklook pages produced;
- –nasty do not reduce process priority;
- –debug produce additional diagnostic information.

Under normal circumstances dvreport is run automatically by cron, however it may also invoked directly at any time. Unless –nasty the process reduces its priority to level 19. Combined quicklook files are stored in the /tmp folder, but this folder is intermittently cleared. Thus the files are moved to /home/dvras/work/combined quicklooks_60days/ and only cleared after 60 days with crontab instructions. The combined quicklook generated file can seen on Figure 2.2, when the dvreport script is executed on the crontab.

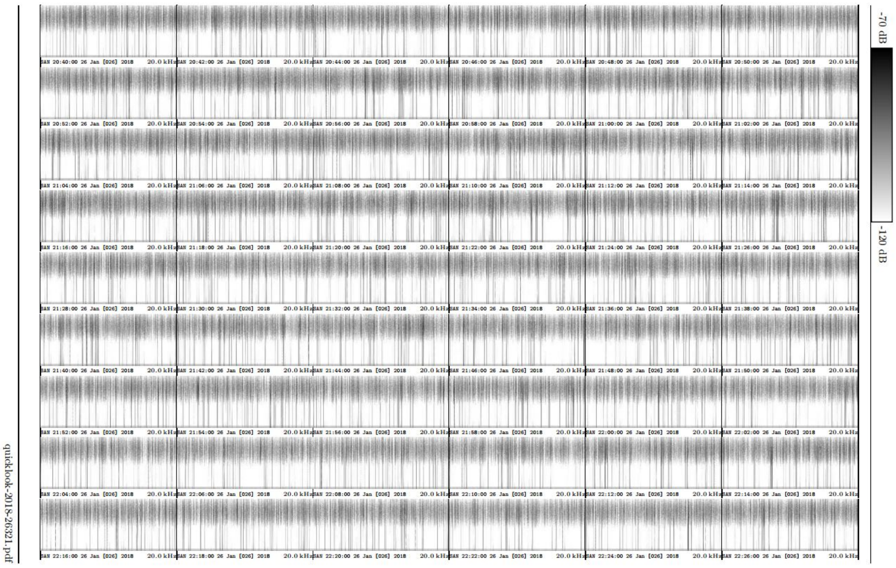

Figure 2.2: Combined quicklook report

### Dvmail

dvmail handles the processing of control messages. Before even parsing the messages they must be authenticated to ensure that they originate from an authorised source. Authentication is by means of a public-key signature. Two emails are sent daily by the DVRAS dvmail script with combined quicklook report attachment.

### Database

The database tables summarised in Figure 2.3 contain data relating to the samples accumulated by system. These tables are filled automatically by the DVRAS code modules, and may be appropriately updated by the user. An additional table, quicklook, which maintains a counter used for automatic numbering of quicklooks, is used internally by the system and should not require user intervention. The replication of fields between various tables is intentional and facilitates cross-table database queries.

(a) data

| field | description |
|---|---|
| filename | sample data file name |
| time | sample start time[s] |
| station | station code |
| channels | number of channels |
| sfreq | sampling frequency [Hz] |
| neglect | data validity |
| quicklook | quicklook number |
| comment | textual description of sample |

(b) statistics

| field | description |
|---|---|
| time | sample start time[s] |
| station | station code |
| channel | channel number |
| mean | average digitised sample value |
| power | average power [dB] |
| max | maximum digitised sample value |
| min | minimum digitised sample value |
| f1 | power spectrum first moment [Hz] (average frequency) |
| f2 | power spectrum second moment [Hz] |

(c) email

| field | description |
|---|---|
| email | email address |
| admin | recipient of system messages |
| report | recipient of daily report |

(d) schedule

| field | description |
|---|---|
| time | start time [s] |
| duration | sample length [s] |
| sfreq | sampling frequency [Hz] |
| nbyte | bytes per sample |

Figure 2.3: DVRAS database tables

## Daily Checks

- **To check the dvrecord if it's running:**
  $ ps aux | grep dvrecord
- **Find files for the last ten minutes:**
  $ cd /mnt/datahdd/dvras/data/
  $ find -mmin -10
- **Check that last quicklook email was sent:**
  $ tail ~/dvreport-log.txt
- **Open WinSCP and copy the quick looks from:**
  /home/dvras/work/combined_quicklooks_60days to `C:\Users\User.HER-EDA1\Desktop\Report\Quicklooks\YYYYMM\`. Review the quick looks and classify all the activity accordingly.

## Troubleshooting

The following scripts which are **dvreport and dvrecord** must be executed every rebooting or Base power failure on the DVRAS System. The scripts are found in this directory : $ cd /usr/local/bin

## DVRAS Useful Linux Commands

- Where is dvrecord: $ find dvrecord
- To see crontab schedule: $ sudo crontab -l
- Edit crontab - i: Insert, -wq: write quit: $ sudo crontab -e
- Startup script for recording: $ /usr/local/bin/dvrecord

## How to delete and insert new email address on DVRAS database

- **To login on Database**
  $ sudo mysql -u dvras -p fofedfi
  User password:> dvras001
- **Database tables query**
  mysql> SHOW TABLES;
  mysql> SELECT * FROM email WHERE email LIKE 'bvaneden@sansa.org.za';
  mysql> DELETE FROM email WHERE email LIKE 'bvaneden@sansa.org.za;
  mysql> INSERT INTO email (email) VALUES ("bvaneden@sansa.org.za ");
  mysql> exit;

## DVRAS System Information

### Contact Details

- **Contact person:** Dr Stefan Lotz
- **Email:** slotz@sansa.org.za
- **Website:** `http://chinstrap.ukzn.ac.za/`

### Computer Details

- **OS:** Ubuntu 10.04 LTS
- **IP:** 172.17.30.53
- **Username:** dvras
- **Password:** dvras001
- **Username** sanvlf1
- **Password:** sanvlf1

### Data Details

- **Data Directory:** /mnt/datahdd/dvras/data
- **Data Type:** Audio .wav files
- **Logging Frequency:** data file per 2 minutes, Size: 721 files/day, 9.6MB/file (6.2MB zipped)
- **Naming format:** yyyymmdd_hhmmss_stationname e.g.20141229_145200_SAN.wav for 2014/12/29 at 14:52
- **Transfer:** return to South Africa after each summer voyage.
- **Backups:** Backup data to NAS
- **Soundcard Gain:** Set in /home/dvras/.dvrasrc (file)

### Auxilliary Programs

- **NTP:** Network time protocol server using the GPS time (GPS_NME) as favourite
- **MySql:** Data base program for data and email server

**DVRAS Calibration**

The Broadband VLF receiver installation on SANAE IV uses magnetic induction to monitor incoming VLF signals. Data are used for studying, amongst others, the association of VLF chorus with sub storm particle injections, the occurrence of VLF whistlers and their relation to their source in lightning, the measurement of magnetospheric electric fields from the drifting of plasma duct enhancements, as well the study of waveinduced electron precipitation. The installation must receive a yearly calibration each austral summer.

**Preparations and required equipment**

- Two VHF radios
- Function generator (load impedance should be set to HIGH-Z)
- Magnetic Compass / GPS
- Dummy Antenna

**Dummy antenna calibration procedure**

For this procedure the system noise, sensitivity and frequency response of the system is determined by disconnecting the loops, and connecting a dummy antenna to the preamplifier.

**Preparations in the Base**

- On computer, urn off recording, with kill 'cat /tmp/dvrec.pid'
- Connect signal generator to cable coming from the antenna (marked with white tape, see Figure 2.4).
- Get two radios, one to the lab group, one to the antenna group.
- Set the load impedance on the 'Stanford Research Systems' signal generator to HIGHZ.
- Set amplitude on signal generator to 0.6 Vrms.
- Check that parallel cable to the CALTONE generator is disconnected Figure 2.5.
- Set INPUT ATTENUATOR on the goniometer signal conditioner to 0 dB Figure 2.6
- Make sure both the low pass and high pass filters are in "OUT" position.

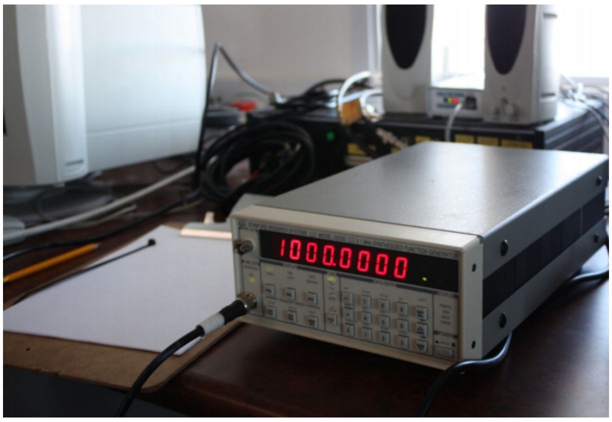


Figure 2.4: Function generator, connected to incoming unterminated coaxial cable (marked white)

Figure 2.5: Disconnected parallel cable for caltone generator

Figure 2.6: Input attenuator must be set to 0, both filters must be on OUT position

**Preparations in the Field**

- Disconnect NorthSouth and EastWest antennas from the preamplifier in the hatch.
- Connect dummy antenna Figure 2.7 and Figure 2.8 where the NorthSouth antenna was connected.
- Connect the white marked cable with BNC connector to the dummy antenna.

Figure 2.7: Dummy antenna units

Figure 2.8: Dummy antenna connected to preamplifier in the field

**Procedure**

- Start 'dvcalibrate' on the PC.
- Double check that the parallel cable to the caltone generator is disconnected, press 'y'.
- Ensure that the northsouth loop is on channel one.
- Put in 0.6 for reference RMS voltage.
- Define other voltages as required:

| |
|---|
| -5dB -> 0.337405V rms. use: 0.34 |
| -10dB -> 0.189737V rms. use: 0.19 |
| -15dB -> 0.106697V rms. use: 0.11 |
| -20dB -> 0.060000V rms. use: 0.06 |
| -25dB -> 0.033740V rms. use: 0 |
| -30dB -> 0.018974V rms. use: 0 |
| -35dB -> 0.010670V rms. use: 0 |
| -40dB -> 0.006000V rms. use: 0 |
| -45dB -> 0.003374V rms. use: 0 |

Figure 2.9: Voltage Reading

- For system noise: Turn off function generator, press enter, and record system noise for required time interval.
- Sensitivity: Turn on function generator, and for each frequency / amplitude pair adjust the generator. After each adjustment, press enter and record. MAKE SURE FREQUENCY ON SIGNAL GENERATOR IS IN THE RIGHT UNIT (kHz).
- Proceed to frequency response, where the amplitude remains fixed at the reference value of 0.6V and only the frequency is adjusted.

**Preparations in the Field**
After N/S responses are complete, change the dummy loop antenna from the NorthSouth connectors to the EastWest connectors.

**Preparations in the Field**
Repeat procedure for E/W connectors.

## 2.2 Calibration Coil Procedure

A calibration coil is utilised, where a known offset is sent into the system and the responses, sensitivities and noise are recorded.

### Preparations and Required Equipment

**Equipment required are:**

- Two VHF radios
- Function generator (load impedance should be set to HIGHZ)
- Magnetic compass / GPS
- Impedance matching unit
- Calibration mirrors
- Light source (headlamp, torch)
- Calibration pole (sectioned in two, terminated with a slotted copper fitting)
- Step ladder
- Tall individual

**Preparations in the base:**

- Connect impedance matching unit Figure 2.11 to the calibration coil with the incoming coaxial cable marked "calibration coil", as depicted in the diagram below:

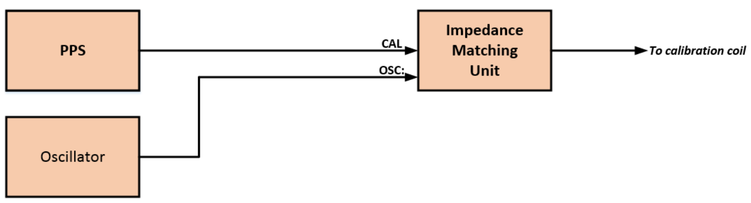


Figure 2.10: Impedance matching unit Diagram

- Connect the function generator and the CALTONE generator to the impedance matching unit, as clearly marked on the unit.
- Make sure the flick switch is in the OSCILLATOR position.

- Switch attenuator to 20 dB on the signal conditioner in the lab.


Figure 2.11: Impedance matching unit

**Preparations in the Field/Science area:**

- Get the calibration stick (shown in Figure 2.12) and a very tall person and/or a stepladder to stand on. Also bring a compass and an extra person (and maybe a light source to make it easier to see reflections in the mirror).
- Reconnect the loops antenna to the required connectors on the preamplifier.
- Align the calibration coil, mounted high on the antenna mast, to geographic bearing 0°. Use the below table as reference for bearings:

Table 2.1: $ calibration-coil.py -17

| geo | mag | mgeo | mmag |
|---|---|---|---|
| 0.00 | 17.00 | 270.00 | 287.00 |
| 15.00 | 32.00 | 285.00 | 302.00 |
| 30.00 | 47.00 | 300.00 | 317.00 |
| 45.00 | 62.00 | 315.00 | 332.00 |
| 60.00 | 77.00 | 330.00 | 347.00 |
| 75.00 | 92.00 | 345.00 | 2.00 |
| 90.00 | 107.00 | 0.00 | 17.00 |
| 105.00 | 122.00 | 15.00 | 32.00 |
| 120.00 | 137.00 | 30.00 | 47.00 |
| 135.00 | 152.00 | 45.00 | 62.00 |

| | | | |
|---|---|---|---|
| 150.00 | 167.00 | 60.00 | 77.00 |
| 165.00 | 182.00 | 75.00 | 92.00 |
| 180.00 | 197.00 | 90.00 | 107.00 |

- **Dress warmly, as you will be standing around a lot!**

Figure 2.12: Calibration stick and operator

**Procedure**

**Preparations in the Field/Science area:**

- The general procedure will have the person with the stick stay close to the mast and is ready to be able to move the coil with the mirror attached to them.
- The person with the compass goes out to a distance of about 40 meters from the mast, and looks toward the mast. The bearing on his/her compass should show 287 deg, which correlate with 0 deg bearing.
- The first person at the mast is now twisting the coils so that the second person can see him/herself (or the light from the torch) in the mirror Figure 2.13, Figure 2.14 and Figure 2.14.

- When in place, and coils turned in position, wait for the lab scientists to do their measurements (don't forget to let them know you are in place).
- The base will transmit instructions on where to go, what bearing and when they are ready to do the next measurement.

Figure 2.13: One person will walk around the mast in a big circle, finding the desired bearing. Once in place, he will shine a light and wait for the reflection from the mirror on top of the mast, being tuned into position by using a long poking stick.

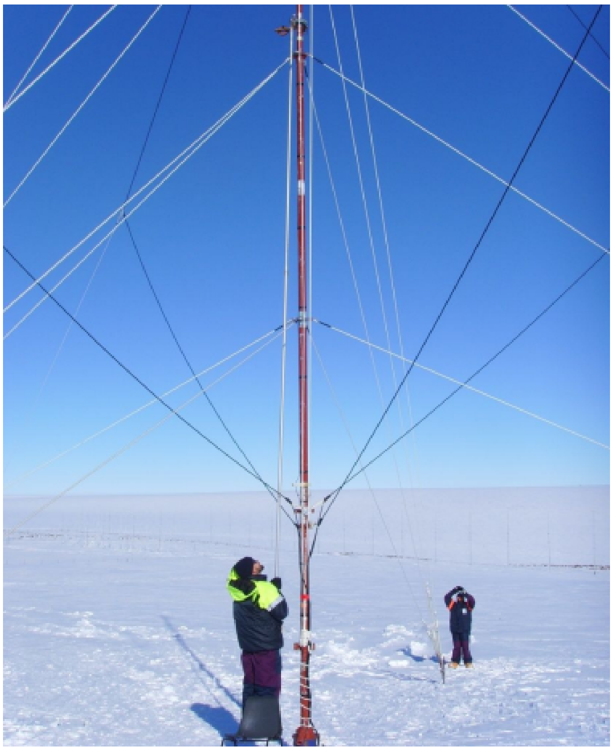

Figure 2.14: Twisting the location of the mirror with the stick

Figure 2.15: The stick fits into a small hole on the plate holding the mirror

**Preparations in the Base:**

- When confirmed from the field team that the coil is in position, proceed taking measurements for the azimuth response, with the signal generator at the specified positions and frequencies given by the program.
- The last signal of each set will be given by the calibration recording (flick the switch to CAL) and press the green button on the signal conditioner Figure 2.16.
- **NB: Switch back to OSCILLATOR when done!!!**. Also the switch have three positions. Take care not to use the middle position for any of the measurements.
- Repeat for all 13 bearings listed in 4.1, at 1, 2, 5 and 10 kHz. The field crew has to move the calibration coil to the correct position 13 times for 4 frequencies.
- The procedure is very cumbersome and take a lot of time.

Figure 2.16: The green button to press for CAL recording

**Preparations in the Field/Science area:**

- Return the antenna to bearing 0 (287 in the field) for the calibration coil sensitivity check upon instruction from the base party.
- After this section is completed, return the coil to bearing 45 deg upon instruction from the base party.

**Preparations in the Base:**

- Start with the calibration coil sensitivity check at four frequencies on bearings 0°, 90° and 45°.
- Request the field team to leave the calibration coil at 45° for the antenna noise.
- Switch off the signal generator.
- Record antenna noise by pressing enter, and leave the recording to finish.
- Start with calibration coil frequency response, with the antenna on 45 degrees. Complete the required measurements by only altering the frequency, and keeping the amplitude on 0.6V RMS.

**Preparations in the Base:**

- When all measurements are done, return the calibration coil to geographic 45 deg.
- Reconnect cable to parallel port.
- **Restart dvrec.**

## 2.3 AWD - Automated Whistler Detector

The AWD system identifies whistlers in broadband VLF data. Detailed analysis of these whistlers yields magnetospheric parameters. Traditionally performed by hand in an arduous and error-prone procedure, this analysis has been automated using an extended whistler inversion method.This procedure is, however, computationally expensive and for remote stations where network bandwidth prohibits the transfer of the raw data, analysis will take place on local supercomputers. An Automated Whistler Detector (AWD) station consists two magnetic loop antennas, VLF preamplifier,VLF Receiver, VR2 VLF Sampler and AWD software running on x86 PC with a Linux kernel, see the Figure 2.17 .

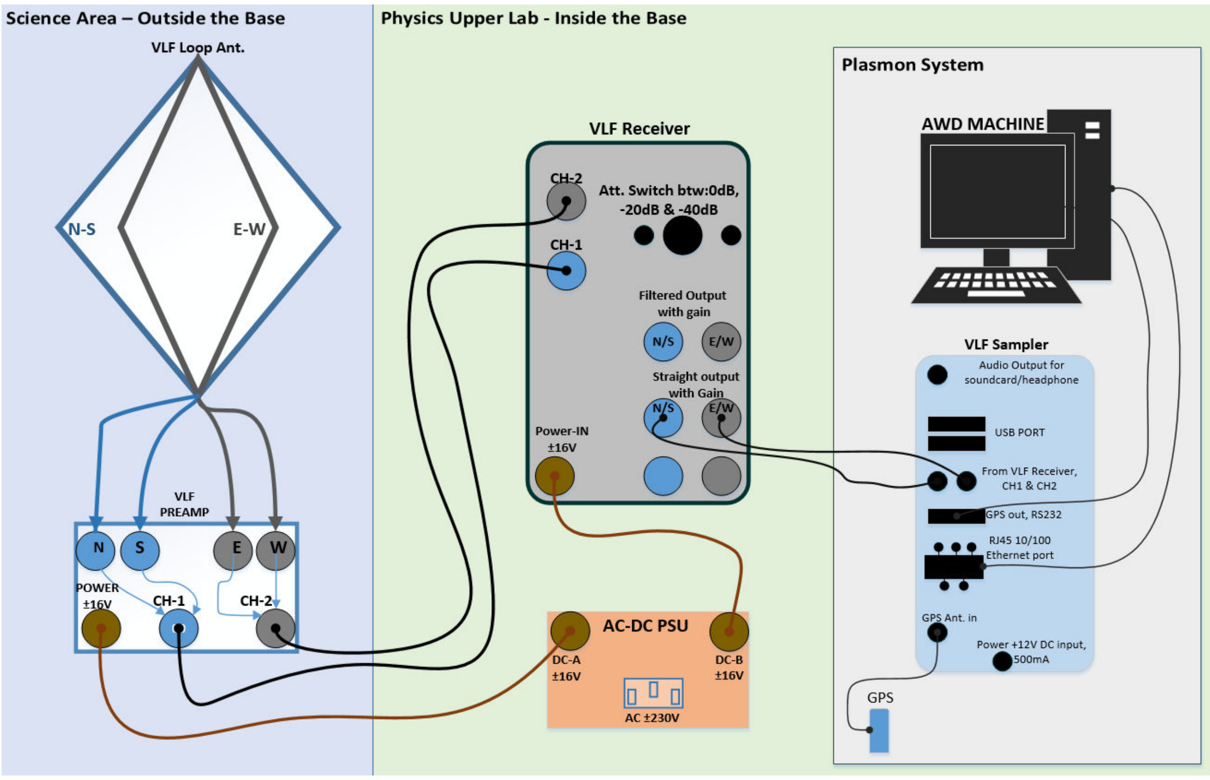


Figure 2.17: Diagram of connections to PLASMON System.

The processing of the VLF broadband waveform which contains whistlers composes of four computers system which are labelled AWD1, AWD2, AWD3 and AWD4, refer to Figure 2.18. All the AWD machines are connected via their onboard network interface cards (NIC) to a gigabit switch. This gigabit switch is connected to the SANAE network Table 2.2. AWD1 has an additional NIC which is connected the VLF Sampler (VR-2). It should have 1 serial port for GPS input and occasional bootup commanding.Though VR2 and the PC can be set to any IP address, it is preferable to put them on a separate network using a dedicated network card in the PC.This way the communication with VR2 is independent to any other network traffic and VR2 is protected from spikes induced in long Ethernet cable. AWD runs on 2.6.39.4 kernel.This kernel has a PPS patch that enables it to use Jupiter GPS card in VR2 as reference clock with NTP server.This way AWD PC can be used as a time server in the local network.


Figure 2.18: AWD Computers Rack.

Table 2.2: Automatic Whistler Detector Machines List

| PC Name | Machine Type | IP Address | Subnet | Gateway |
|---|---|---|---|---|
| AWD 1 | Storage | 192.168.1.170 | 255.255.255.0 | 192.168.1.2 |
| AWD 2 | Storage | 192.168.1.171 | 255.255.255.0 | 192.168.1.2 |
| AWD 3 | Processing | 192.168.1.172 | 255.255.255.0 | 192.168.1.2 |
| AWD 4 | Processing | 192.168.1.173 | 255.255.255.0 | 192.168.1.2 |

VR2 has two input MINIDIN connectors Figure 2.19. Both differential and asymmetric input signal from VLF preamp can be connected. For asymmetric input a 'Y' cable is supplied with two MINIDINs for CH1 and CH2 inputs and a 3.5mm stereo jack plug.


Figure 2.19: VR2 Sampler Backside.

GPS OUT has to be connected to COMM1 serial port on PC (ttyS0 in Linux), RJ45 has to be connected to Ethernet port on PCI card by crossover cable. The serial cable is standard straight cable are (if not supplied). The supplied small rectangularshape GPS antenna has to be connected to ANT. GPS antenna has a small magnet on the bottom of its plate for easy mounting on the roof. A 12V PSU is supplied, but any PSU can be used if it supplies 500mA at 12V least.

The amplification of VR2 can be set via the DIP switch between 0dB and +30dB independently for the two channels. Though the amplification can be set for the two channels independently, it is better to keep them on the same level to avoid calibration problem. The signal level has to be set to optimize ADC range: all samples should be within + 32765 (i.e. only strong sferics should reach this value).

There are another two DIP switches on for signal impedance matching.It can be used for matching VR2 input impedance with VLF signal cable's one. It can be set to 50, 100, 200 or 620 Ohm. Mismatching causes decrease in signal level. 200 Ohm is good rough value for 2300m long signal cable.

There are two times two jumpers behind these DIP switches. If they are on, the input signal is attenuated by 18dB. Both two jumpers have to be set on to set this attenuation for an input channel. The channels can be set independently.

There are two leds (a green marked 'NAV' and a red marked 'GPS' ) at front side of V21 box Figure 2.20 serving for diagnostic purposes. When power is switched on, VR2 waits 5 second for command input through serial port, if no command received starts to boot from internal flash memory; during this time the leds are off. After startup leds are blinking alternately waiting for the PC side data logger program to be started. If the PC side program runs, red led blinks 1/sec showing 1PPS is present. The green led is on when the GPS card inside VR2 navigates properly (sees enough satellites).


Figure 2.20: VR-2 Sampler.

VR2 is setup upon PC program startup, parameters can be set via vr2.conf file. vr2.conf has to be in AWD 'root' directory **(/u1/sanae/vr2)**, it is a simple ASCII file.VR2 has a DSP processor running a simple linux kernel (blackfin) that:

- – processes GPS navigation data
- – synchronize ADC clock (12.8MHz) to GPS PPS signal achieving 80nanosec timing accuracy
- – puts data into frames and adds sync, status bytes and time stamp to the beginning of each frame.

Data collecting module is started through init system upon PC boot. There is a user level program called driver, it communicates with VR2 upon startup and during data logging, it writes data to disk. It opens a file in every hour. The filename contains date and time info based on system (PC) time. This is just an approximate time of the first sample of file, the exact times can be found at each frame header. The filename format is yyyymmddUThh:mm:ss.sitename.vr2, e.g 2018-05-31UT01:59:45.14380156.sanae.vr2 and the data directory is **/u1/sanae/vr2/wh_vr2_rt/**

### AWD Daily Checks

- Use Putty and Login with **username: root and password: Tihany**
- Verify in putty with **ls | tail** that files are created in **/u/sanae/vr2/wh_vr2_rt/**
  > $ cd /u1/sanae/vr2/wh_vr2_rt
  > $ ls | tail
- Check the email from **sanae@hopkins.elte.hu**; previous day system performance overview.

### Troubleshooting

**ntpq -q** :- Checks the NTP server accuracy.

### AWD -PLASMON System Information

### Contact Details

- **Contact person:** Dr Jonas Lichtenberger
- **Email:** lityi@sas.elte.hu

### Computer Details

- **OS:** Fedora 8
- **IP:** 192.168.1.168
- **Username:** root
- **Password:** Tihany

### Data Details

- **Data Directory:** /u1/sanae/vr2/wh_vr2_rt/
- **Data Type:** *.vr2 Wh_vr2_rt: minute files and Kesz: hourly files
- **Logging Frequency:**Hour data files, closed when round hour is reached. Hour files is processed by PLASMON to create files that may contain whistlers (4 second files) (2.3MB )
- **Naming format:** yyyy-mmddUThh:mm:ssssssss.sanae.vr2 (records fraction of a second up to 8th digit) e.g 2018-05-31UT01:59:45.14380156.sanae.vr2

- **Transfer:** return to South Africa after each summer voyage.
- **Backups:** Backup data to NAS

**Software Details**

- **AWD:** Data collection and software module (driver starts data logging)./u/sanae/vr2/rec_vr2_60_bc

**Auxilliary Programs**

- **NTP:** NTP: Network time protocol server 172.17.30.50

## 2.4 World Wide Lightening Location Network - (WWLLN)

The University of Washington operates a network of lightning location sensors at VLF (3-30kHz) that accurately monitors location and time for lightning strokes over the entire world. The World Wide Lightening Location Network - (WWLLN) project has been providing continuous accurate locations and times for lightning strokes globally since August 2003 [Lay et al., 2004; Rodger et al., 2005a; Jacobson et al., 2006]. Figure 2.21 shows the real-time global lightning detection capabilities of the WWLLN. A real-time, global lightning detection system has a variety of applications in the scientific, commercial, and governmental sectors. Scientifically, it could provide better global tracking of severe storms, especially storms and hurricanes over the oceans. Its seasonal and yearly averaged data could be used as an indicator of global climate change [Schlegel et al., 2001].

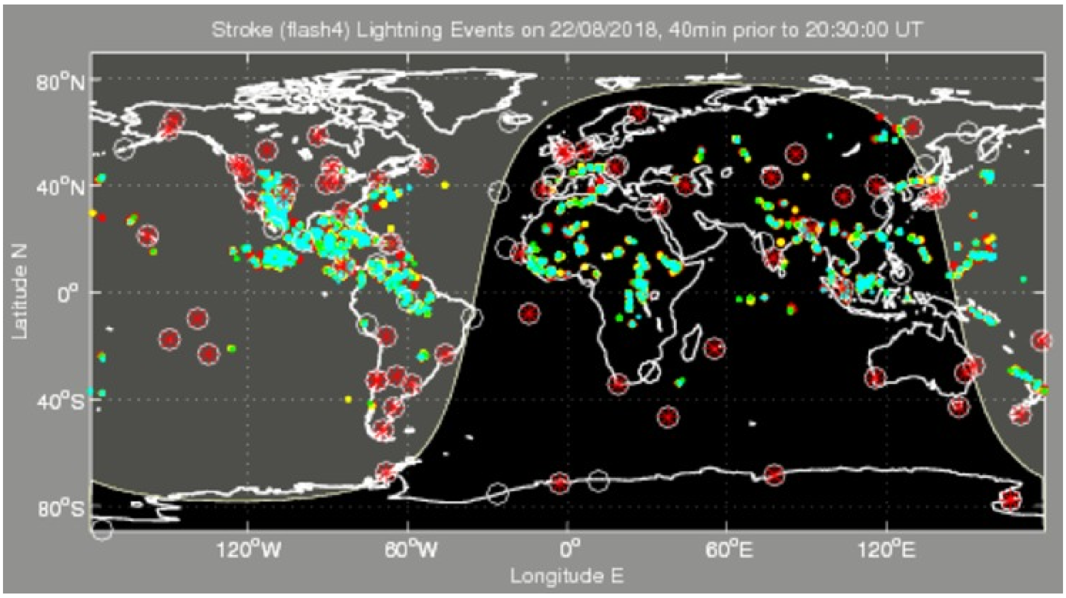


Figure 2.21: WWLLN world map for 22/08/2018. [wwlln.net].

This is achieved by the monitoring of sferics on the VLFL system. Sferics are impulsive signals produced by lightning discharges. By calculating the Time of Group Arrival (ToGA) of the sferics, the location of lightning strikes is calculated.The TOGA is determined relative to GPS at each site from the progression of phase versus frequency using the whole wave train. Unlike current VLF methods which require transmission of the whole wave train from each site to a central processing site, the TOGA method requires transmission of a single number (the TOGA) for lightning location calculation. The WWLLN node at SANAE forms fart of this network and actively contributes to the global database.

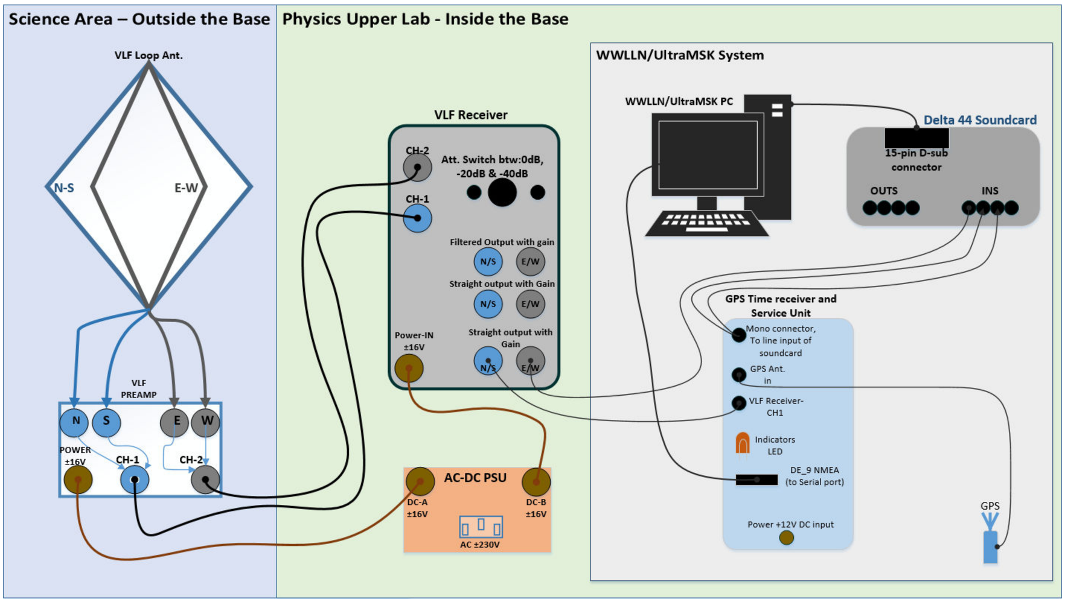


Figure 2.22: Diagram of the WLLN/UltraMSK systems.

The sferics are picked up by the VLF antennae. The signal is amplified by the pre-amp. The amplified signal is then routed via a long ($\approx$ 350m) coaxial cable into the Base, to the Service Unit, which serves to isolate the signal via an audio transform.A schematic diagram of a WWLLN station is shown in Figure 2.22. The service unit feeds the signal to the UltraMSK/WWLLN PC via a Delta 44 sound card that digitises the signal. The GPS provides one pulse per second input to the computer sound and too adjust the time-stamp on each Vlf waveform. The GPS also provides a NMEA() signal giving the exact location of SANAE.The requirements for the station computer are minimal:it must be able to run Linux, and must have a sound card and serial port. A sufficient amount of RAM is 248 or 512 MB and 20-40 GB is plenty of hard-disk space. The computer also must be continuously connected to the internet.The global data are then posted to the internet every 10 minutes (see

## WWLLN Useful Linux Commands

- **/sbin/reboot**: Reboot computer
- **ntpq -p**: Checks NTP server for accuracy.
- **ps aux | grep toga**: checks if the Toga processes is running.
- **ps aux | grep vtcard**: checks if the vtcard processes is running.

## WWLLN System Information

## Contact Details

- **Contact person:** Prof. Robert Holzworth
- **Email:** bobholz@washington.edu
- **Website:** http://wwlln.net

**Computer Details**

- **OS:** Linux CentOS release 6.7 (Final)
- **IP:** 192.168.1.71
- **Username:** root
- **Password:** ultramsk001

**Data Details**

- **Data Directory:** As root: ~/sferics.log file – Logs sferics that gets send per hour/day etc. Note that none of the sferics data are saved for more than 24 hours.
- **Data Type:** sferics.log
- **Size:** sferics dependant Daily .png: On server pc
- **Transfer:** Transmitted to Seattle and Dunedin. The E/W signal does not go through the SU box Figure~2.22.

**Auxilliary Programs**

- **NTP**: Network time protocol server using the GPS time (GPS_NMEA) as favourite

## 2.5 UltraMSK

The UltraMSK is used to remotely sense the bottom side of the ionosphere for magnetospheric disturbances. The instrument records the phase and amplitude of minimum shift keying (MSK) modulated narrow band signals. There are number of transmitters world wide, of which signal is received from 7 at SANAE IV. Because of SANAE IV's position relative to the global VLF transmitters, signals originating from the east or west travel a great distance over the Antarctic ice mass, as illustrated in Figure~2.23. An overview of transmitters is given in Table~2.3. These transmitters have been chosen base on the propagation path from Tx to Rx. Paths are for different science purposes. In general, the signals received from these transmitters will change in a semi-predictable manner throughout the day (during the diurnal cycle), however, certain space weather events such as solar flares will have an immediate effect on the MSK signals. %This manual describes the operations of UltraMSK on a VLF system at the SANAE IV base in Antarctica (71° 40'S, 2° 50'W).

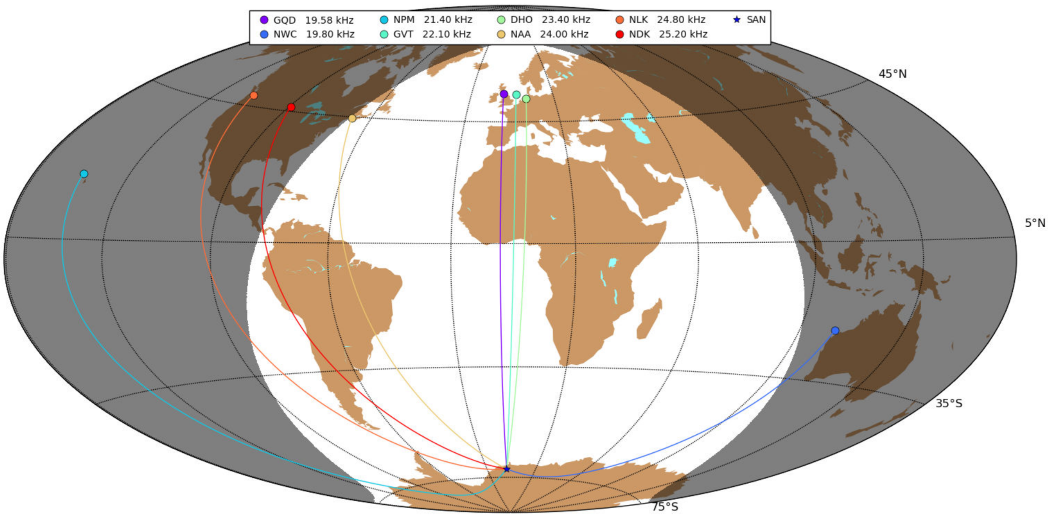


Figure 2.23: Great circle paths from various minimum shift keying transmitters to SANAE IV.

UltraMSK is installed in parallel with the WWLLN System on the same PC. A magnetic loop antenna located a few hundred meters from SANAE IV was used for this purpose. The antenna consists of two vertically mounted diamond shaped loops with sides of length 7.6 m, aligned with the four cardinal directions. The loop facing north–south is a better choice for monitoring signals of European origin, whereas the east–west loop is more sensitive to signals propagating zonally.Figure~2.22 shows a schematic of the UltraMSK system. A preamplifier at the base of the antenna boosts the signal, which is transmitted to the laboratory via a lengthy coaxial cable. The signal is passed through a second amplifier before reaching the service unit. From here the signal is transferred to the sound card on a personal computer. The service unit also integrates GPS timing. The phase of the signal is determined by a quadrature-phase mixer, where the received signal is split and mixed with an in-phase component on one hand and a quadrature-phase component on the other. After the signals have been demodulated, the two components can be compared and information regarding the phase and amplitude of the signal can be extracted. In order to achieve a reliable centre frequency for the quadraturephase mixer, the precise sampling frequency of the sound card is calibrated using the pulse-per-second signal from the GPS. The system runs at a sampling rate of 96 kHz, and the signal intensity and phase are recorded at 20 Hz. UltraMSK is a VLF narrowband receiver designed to measure both the amplitude and phase of modulated VLF signals. Data from several M-class and C-class solar flares illustrate the response of the instrument, and from these measurements the characteristics of the D-region can be modelled. Energy exchange between the magnetosphere and the surrounding solar wind is a continuous process which is enhanced during periods of increased solar activity. Coronal mass ejections and solar flares release an enormous number of highly energetically charged particles which are transported through the solar wind to Earth. These particles are accompanied by X-ray bursts, which are harmful to satellites, spacecraft and astronauts. These events have an appreciable impact on the Earth's ionosphere. This radiation penetrates down into the lower ionosphere and leads to sudden ionospheric disturbances.12 Solar flares cause a broad increase in plasma density in the dayside ionosphere, which in turn affects VLF signals propagating in the EIWG Figure~2.24.

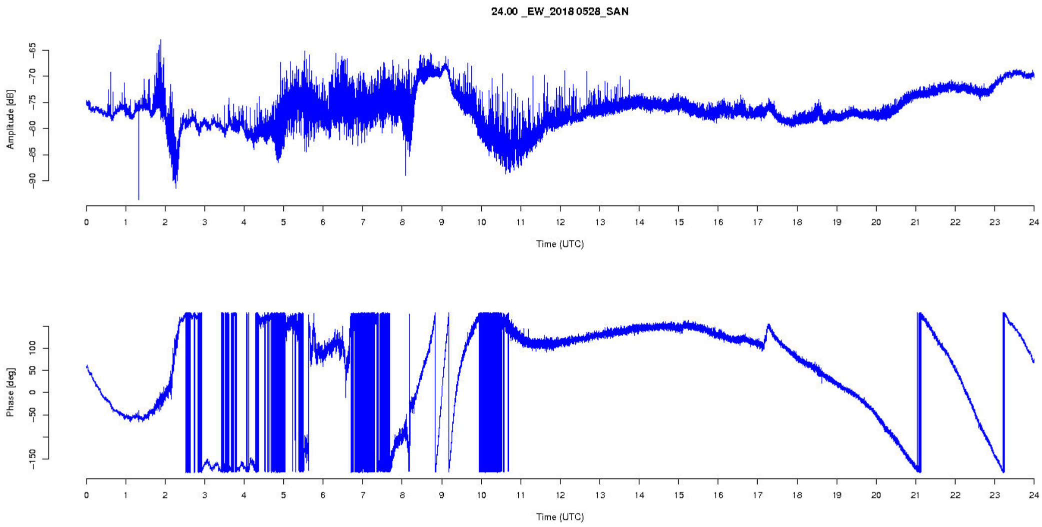


Figure 2.24: Solar flares.

The attenuation of the signal is higher during the day as a result of the lower conductivity of the D-region compared to the E-region at night. The average daytime signal amplitude is about –65 dB, compared to –57 dB at night.

### UltraMSK Daily Checks

- **sferix@Vito** ~**: $ ps ux | grep msk**\ To check that all msk frequencies of raw data are running
- **Verify that the daily email has been sent:**\ In WinSCP open "/home/sferix/ultramsk/ultramsk_bin.tx and verify that the email was sent successfully. Log should read as follows:\ Sending email...\ Bash file report-ultramsk-bin_mutt.sh exited at: Wed Aug 22 04:10:01 UTC 2018\
- Check the attached .png files on the sent email, for solar flares activities

### Troubleshooting

- UltraMSK narrowband software are running and will automatically restart whenever the PC powers up or reboots. After rebooting, run this command: **ls -l *20180824*.bin** , to see if all the 14 msk frequencies are recording data.
- If there is no email sent from UltraMSK though the script has been automated, then you can run script manual as follows: $ cd /home/sferix/ultramsk/\ $ ./report-ultramsk-bin_mutt.sh

## UltraMSK Useful Linux Commands

- **/sbin/reboot:** Reboot computer
- **ntpq -p:** Checks NTP server for accuracy.
- **ps aux | grep toga:** checks if the Toga processes is running.
- **ps aux | grep msk:** Instances of different frequencies running.
- **vim /home/sferix/ultramsk/report-ultramsk-bin_mutt.sh** - Mail script for adding or removing email address.

## UltraMSK System Information

### Contact Details

- **Contact person:** James Brundell
- **Email:** jbrundell@gmail.com

### Computer Details

- **OS:** Linux CentOS release 6.7 (Final)
- **IP:** 192.168.1.71
- **Username:** root
- **Password:** ultramsk001

### UltraMSK Gmail Email Detail

- **Host:** smtp.gmail.com
- **Email Address:** sanae.physics@gmail.com
- **Password:** whistlers789

### Data Details

- **Data Directory:**/home/sferics/ultramsk/data/
- **Data Type:** .bin(binary files)

- **Size:** 1.8MB/file per frequency per day.
- **Naming Format:** frequency_YearMonthDay_SAN.bin e.g 24.00_SAN_NS_20180421.bin
- **Notification:** Spectrogram report via email. Daily .png: On server pc.
- **Transfer:** return to South Africa after each summer voyage.
- **Backups:** Data is backed up data to NAS.

**Software Details**

- **VT Card:** Audio server splitting audio input between WWLLN and UltraMSK
- System has been configured to restart both the WWLLN & ultramsk software on reboot.

**Auxilliary Programs**

- **NTP**: Network time protocol server using the GPS time (GPS_NMEA) as favourite

# 3 Infrastructure

## 3.1 VLF Mask Design

Figure~3.1 below, shows where VLF Antenna is placed.

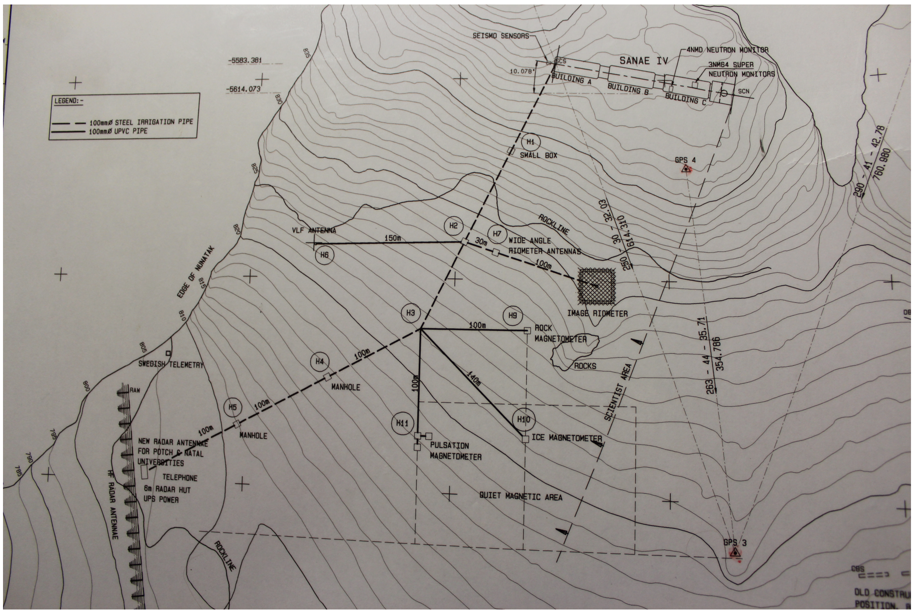


Figure 3.1: VLF SANAE Site map

The VLF mast is constructed from 5 aluminum tubular sections bolted together to form a mast of 12.8 meters high with 4 stayropes positions, hinged on a metal plate as shows on Figure~3.2. All mast measurements were based on a multiplication factor of 3 (eg 400 pixel mast height multiplied by 3 equates to a 1200cm). Scaled distance to support base is based on a scaling factor of 6 (eg mast center to external loop support post is 450 pixels multiplied by 6 gives 2700cm).

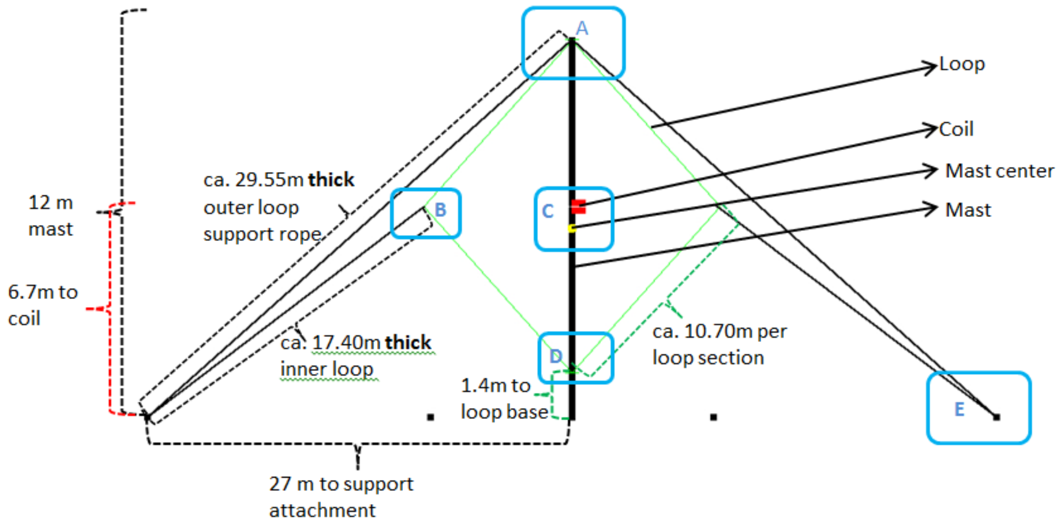


Figure 3.2: VLF Mast Diagram

## A - Top of Mast


Figure 3.3: 4 "D" Shackles for 15m stayropes

### B - Mid-Upper Thick rope

Figure 3.4: Mid-upper thick rope – 12.94m

### C & D- Mid and Lower Thick rope

The hole in this attachment for calibration coil to run through.This is in both C and D layers as they look alike on the connection of the shackles.

Figure 3.5: Mid-lower thick rope – 10.46m and lowest thick rope – ca. 9.6m

**E - Pivot mast base**

Figure 3.6: VLF Antenna Pivot mast base

### F. - Stabilisation rope connector

Figure 3.7: VLF Antenna Mast Stabilisation rope connector

## 3.2 VLF Hatch

The VLF hatch is next to VLF antenna outside the base at the science area.The loop antennas are channelled inside the hatch, where they are connected to the vlf preamp. The hatch is supported by stayropes, to stabilize it during the heavy winds and storms. The hatch was constructed using wooden materials.

Figure 3.8: VLF Hatch

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## 3.3 VLF Rack

The VLF rack is at Physics upper Lab 2, inside the base. That's where all VLF system projects are.

Figure 3.9: VLF Rack

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# 4 VLF Hardware

All VLF based projects in the SPRI system have a similar stage design. The stages consists of North-South and East-West Loop Antennas, pre-amplifier, band receiver, power supply and systems data logging machines. On this section we will look on the antennas, pre-amp, receiver and power supply. The data logging systems will be discussed on the next chapter. The illustration can be seen in the figure below

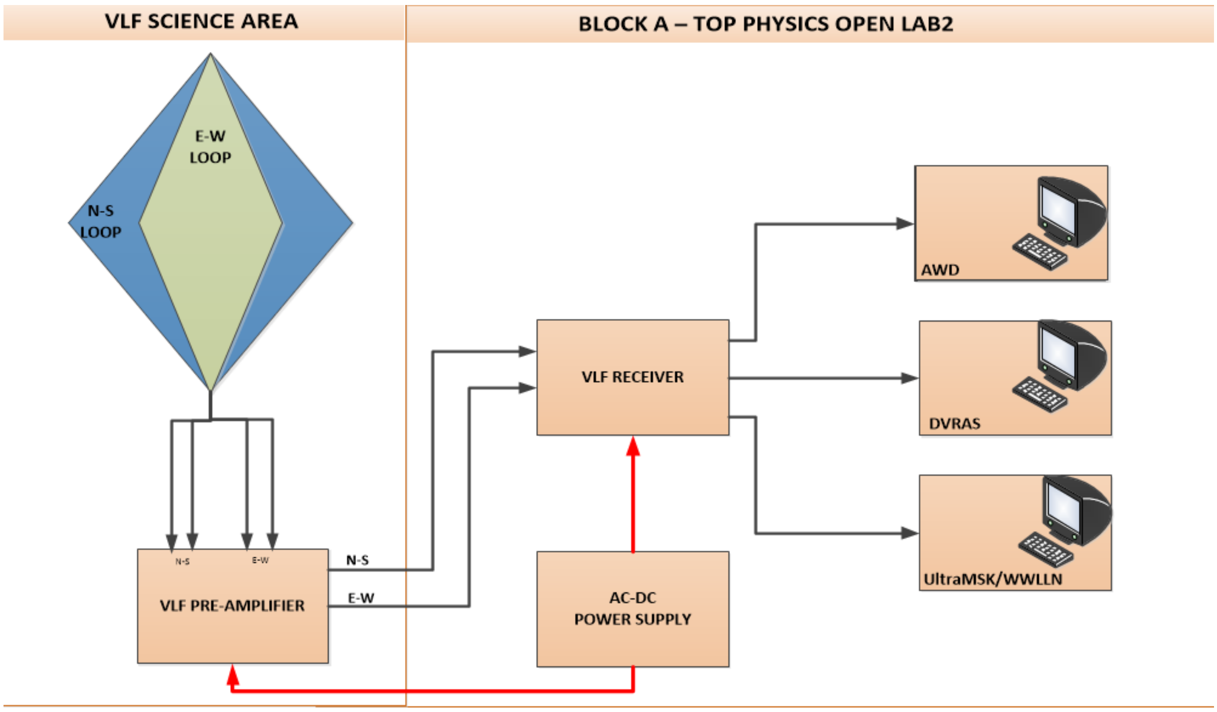



Figure 4.1: VLF System Diagram

## 4.1 VLF Loop Antenna

The purpose of this guide is to give basic instructions on how the loops of for the large loop VLF mast are to be constructed. The information in this guide is taken from the "VLF goniometer system for SANAE, Antarctica" instruction manual by A.J. Smith, and from personal experience. **Required material:** Please note that the amounts listed here are per single loop. Two would be needed per set for the mast.

**Construction** The construction of a loop will be described through the use of the picture below, following the order as indicated by the red circles and numbers. Take note of the distances of the sides as indicated on the sketch during construction

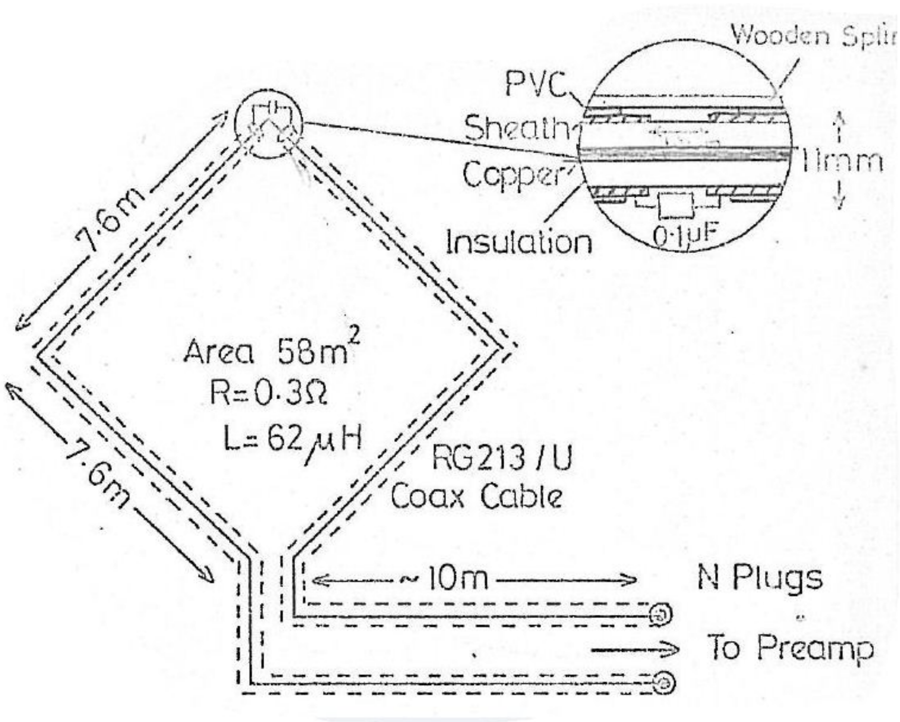
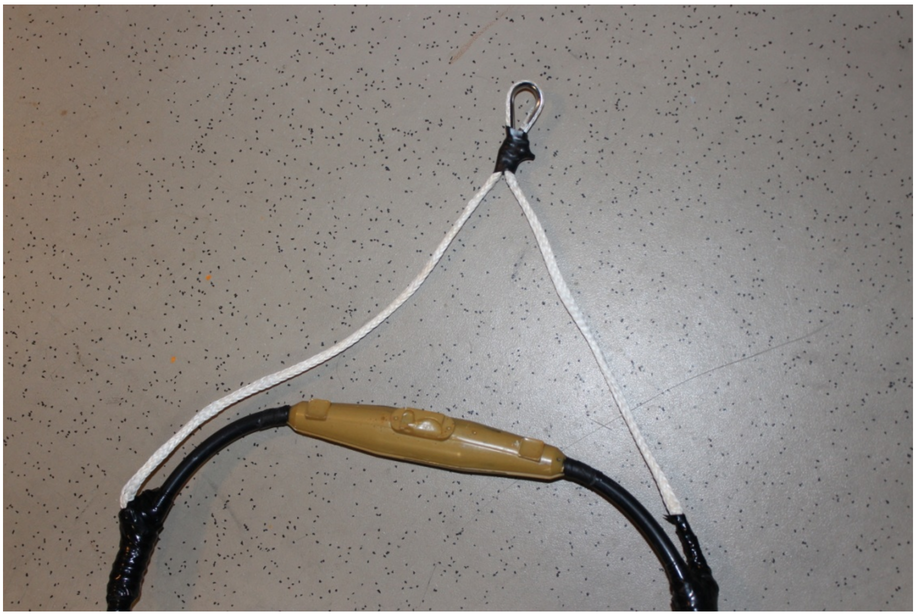



Figure 4.2: Schematic for VLF loop construction

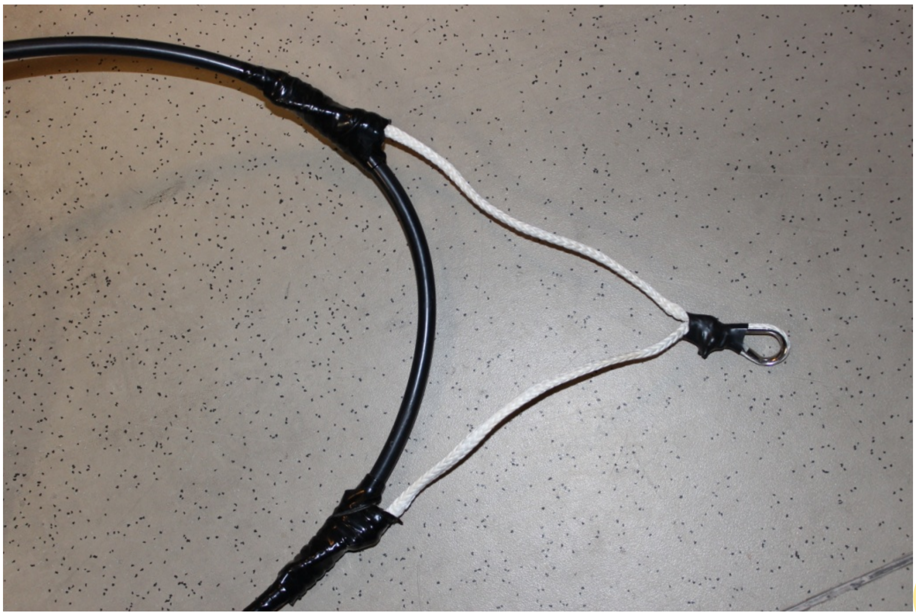
**Point 1** Gap capacitor - At the top of the loop (middle of the 50m cable), take off a short portion of the insulation (around 50 mm) and make a cut through the outer copper sheath in the middle of the exposed section. Make the copper sheath on both sides of the cut into bundles and solder the capacitor between these two points. Cover the area with insulation tape if so desired and then use a resin joint cut to seal and strengthen the capacitor area. Top loop suspenders – With the use of the rope, thimble, U bolt clamp and tape construct a suspender for the top of the loop, as seen in the picture below.



%

Figure 4.3: Schematic for VLF loop construction

**Point 2** Top loop suspenders –At the points 7.6 meters from the centre of the loop, construct the side suspenders of the loop, as per the method followed at point 1. The second picture below shows how the side suspenders are used to achieve the diamond shape of the loop.



%

Figure 4.4: Schematic for VLF loop construction

**Point 3** Bottom loop connectors –At the points 7.6 meters from the centre of the side suspenders, the bottom loop connectors are attached to the mast, with the use of round disks. These disks may be constructed from plastic or aluminium disks (only non-magnetic materials), with a groove around the outer edge to guide and hold the rope. The outer diameter of the disk shown below is 40 mm, but this is not an important measure. The diameter of the hole through the disk is 10.7 mm. This hole must be between 10.5 mm and 11 mm.


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Figure 4.5: Schematic for VLF loop construction

**Point 4** N-type connectors – Connectors at the ends of the loop connect it to the instrument. The reusable screw type connectors are suggested.

**VLF Loop Antenna Troubleshooting** The loops should be located as high as possible on the mast and NOT be pulled tight as this will cause vibrations on the loops and damage to the loops. The stay ropes of the antenna mast should remain tight and to aid in tightening these stay ropes the best technique was found to insert an alpine butterfly above the alpine butterfly made for the trucker's hitch and use a winch to tighten the stay rope. Once the winch has pulled the stay rope as tight as desired the trucker's hitch can be tightened and secured where after the winch is released. Do this procedure on both sides of the mast preferably at the same time as to not cause the mast to lean to one side or the other. After heavy storm, it's advisable to go to sciences area to check if there's the loops are in good conditions. Adjust stay ropes where it's necessary.

## 4.2 VLF Preamplifier

The VLF pre-amplifier is adjust to the gain on the received signal from the antenna.The preamplifier contains filters, amplification and balanced signal output for driving long cable runs.The preamplifier unit is mounted outside, and place inside the VLF hatch next to VLF Loop Antenna. There are two coaxial cables running from the VLF hatch to Base Physic Labs. The cables represent N-S and E-W loop Antenna.

## 4.3 VLF Receiver

The VLF Receiver uses the low pass, high pass and/or band pass filters depending on the particular projects. This is where the VLF signal from both Loop antennas are distributed to VLF Systems.

## 4.4 VLF Power Supply Unit

The VLF power supply unit is converting 230/240V AC supply into +15V and -15V dual DC supply output, thus fed to the VLF preamplifier and receiver. There is electrical wire that is running from the Base Physics Lab to VLF hatch to power the preamp.

%

## 4.5 VLF Systems Hardware

### DVRAS

The DVRAS system are made up of the following hardware:

- LG PC
- Dummy Antennas
- Brunton Compass
- VLF Mirror

### AWD

The AWD system are made up of the following hardware:

- Four PC's
- VR-2 Sampler

### WWLLN & UltraMSK

The WWLLN & UltraMSK systems are made up of the following hardware:

- Supermicro PC
- Delta Soundcard
- GPS Time receiver and Service Unit.

### Shared Electronics Devices

- Monitor
- Keybiard
- Mouse
- 4Ports USB Console KVM Switch

%

# 5 VLF Systems Software

## 5.1 DVRAS Software

The software consists of low-level modules written in C and C++, glued together by Python scripts. This strategy was adopted to allow high efficiency for time-critical portions of the system and to facilitate extension of the code to include additional features. The system software is designed to operate on a Linux platform. Data from the signal conditioner is digitized by the computer's sound card and recorded as 8-bit samples at a nominal sampling rate of 20 kHz. The dynamic range obtained with 8-bit samples is 48 dB. The data are stored in a common digital audio file format with additional information (station name and data epoch) appended as an extra header record. The choice of a common audio file format was motivated by the fact that it would allow sample playback on most computer platforms. The space required to store 1 minute of two-channel data sampled at 20 kHz is 2 400 072 bytes. Compression of the data results in a 50% reduction of file size on average.

**Software Details**

- **dvrecord.sh:** Recording script for new DVRAS
- **dvreport:** Quicklook generator from database

**Data Analysis Software**

- **Audacity**\ Audacity (`http://www.audacityteam.org`) is an open source audio analysis program. It is available for Linux, Mac OS and Windows.

%

## 5.2 AWD Software

AWD system consists of two main parts:

- data collecting module
- AWD software modulege

Data collecting module is started through init system upon PC boot. There is a user level rogram called driver, it communicates with VR2 upon startup and during data logging, it writes data to disk. It opens a file in every hour. The filename contains date and time info based on system (PC) time. This is just an approximate time of the first sample of file, the exact times can be found at each frame header. Each file is closed when round hour is reached and a new one is immediately opened. The justclosed file is then processed by AWD. If no other purpose, it is deleted after processing to save disk space. Parallel port kernel buffer is read periodically and because frame size and buffer size are not the same, a hourfile may not start on frame border. AWD is run periodically by crontab, usually crontab starts AWD at 5th minutes of every hour through a script :

```
[root@wds ~ (sanae)]# crontab -l
5 * * * * /u/sanae/vr2/rec_vr2_60_bc>>/u/sanae/vr2/rec_vr2_60.log 2>&1
30 00 * * * /usr/bin/rsync -avH --exclude=filewrite/ --exclude=tmp_NAS_transfer/ /u1/sanae/vr2/  /u2/sanae/vr2/ >&/u/san
ae/rsync_u1.log
#copy all AWD files for previous day into a temp folder
#01 00 * * *  find /u1/sanae/vr2/wh_vr2_rt/ -mtime -1 | xargs cp -apt /u1/sanae/vr2/tmp_NAS_transfer
01 00 * * * /root/bin/DataTransferToTMPNasFolder.sh > /root/bin/log/DataTransferToTMPNasFolder.log

[root@wds ~ (sanae)]#
```

Figure 5.1: AWD Crontab snapshot

The full data file thus can be saved/moved by appropriate modification (replacing the last line with other command) of this script.

## 5.3 WWLLN Software

The software for each WWLLN station was developed by Dr. James Brundell and the TOGA (time of group arrival) methodology was developed by Dowden and his team [Dowden et al., 2002]. This software functions as follows: The VLF electric field is sampled at ~48kHz. When the difference between two consecutive samples exceeds a given threshold level, a 64-sample waveform is saved to short-term memory to be analyzed. This waveform consists of 16 pre-trigger data points and 48 post-trigger points. When a sferic waveform is captured, the software determines the time of group arrival (TOGA) of the group energy for that sferic. The reason the TOGA method was developed was because the sferic waveform becomes dispersed during its propagation of often thousands of kilometers in the Earth-ionosphere waveguide. Thus the trigger time does not necessarily indicate the time of arrival of the group energy. If the wave is extremely dispersed, the arrival of the group energy will occur later than the trigger time.

**Software Details**

- TOGA - Time Of Group Arrival
- sferix 1567 8.0 1.1 124256 92484 ? Sl Jul11 5624:43 toga -s 48 -V @raw:2,1 -j 1 -a 3 -g -o -20.8 -R /home/sferix/R-files/ -t 128.208.22.18, and software restart after reboot.

%

## 5.4 UltraMSK Software

The system has been configuresd to restart ultramsk software on reboot. **@reboot /home/sferix/ultramsk/ru ultramsk.sh**

# 6 Grafana Monitoring and Faulty Reporting

## 6.1 Grafana Data Live Monitoring

The primary goal is to monitor instrumentation data live to enable quick response time to resolve problems as they occur. Data is therefore captured live at the source which is in most cases the instrumentation data logger. It is transmitted over Ethernet to the Grafana PC where the data is then saved in a SQL database. The InfluxDB allows quick access to the data which can then be displayed according to the data type of the instrument at hand. The Grafana PC is accessible through any of the PCs on the local network and at Harmanus through the external IP assigned by the DEA allowing the engineer on base to easily keep an eye on all the systems.

The VLF systems are configured to be monitored on the Grafana Dashboard. To view the instruments activities, use the URL given. The VLF Grafana logging details are as follows:**username = VLF & password = @sansa2016**

**DVRAS Grafana Dashboard**

`http://172.17.30.26:3000/d/000000033/dvras?orgId=1`

**AWD Grafana Dashboard**

`http://172.17.30.26:3000/d/000000030/awd-pc-status?orgId=1`

**WWLLN Grafana Dashboard**

`http://172.17.30.26:3000/d/000000035/wwlln-new-pc?orgId=1`

**UltraMSK Grafana Dashboard**

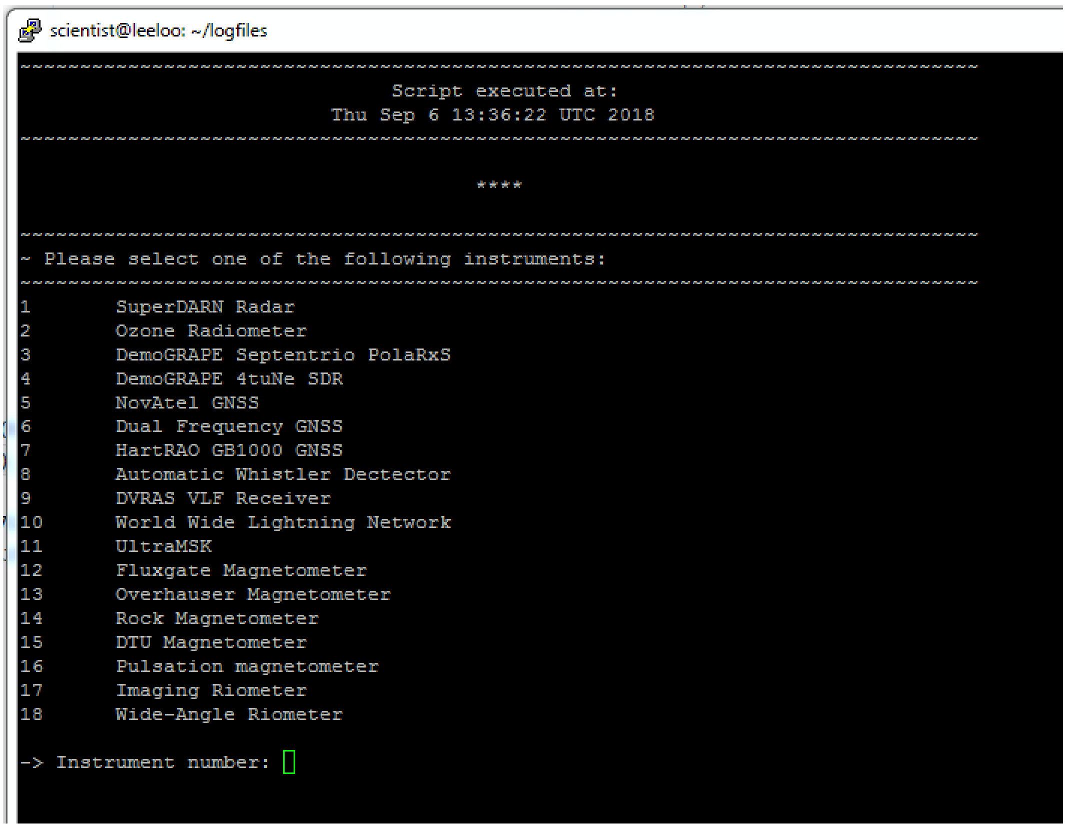
`http://172.17.30.26:3000/d/000000064/ultramsk-pc-new?orgId=1`

## 6.2 Faulty Logging Reporting

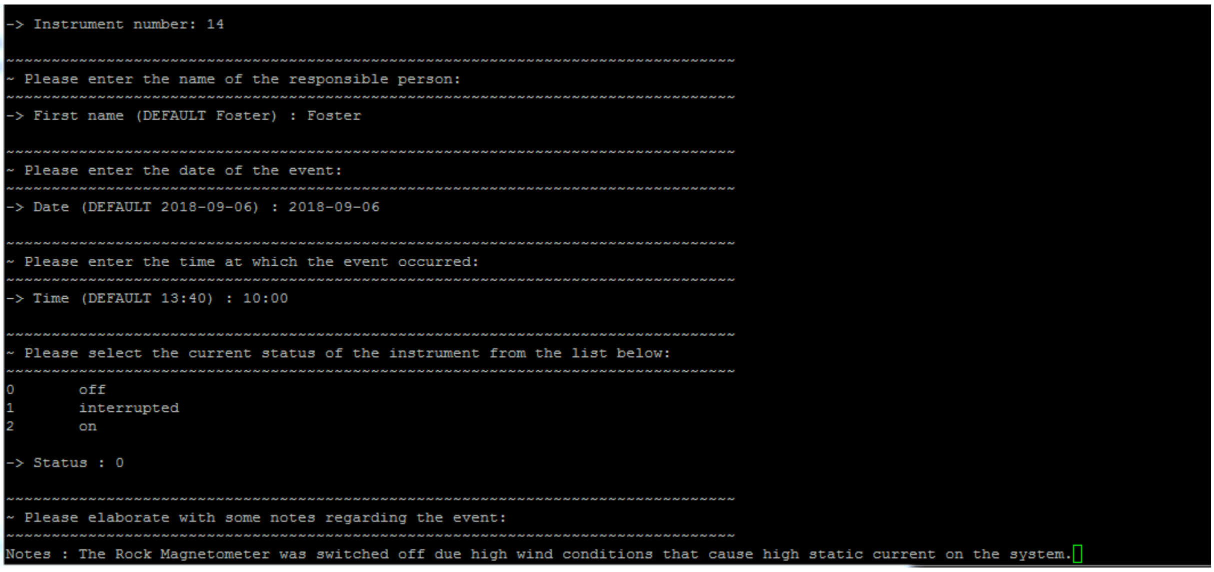
The VLF systems are expected to run 24hours a day for 365 days of the year but due unforeseen reasons the systems turn to be switched off for maintenance that include serious damage to the loop antenna, hardware problems or antenna maintenance.These reasons need to to recorded, when did it happen, what time when it happen and how long did the fault lasted. All this information are require to keep track of the instrument performance and up-time; as well for monthly reporting. The two scripts were developed on the Scientist Machine, which help to log any system interruptions The first script is **log.sh**, it is used to log instrument fault event, while the second script **del.sh**, is used to delete a fault event in case of error happened while logging e.g typing error.

**How to Log a system interruptions or fault:**

1. Use PuTTY Login on Scientist : username:scientist and password:5*element
2. Change to the Logfile Directory: $ cd /home/scientist/logfiles/ and $ ls
3. Run log.sh script : ./log.sh The menu will appear on the screen with list of the all SANSA SANAE instruments, refer below



4. Select the number next to the instrument wish to log an event, e.g for UltraMSK : Instrument number: 11, you will type 11 and Press ENTER after typing.
5. It will ask you to type your name:"'Please enter the name of the responsible person:Foster"', Press ENTER after typing your name.
6. "'Please enter the date of the event:"', the date of when the event happened
7. "'Please enter the time at which the event occurred:"', starting time of the event.
8. "'Please select the current status of the instrument from the list below:"',The status can be represented by any of the following three values:
   - 0 - The system is off and not generating any data.
   - 1 - The system is on and generating data, but may be affected by some form of interference.
   - 2 - The system is on and generating data normally.
9. "'Please eloborate with some notes regarding event:"', give full details of event, what real happened ?



```
-> Instrument number: 14

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
~ Please enter the name of the responsible person:
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
-> First name (DEFAULT Foster) : Foster

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
~ Please enter the date of the event:
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
-> Date (DEFAULT 2018-09-06) : 2018-09-06

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
~ Please enter the time at which the event occurred:
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
-> Time (DEFAULT 13:40) : 10:00

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
~ Please select the current status of the instrument from the list below:
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
0       off
1       interrupted
2       on

-> Status : 0

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
~ Please elaborate with some notes regarding the event:
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Notes : The Rock Magnetometer was switched off due high wind conditions that cause high static current on the system.
```

To close the event, repeat all the steps from 1 - 7, then "'Please select the current status of the instrument from the list below:"',The status can be represented by any of the following three values:

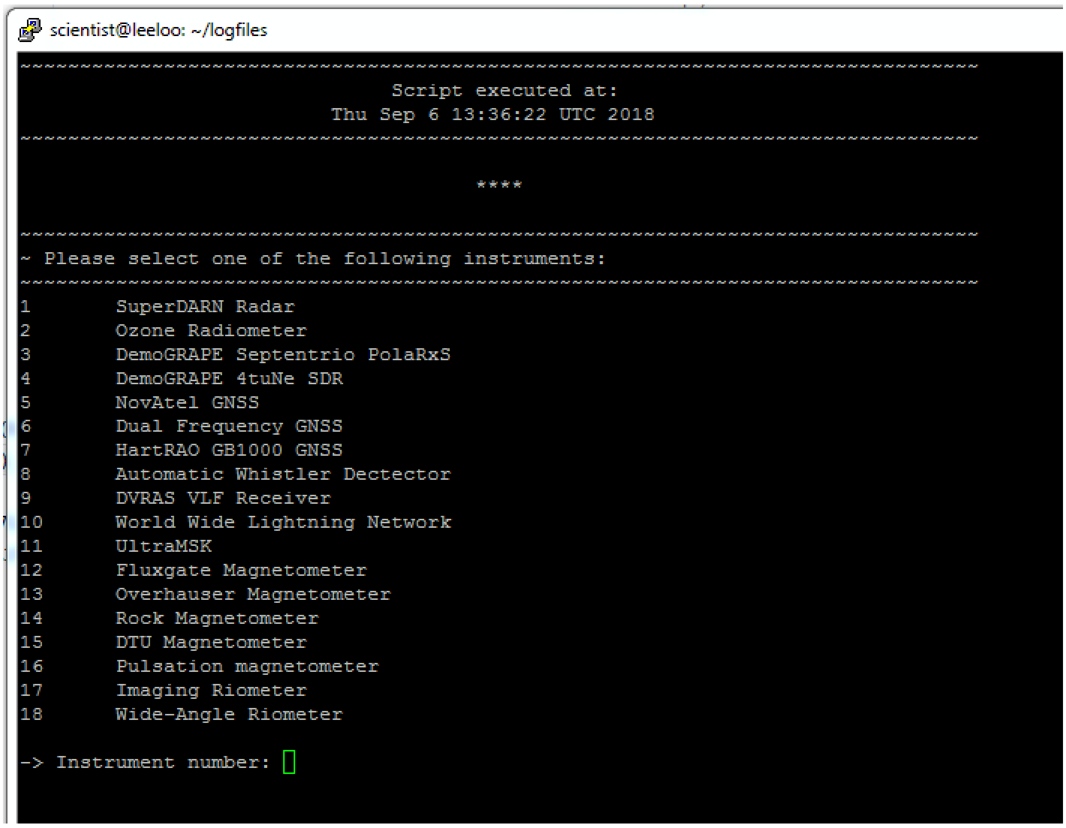
- 0 - The system is off and not generating any data.
- 1 - The system is on and generating data, but may be affected by some form of interference.
- 2 - The system is on and generating data normally.

**NB: This is done after maintenance of the system is completed.**

### How to delete a system's event

If it's happned that you have entered incorrect information, the **del.sh** script can be used to deleted wrong system event as follows:

1. Use PuTTY Login on Scientist : username:scientist and password:5*element
2. Change to the Logfile Directory: $ cd /home/scientist/logfiles/ and $ ls
3. Run del.sh script : ./del.sh The menu will appear on the screen with list of the all SANSA SANAE instruments, refer below




4. Select the number next to the instrument wish to log an event, e.g for UltraMSK : Instrument number: 11, you will type 11 and Press ENTER after typing.
5. "'Please enter the date of the event:"', the date of when the event happened
6. "'Please choose the activity you want to remove from the list below:"'

```
-> Instrument number: 14

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
~ Please enter the date of the event:
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
-> Date (DEFAULT 2018-09-06) : 2018-09-06

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
~ Please choose the activity you want to remove from the list below:
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

--------------------------------------------------------------------------------
Index   Time    Person          Status          Description
--------------------------------------------------------------------------------
1       10:00   Foster  off             The Rock Magnetometer was switched off due high wind conditions that cause high static current on the system.
2       13:20   Foster  on              The high wind conditions subsided and the instrument resume normal operation
--------------------------------------------------------------------------------

-> Index of activity to be removed : 2
```

# 7 Conclusion

The manual was compiled base on the previous training manual and it gives short theory of each VLF systems. The manual can be update where it's necessary.