Setup of "Spectrum Lab" and "GPS2Time" SW for the suggested VLF/LF receiver.

First, download the latest version from [Here.](#) Unzip, and run the setup program (InstallSpecLab.exe), when finished, run SpecLab. Load configuration setting provided "ACH_20211122.USR" through *File – Load setting from…* And…. Done.

Another way is to configure manually the options to start receiving signals. First of all software must connect to the right soundcard. From options we open the Audio I/O card (Figure 1).

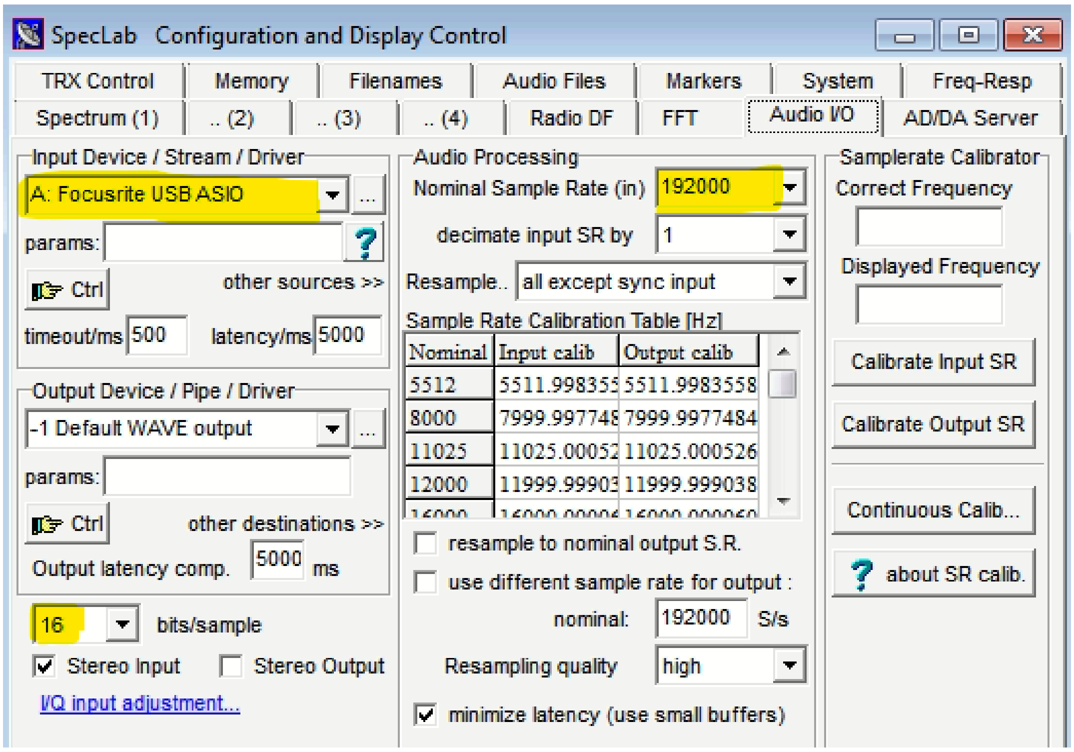


Figure 1 Sound I/O card.

We must choose the low-noise external sound ard. In our case, for the ACH station the soundcard is the Focusrigth USB Asio. If the sound card is referred to by two similar names, one must try both, to determine which is the right one. We use both audio channels, the left is connected to the antenna, and the right channel to the 1 PPS pulse from the GPS receiver. Soundcard sample rate must set it to 19200 Samples/sec.

Then we must configure FTT (Figure 2). *Real FFT, starting at 0 Hz (audio)* is chosen for FTT input, and the source is *L5* (the input of the analyzer and data record after processing the signal).

From FTT properties we choose the higher FTT input size for lower equivalent noise. The relation between this parameter and the minimum sample time is reported in an info window at the bottom of the same card. If is essential for higher sample rates, the FFT length must be lower according to our needs.

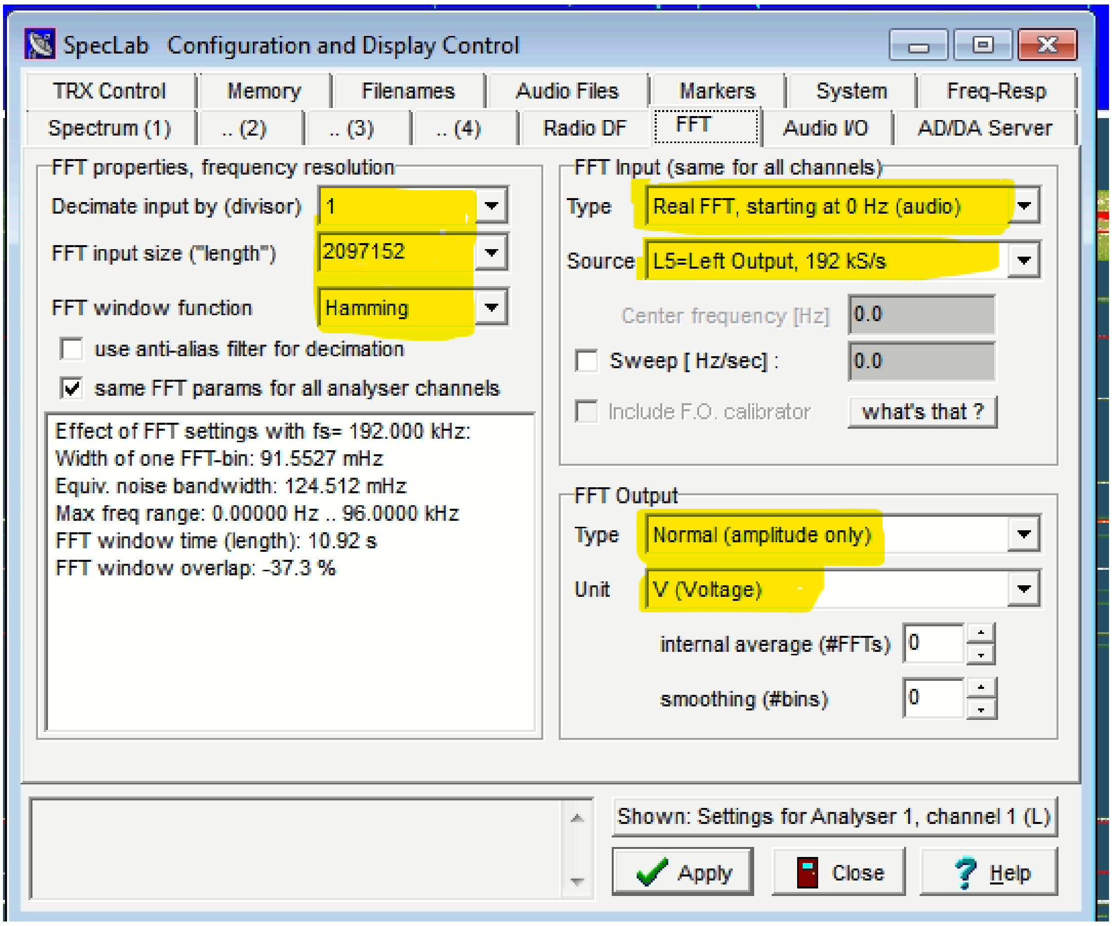


Figure 2 FFT configure card

It's up to our needs to report readings as Volage, power, percent, or dB, through the *FTT Output setting.*

Next comes the display settings. The way signals appear on to screen affects the data record. Spectrum settings are split into four cards. In the first (Figure 3) card we set the way the spectrogram (Waterflow) is running, what information appears on it, and the refresh rate, which is the same as to sample rate (for convenience reasons). At the bottom of the spectrogram, we can enable time info. This is useful as there is the ability to save periodically spectrograms for an easy and quick later view of spectral conditions.

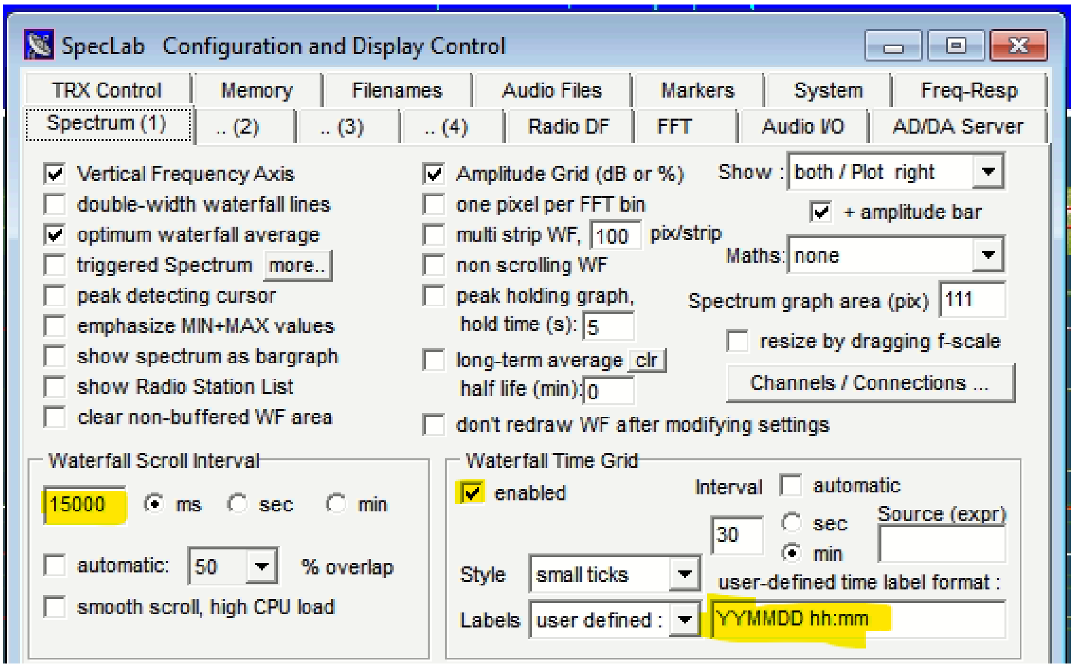


Figure 3 Spectrum card no 1

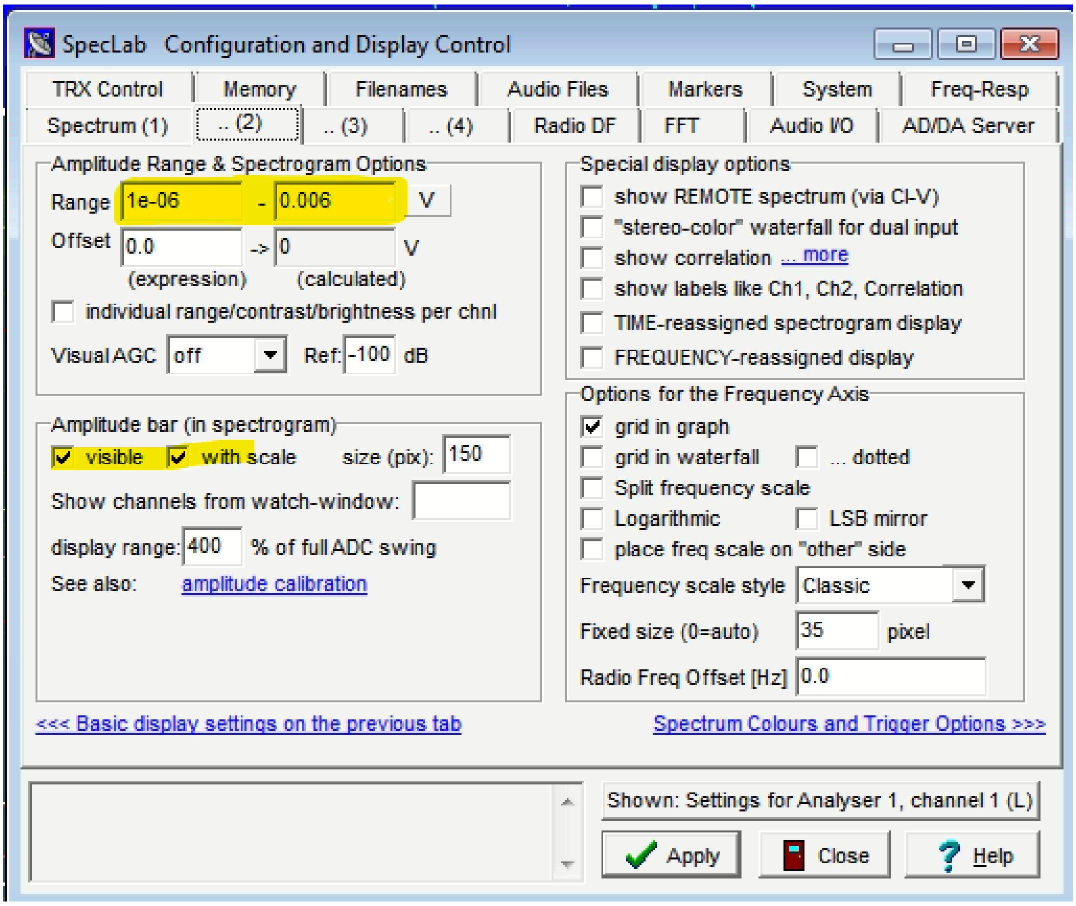


Figure 4 Spectrum card no 2

In the fourth spectrum card, we are set visual limits of signal strength and the option an amplitude bar to appear at the top of a spectrogram (Figure 5)

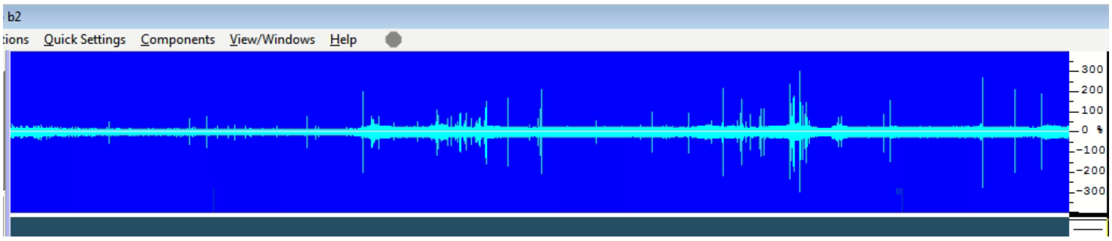


Figure 5 Amplitude Bar

At this point, SpecLamp can receive and display signals of VLF/LF frequencies up to 90 kHz. Next step is to improve accuracy.

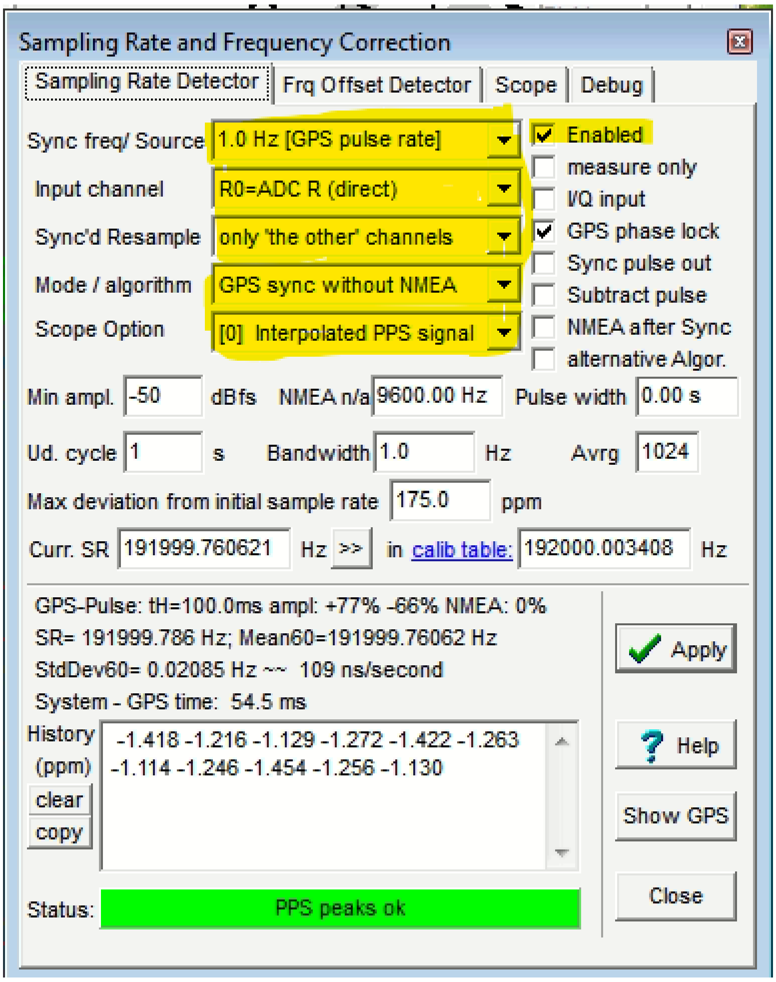


Figure 6 sampling rate and frequency correction configuration

Recording of an 1 PPS pulse from a GPS receiver is necessary. From *sampling rate and frequency correction configuration* card (chosen from Spectrum Lab Components, SR cal) we set *synchronization through 1.0 Hz, GPS sync without NMEA*. If the GPS can not deliver a 1PPS pulse one can synchronize time by receiving a strong time-station such as RBU or DCF-77. This synchronization is essential to measure the phase variation of the stations. Phase measurements are possible through the *Watch list and plotter* window.

Nr	Title	Expression	Result (Value)	Format	Scale Min	Scale Max
0	WWVB	pam0(60000,CW10,1,L5).abs_phase(10)	54.673	####0.0##	-180	180
1	DCF-77	pam1(77500,CW10,1,L5).abs_phase(10)	-160.861	####0.0##	-180	180
2	SXA	pam3(48999.99469,MSK200,1,L1).phase(10)	189.432 °	####0.0##	-1800	1800
3	RBU	pam5(66666.6666666666,CW10,1,L5).abs_phase(10)	-125.969	####0.0##	-180	180

Figure 7 Watch list and Plotter window

SpecLab can record data for up to nine transmitters, depending on the available processing power of the host PC. Recording is continuing as long as the window is open.

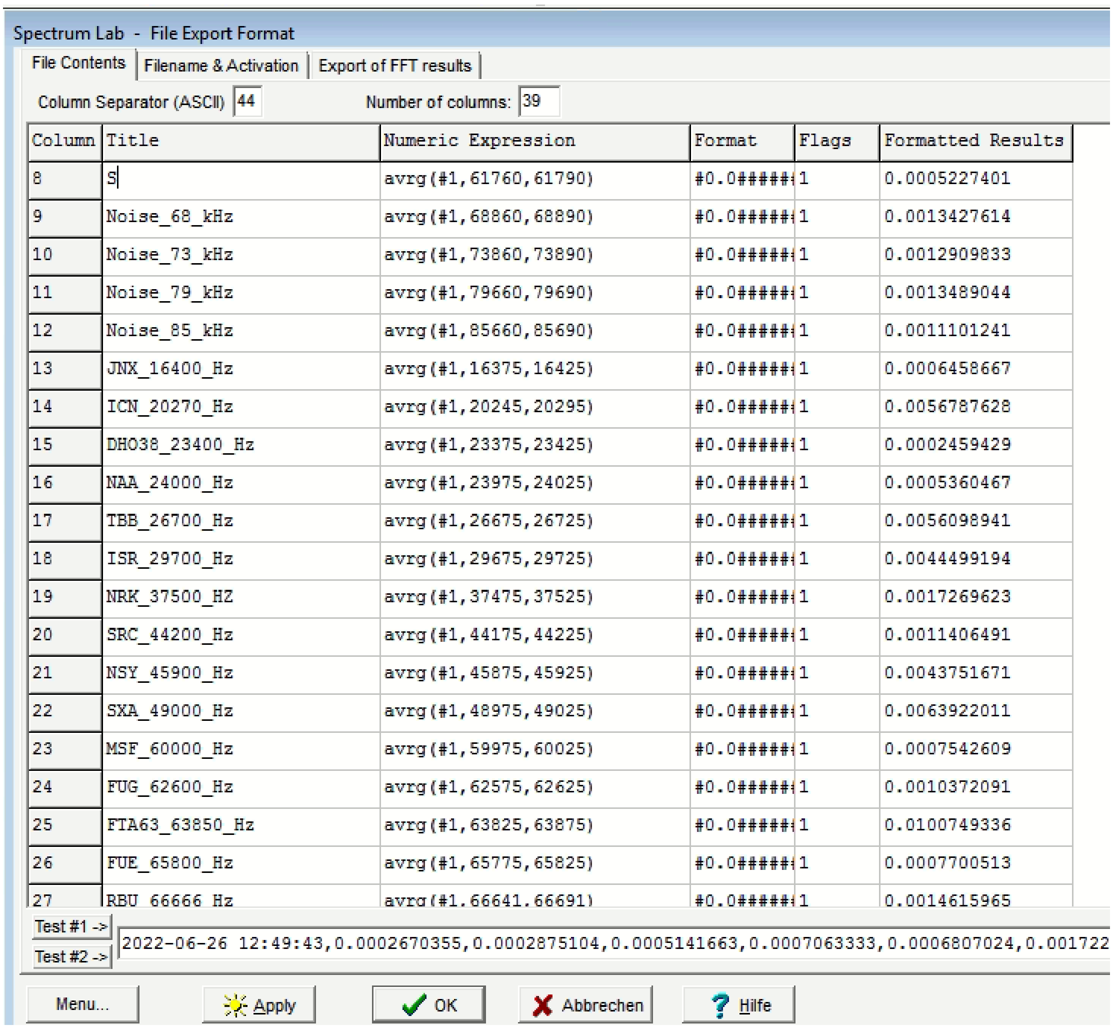
From *export calculated data continuously, we can set, up as to 40 frequency areas for monitoring (*Figure 8*).* The most common expression used is just to record s the (power-) average value in a specified frequency range, other parameters that can be recorded are minimum, maximum, or signal to noise in a range. The syntax is shown in Figure 8.

Plot window data, spectrogram, and calculated data are continuously stored in individual files. Setting periodic or scheduled action, these files can change the name at a scheduled time through *screen capture, Periodic, and scheduled Action* window (Figure 9).

To change plot data use: plot.export (str("YYMMDDhhmm",now)+"_plot.csv")).

To change main data record use: export.start(str("YYMMDDhhmm",now)+".csv")

As all recordings use UTC is easier to change the time zone of the PC to UTC zone.



Spectrum Lab - File Export Format

File Contents | Filename & Activation | Export of FFT results

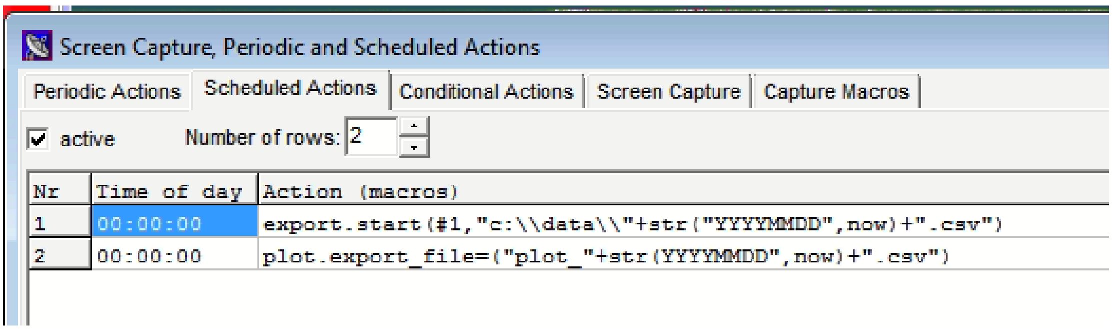
Column Separator (ASCII) 44   Number of columns: 39

Column	Title	Numeric Expression	Format	Flags	Formatted Results
8	S	avrg(#1,61760,61790)	#0.0#####	1	0.0005227401
9	Noise_68_kHz	avrg(#1,68860,68890)	#0.0#####	1	0.0013427614
10	Noise_73_kHz	avrg(#1,73860,73890)	#0.0#####	1	0.0012909833
11	Noise_79_kHz	avrg(#1,79660,79690)	#0.0#####	1	0.0013489044
12	Noise_85_kHz	avrg(#1,85660,85690)	#0.0#####	1	0.0011101241
13	JNX_16400_Hz	avrg(#1,16375,16425)	#0.0#####	1	0.0006458667
14	ICN_20270_Hz	avrg(#1,20245,20295)	#0.0#####	1	0.0056787628
15	DHO38_23400_Hz	avrg(#1,23375,23425)	#0.0#####	1	0.0002459429
16	NAA_24000_Hz	avrg(#1,23975,24025)	#0.0#####	1	0.0005360467
17	TBB_26700_Hz	avrg(#1,26675,26725)	#0.0#####	1	0.0056098941
18	ISR_29700_Hz	avrg(#1,29675,29725)	#0.0#####	1	0.0044499194
19	NRK_37500_HZ	avrg(#1,37475,37525)	#0.0#####	1	0.0017269623
20	SRC_44200_Hz	avrg(#1,44175,44225)	#0.0#####	1	0.0011406491
21	NSY_45900_Hz	avrg(#1,45875,45925)	#0.0#####	1	0.0043751671
22	SXA_49000_Hz	avrg(#1,48975,49025)	#0.0#####	1	0.0063922011
23	MSF_60000_Hz	avrg(#1,59975,60025)	#0.0#####	1	0.0007542609
24	FUG_62600_Hz	avrg(#1,62575,62625)	#0.0#####	1	0.0010372091
25	FTA63_63850_Hz	avrg(#1,63825,63875)	#0.0#####	1	0.0100749336
26	FUE_65800_Hz	avrg(#1,65775,65825)	#0.0#####	1	0.0007700513
27	RBU_66666_Hz	avrg(#1,66641,66691)	#0.0#####	1	0.0014615965

Test #1 -> / Test #2 -> 2022-06-26 12:49:43,0.0002670355,0.0002875104,0.0005141663,0.0007063333,0.0006807024,0.001722

Menu... | Apply | OK | Abbrechen | Hilfe

Figure 8 set frequencies for monitoring



Screen Capture, Periodic and Scheduled Actions

Periodic Actions | Scheduled Actions | Conditional Actions | Screen Capture | Capture Macros

active   Number of rows: 2

Nr	Time of day	Action (macros)
1	00:00:00	export.start(#1,"c:\\data\\"+str("YYYYMMDD",now)+".csv")
2	00:00:00	plot.export_file=("plot_"+str(YYYYMMDD",now)+".csv")

Figure 9 screen capture, Periodic and scheduled Action *window*

Finally, from *Lab Components* one must set DSP filters. It is a graphical interface. Bandwidth and attenuation are chosen, one can normalize all (if possible) the recorded transmitter signals. Every frequency that is not recorded can be highly attenuated, so processing uses less computing power. After the DSP section, a final stage can amplify or attenuate all signals.

User settings and DSP filters can be backed-up and restored by means of TXT-like files, such as the provided “ACH_20211122.USR” and “ACH_20211122.FRS”, respectively.

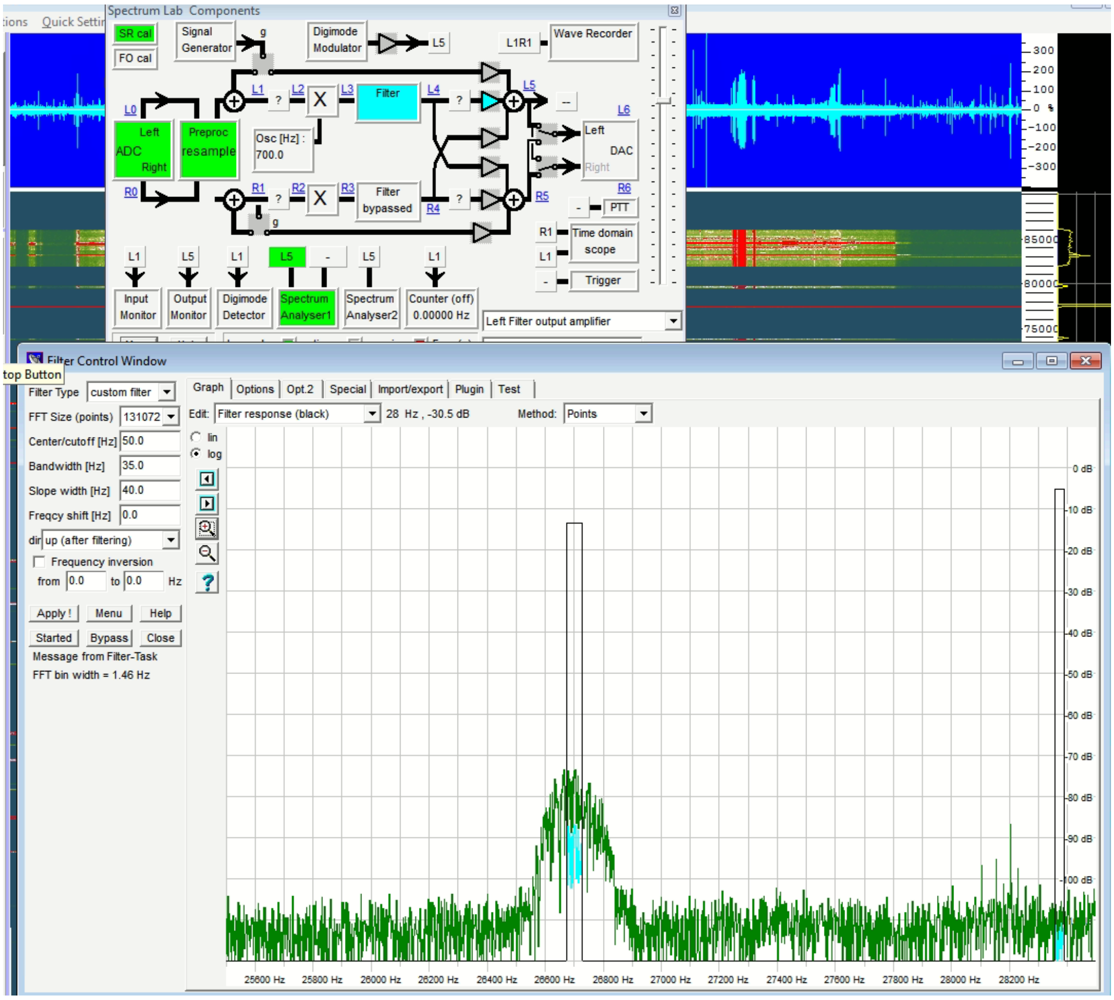


Figure 10 DSP filter set, GUI

GPS2Time free software

An accurate pulse of 1 PPS helps SpecLab to resample sounds card sample rate to exactly 192000 Samples/sec. This is crucial, especially for phase variation measurements. PC’s real-time clock is responsible too for these measurements. It comes to our attention that fixing the accuracy of the PC RTC phase measurement were improved. Using a freeware program called GPS2Time we managed to synchronize RTC using a GPS receiver. The only settings are to run it as administrator and after connecting to GPS receiver one needs to set the update rate to zero. That means that GPS2Time is continuously correcting the PC’s RTC. The suggested VLF/LF recever uses the same GPS receiver for both SW. 1 PPS pulse is applied to the left channel of the sound card, while GPS data are also handled by GPS2Time.