A Front End for a Software VLF Receiver

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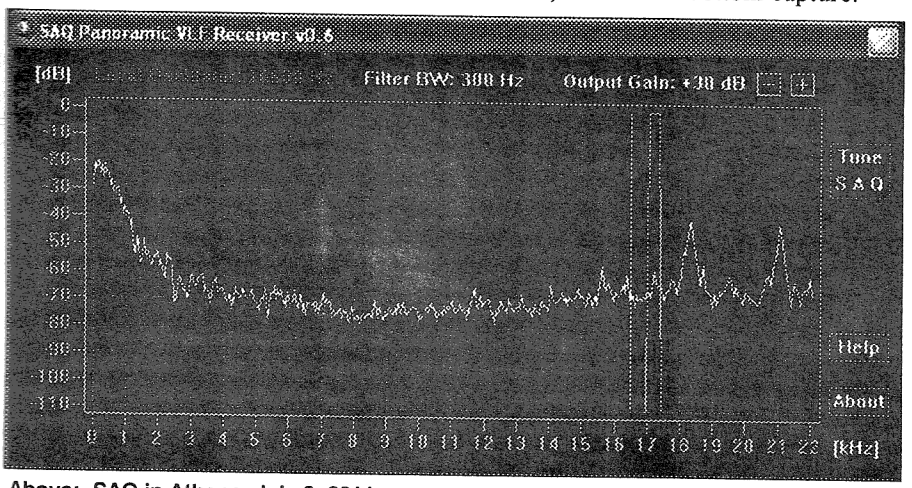
In the August *LOWDOWN* I had the pleasure to report successful reception of one of the annual SAQ transmissions, on July 3, 2011, between 08:48 ("VVV DE SAQ" callup) to the end of transmission at 09:07 UTC. There was a lot of noise, as I installed my receiving setup on the roof of a block of flats in central Athens.

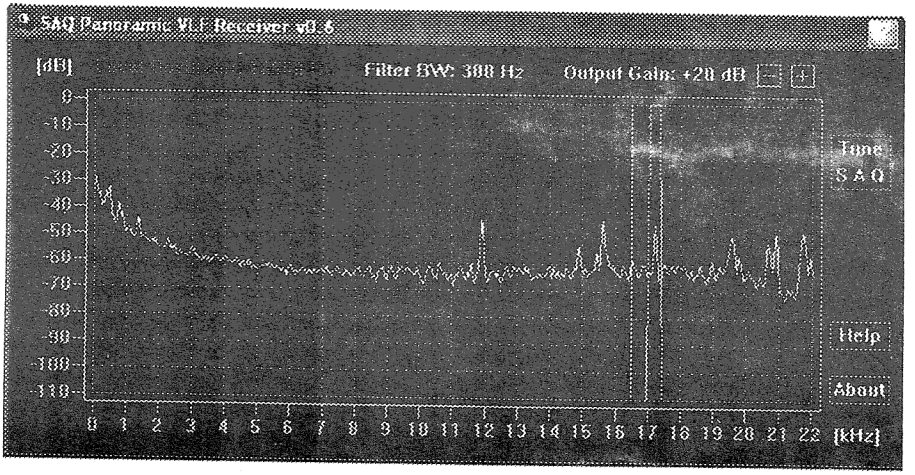
The historic station transmitted again on August 5, with an excellent signal from 0840-0909 UTC. During the long dash sent before the message, SAQ was as strong as any other station between 12 and 24 kHz, seen in the bottom capture.

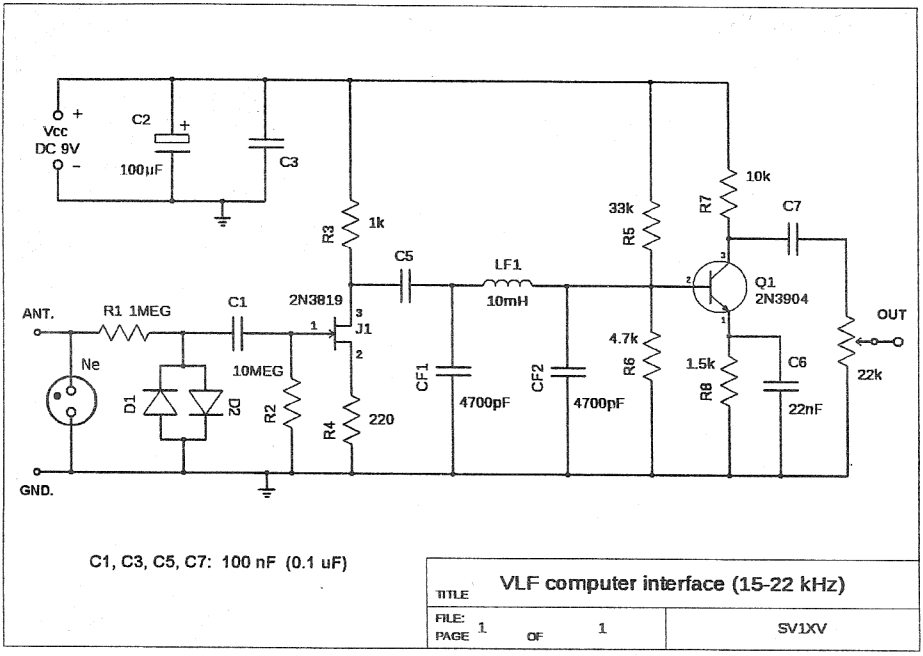


Above: SAQ in Athens, July 3, 2011

Although SAQrx presents a panoramic display, actual reception is by ear, via headphones connected to the sound card's output. The bright vertical line represents the virtual "local oscillator" frequency, and the gray outlined window to its right is the 300 Hz bandwidth to which the receiver is tuned, with SAQ visible at 17.2 kHz. (More about this program at the end.)

Below: SAQ Again, August 5, 2011





Both times, I used a modified BBB-4 VLF receiver as a front end, feeding the soundcard of a Toshiba laptop, which was running Johan Bodin's **SAQ-rx** receiver software. The antenna was an inverted-L, 2 m vertical and 5 m horizontal section.

Steve McGreevy's original sferics receiver design is available for viewing at http://www.auroralchorus.com/bbb4rx3.htm but I have modified the circuit a little for improved reception on 12-22 kHz.

Coil L1 (shown here as LF1) is reduced to 10 mH. It is home made, as I could not find a 10 mH inductor in the local shops.

I removed the original C2 and C6 completely; the former because of its high frequency rolloff, and the latter because it was not really needed for DC blocking.

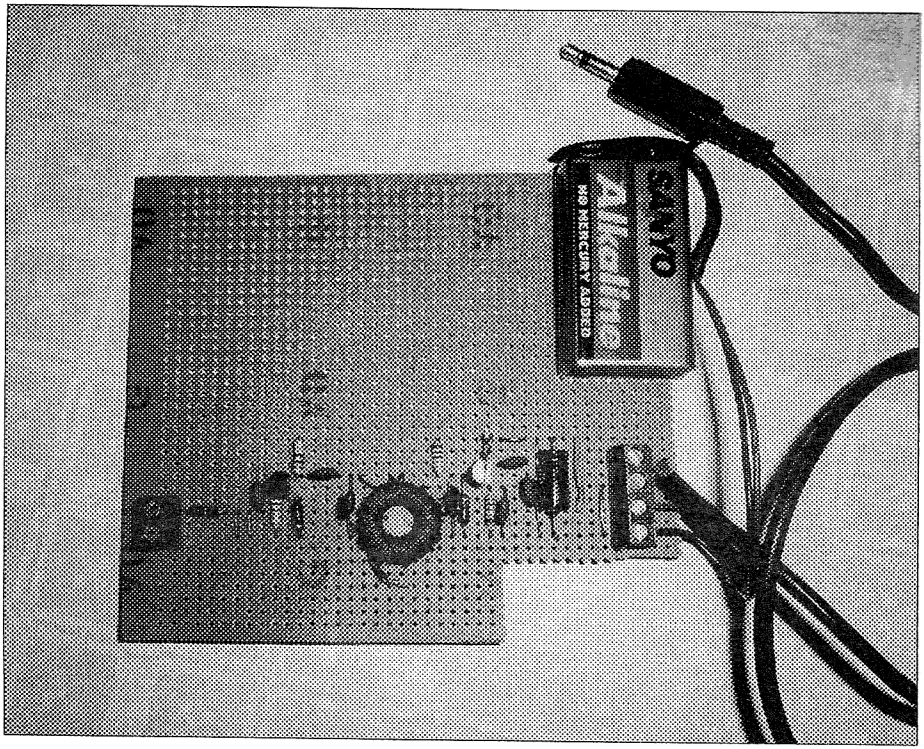
Also, the emitter bypass for Q1 is reduced to 22 nF. Initially I had installed a 1 uF tantalum electrolytic there, but the soundcard was overloaded by low frequency noise (below 1 kHz) so I replaced the capacitor with a 22 nF ceramic.

I added a 22 kilohm potentiometer at the output after the July transmission, when I found that it was tricky to control the signal level only with the software slider control of the computer.

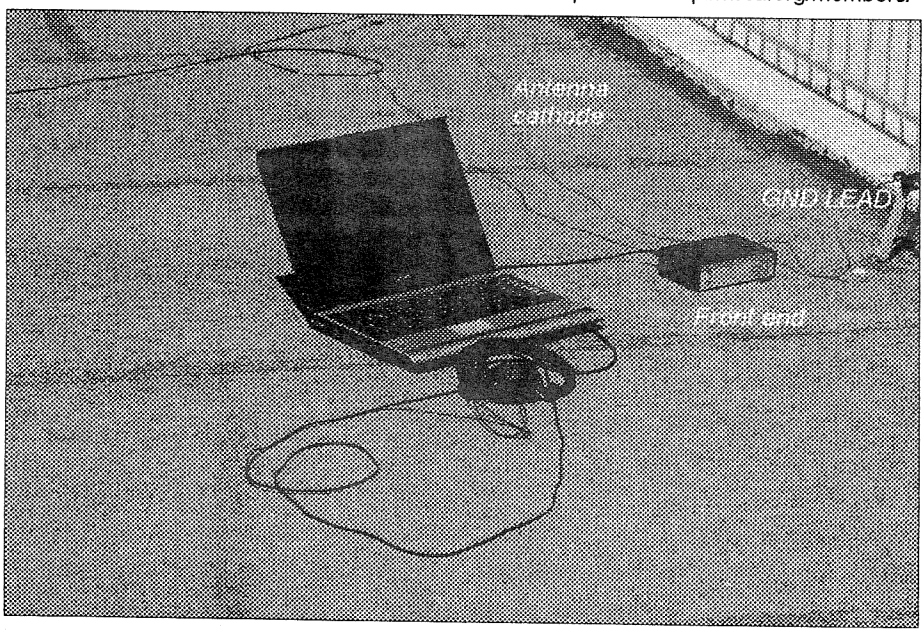
A miniature neon lamp across the input terminals provides additional protection. I also kept the two diodes, as shown in the drawing. Until now I have used only short antennas and have not been close to mains circuits, so I don't expect them to conduct from residual AC pickup.

I strongly recommend both the neon lamp and the diodes where possible, as they provide a path to discharge any stray static charges collected on a well insulated antenna. Otherwise the static charge might destroy C1 and subsequently the FET. Even wind friction can charge an insulated antenna with many kV.

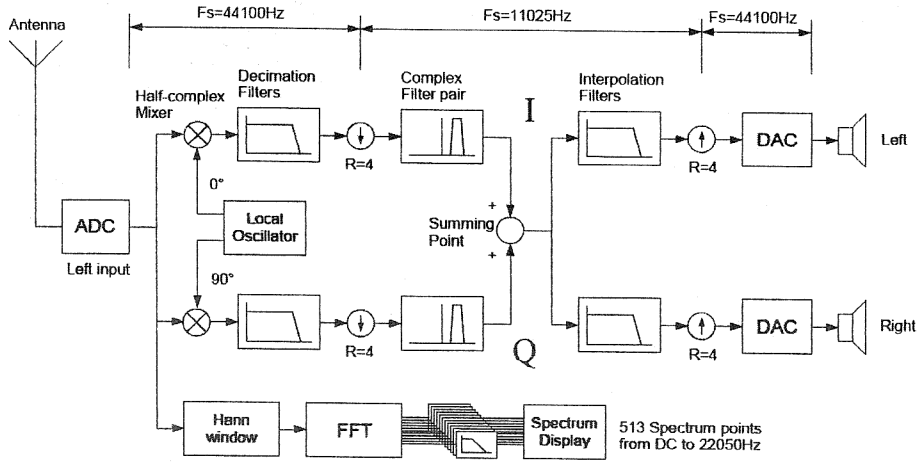
The two photographs on the next page show the front-end circuit board as it was under test before mounting it in a metal box, and the temporary setup in use on the apartment rooftop.



Costas' circuit is a marvel of compactness, easy to take to the roof for monitoring signals in the lower VLF spectrum. As the author of the SAQrx program noted, "SAQrx was written primarily for reception of the 2006 Christmas transmission from SAQ but it was made tunable so it can be used for other purposes while waiting for the next SAQ transmission." See color views of these pictures and the SAQ screen captures at http://lwca.org/members/



Quick Software Review: SAQrx VLF Receiver



SAQrx Block Diagram

Building on software developed by Wolfgang Büscher DL4YHF, Alberto di Bene I2PHD, and others, Johan Bodin SM6LKM has wrought a compact miracle. Designed to allow a computer to receive SAQ, it is a tunable VLF SSB receiver and a convenient audio spectrum analyzer in one handy package that—as an added bonus—can be used simultaneously with some other programs that access sound card data.

It requires a full-duplex sound card with 44.1 kHz sampling, and appears to work fine on Windows XP through Windows 7. You get tunability in steps down to 1 Hz, and a selection of three filters (300, 1000 and 2400 Hz), mainly via keystrokes. Everything you need to know is on a single screen at the Help button.

Johan calls it a "schoolbook example of a phasing method SSB receiver, the main difference is that SAQrx is held together by DSP software instead of solder." It's true; between the ADC and the DACs, there's nothing but arithmetic going on!

You'll notice that there is no need for the user to furnish quadrature inputs. The I and Q channels are obtained by multiplying the input data with what is basically numerical output of the math end of a DDS "local oscillator" ...no D/A conversion for an (unneeded) analog signal. The half-complex mixers are the digital equivalent of direct-conversion receivers, upon whose output additional filtering and frequency shifting are performed in a very clever manner that introduces the additional quadrature shift necessary before summing to achieve the desired single-sideband response. It's a complex-frequency filtering technique that would be *very* hard to realize in the analog world! There's also decimation and interpolation going on to save processor time, and simultaneously, FFT spectrum analysis "on the side."

A more detailed summary of the principles can be found in the PDF file available at: http://sites.google.com/site/sm6lkm/saqrx You can download the source code too, in case you wish to compile your own modified version (*ie*, changing signs in the summing process to produce an LSB response instead of USB, or implementing different filters). But most users will simply download the 26 kB executable. That's no misprint—Johan fit it all into a single **26 kB** file. It's only 5 times the size of the Apollo lunar navigation routines in 1969, and NASA wasn't saddled with Windows bloatware! I *did* call it a compact miracle, didn't I? *- John Davis*