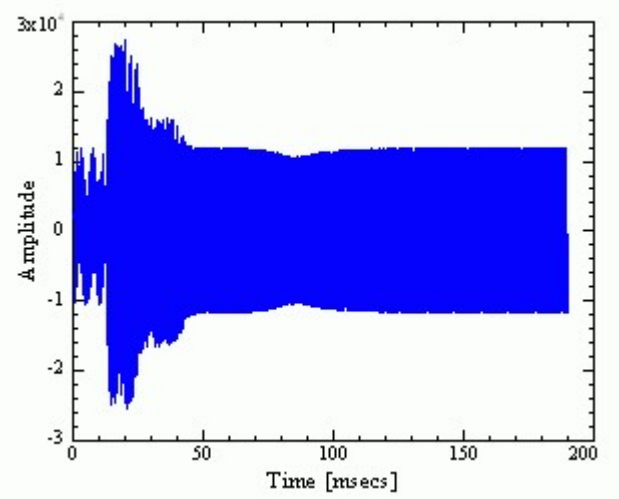
Very Low Frequency Measurements

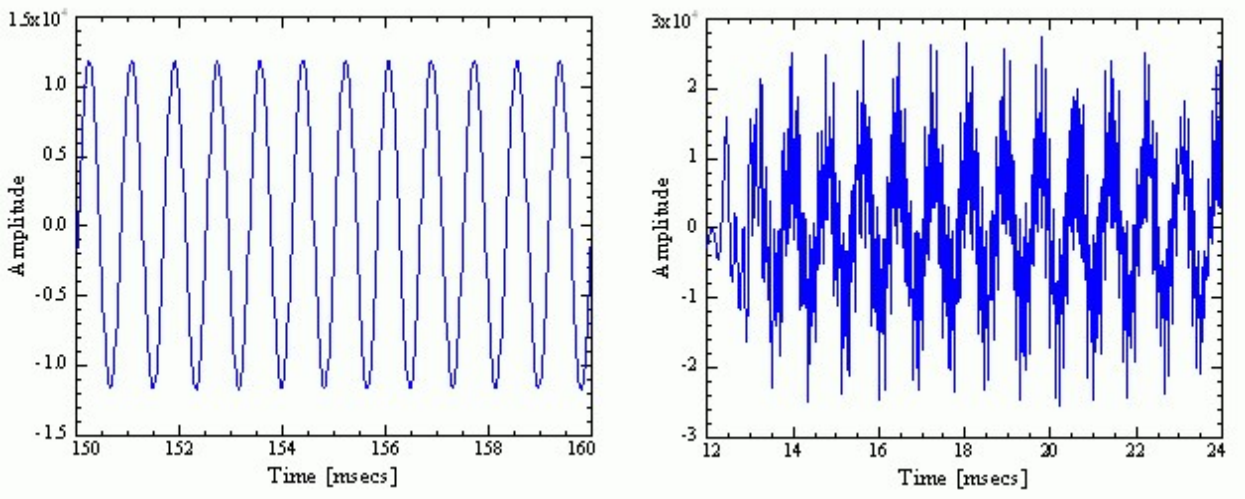
VERY LOW FREQUENCY MEASUREMENTS

Special care must be taken, when the VNWA is used at audio frequencies **below 20 kHz**.
The reason is that the mixers used show some "RF" feed through from the RF input to the IF output and from the LO input to the RF output. Thus, when measuring in the audio range the RF feedthrough signal will be superimposed on the IF signal leading to **signal distortion** and **ADC overloads** as it falls inside the sound card bandwidth.

The following image shows the raw audio stream captured with a 16 bit audio card for a sweep from 1 kHz to 100 kHz. Note, that for a 16 bit card the maximum amplitude range is -32767...32768.



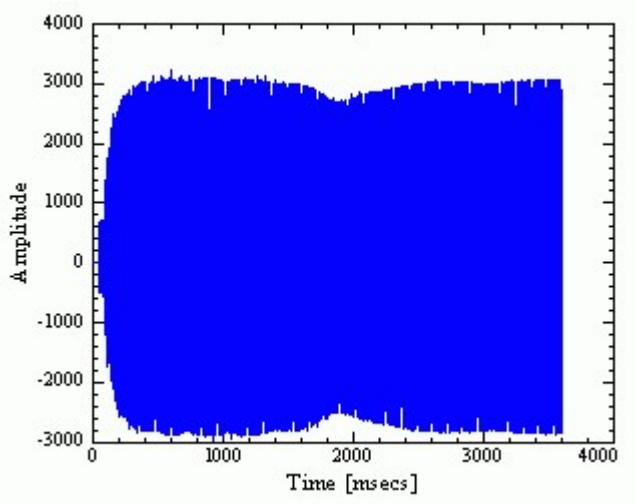
For frequencies outside the sound card bandwidth (>20 kHz, beyond 50 msecs in the plot) the amplitude of the sound stream is about 50% of the allowed maximum amplitude. This will also be seen with the Test Audio function, as it performs the test in the MHz range. At low frequencies the amplitude approximately doubles with the risk of overloading the sound ADC. The mechanism leading to this amplitude increase can be seen when zooming into a high frequency and a low frequency region for comparison:



The left image shows a clean IF signal corresponding to a 100 kHz input frequency, while the right image shows an apparently "noisy" IF signal corresponding to an input frequency in the 1kHz range. Here, the superimposed "noise" is actually a superposition of RF, LO and all kinds of mixing products.

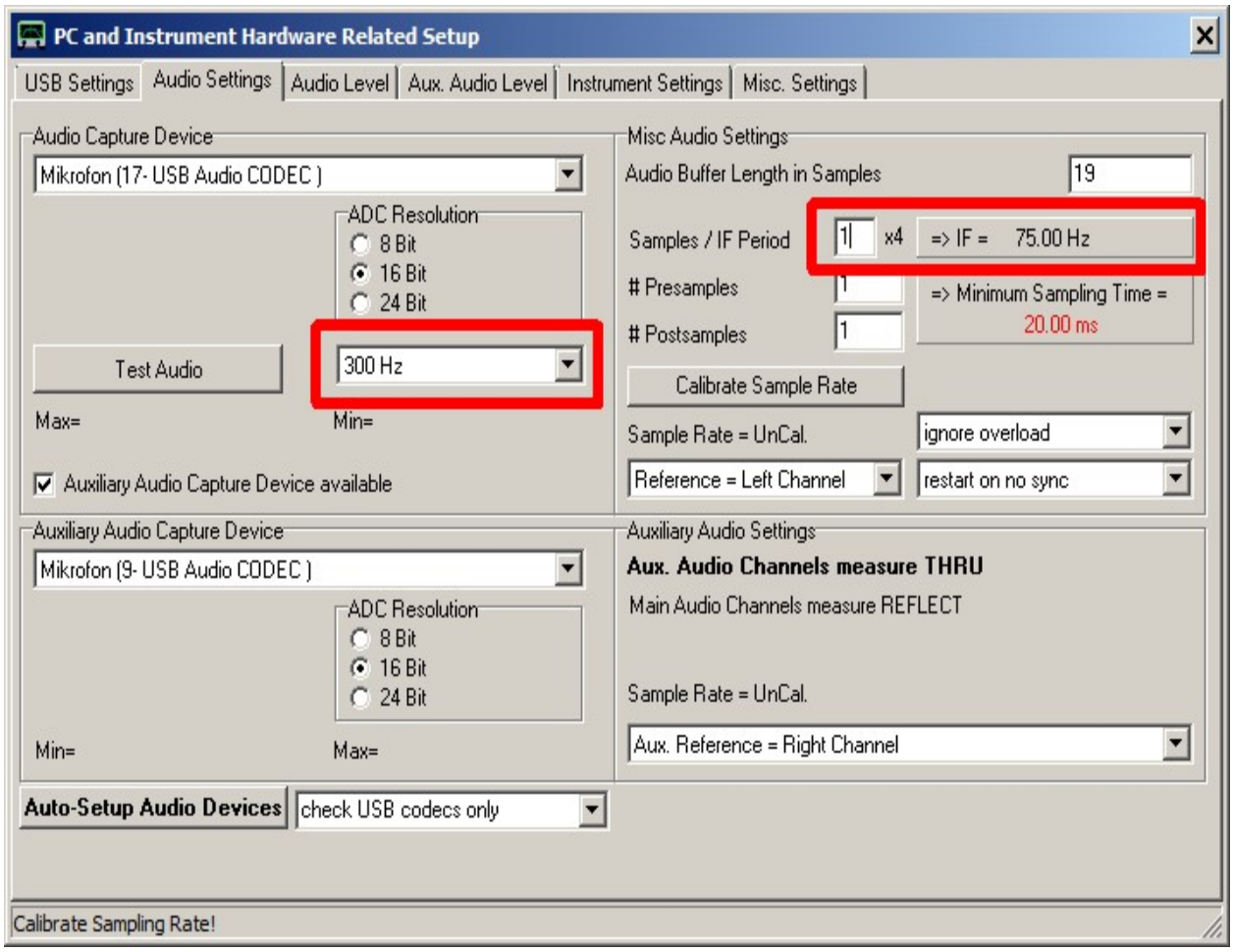
Thus, with default settings, measurements in the audio range are not possible because of strong interference inside the sound card bandwith!

But there is a simple workaround. All sound cards I know of have a built-in anti-aliasing low pass filter, which adapts according to the Shannon sampling theorem to the selected sample rate. Reducing the sampling rate from 48 kHz to 900 Hz will reduce the upper cutoff frequency from about 20 kHz to about 400 Hz.
The effect is demonstrated in the following image, which shows the audio stream for the same frequency range as above, but with a capture rate of 900 Samples per second.



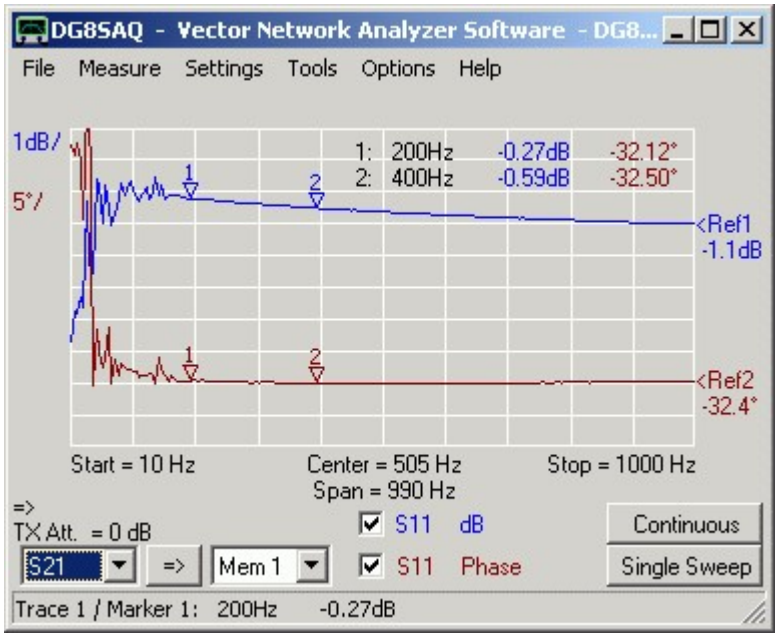
The overall amplitude is a lot smaller, as the response at very low IFs is dropping. But note, that the amplitude is now approximately constant with no overshoot over the whole frequency range.

Note, that when lowering the sample rate also the number of samples per IF period must be reduced and the IF in turn raised, otherwise the IF might fall out of the lower end of the sound card bandwidth. The lowest possible sample rate is 300Hz. With this sample, we end up with 75Hz IF when using the minimum 4 samples per IF period:



Note, that the audio buffer length is adjusted automatically when changing the sample rate. Manually changing the buffer size is not necessary.

Now, what's the practical lower frequency limit of the VNWA? This is best answered with a test measurement. The following extreme low frequency sweep is performed with the lowest possible sample rate of 300 samples per second and the highest possible IF of 75 Hz which are just the settings shown above.



As expected, the sound device anti-aliasing filter cleans the respone above 150 Hz. **200 Hz seems the practical lower frequency limit of the instrument.**

Summary:

- The VNWA can work down to 200 Hz.
- Below the sound card cutoff frequency (typically 20 kHz, on some sound cards up to 100 kHz) the sample rate must be decreased.
- **A wideband mastercalibration with standard settings should not extend below the sound card cutoff frequency**. Note, that changing the sample rate will invalidate any calibration including the master calibration.