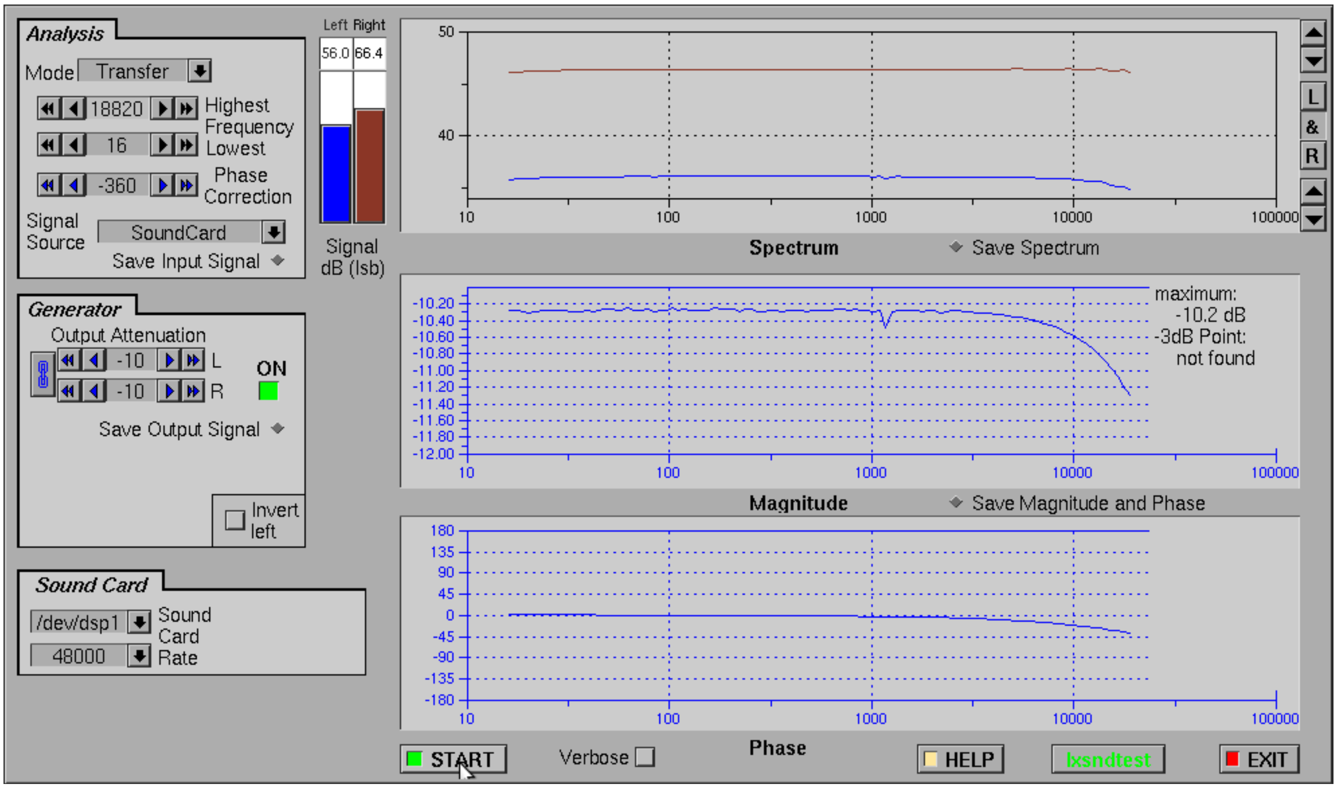
Measurements on Preamplifier for LXARDOSCOPE

The measurement results presented here were generated using the LXSNDTEST utility, available from Sourceforge. The program works with a sound card in duplex mode, driving the device under test (DUT) with accurately defined waveforms, and receiving the signal from the DUT. The data from the sound card is processed using FFT to determine the characteristics of the DUT.

High quality sound cards are well suited for these kind of measurements, because they work with signals in a similar range as the preamplifier. A parameter which summarizes the quality of a signal path is the number of bits (ENOB). High quality sound cards show values in excess of 13 bits for the path digital input → analog out →analog in → digital out.

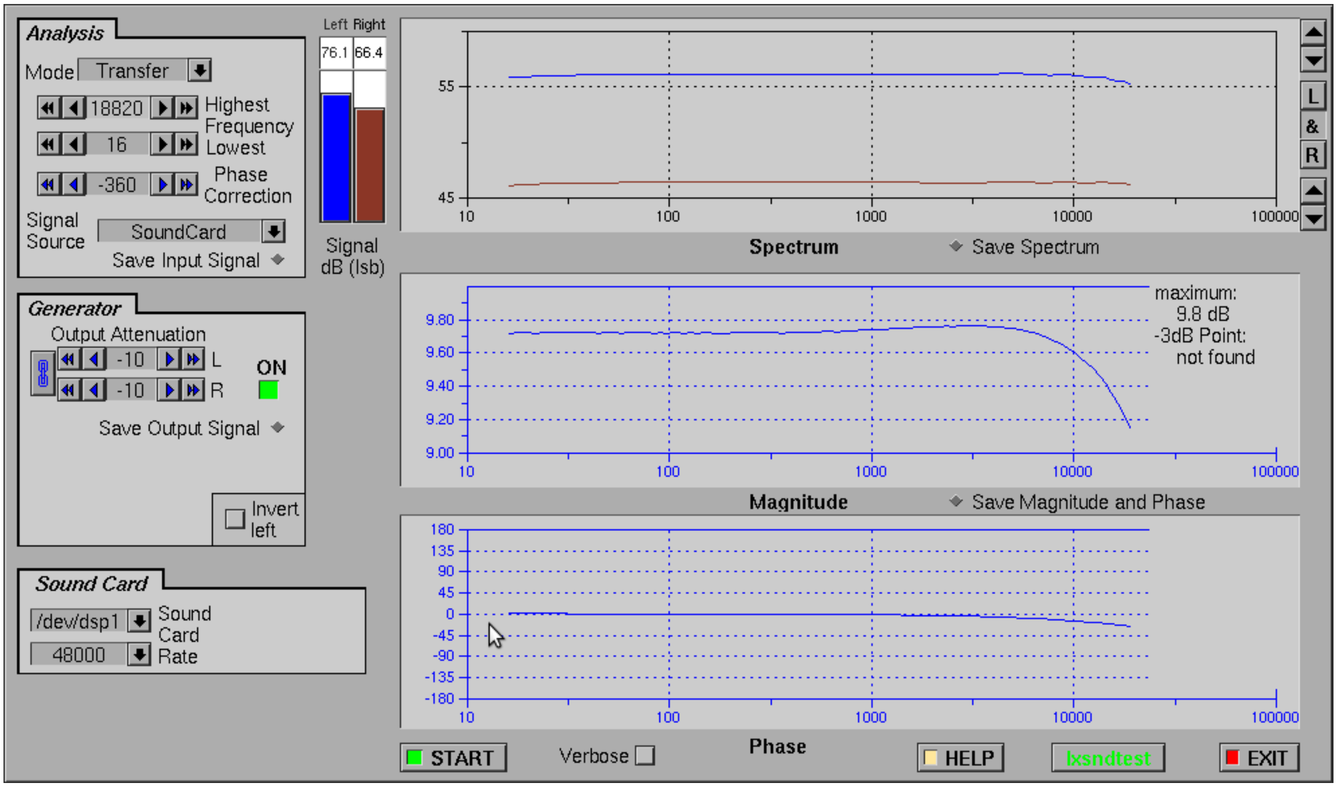
1 Phase/Frequency response of DC path



This response was measured from the preamplifier input to the amplifier output of the DC path, before the lowpass filter. The response drops by about 1dB at 18kHz, which is way above what the ATmega ADC can handle (theoretically half of 2350Hz, which is 1175Hz).

The top graph shows the input and output signal on the same scale. The middle graph shows the difference in frequency response from input to output. This is effectively the amplitude response of the preamplifier. The bottom graph shows the phase response of the preamplifier. The spike around 1200Hz is probably due to the switching noise of the ATmega device, which needs to be running in order for the reference voltage generator to work.

2 Phase/Frequency response for AC path with gain



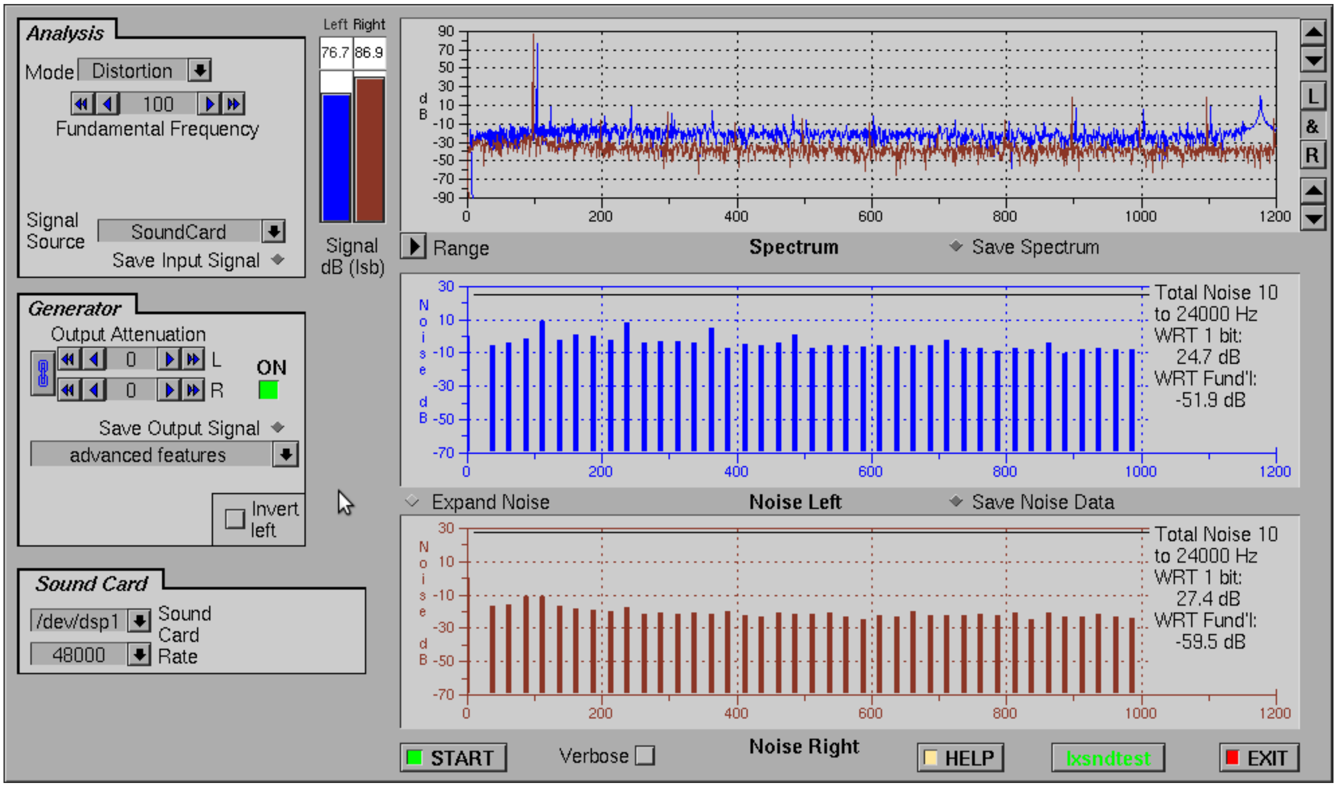
This response was measured with a sound card from input to the amplifier output of the AC path. The frequency response drops by less than 1dB at high frequency, which is way beyond the frequency which the ATmega device can handle. The low frequency gain is 9.8dB.

3 Distortion measurements

In the next two chapters, the results are presented from distortion measurements using a sound card as generator and input device.

In the subsequent chapters the results are presented where a sound card is used as sine wave generator and the preamplifier is actually driving the ATmega ADC. The LXSNDTEST picks up the ADC output through the USB port.

4 Distortion of DC path



The top graph shows in the right channel the spectrum at the input of the preamplifier, with an input signal of 100Hz, and in the left channel the spectrum of the signal at the output of the amplifier of the DC path (before the lowpass filter). The attenuation is 86.9-76.7dB=10.2dB.

The table below shows the parametric results for the preamplifier, with numbers for the right channel representing the input, and the numbers for the left channel representing the DC path:

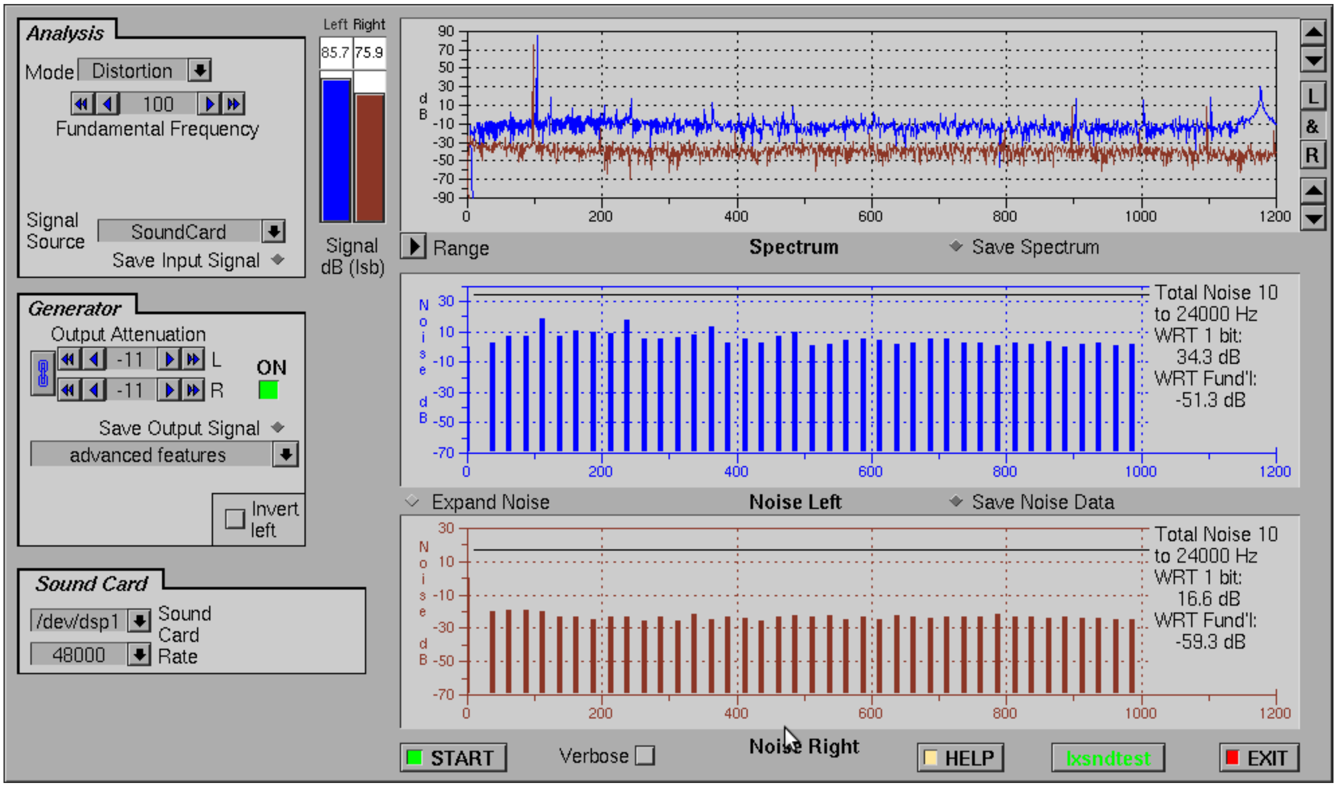
	left	right	
Min (lsb)	-9680	-31420	
Max (lsb)	9683	31421	
FUND	76.7	86.9	dB
THD	0.041	0.041	%
ENOB	8.3	9.5	
SNR	51.8	59.5	dB
SINAD	51.7	58.9	dB
SFDR	56.5	67.9	dB
@freq	1174	1100	Hz

close Save Results

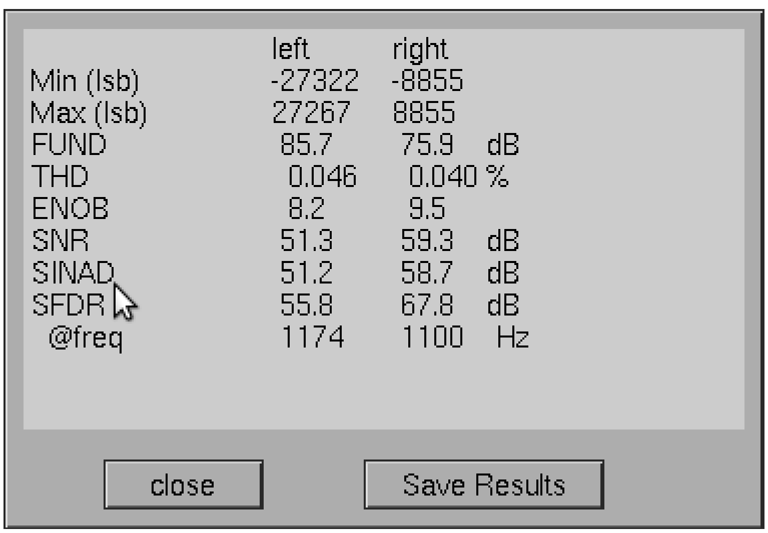
– signal swings,
– the level of the fundamental with respect to 1-bit of the sound card,
– the distortion,
– effective number of bits,
– signal-to-noise ratio
– signal-to-noise-and-distortion ratio
– spurious free dynamic range, and the frequency at which the highest spur occurs.

The results are pretty good. For further investigations, a generator with lower noise would be required.

5 Distortion of the AC path



The input signal for this measurement was reduced by 11dB with respect to the DC path to avoid overloading the amplifier. The overall path gain is 85.7-75.9dB=9.8dB.



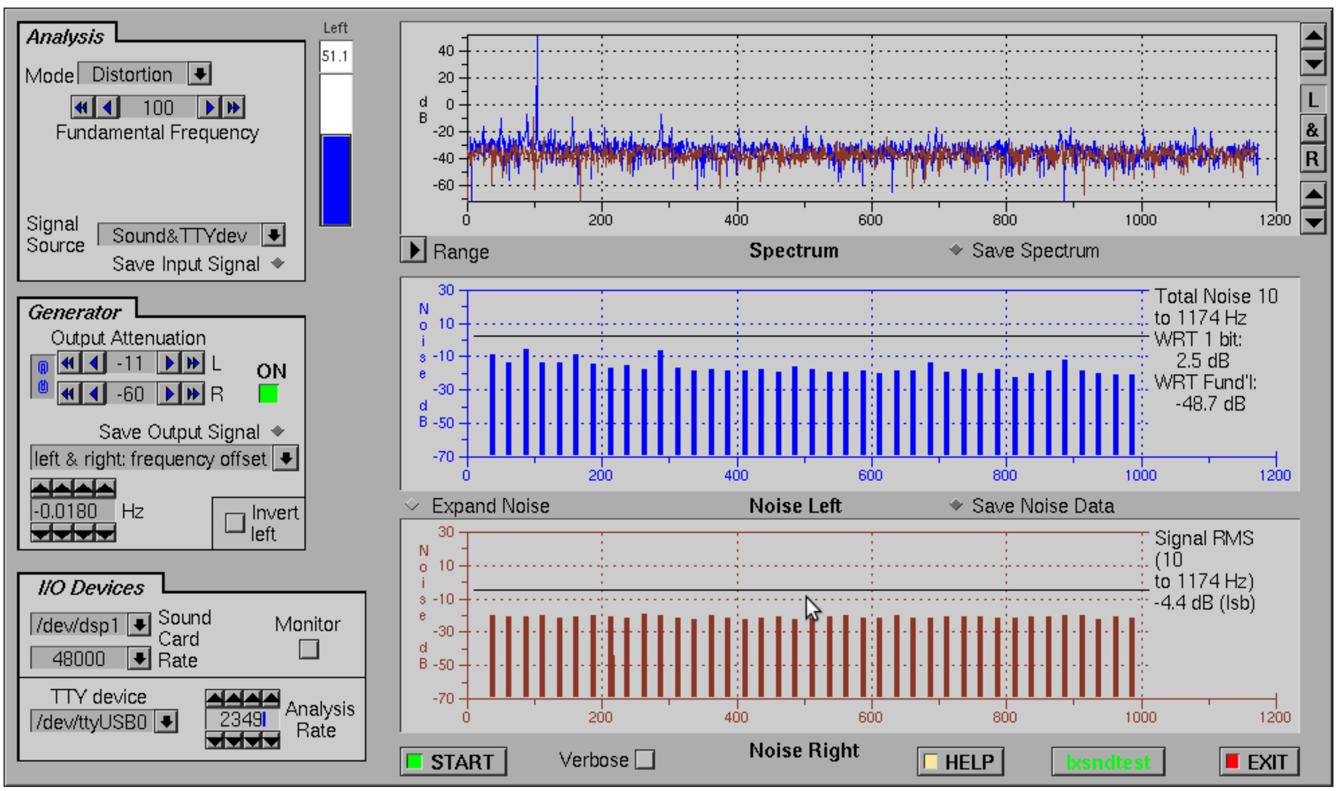
	left	right	
Min (lsb)	-27322	-8855	
Max (lsb)	27267	8855	
FUND	85.7	75.9	dB
THD	0.046	0.040	%
ENOB	8.2	9.5	
SNR	51.3	59.3	dB
SINAD	51.2	58.7	dB
SFDR	55.8	67.8	dB
@freq	1174	1100	Hz

The result which summarizes it all is ENOB at 8.2 bits.

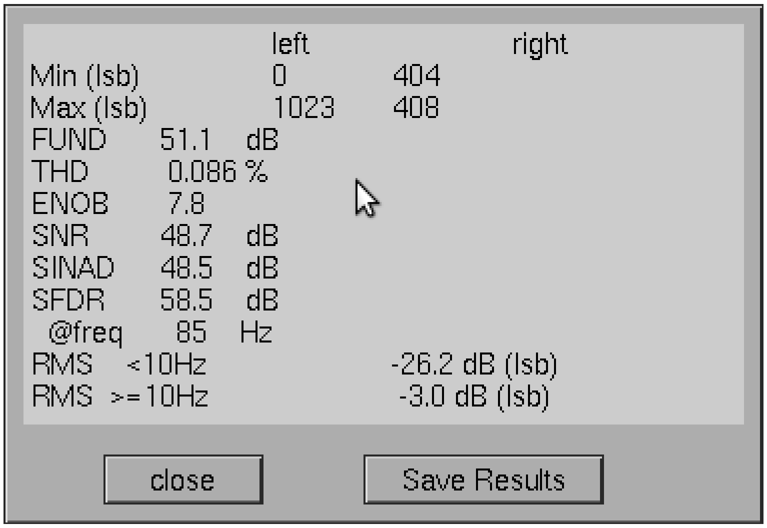
6 Distortion of DC path with ATmega ADC

The signal swing is 366 bits from the ATmega ADC, which represents 36% of full scale. Considering that distortion is low with respect to the overall noise (from quantization etc), the result for ENOB with a full swing signal should approach 8 bits.

7 Distortion of AC path with ATmega ADC



The screenshot from the LXSNDTEST GUI shows on the left side the setup required to measure distortion from an ATmega device. The generator is (empirically) set to -11dB, to get the maximum output signal without distortion. The frequency of the sine wave is 100Hz with an offset of -0.018Hz, to achieve an exact integer number of periods in the interval where the ATmega is producing 2349 samples per second for each channel.



The input signal is driving the ADC exactly full scale in this case. The ENOB result is slightly higher than for the DC path (was 7.2 bits), probably due to the difference in input signal.

8 Conclusion

Considering that the prototype was built on a plugin breadboard, the results look good. The frequency response extends about 10 times as much as required. The effective number of bits is close to 8, which is good enough for an oscilloscope application. Many low cost oscilloscopes digitize only to 8 bits, thus certainly producing an ENOB result below 8 bits.

August 6, 2013 Oskar Leuthold