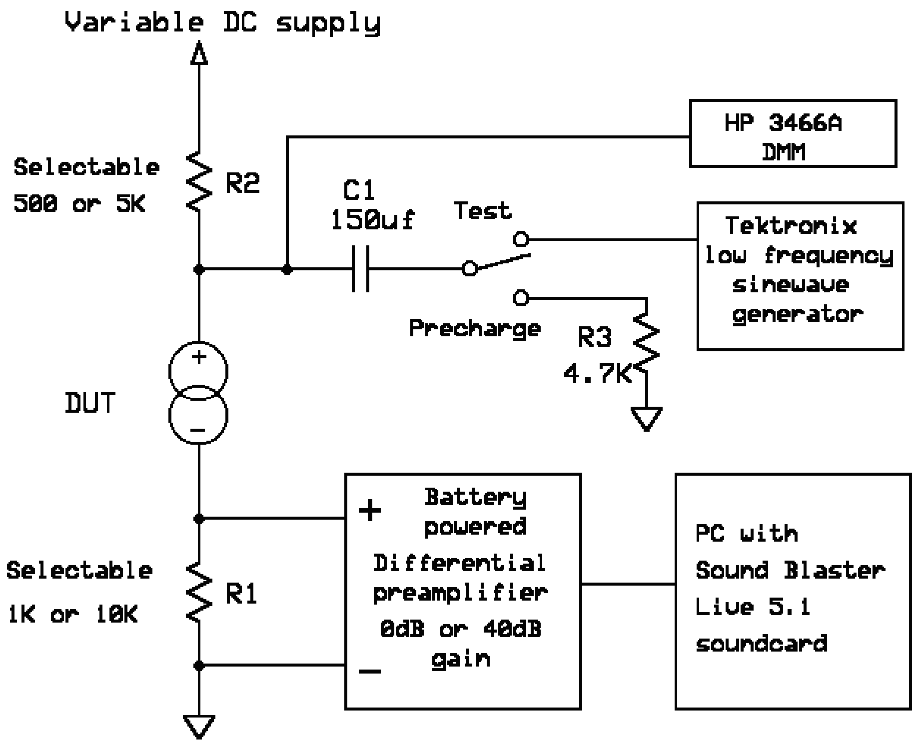
CCS performance measurements

This section will describe how to measure the performance of CCS's. As the performance of the CCS's increased it was necessary to develop a new way to measure the performance. The old system of using a scope just did not have the sensitivity necessary.

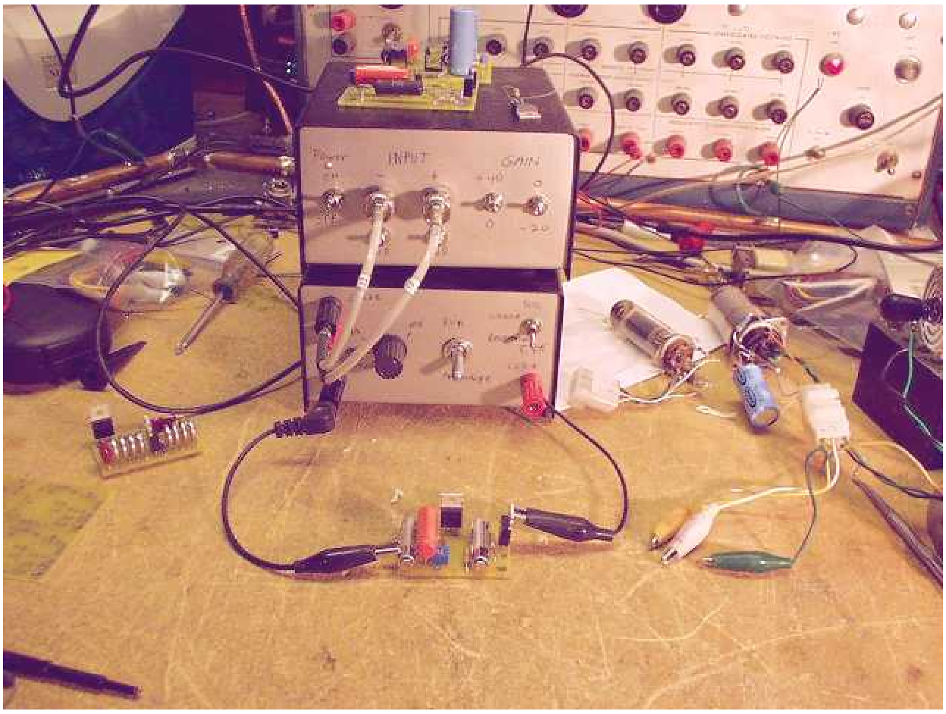
The theory behind testing the performance of a CCS is to inject a signal into the positive power supply rail and sense how much change in current this causes in the sense resistor (R1). The test fixture setup is shown in the diagram below.



The basic test setup is to set the sinewave generator to 10Hz, 100Hz, 1Khz or 10Khz. For most testing the sinewave generator output is set to 10 volts RMS. On the higher performance CCS's at 10Hz the output of the sinewave generator is raised to 30 volts RMS. to make the test signal visible.

For data acquisition the new test system uses a battery powered differential preamplifier that feeds into the sound card in my lab PC. At the low signal levels measured here it was necessary to have the differential preamp. Without the differential preamp breaking the ground loop the ground noise was much larger than the signal of interest. It does not help to include a generic PC in the measurement chain. With the preamp having battery power (2 9 volt batteries) the coax cable connection between the preamp and the PC is the only ground reference.

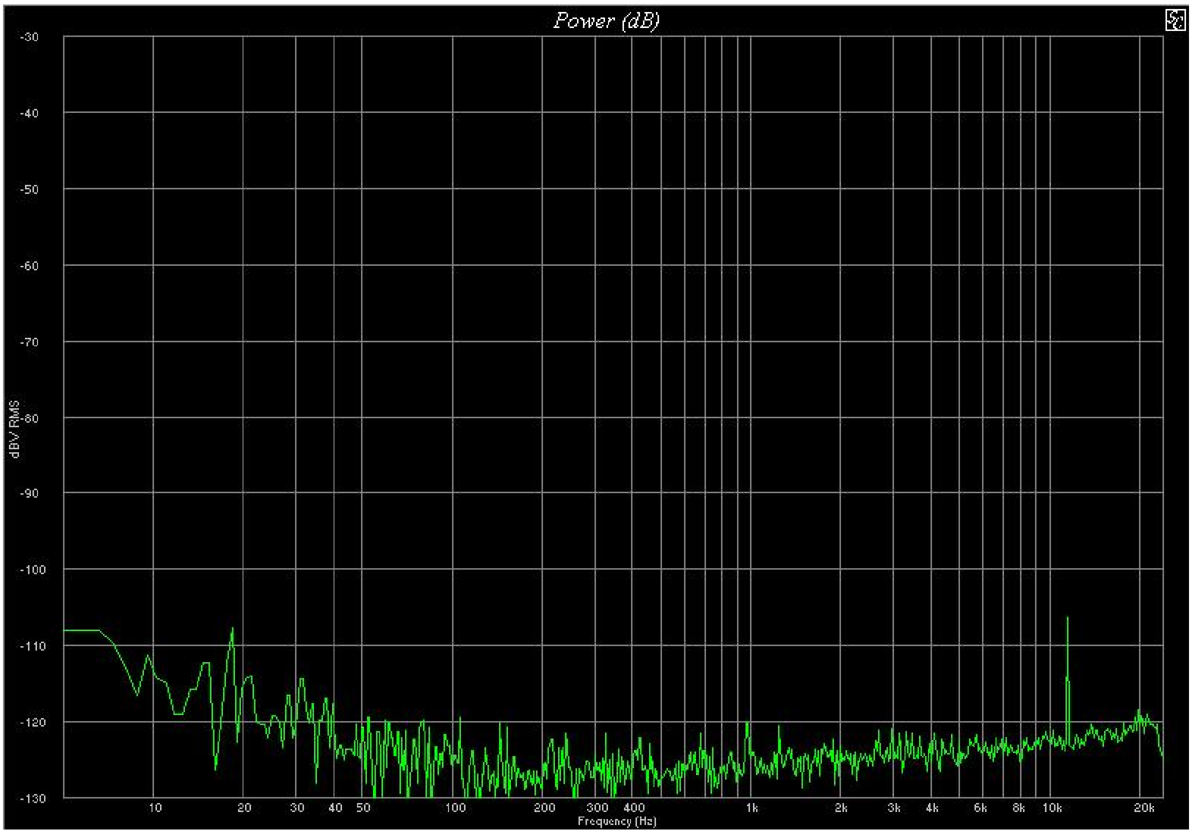
Here is a picture of the test bench with the preamp and the test jig. It is connected to one of the new battery biased CCS's.



The PC is running Sample Champion software www.purebits.com for data acquisition and analysis. Sample Champion records a 16bit 48K record then runs a 64K FFT and presents the output in spectrum analyzer format. Another software package that works nice and is more affordable is Audio Tester. www.audiotester.de

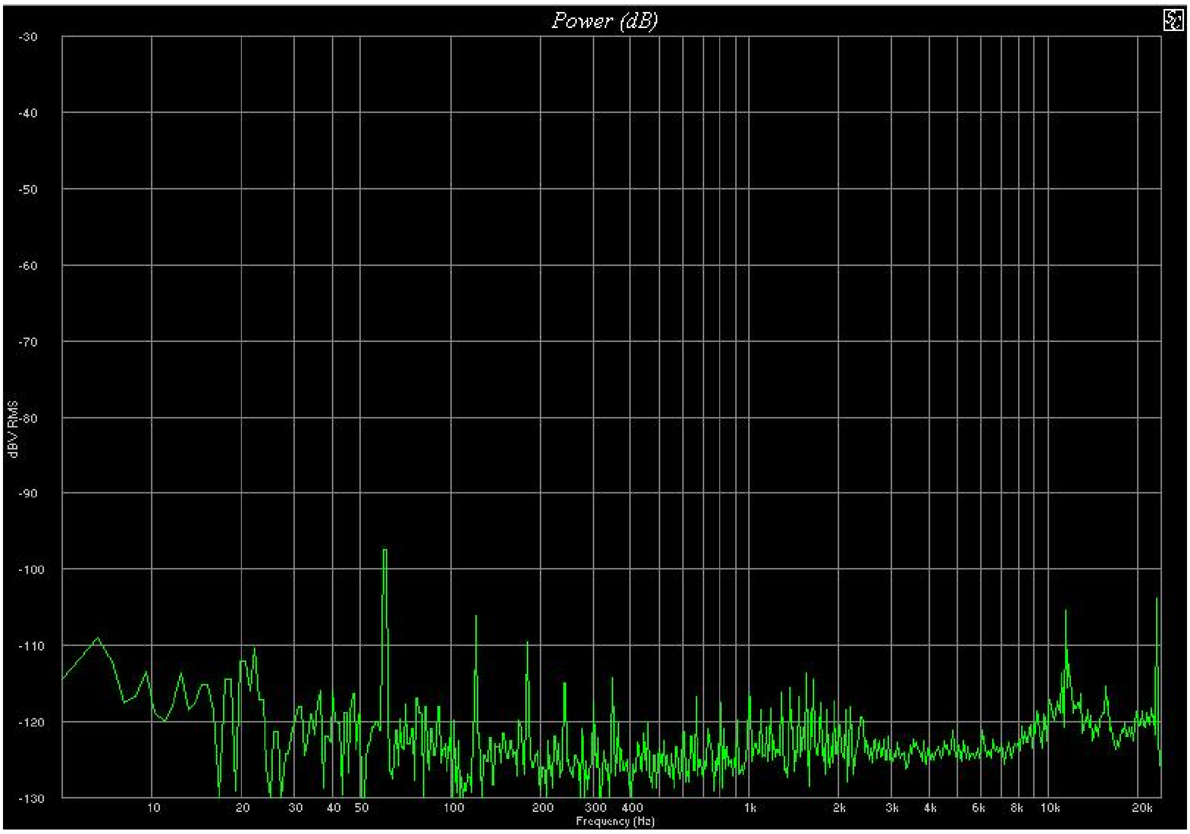
The data from the PC is entered into an Excel spreadsheet. The spreadsheet accounts for voltage drive, sense resistor, preamp gain and how many dB down a measurement signal is. It does all the calculations and arrives at the impedance of the CCS. The output of the spreadsheet is used to graph the performance Vs. frequency.

Here is what the spectrum analyzer output looks like. This setup has both inputs of the preamp grounded and gain set to 0dB. Sound card gain is set to maximum for all measurements. The software is calibrated so that 0dB=1 volt RMS. The noise floor of the sound card is the limiting factor in this setup.

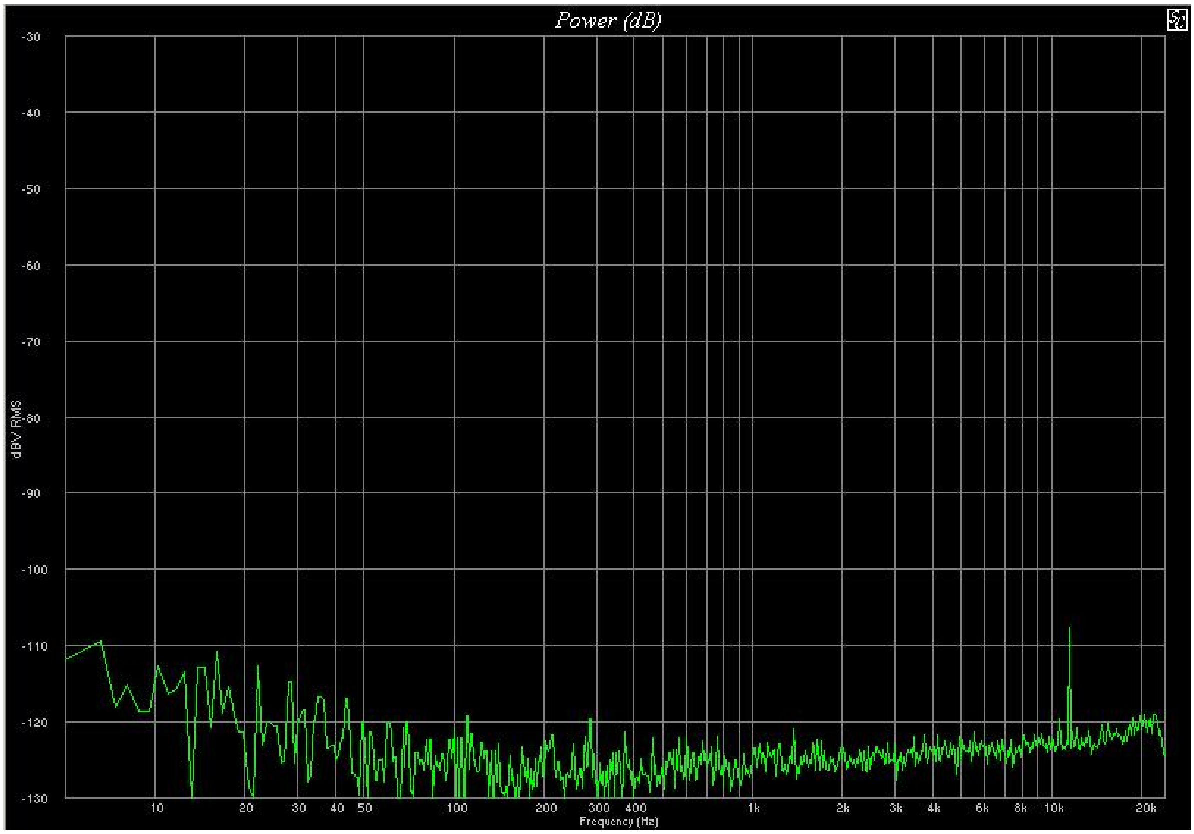


The little spike at ~11K is an artifact from the sound card.

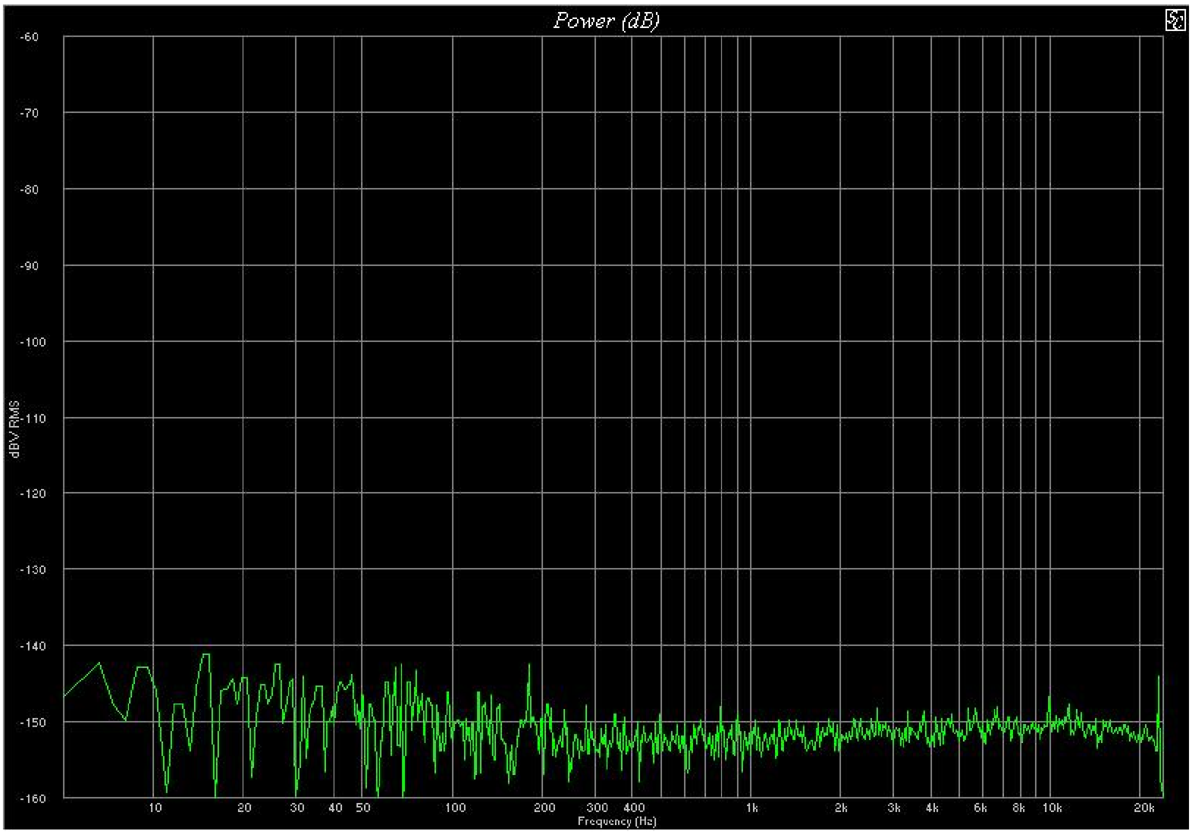
The next spectrogram is with only the (+) input of the preamp open making a single ended measurement. You can see how much noise is floating around in the ground loop.



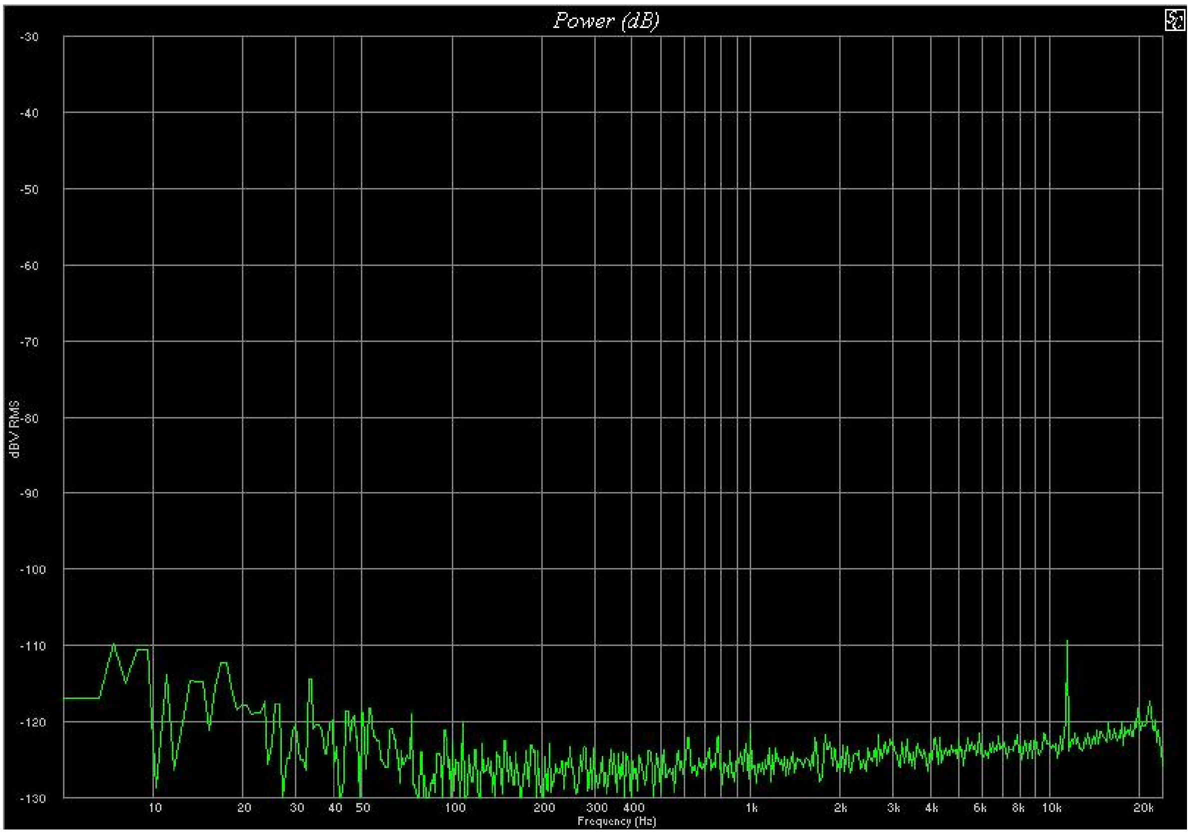
When the (-) input is opened the preamp makes a differential measurement. What this means is it only amplifies the signal difference between the inputs instead of the sum of the signal across the sense resistor plus the ground noise like in the SE case. It effectively ignores the ground loop noise that is common to both inputs. The next spectrogram shows the noise floor when making a differential measurement. Once again the sound card is the limiting factor.



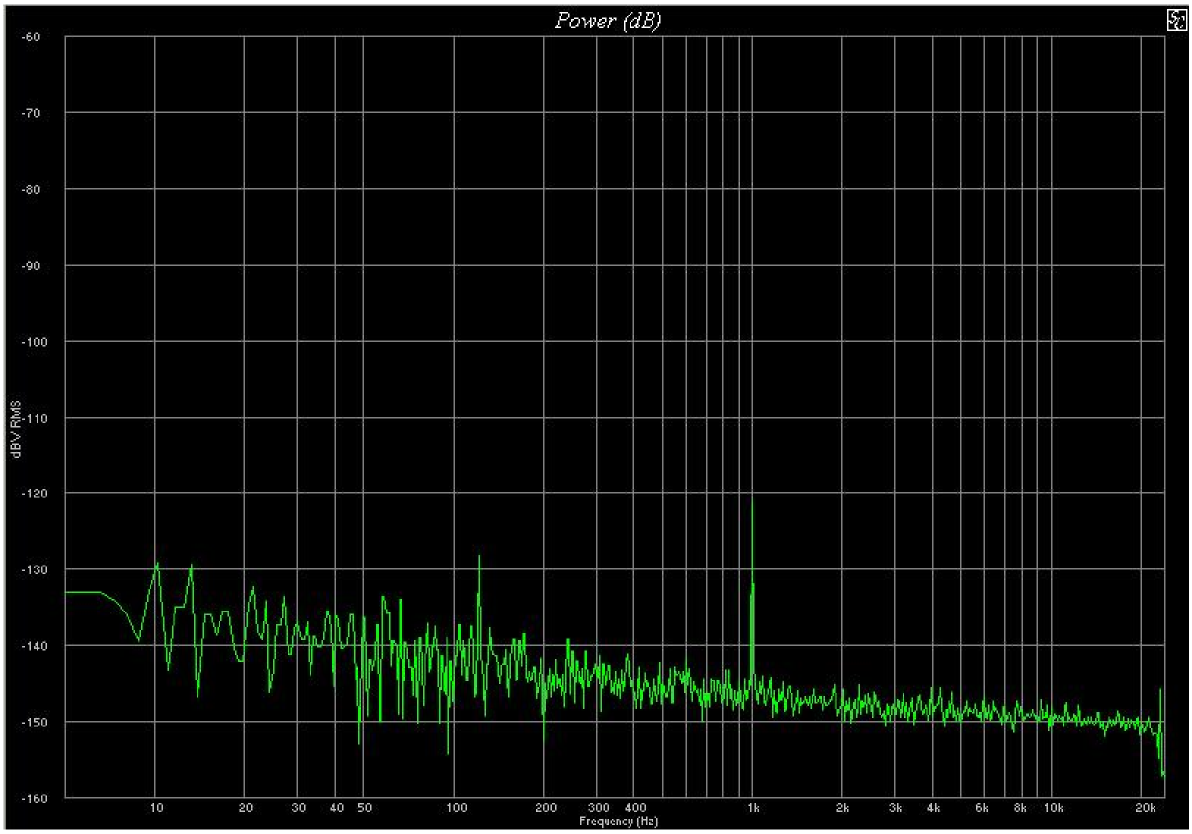
The next step is to enable the 40dB gain of the preamp. The noise in the preamp is now the limiting factor for measurements. You can see that the noise floor is not 40dB down from the noise floor measurement made with the preamp gain at 0dB. The preamp is using pretty generic IC's (TLO84's) at this time. I had some higher performance chips in the preamp and was getting about 10dB lower measurements of the noise floor. Unfortunately one of them gave up the ghost and forced a switch back to the TLO84's. Here is the noise floor with the preamp set for 40dB of gain.



On to some real measurements. The next spectrogram shows the signal from applying 3 volts RMS. @ 1Khz to one of the new battery biased CCS's. The lower voltage drive is used to demonstrate the effectiveness of the preamp. In this image the 1Khz test signal is just barely visible in the "grass" of the background noise. The tip of the signal is just below the -120dB line.

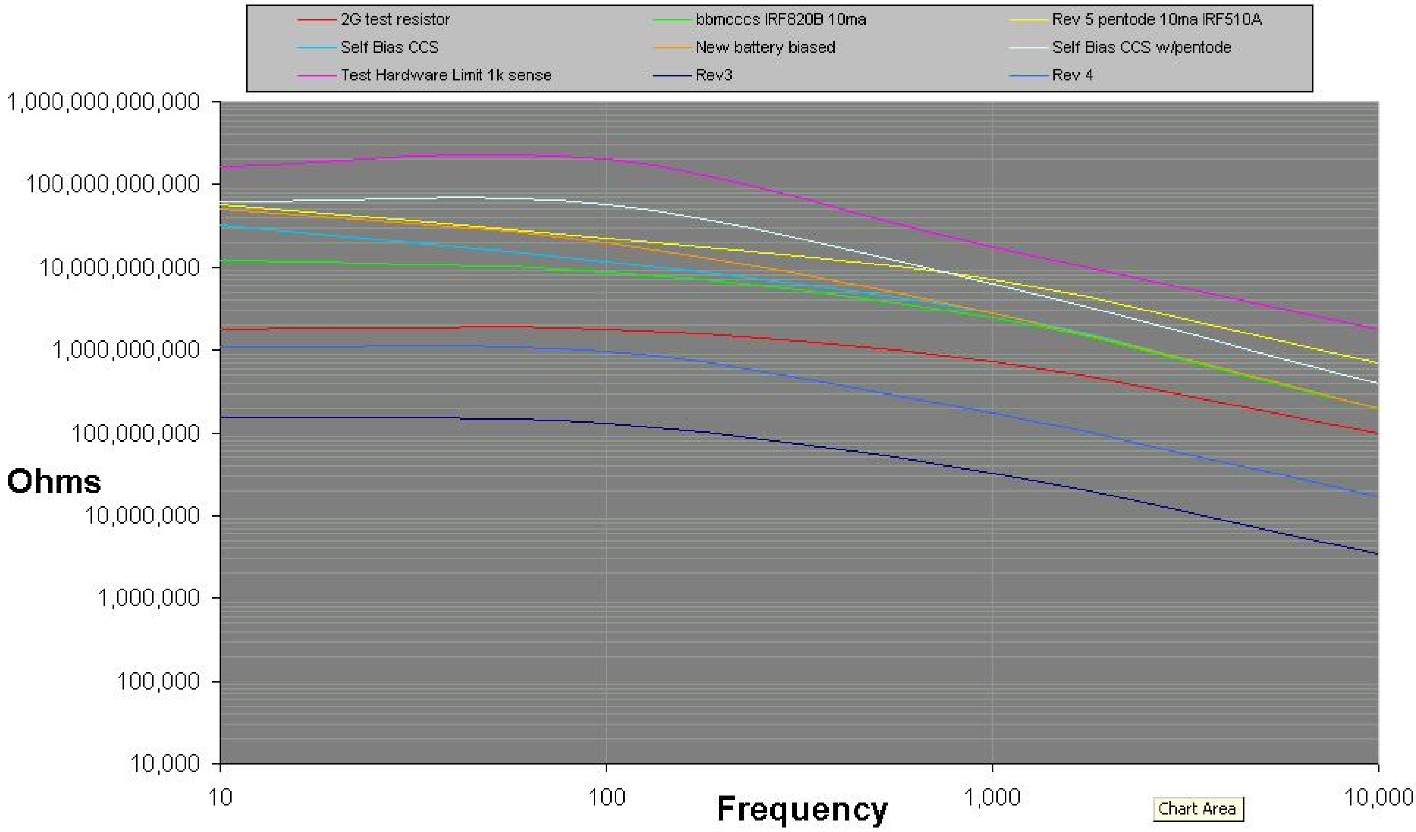


After setting the preamp gain to 40dB the test signal is very easy to see and measure. The tip of the 1Khz signal is still just below the -120dB line and you can see the 120Hz power line noise that was buried in the background noise without the extra gain.



The 1Khz test signal is very easy to see in this spectrogram. We can see that the noise floor has moved up some also. This is the noise floor of the CCS. This shows that a ordinary PC sound card with a simple preamplifier and some good software can make some pretty low level measurements.

Here is a graph showing the impedance Vs. frequency for several of the CCS's of my designs. The fixture limit was measured with the clip leads from the fixture laying on the bench about 2" apart, the same distance apart that they are when measuring most of the CCS's.

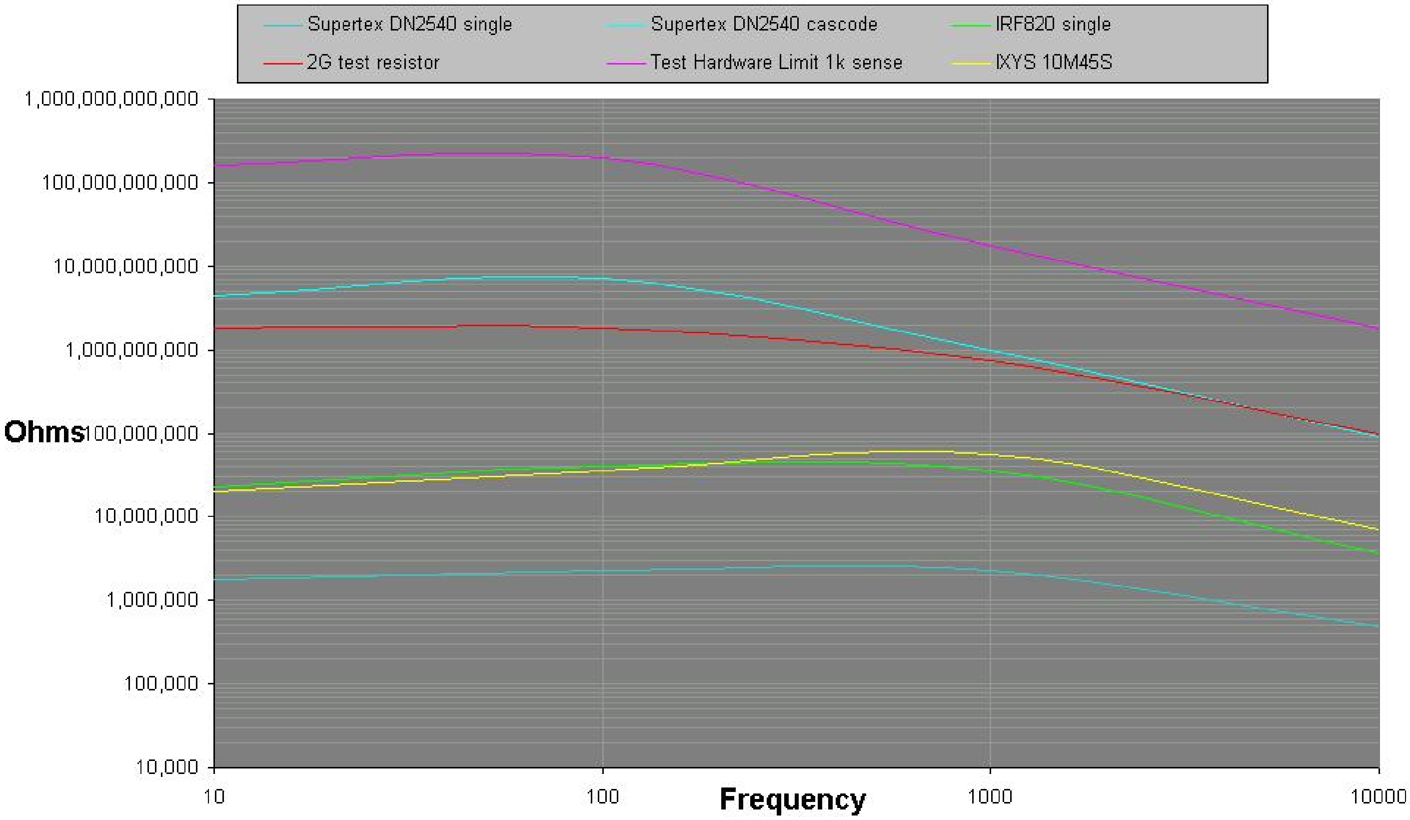


When measuring CCS's there are 2 numbers that define the performance of the CCS. Impedance and shunt capacitance. The impedance can be read from the graph almost anywhere to the left of the 100Hz line. The shunt capacitance can be calculated from the impedance at 10Khz by using the formula 1/(2*pi*frequency*impedance). I have this incorporated into the spreadsheet now but darn if I can figure how to make Excel show a secondary axis on the right side of the graph. The help file shows a nice graph like I want to do but has no info on how to do it! Here are the numbers in a table format.

Fixture limit	.009pf

Rev. 5	.023pf
Self Bias w/pentode	.04pf
Old battery bias	.08pf
New battery bias	.08pf
Self bias	.08pf
2G test resistor	.159pf
Rev. 4	.932pf
Rev. 3	4.682pf

For comparison purposes, here is a graph of some other CCS's.



The Supertex parts are self biasing (depletion mode) mosfets. The single IRF820 mosfet was biased with a 9 volt battery. The IXYS 10M45S is an off the shelf 3 terminal CCS.

Fixture limit	.009pf
2G test resistor	.159pf
Supertex cascode DN2540	.177pf
IXYS 10M45	2.248pf
Single IRF820	4.426pf
Single Supertex DN2540	32.4pf