Testing a PAiA model 9802k riaa Phono Pre

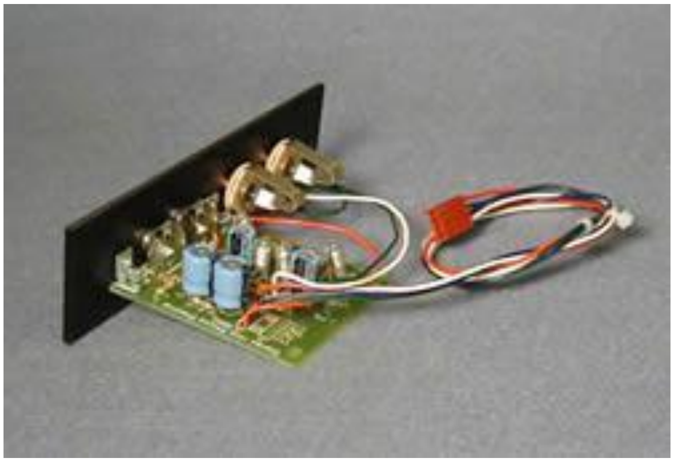
photo from paia.com website

I purchased this small kit from PAiA and assembled it in less than an hour. This is a phono preamp with RIAA equalization, based on the NE5532 op amp. The 9802k was assembled using only the parts supplied by PaiA; I made no modifications or substitutions.

This kit is designed for “moving magnet” cartridges – these usually supply roughly 2-5mV into 47k load. These are the most common photo cartridges. Mine is a Shure SC-35C. There are also “moving coil” cartridges that have much lower output (typ. 0.2mV output into 10-1000Ω load impedance). MC types are expensive, and have (allegedly) lower distortion and ridiculously wide bandwidth.

The reason I bought the 9802k was to build it into the base of a vintage Technics turntable, so that it would have a standard “line level” output. It’s rare to find a “phono” input on modern audio equipment. In this way, it’s convenient to plug the turntable directly into a sound card, for example, to do high quality digitizing of analog LP’s. I have it connected to a small, linear power supply module that provides +/-15VDC at 150mA max.

After assembly, the 9802k was tested on an Audio Precision APx525 audio analyzer. The analyzer output was set to unbalanced, 600Ω and connected directly to the 9802 input (without a cartridge). The analyzer input was set to unbalanced, 100KΩ, DC-coupled, 90kHz bandwidth, and connected to the 9802 line output.

First, a quick gain measurement was made.

- A 10.0mV$_{rms}$ sine at 1000Hz into the 9802k, produces 1.520V$_{rms}$ left channel/1.512V$_{rms}$ right channel (gain 43.64dB left channel/43.59dB right channel).
- Note: for a load of 600Ω on the preamp output, this becomes 1.409V$_{rms}$ left channel/1.401V$_{rms}$ right channel (gain 42.98dB left channel/42.93dB right channel).

Figure 1 is an FFT of a 1kHz sine fed into the preamp input, at 10.0mV$_{rms}$ (256K point FFT, 10 averages, Blackman-Harris window). All noise is at least -76dBC. The 60Hz noise and its harmonics could be further reduced with a simple filter added to the power supply.

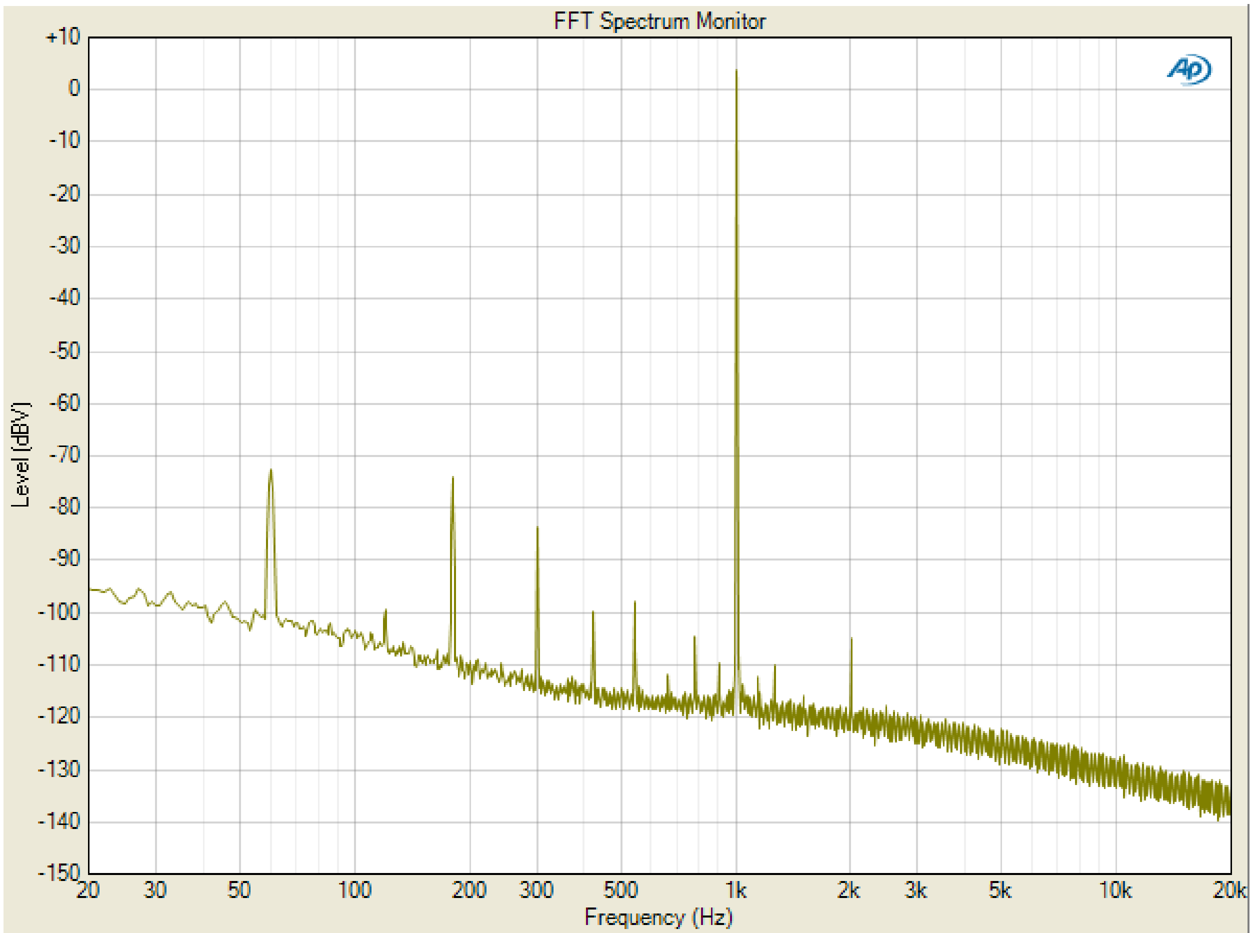

Figure 1. FFT of 9802k for a 1kHz Input

Next, the operating range of the preamp was checked, as well as amplitude linearity. Figure 2 is a plot of the output voltage vs. input voltage, at 1kHz.

Figure 3 re-plots the exact same data as in Figure 2, but is presented as relative gain. The 9802k preamp is perfectly linear from about 10µV_{rms} up to 60mV_{rms}, which should be plenty of “headroom” for loud passages.

This means the preamp has about 80dB of dynamic range. It is doubtful a record has this much S/N even under the best of conditions.

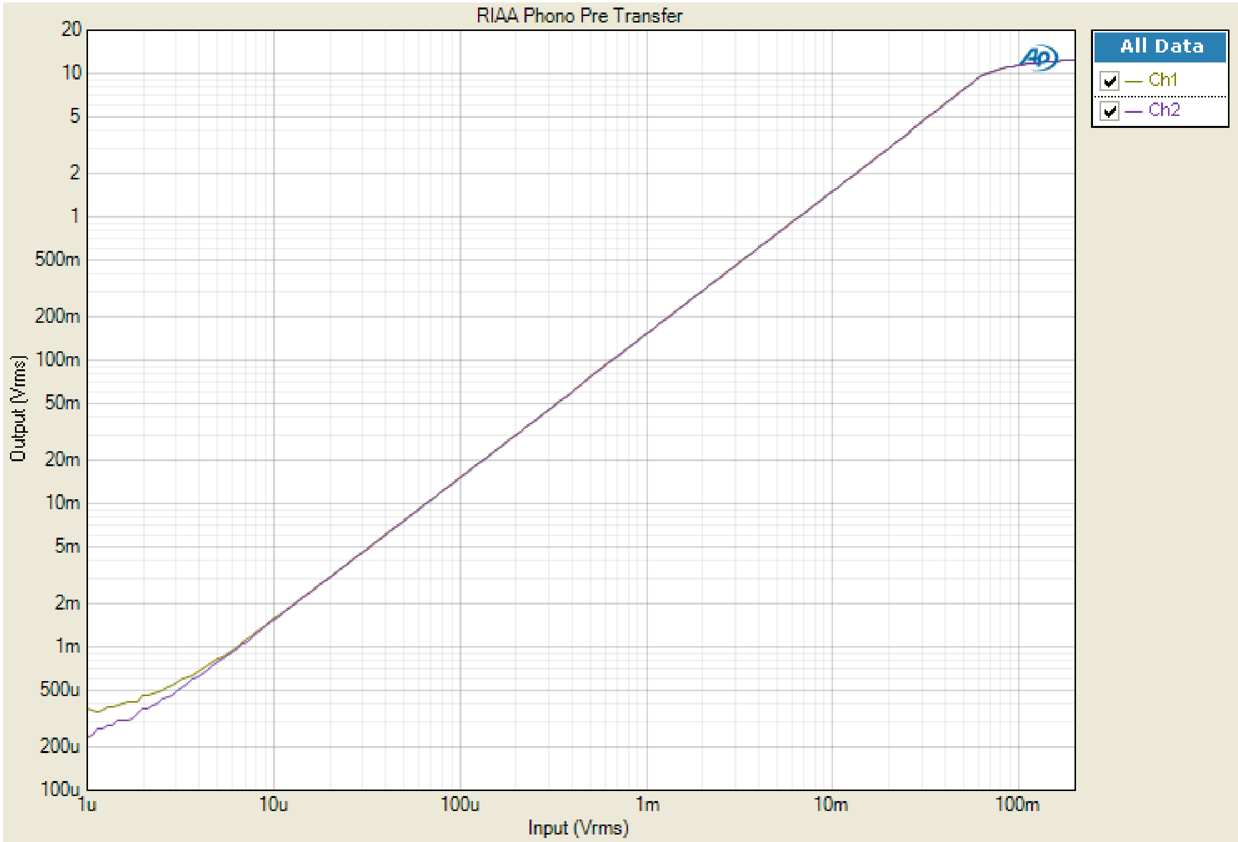

Figure 2. Voltage Transfer plot of 9802k

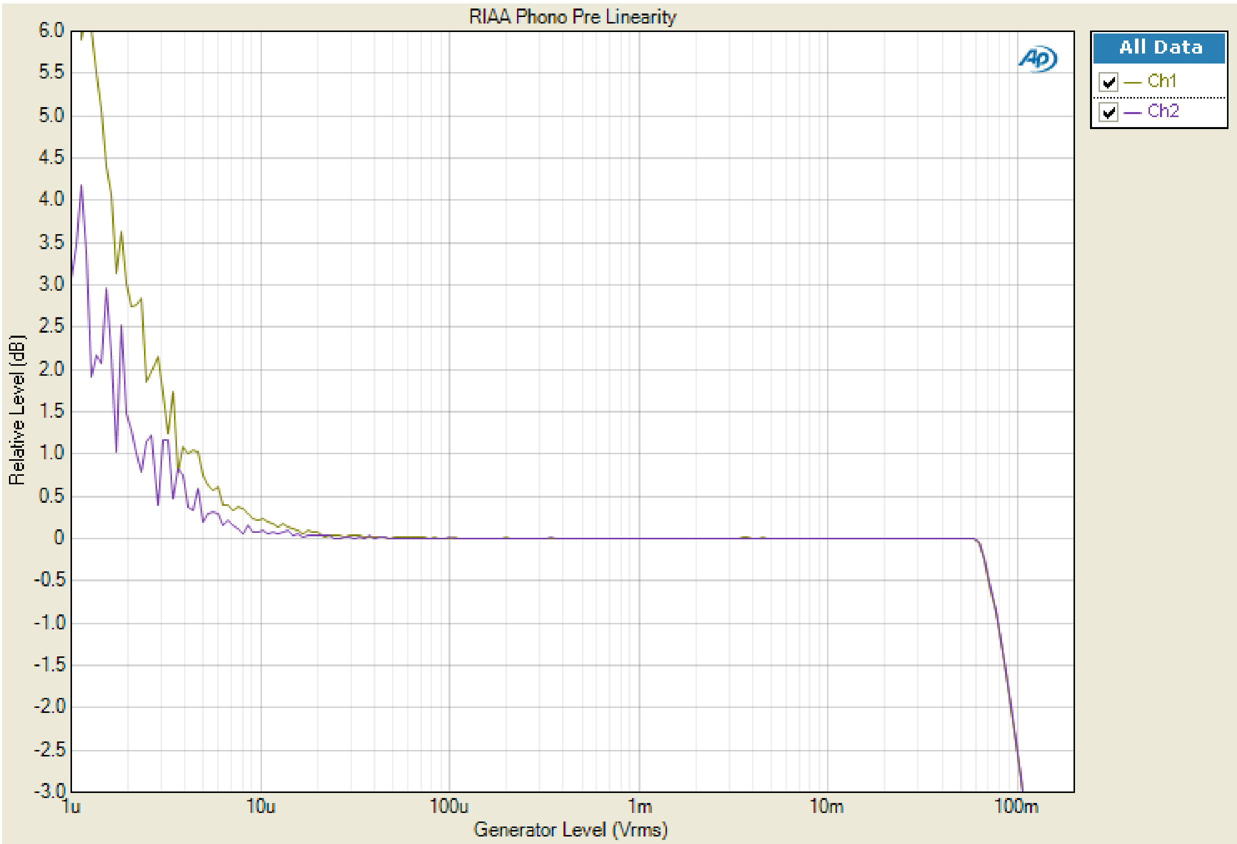

Figure 3. Linearity of 9802k

Figure 4 is a plot of THD+N (A-weighted, 80kHz LPF) vs input level, using a 1kHz sine test signal. Since the distortion level doesn't change for all inputs less than 30mV$_{rms}$, it is noise-limited. The lowest THD is .002%, both channels.

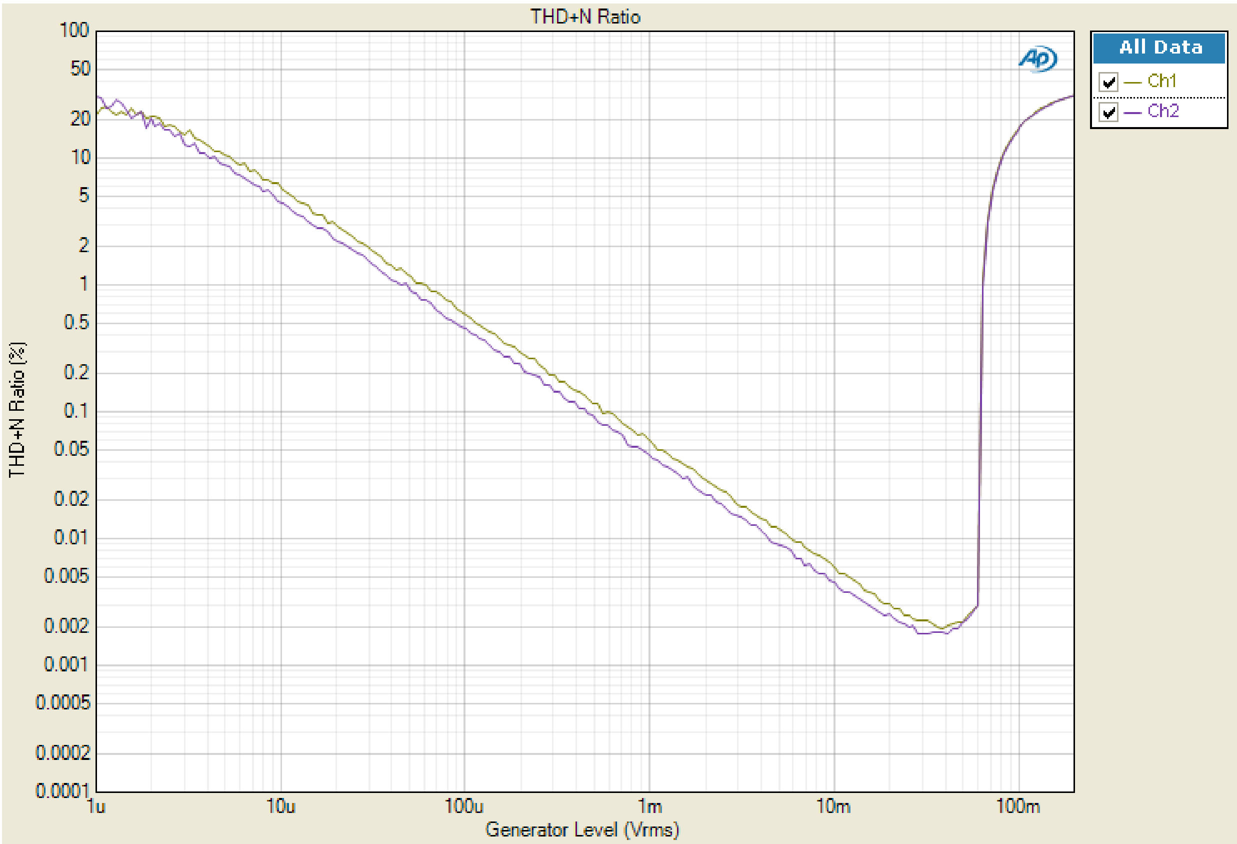

Figure 4. Distortion vs input amplitude plot of 9802k

Figure 5 is a plot of frequency response (Ch 1 is left, Ch2 is right), 5mV$_{rms}$ input. Note the plot extends from 5Hz-50kHz to show how the preamp responds to out-of-band signals.

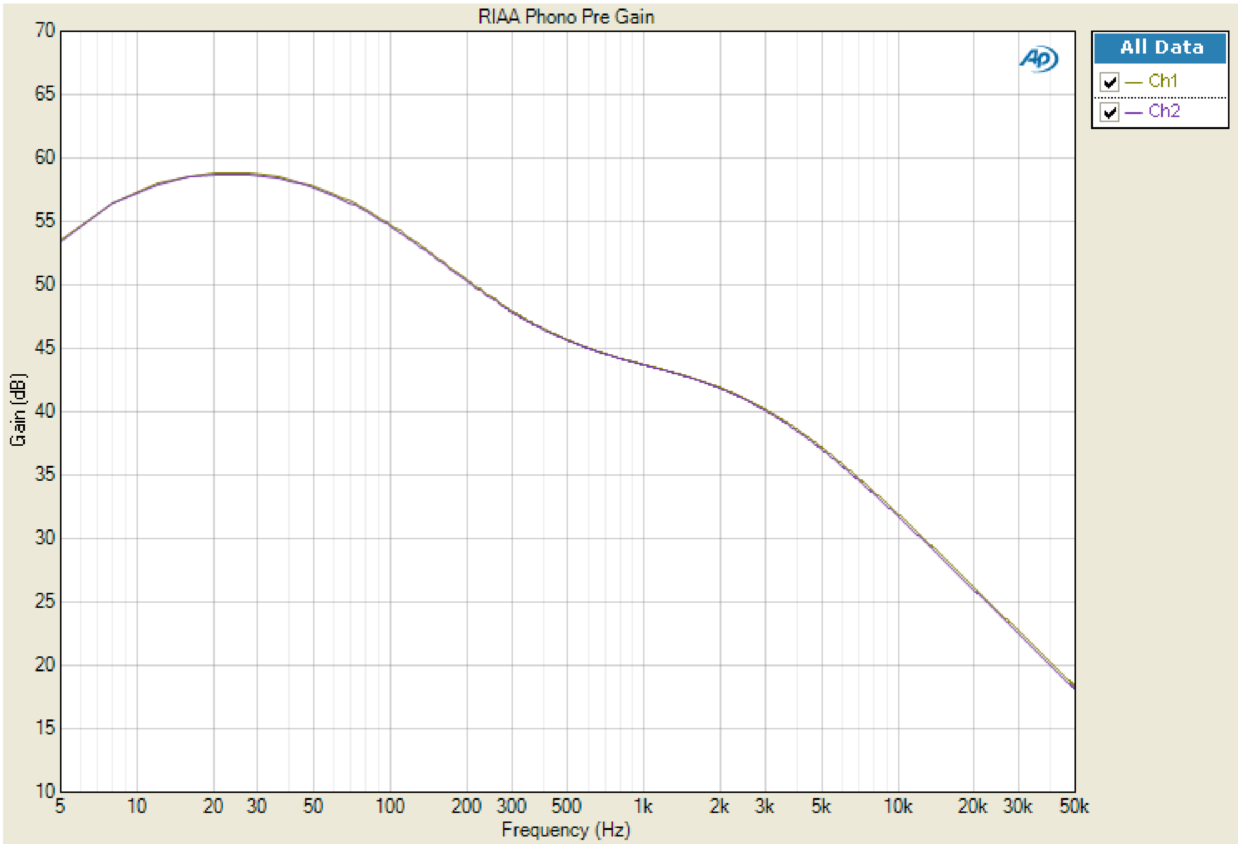

Figure 5. 9802k frequency response

Figure 6 is the exact same data, plotted as dB relative to the gain at 1kHz. The left and right channels track each other extremely well. The plot is useful for comparing the preamp response to the "specified" RIAA equalization. In my mind the 9802k preamp is accurate enough and there is no need to modify components to achieve a closer match, which most records wouldn't follow exactly anyway.

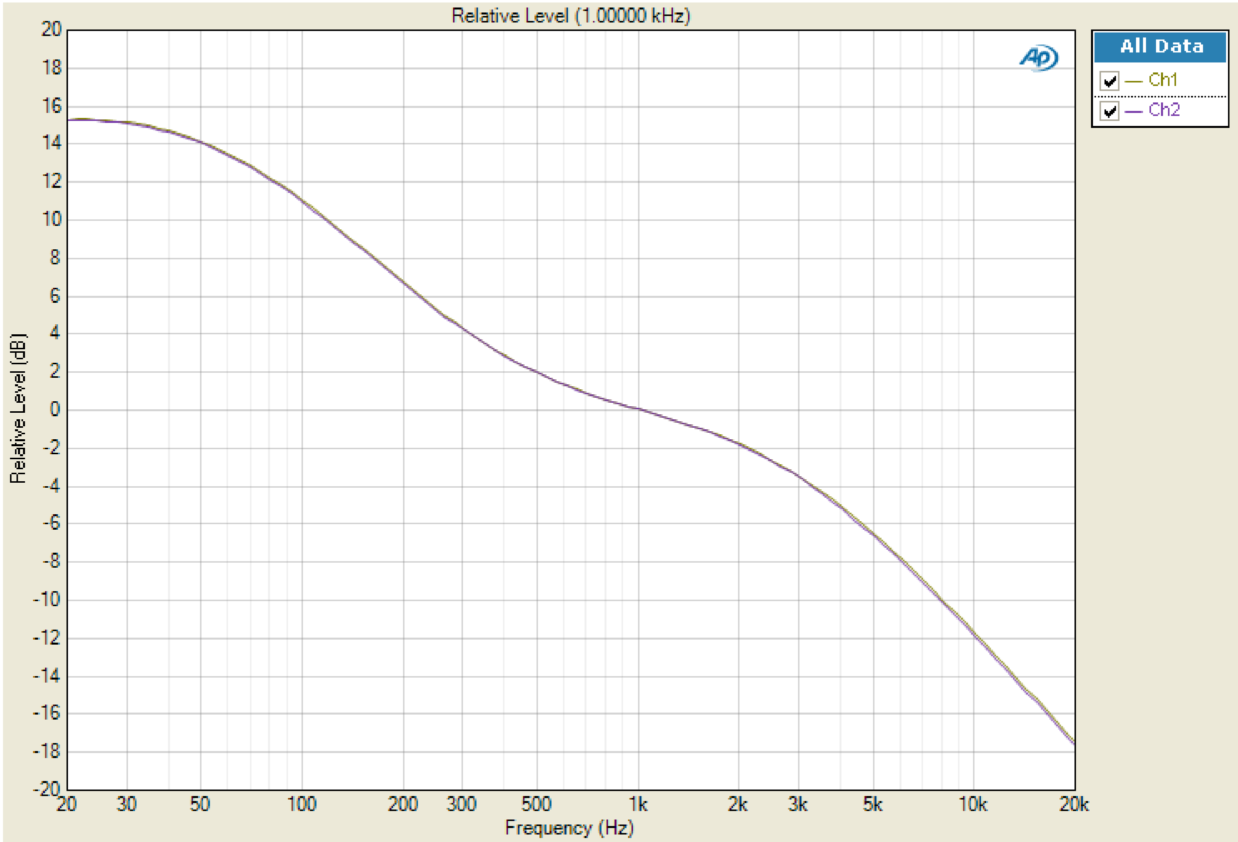

Figure 6. 9802k frequency response, relative to 1kHz

The RIAA table vs measured values (at 5.0mV$_{rms}$ input) are:

Frequency	RIAA Curve	9802k, measured in Figure 6	Deviation from RIAA curve (dB)
20	+19.36	+15.15	-4.21
49	+17.12	+14.03	-3.09
100	+13.18	+10.86	-2.32
210	+7.97	+6.26	-1.71
480	+2.93	+2.05	-0.88
950	+0.26	+0.12	-0.14
1000	0	0	0
1100	-0.23	-0.22	+0.01
2100	-2.73	-2.04	+0.69
3000	-4.65	-3.59	+1.06
6100	-9.64	-8.07	+1.57
9500	-13.22	-11.51	+1.71
15000	-17.07	-15.29	+1.78

Figure 7 is a plot of THD+N vs. frequency (A-weighted, 80Hz LPF) for 10mVrms input signal level.

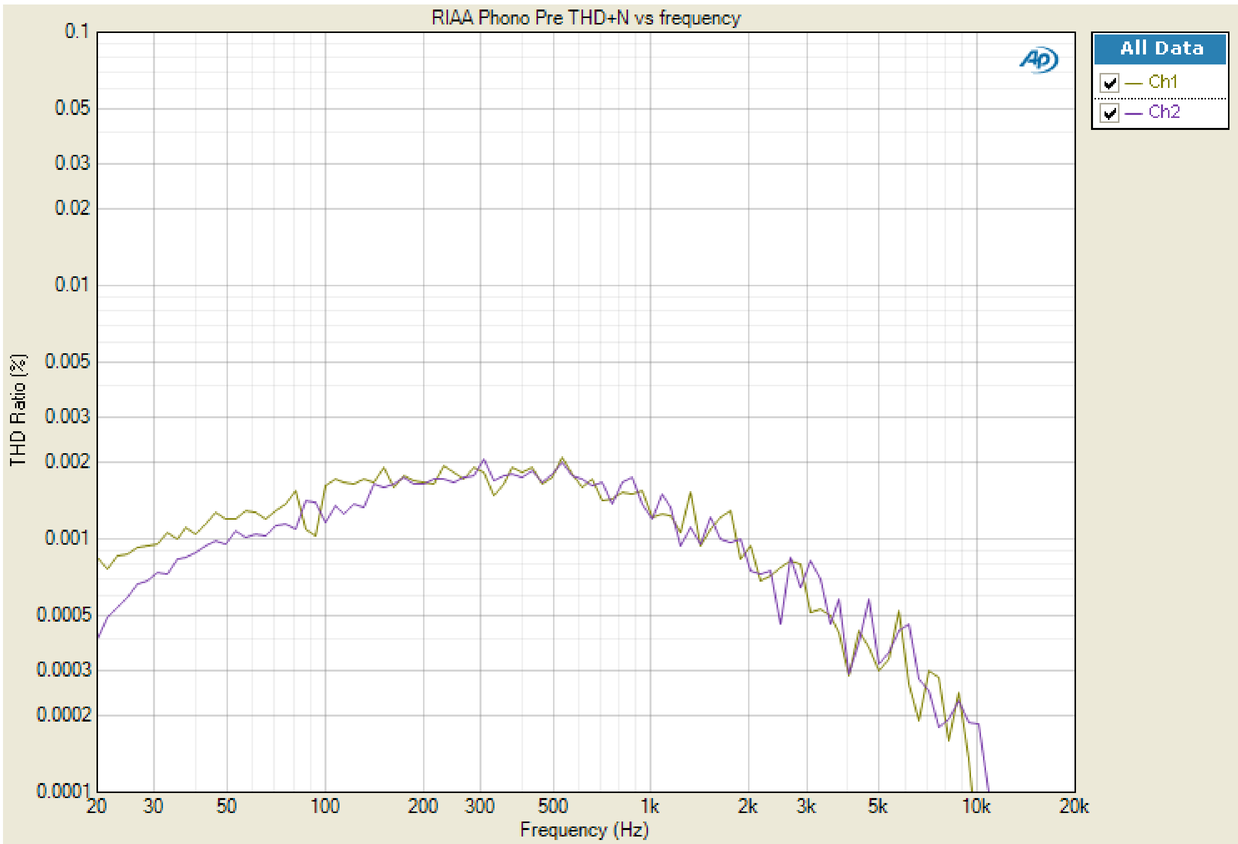

Figure 7. 9802k distortion vs. frequency

Figure 8 is a plot of phase deviation, using the Left channel as reference. This shows the two channels have the same polarity and track very closely in phase.

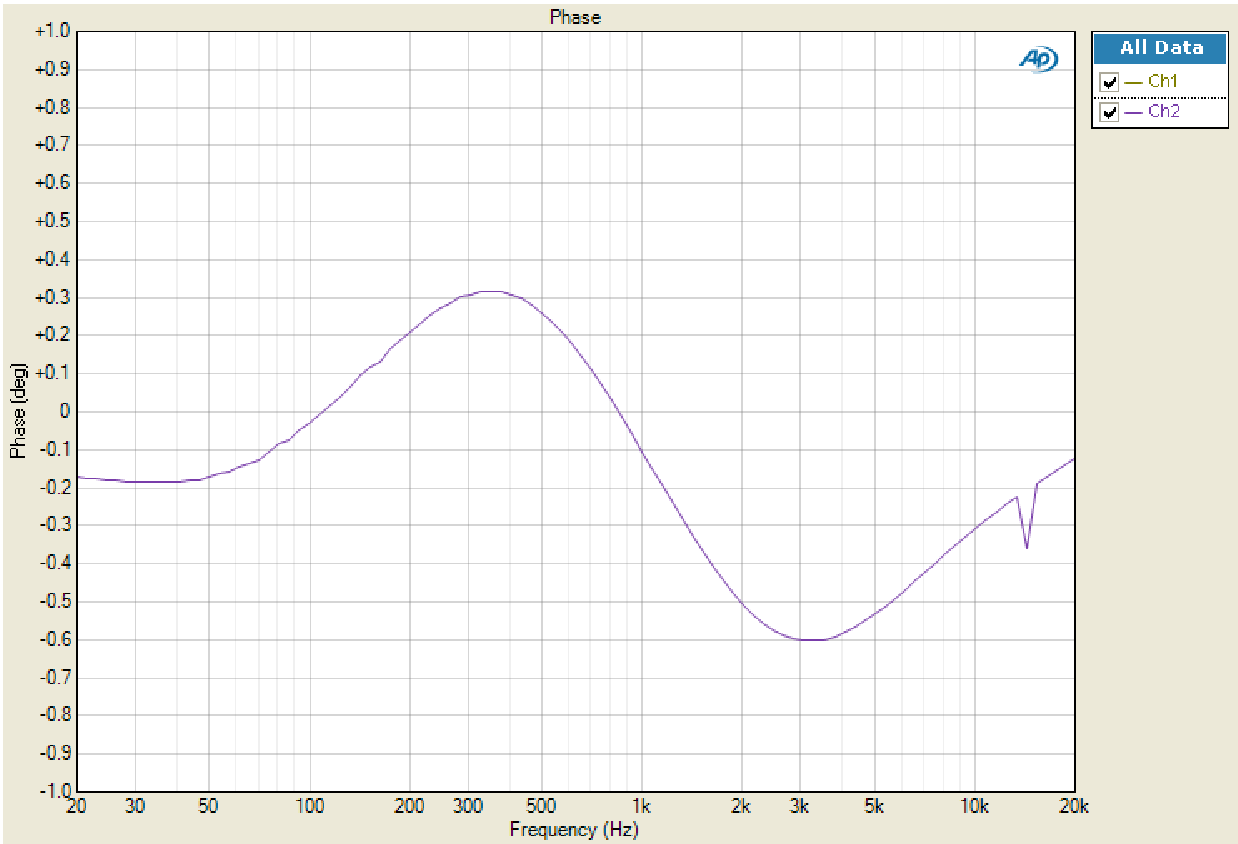

Figure 8. 9802k Phase deviation vs. frequency

I measured crosstalk using 10mV$_{rms}$ input levels:

Frequency	Left relative to right	Right relative to left
100Hz	-71.5dB	-70.2dB
1000Hz	-98.0dB	-82.1dB
5000Hz	-81.5dB	-76.3dB
10kHz	-79.0dB	-75.1dB

Figure 9 shows the results of the old SMPTE two-tone IMD test, 10mV$_{rms}$ input level, 60Hz and 7kHz, 4:1 ratio:

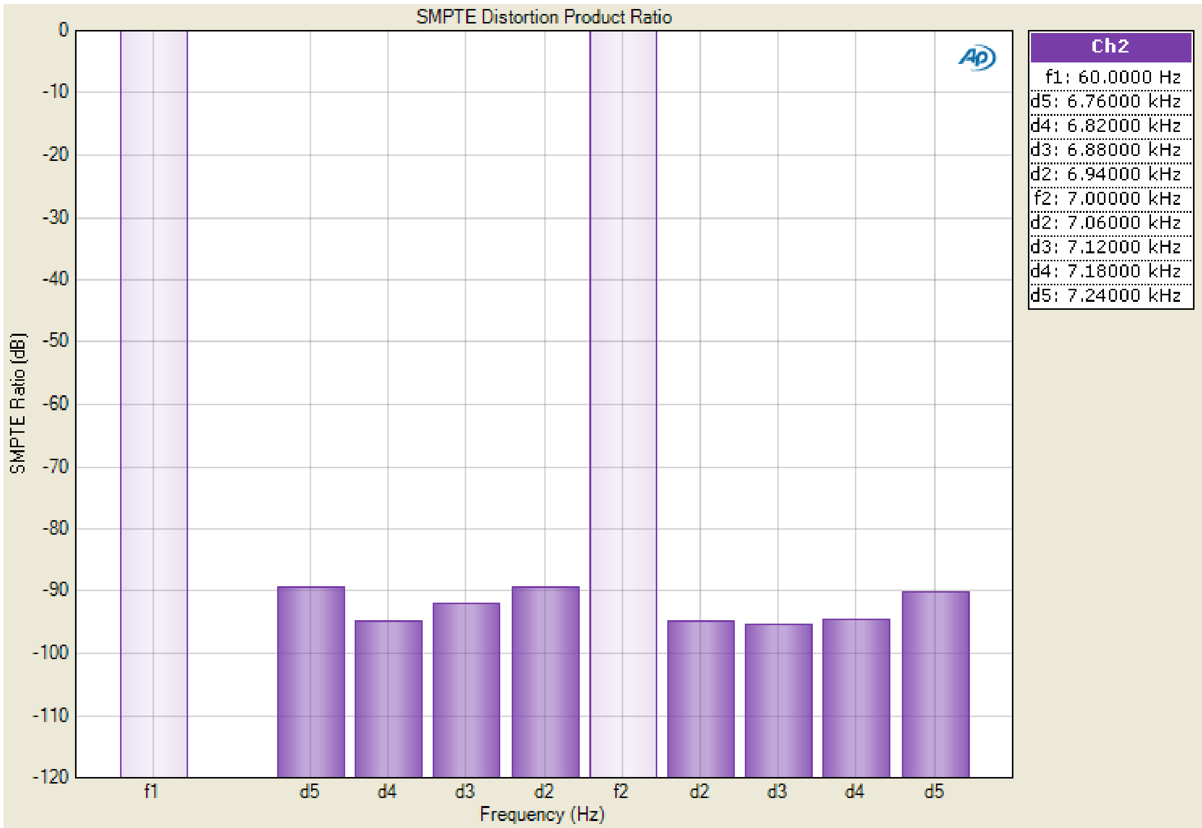

Figure 9. SMPTE two-tone Intermodulation

The APX525 was used to do a quick noise test of the 9802k preamp:

	RMS noise, left channel	RMS noise, right channel
20Hz-20kHz	370uV max.	230uV max
A-weighted, 20kHz LPF	96uV max.	74uV max.

The performance of this preamp is good, so I didn't bother to experiment with it. There is no record that is of better quality than this. I think the only substitution that might under ideal conditions make a (possibly) subtle audible change is the OPA2134 which is designed with FET's. Compared to the NE5532 bipolar op-amp, it has significantly faster slew rate (20V/µs versus 9V/µs). Square waves played through the 9802 could be rounded significantly, but there are no square waves on records, so who cares. The most important issue in building this project is to keep leads away from noise sources, and wire the grounds properly. It's easy to introduce hum into the audio; this will dominate any "audiophile" concerns. Once the preamp was wired and installed into my turntable, it worked great.

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