22 January 2005

Aikido e-mail

Subject: Tubes: Aikido Amplifier Revisited
The main virtue of the Aikido seems to be power supply noise rejection. Why not just use long tail pair to reject as common mode noise????

Keep whole amp balanced, use CF only where low impedance essential not just to inject noise.

Am I missing something here??

Cheers,
Bart
Australia

Power supply noise reduction is only half of the Aikido's virtues—possibly the smaller half. This circuit offers an amazing amount of flexibility, as different input and output tubes can be easily interchanged, as long as they share the socket pin-out and heater voltages. Because the circuit uses symmetrical triodes in place of plate and cathode resistors, a 6AQ8, 6BC8, 6BK7, 6BS8, 6CG7, 6GU7, 6FQ7, and 6N1P could be interchangeably used in an Aikido amplifier designed for 6DJ8s. Remember, tubes are not yardsticks, being more like car tires—they wear out. Just as a tire's weight and diameter decrease over time, so too the tube's conductance. So the fresh 6DJ8 is not the same as that same 6DJ8 after 2,000 hours of use. But as long as the two triodes age in the same way—which they are inclined to do, as they do the same amount of work and share the same materials and environment—the Aikido amplifier will always bias up correctly, splitting the B+ voltage between the triodes.

Additionally, unless regulated power supplies are used for the B+ and heater, these voltages will vary at the whim of the power company and your house's and neighbors' house's use, usually throwing the once fixed voltage relationships askew. Nevertheless, the Aikido amplifier will still function flawlessly, as it tracks these voltage changes symmetrically.

Moreover, the Aikido amplifier does not make huge popping swings at start up, as the output does not start at the B+ and then swing down a hundred or so volts when the tube heats up, as it does in a ground-cathode amplifier.

Most importantly, the circuit produces far less distortion than comparable circuits. The triode is not as linear as resistor, so ideally, it should not see a linear load, but a corresponding non-linear load. An analogy is found in someone needing glasses; if the eyes were perfect, then perfectly flat (perfectly linear) lenses would be needed, whereas imperfect eyes need counterbalancing lenses (non-linear) to see straight. Now, loading a triode with the same type of triode works well to flatten the transfer curve out of the amplifier.

Furthermore, the Aikido amplifier—like other Aikido techniques I have tried—seems to bypass much of the power supply squirrelliness, making the circuit sound as if it were attached to batteries or a well-regulated power supply. (This includes the sonic traces left by imperfect power supply capacitors.)

So, in sum, we get quite a bargain in the Aikido amplifier: low noise, low distortion, low output impedance, and no global feedback loop. Really, quite amazing.

Subject: Tubes: Aikido linestage bench tested
Thought you would be interested in the result of a benchtest of a version of the Aikido preamp.

The circuit: all tubes E88CC, B+ 250V. Cathode resistors for the first stage: 330 ohms (8.7mA Iq), for the CF: 200 ohms (11.6mA Iq).

Distortion test results:

At first tube plate:

Vout(Vpp)	2nd[%]	3rd[%]
40	0.7	0.02
10	0.18	0.07
5	0.09	0.003?
2	0.025	—

At output:

Vout(Vpp)	2nd[%]	3rd[%]
40	0.7	0.02
10	0.16	0.005
5	0.09	—
2	0.022	—

There seems to be some cancellation of 3rd harmonics here, and a little of the 2nd.

Noise canceling was about 25dB, and resulted in both lower hum and a lower noise floor overall.

Distortion tests with different loads (Vout: 10Vpp):

Load[kohm]	2nd[%]	3rd[%]
22k	0.16	0.005
10k	0.15	0.005
4k7	0.13	0.0055
2k2	0.11	0.011
1k	0.18	0.028

The most amazing thing is that when presented with a load, it just wants more. Distortion goes down with heavy loading. Why is that?

I also did a test with a 15k resistor replacing the top input tube, to see if there were any distortion canceling going on in this stage, but it does not seem so. Here are the results, measured at the output:

At output:

Vout(Vpp)	2nd[%]	3rd[%]
40	0.75	0.028
10	0.18	0.006
5	0.10	—
2	0.026	—

Quite similar, but a little worse.

All tests were done using AudioTester SW and a Soundblaster Live! soundcard. Not state of the art, but it gives an indication. Where 3rd harmonic is not listed, it is to close to the system residuals or noise floor to be valid.

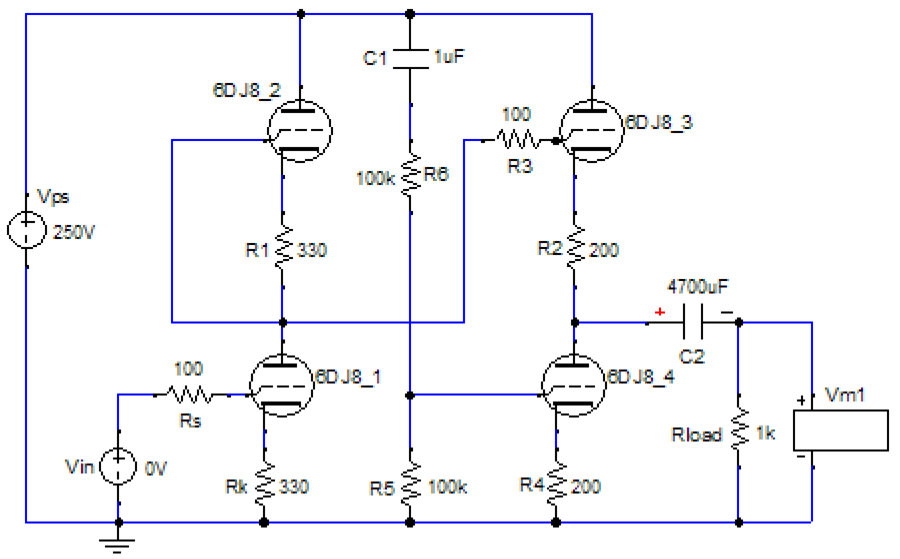
Hope you find this interesting. I'll build a stereo version and test it in the near future.

Best regards,

Bjørn
Norway

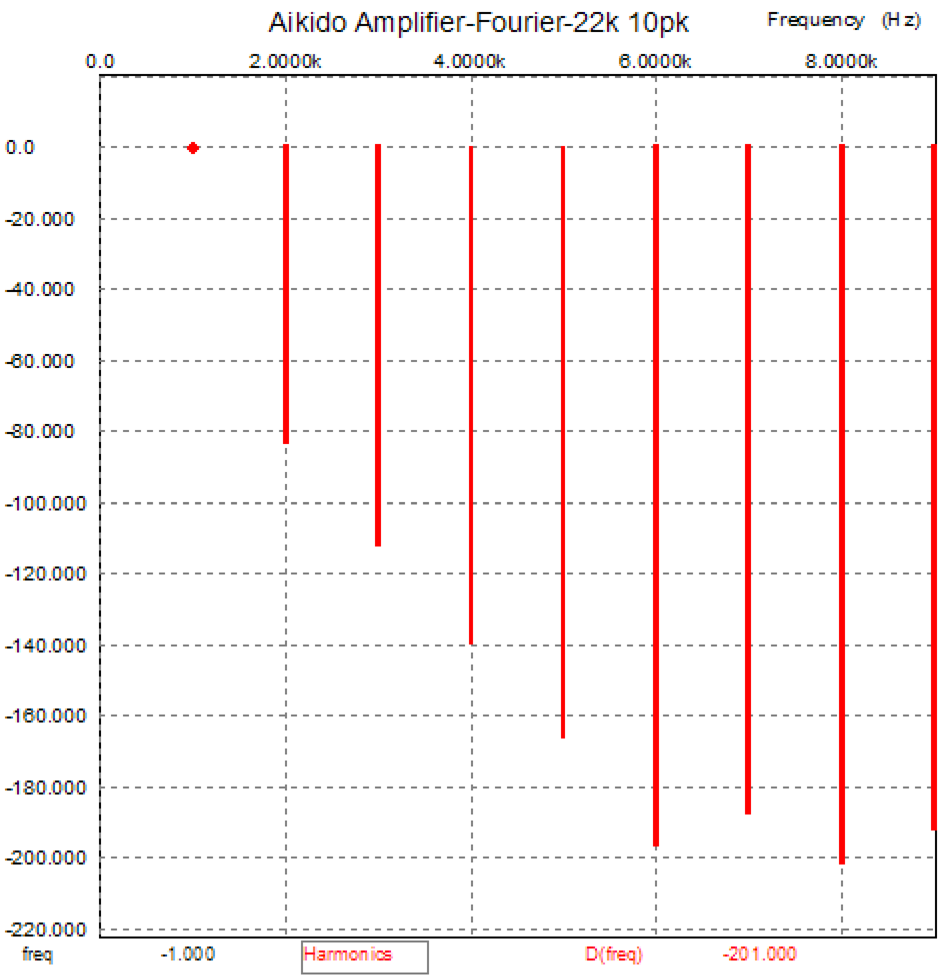
Reality check

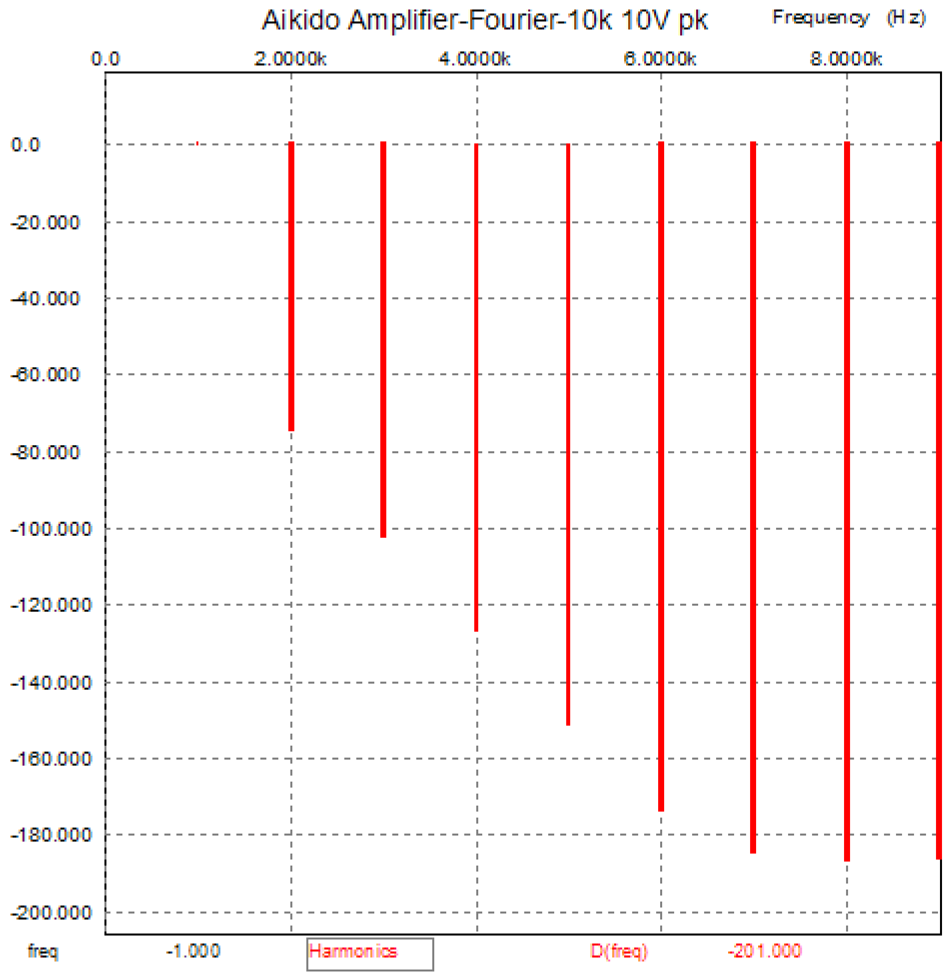
Bjørn's actual testing of the Aikido amplifier is quite intriguing (and welcomed by me) and offers an opportunity to test SPICE against reality. (Well, one reality, as once again, tubes are not yardsticks, as they vary from each other and even themselves over time.)

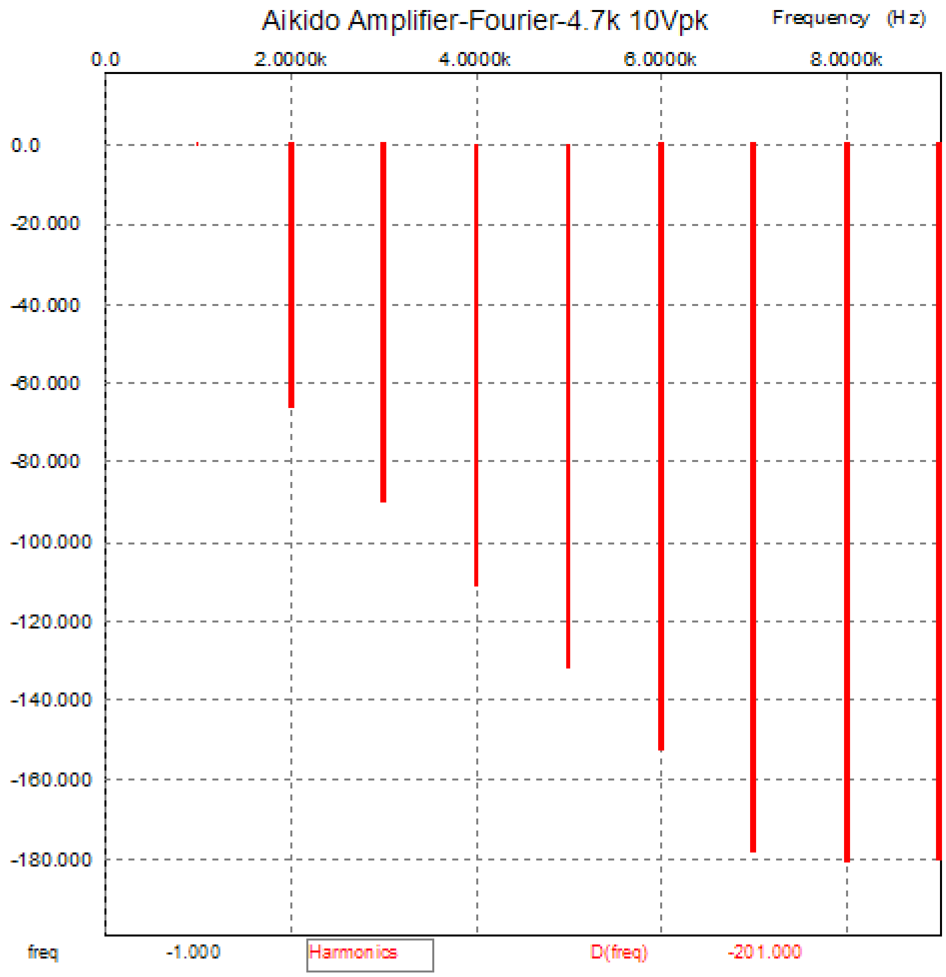


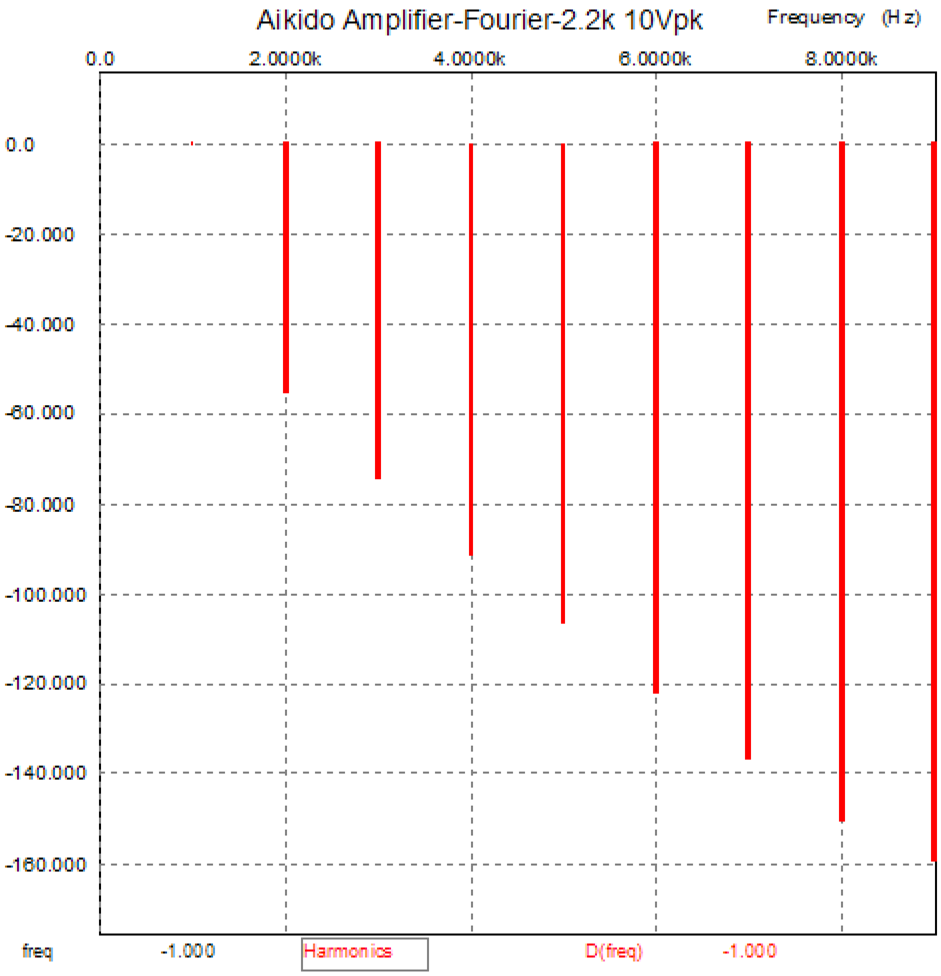
Above is a schematic of the circuit used in the B² Spice A/D simulator. The idle currents were close with 8.22mA for the first stage and 11.88mA for the second stage.

The advantages a circuit in SPICE enjoys are that all the resistors and capacitors are 0.000000000001% tolerance parts and all the triodes, pentodes, transistors, MOSFETs, and JFETs match perfectly and the power supply holds zero noise and zero output impedance—quite unlike reality. As a consequence we should expect better performance in SPICE than in grubby reality. And our expectations were fulfilled, as we can see in the slightly better results from doing the same array of varying-load-resistance-at-10volts-peak tests that Bjørn had actually tested the Aikido amplifier under.

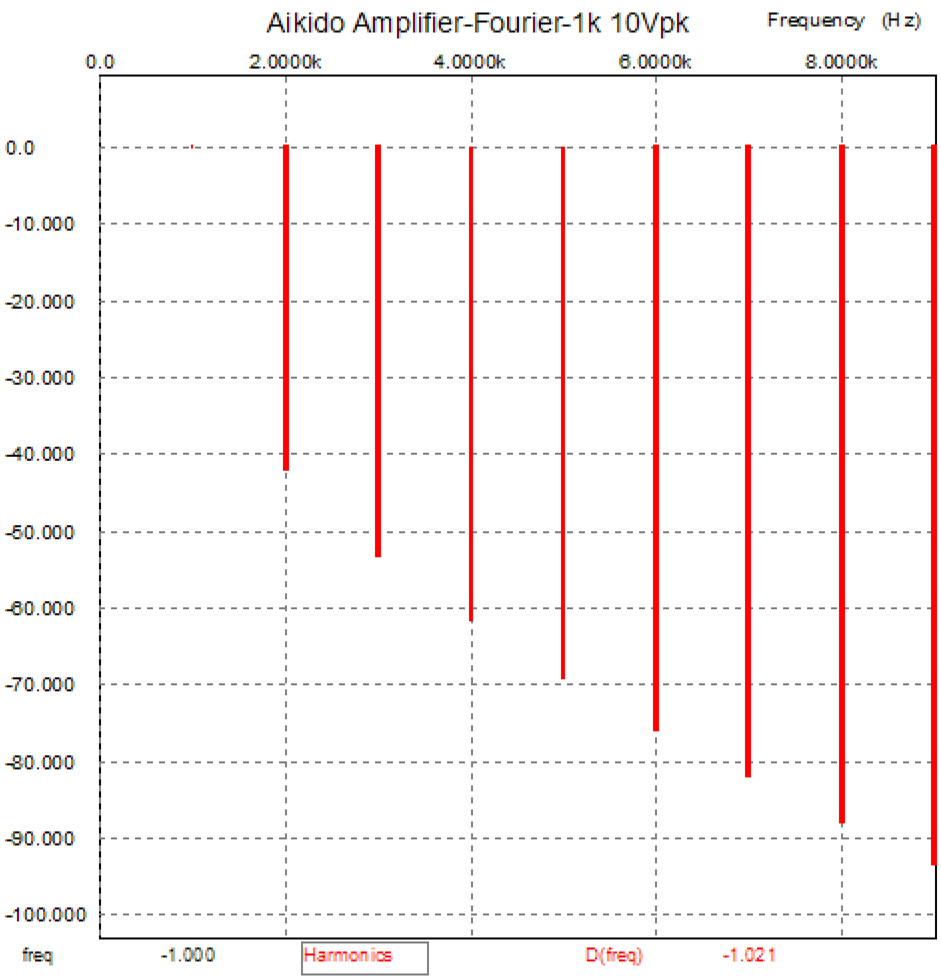



Aikido Amplifier-Fourier-10k 10V pk
Frequency (Hz)
0.0
2.0000k
4.0000k
6.0000k
8.0000k
0.0
-20.000
-40.000
-60.000
-80.000
-100.000
-120.000
-140.000
-160.000
-180.000
-200.000
freq
-1.000
Harmonics
D(freq)
-201.000


Aikido Amplifier-Fourier-4.7k 10Vpk
Frequency (Hz)
0.0
2.0000k
4.0000k
6.0000k
8.0000k
0.0
-20.000
-40.000
-60.000
-80.000
-100.000
-120.000
-140.000
-160.000
-180.000
freq
-1.000
Harmonics
D(freq)
-201.000



Aikido Amplifier-Fourier-2.2k 10Vpk
Frequency (Hz)
0.0
2.0000k
4.0000k
6.0000k
8.0000k
0.0
-20.000
-40.000
-60.000
-80.000
-100.000
-120.000
-140.000
-160.000
freq
-1.000
Harmonics
D(freq)
-1.000



Aikido Amplifier-Fourier-1k 10Vpk
Frequency (Hz)
0.0
2.0000k
4.0000k
6.0000k
8.0000k
0.0
-10.000
-20.000
-30.000
-40.000
-50.000
-60.000
-70.000
-80.000
-90.000
-100.000
freq
-1.000
Harmonics
D(freq)
-1.021

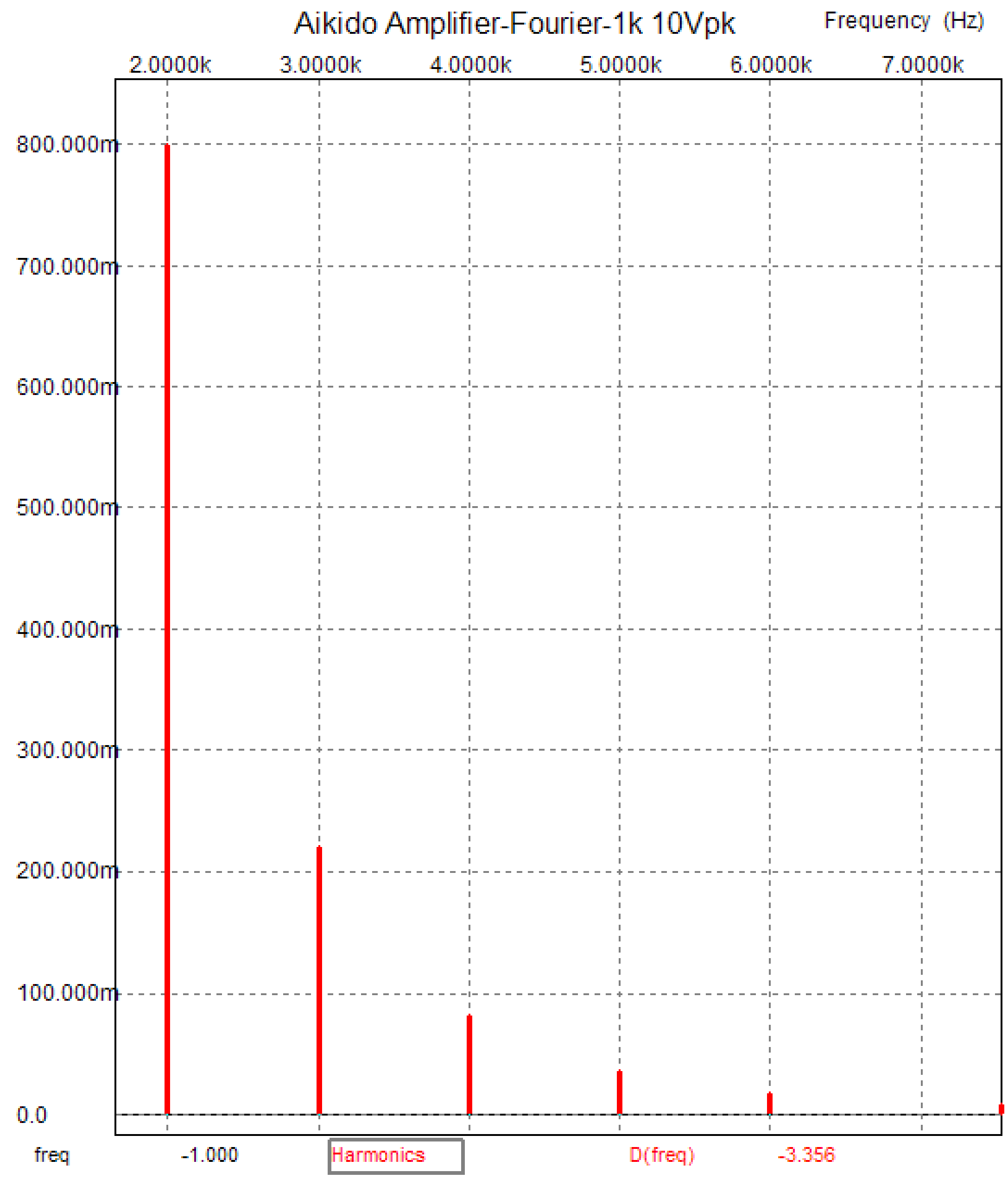
The code to deciphering dBs into percentages is

percent = 100 x 10^(dB/20),

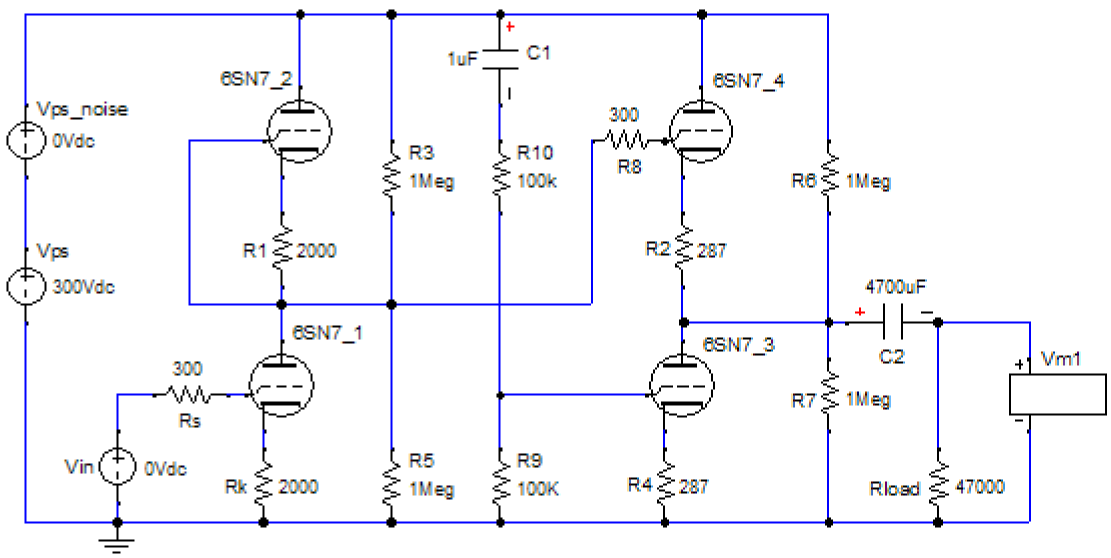
where the dBs retain their negative sign. For example,

0dB = 100%
-10dB = 31.6%
-20dB = 10%
-30dB = 3.16%
-40dB = 1%
-50dB = 0.316%
-60dB = 0.1%
-70dB = 0.0316%
-80dB = 0.01%
-90dB = 0.00316%
-100dB = 0.001%
-110dB = 0.000316%
-120dB = 0.0001%

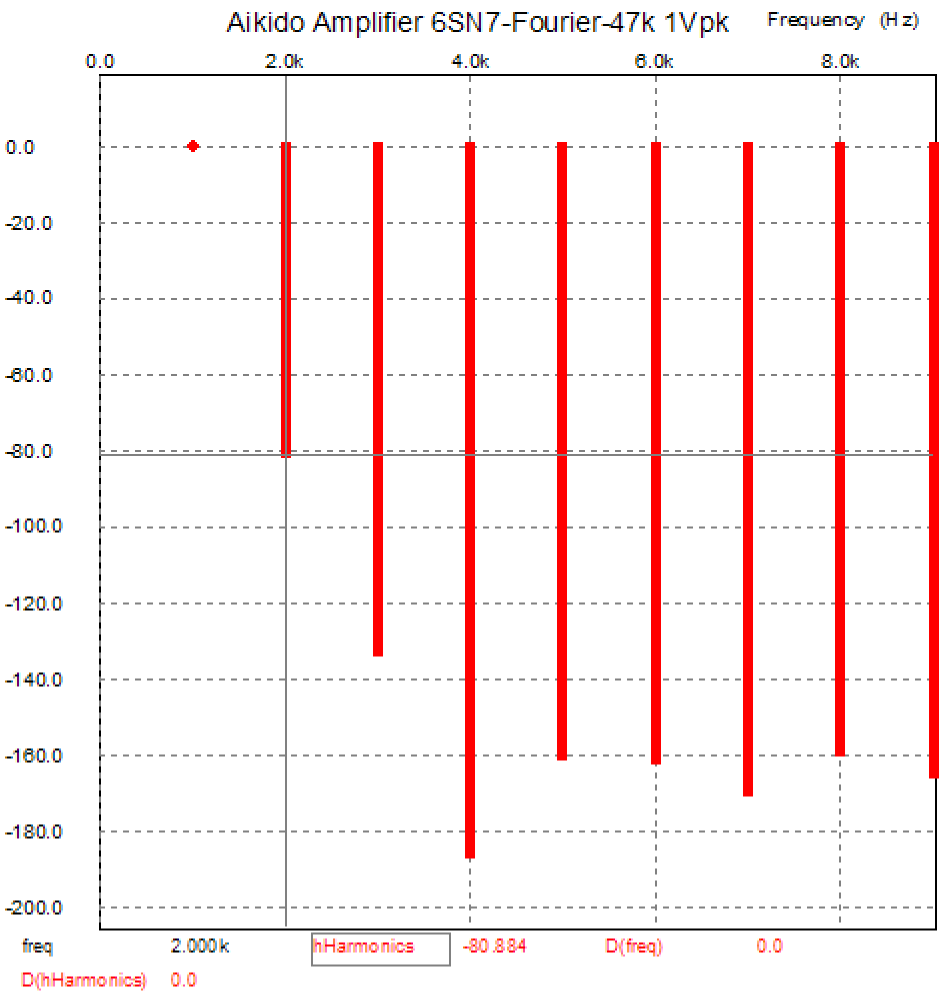
After much graph gazing, you will see dBs as percentages and percentages as dBs. Below is the last graph shown in percentages rather than dBs (the units are millipercents; thus, 800m% equals 0.8%)



The actual Aikido amplifier I plan on building is shown below (I have to dig out my drill press out of storage).



The results in SPICE look simply marvelous:



Once again, -80dB equals 0.01% distortion. Reality is unlikely to beat the simulation, but I bet it comes close to matching it.

Next time—how I wish I had more time for the journal—we will look into adding a snazzy new feature to the Aikido amplifier.

//JRB