Letter to the editor

Marcel van de Gevel from Haarlem, The Netherlands, writes:

Dear Editor,

After reading Gary Galo's excellent article on the archival phono preamplifier in Linear Audio Vol 5, ("An Archival Phono preamplifier") I realized that my own article about a phono pre-amplifier in Linear Audio Vol 4 ("A Tube-based phono preamplifier") is not entirely accurate. Knowing how fond most people are of round numbers, I have always erroneously assumed that the RIAA curve is determined by 50 Hz, 500 Hz and 75 us. In fact that should be 3.18 ms, 318 us and 75 us. Fortunately, the error is only about 0.1 %.

As an aside, I realized there is another inaccuracy in my Vol 4 article. I claimed that my pre-amplifier is free of semiconductors, but after reading some 1950's books on valve device physics, I now know that the oxide cathodes of the valves I used are, in fact, semiconductors. You would need to use bright emitter valves or valves with thoriated tungsten cathodes if you want to avoid semiconductors altogether.

Gary Galo replies:

From Mr. van de Gevel's comments, I gather that he might not be familiar with Stanley Lipshitz paper "On RIAA Equalization Networks", published in the AES Journal back in 1979. I'd be happy to email him a copy, if he would find it useful (I scanned it years ago and Stanley gave me permission to send it to any interested parties).

I have a couple of comments:

-Although older phono EQ curves were usually specified by the turnover frequencies, the RIAA curve is defined by the three time constants 3180uS, 318uS and 75uS. Lipshitz labeled these T3, T4 and T5. This ensures greatest possible accuracy in designing the filters that generate the recording curve, and that apply the complementary playback curve. These three time constants correspond to 50.05Hz, 500.5Hz and 2122Hz (F3, F4 and F5). However, deriving the time constants from those frequencies, rather than using the actual time constants, will result in errors.

-Mr. van de Gevel says that he used rounded-off frequencies of 50Hz and 500Hz in calculating the values in his network (I assume that he derived the time constants that he used in his calculations from these rounded-off frequencies). He notes that the error is about 0.1%.

Actually, the error is much greater. As Lipshitz points out, there are unwanted interactions in composite RIAA networks that result in significant errors when the real time constants are used to calculate the component values. The math he presents for doing the calculations takes those interactions into account. One example Lipshitz showed, where the real time constants were used, resulted in an 8% error.

-I designed spreadsheets to do the Lipshitz math for the four composite RIAA networks many years ago. This evening I used the one for Network A (the one Mr. van de Gevel used) to come up with the ideal values for his RIAA network. They are:

C1 = 3.6nF (2 x 1.8nF)
R1 = 883.3333K
C2 = 1.017916nF
R2 = 73.67995365k

My method is to start by picking the large capacitor value, so I left his value for C1 unchanged. Then, I calculate the values for the other components. As far as coming up with series/parallel R combinations, and parallel C combinations, I run simulations with the actual component values to verify accuracy.

As Lipshitz points out, high-frequency loop gain of the active circuit will affect the RIAA response at high frequencies. I have always found his math for calculating this to be rather indecipherable (I am NOT a mathematician - not even close!). So, I trim C2 in simulation for the most accurate high-frequency response. I invariably use op-amps - tube designers will have to work this out for themselves.

Marcel van de Gevel replies:

I read the Lipshitz paper Gary refers to a long time ago and I think I still have a copy in the attic, but I never actually used it. Calculating a RIAA correction network isn't all that difficult when you assume infinite loopgain and either neglect the +1 term or use a topology that has no +1 term, like my valve-based circuit. It becomes a lot more complicated when all corner frequencies have to be set individually, of course.

I believe I calculated the interactions correctly, because the measured response with 1 Mohm load was within +0.015 dB/-0.164 dB from the intended response for the left channel and +0.123 dB/-0.148 dB for the right channel for all frequencies between 20 Hz and 20 kHz. With "intended response" I mean that of a correction filter having corner frequencies of 50

Hz, 500 Hz and 1/(2*pi*75 us) combined with the 6.05 Hz second-order Butterworth highpass that I built in.

One thing I did wrong in retrospect is that I assumed that 50 Hz and 500 Hz were the official numbers, while these should have been 1/(2*pi*3.18 ms) and 1/(2*pi*318 us), respectively. Using the official frequencies, the error is +0.017 dB/-0.166 dB for the left channel and +0.125 dB/-0.147 dB for the right channel. The difference is quite small because my mistake mainly has an effect for frequencies between 50.05 Hz and 500.5 Hz, and my circuit had its largest response errors outside this frequency interval.