CORRECTION

More legible figures for the published article T-reg: a High-Voltage Regulator for Tube Amps are available on the author's website: www.linearaudio.nl. The figures as published in the magazine (April '09, p. 24) are correct.—Eds.

TESTING IMPEDANCE

I thank Mr. Yaniger for a cordial exchange of e-mails and especially for his willingness to test my 12AX7 suggestion, which did not pan out (Xpress Mail, April '09, "The Impasse Preamp," p. 42). His original 6SN7 was the better gain stage. Unfortunately, we have not been able to agree on his statement that the total impedances at the phase splitter's (PS) plate (P) and cathode (K) are identical if the P and K load impedances are also identical.

Mr. Yaniger's proposed test of output impedance requires that identical test loads be present simultaneously at both the P and K. No justification is given for this requirement, which is not found in any engineering textbook that I have ever seen. The standard prescription for testing output impedance involves driving the input of the circuit under test (C.U.T.) with a signal. The unloaded voltage is measured at the output node under test.

Next, a short circuit to ground at the frequency of the test signal is applied to that node, and the current into the short is measured. The output impedance is defined as the voltage divided by the current. Never is any mention made of placing additional test loads at any other node in the C.U.T. Nor is there any discussion of testing certain kinds of circuits differently, whether those circuits are balanced, symmetrical, have differential outputs, or have any other particular characteristic.

Certainly, shorting an output will lead to operation in a manner quite different

from what was intended by the designer, but this is clearly a legitimate part of an impedance measurement. Clearly, adding test loads to multiple circuit nodes will yield results different from the classical impedance test. Such a change in an established definition requires a hearty justification, especially since the results are at odds with the standard measurement.

Mr. Yaniger mentions the Jones text, which offers two arguments in favor of his position. The first argument states without proof or derivation that feedback in the PS *reduces* the P impedance. It is worthwhile noting that pages 312-313 (and 329-330 in more detail) of the 4th edition of the *Radiotron Designer's Handbook* (RDH4) provide a derivation which shows that the feedback through the cathode load *increases* the P impedance. There are numerous web references (check out, for instance, www.rocw.raifoundation.org/computing/BCA/electroniccircuit/lecture-notes/lecture-26.pdf) which agree with this conclusion as do my own derivations, which I'd be happy to share with anyone interested.

This wealth of contradictory derivations should at least make the text's claim a contentious one requiring a justification. Strangely enough, the text itself on page 404 states that the impedance looking into the plate of a triode is rp + (1 + μ)Rk. This would clearly be *reduced* rather than increased (as later claimed) if Rk were bypassed and cathode feedback eliminated. It is unclear to me how these contradictory statements in the text itself can be reconciled.

The second claim of the text is that since the frequency responses are identical at the P and K in a triode with identical P and K loads, "the output resistances must also be equal." But while this observation is true, the conclusion is demonstrably false.

Suppose I drove a load Z from a voltage source with a low impedance r. A current i(t) would flow from the source through r and Z, and a voltage v(t) = i(t)Z would arise across Z. Now suppose I drove the same load Z with a current source of a high impedance R. If I wished v(t) to arise across Z again, I'd set my current source to supply i(t) + v(t)/R.

The total impedance of these circuits at the load is the parallel combination of the source impedance and Z. Because the source impedances differ in the two circuits, the total impedances differ even though the same voltage arises across each Z. So equal voltages across identical Zs in the PS clearly do not imply equal total impedances. Equal voltages are a simple consequence of the facts that the same current flows through the P load, the triode P and K and the K load, and that the P and K loads are identical, as noted in the *RDH4* reference. Ohm's law takes care of the rest.

A straightforward, classical, by-the-book measurement or derivation of the impedances at the P and K in the PS with identical P and K loads shows those impedances in general to be quite different—not identical.

I stated in my prior letter that it would be possible to eliminate the impedance imbalance of the PS by adding a resistor in series with the cathode output. Mr. Yaniger correctly pointed out that this change alone would cause a voltage imbalance at power amplifier inputs with finite impedances. I was remiss in not having pointed out that there would need to be a compensatory change in the rest of the circuit to address that imbalance.

It turns out that you can modify the PS to have both balanced output signals and balanced drive impedances for a selected power amplifier input resistance. You need to increase slightly the value of the cathode bias resistor when you add the series resistor. Unfortunately, the gain balance then becomes worse than that of the standard PS the moment you add a common value of capacitance across the power amplifier inputs. Not exactly a step forward. Again, if anyone is interested, I'd be happy to share the details.

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STRANGE MIDPOINT

I studied the solid-state piece by Ian Hilton in the April 2009 issue of *audioXpress*, "Keeping the Hobby Alive" (p. 38), with interest. I am sure that

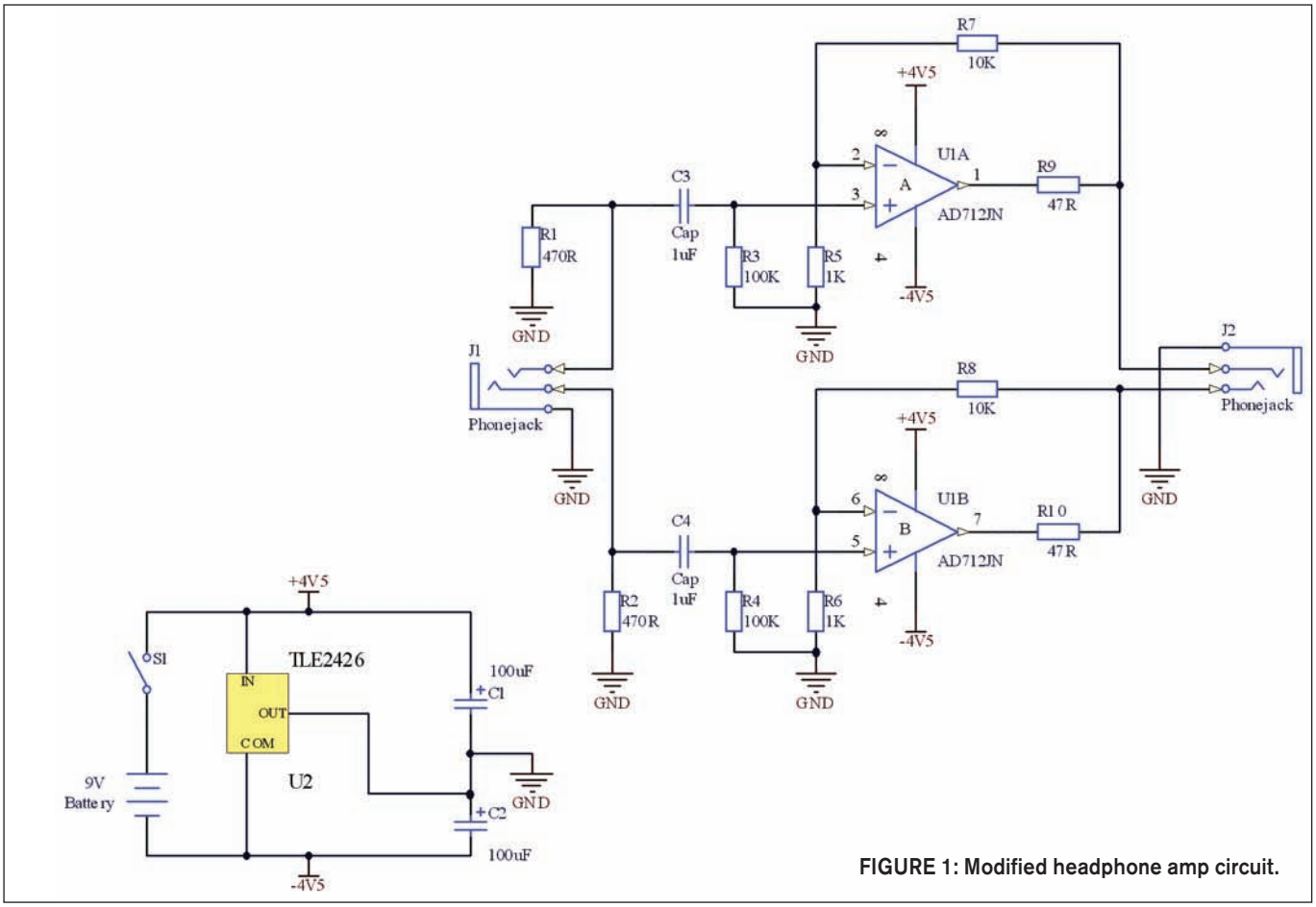

FIGURE 1: Modified headphone amp circuit.

the solution for this headphone-circuit sounds great, but, in my opinion, the emitter-follower midpoint circuit does not work. First of all, there is nothing to define the midpoint voltage. I suggest that what really does the trick is the common mode and the power-supply rejection ratios of the op amps. I believe the circuit would work better if you entirely removed the 2N3904 Q1 transistor and substituted a connection between the junction of R1 and R2 and the junction of C1 and C2, and call that GND.

As it is, the midpoint is not a midpoint at all; it is some voltage in which Q1 just barely—perhaps—conducts. There is nothing to define that voltage if the midpoint is more positive than -0.6V. In other words, if the midpoint is anywhere in the positive direction above -0.6V of the middle, Q1 is completely off and the midpoint is undefined.

I suggest that what really does the job of defining an AC ground are the two 100µF capacitors; the transistor does nothing.

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Ian Hilton responds:

Thanks for pointing that out, Hans. You are right, of course. The emitter-follower scheme will only work if the majority of current is drawn from the pseudo -4.5V rail. In my defense, it was just a quick lash-up and not fully thought out, but it still sounds good.

A better scheme is to have a push-pull NPN-PNP pair driving the pseudo ground. Incidentally, Quad uses such a scheme (push-pull pair) to generate a pseudo ground in their Quad 306 power amp.

Further to the constructive comments from Hans Weedon concerning the pseudo ground circuit in the simple headphone amp, I have revisited the design and amended it (**Fig. 1**). The pseudo ground is now generated using U2, a TLE2426, a device specifically designed for that purpose. Further amendments are the inclusion of 470R input resistors. These were required with a specific MP3 player that did not like a high impedance load and commenced oscillating. *aX*

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