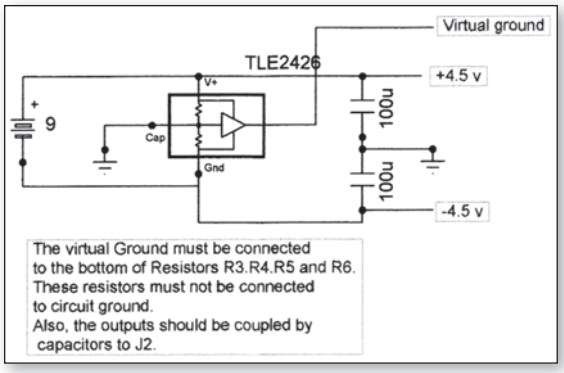
DIY AUDIO EVENT

The third international Burning Amplifier Festival will be held October 18 at the Presidio Yacht Club in San Francisco/Sausalito. An international group of audio DIY-ers will gather to show their projects and discuss audio matters. Presentations will include a talk on audio op amps by the designer of the AD797, Scott Wurcer, as well as a presentation of a new DIY project by Nelson Pass of Pass Labs. This event promises great equipment, great sound, and plenty of new ideas. Be there and bring your stuff! Go to www.burningamp.com for more information and to register.

CORRECTION

I would like to point out an error in your June 2009 issue. Ian Hilton (Xpress Mail, p. 45) refers to a revised design in Fig. 1 on p. 44. The enclosed schematic drawing shows the corrections with suitable notes.



Keep up the good work! I really enjoy your magazine.

Ed Sioma
sioma@erols.com

AMP PROJECT

Congratulations to Arto Terho for his very impressive redesign and the improved modifications he made to the 20W $260 amplifier (Feb. '09 *aX*, p. 38). I'm glad you enjoy the performance of the amp. I, too, was impressed with the sound. Your design using a larger chassis is indeed commendable. This amp, as I'm sure you'll agree, is ideal for a DIY project. Thank you for building it!

Joseph Still
Mt. Holly Springs, Penn.

HISTORIC GR DATA

The General Radio Historical Society is selling a series of CDs containing General Radio instruction manuals, handbooks, documents, photos, bulletins, parts catalogs, issues of the *Experimenter* publication, application notes, and technical papers. Proceeds from sales of this treasure trove of information will benefit the museum dedicated to General Radio, one of the giants in the instrumentation field. This effort is the work of Henry Hall, longtime instrument designer at GR, from his home in Concord, MA. For a listing of available CDs and pricing information, contact hphall@ieee.org.

TUNER MEASUREMENTS

In the Sony XDR-F1HD review (*aX* 8/09, p. 34), David Rich said Brian Beezley is the only reviewer still making measurements of FM tuners. Not so. I have made measurements for a number of FM tuners:

Blaupunkt Munchen RDM 169 Car Audio Head Unit, Hansen, C., *audioXpress* 9/01, pp. 62-65.

FM Tuners: Adcom, NAD, Parasound, Hansen, C. *audioXpress* 6/02, pp. 60-64.

NAD L53 DVD/CD Stereo Receiver, Hansen, C., *audioXpress* 12/05, pp. 38-53.

My FM test equipment is still available should you ever need FM tuner measurements.

Chuck Hansen
Ocean, N.J.

MORE IMPEDANCE TESTS

I welcome the opportunity to respond to Messrs. Blencowe and Mallory ("Impedance Dispute," Xpress Mail, 8/09, p. 45). It's at least 60 years past the time to clarify and settle this matter.

Regarding Mr. Mallory's letter, I'm with him through the paragraph where he points out that if voltage sources in *two* separate circuits were loaded identically, and their output voltages "changed equivalently" (the ratios of loaded to unloaded voltages were equal), then their output impedances would be equal. But then he applies this observation to a *single* circuit with loads on *two* sides of *one* source!

Because of that unsupported leap of logic, he is not entitled to his conclusion. I invite Mr. Mallory instead to derive expressions for the impedances (not voltages) of the plate (P) and cathode (K). Surely this is possible to do, and it gets right to the heart of the matter.

Regarding Mr. Blencowe: first, I never made the false claim that, ". . . mutual feedback between each output and the grid causes the output impedances to become identical. . ." Second, Mr. Blencowe needs to read all of his sources more carefully. The page 330 RDHB4 expression he cited is described by a sentence he incompletely quoted which states in full, "The equivalent source impedance that determines the high frequency attenuation for each channel due to shunt capacitance is given by (equation 34a)." But this "equivalent source impedance" is *not* the output resistance of P or K, which can be found earlier on the same page: "The effective output resistance is different for the two output channels, since P operates with current feedback and K operates with voltage feedback:"

Channel P:	rp` = rp + u Rk	where Rk = RL	(30)
Channel K:	rp` = (rp + RL) / (u + 1)		(31)

The Priesman paper Mr. Blencowe cites reprises the above equations as (1) and (2), with the exception that the u in RDHB4 equation (30) is replaced with u + 1. And in the Jones paper Mr. Blencowe cites, the second paragraph states, "The cathode source impedance, being that of an amplifier with degenerative voltage feedback, is low. At the plate terminal an amplifier with degenerative current feedback is seen, and here the source impedance is high." **All three authors specifically deny the claim of equal electrode impedances (EEI)!** RDHB4 goes on to explain that the currents out of the P and K are equal, and when they flow into equal loads, they produce equal voltages. This fact neither implies nor is implied by EEI.

Mr. Blencowe agrees that if one measures the output impedances one at a time, they do indeed "appear" different. But he opines that this is "pointless,"

since more than one output is used at a time, and so therefore this definition of output impedance is also pointless! (It is telling that he offers no alternative definition.) And although no proof of this sweeping assertion is supplied, it's supposed to be so "obvious" that the texts wouldn't even mention it! Allow me to observe that the absence from the texts of an error is even more likely than the absence of the obvious.

But you must pick your battles, so let's make sure that we respect Mr. Blencowe's admonition of "using the circuit as a phase inverter" when deriving its output impedances. From this I infer that he requires the P and K loads to remain identical and the voltages equal and opposite—the circuit must stay "balanced" at all times. Unfortunately, I don't know how to measure circuit impedances by adding a standard test load while keeping this circuit balanced. So I'll need to use a less common technique.

Impedances can always be expressed as a test current-induced change of voltage divided by that test current. The test current must flow between the circuit node under test and some point outside of the circuit under test. The following method is in accord with this principle, and I'd be glad to provide a generalized, algebraic proof of its equivalence to the more traditional ones if anyone is interested.

Referring to **Fig. 1**, drive opposing but equal AC test currents into the two cathodyne outputs. This maintains balance without adding any load impedances to the circuit being tested. Now write conservation of current equations at the plate and cathode:

$$\frac{Vp}{Rp} - ip + \frac{Vp - Vk(\mu + 1) + \mu \cdot Vg}{rp} = 0$$

$$\frac{(\mu + 1)\cdot Vk - \mu \cdot Vg - Vp}{rp} + \frac{Vk}{Rk} - ik = 0$$

You can solve the first equation for Vk, substitute the expression for Vk into the second, and then solve for Vp. The process is reversed for Vk, first solving the second equation for Vp, and so on. Sparing readers the algebra (which I'd supply if this weren't a letter), you can rearrange these equations to form two others more suited to our purposes:

$$Vp = \frac{[rp + Rk\cdot(\mu + 1)]\cdot Rp}{Rp + rp + Rk\cdot(\mu + 1)}\cdot ip + \frac{(1 + \mu)\cdot Rk\cdot Rp}{Rp + rp + Rk\cdot(\mu + 1)}\cdot ik - \frac{\mu\cdot Rp}{Rp + rp + Rk\cdot(\mu + 1)}\cdot Vg$$

$$Vk = \frac{Rk\cdot\frac{Rp + rp}{\mu + 1}}{Rk + \frac{Rp + rp}{\mu + 1}}\cdot ik + \frac{\frac{Rk\cdot Rp}{\mu + 1}}{Rk + \frac{Rp + rp}{1 + \mu}}\cdot ip + \frac{\mu\cdot Rk}{Rp + rp + Rk\cdot(\mu + 1)}\cdot Vg$$

There is a simple way to gain confidence that this second pair of equations is correctly derived from the first. Choose arbitrary values for all terms in the first pair except for ip and ik and calculate, solving for ip and ik. Now substitute all of these values into the second pair. The second pair will equate if they were correctly derived from the first. You can repeat this for more sets of values to gain even more confidence. (I routinely do this to check my derivations.) Or, you can continue the derivation process I described and arrive at the second equation pair yourself.

Let's look at the third equation. The portion of Vp that is due to the test current flowing between P and ground outside the cathodyne is expressed by the first (ip) term on the right-hand side. Dividing that term by ip leaves us with

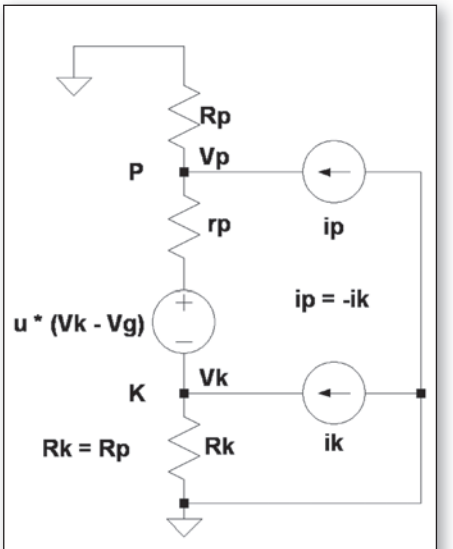


FIGURE 1: Balanced cathodyne phase splitter test circuit.

a result that can be expressed as Rp || rp + (1+u)Rk. But this is simply the plate resistor Rp in parallel with Priesman's result for the impedance looking into the plate, which as noted earlier is virtually identical to the RDHB4 result.

A similar approach is taken with the fourth equation, for Vk. Now the ik term is the relevant one. Dividing that by ik leaves an expression equivalent to the parallel combination of Rk and (Rp + rp)/(1 + u). This is the cathode resistor in parallel with the impedance looking into the cathode, as arrived at by both Priesman and RDHB4.

So now we have proven that the output impedances of a perfectly balanced cathodyne operating as a phase splitter are quite different. You can also see that these results are identical to what we would have obtained if we had applied the test currents one at a time. You can demonstrate this by turning on only the current of interest while removing (zeroing) the other. You can even set Vg = 0. All of this works because of the principle of superposition. Anyone who is surprised by this result may wish to investigate that principle. It can also be shown that the traditional method of adding test loads to the plate and cathode one at a time, unbalancing the circuit, will produce the same results.

To sum up, anyone still contending EEI will need to successfully refute RDHB4, Jones, Priesman, and the algebra above, to say nothing of providing his/her own algebraic proof—the gold standard of any such argument—for EEI. Anyone still asserting that the cathodyne P & K output impedances cannot be tested one at a time will need to explain why the results of doing so are identical to those of Priesman and the algebra above, and virtually identical to those of RDHB4.

To just ignore these results would obviously be pointless.

Chris Paul
cpaul@suffolk.lib.ny.us
aX

CONTRIBUTORS

Jim Wood ("Build The "Groove Jockey", p. 8) is the founder and CEO of Inovonics, Inc., a longtime California manufacturer of professional audio and RF support equipment for radio broadcasting. Jim has been an avid audio and RF circuit experimenter since the mid-1950s.

Kenneth L. Bird ("A Visit With Dave Weems," p. 17) has been building speakers since 1954, and was installing 12" speakers in the rear decks of 1958 Chevys and Cadillacs long before the word "autosound" was coined. Armed with a BSEE and much later with an MBA, he has spent most of his career in audio related pursuits with firms such as GTE, Rockwell International, and Shure Brothers. Currently, he is a Product Manager with MAXTEC International, makers of the B+K line of test equipment.

Bill Fitzmaurice ("The Jack 10, Pt. 2," p. 20) has been a professional musician since 1966 and has been constructing instruments, amplifiers, and speakers for just as long. Vice president of DeltaSounds Loudspeakers Inc., Fitzmaurice is the author of *Speaker Builder's Loudspeakers for Musicians* and over 30 magazine articles dealing with speakers and electric instruments, as well as the action-adventure novel *Operation: Sergeant York*. Bill and his wife of over 30 years reside in Laconia, N.H.

Jan Didden ("paX, Part 3," p. 24) built his first OTL amp with 807 tubes 35 years ago. He has built speakers, preamps, and tape recorders, but is most interested in power amps, especially using error correction as discussed by Hawksford. Many of his projects have been published by *audioXpress*. Now retired from a career with the Netherlands Airforce and NATO, he tries to complete all those half-finished projects accumulated for lack of time. He now also has the time to travel to interesting audio events and interview audio luminaries. His projects are documented on his Linear Audio website.

Ed Simon (Review: Burson Audio Modules, p. 30) received his B.S.E.E. at Carnegie-Mellon University. He has installed over 500 sound systems at venues including Jacob's Field, Cleveland, Ohio; MCI Center, Washington D.C.; Museum of Modern Art Restaurants, New York; The Coliseum, Nashville, Tenn.; The Forum, Los Angeles; Fisher Cats Stadium, Manchester, N.H.

Tom Lyle (Review: PrimaLuna ProLogue Six Tube Monoblock Power Amplifiers, p. 34) has written for the web magazine Enjoy the Music, as well as *The Sensible Sound*.

David A. Rich (Review: Pioneer X-Z9 Compact Stereo System, Pt. 2, p. 39) received his MSEE from Columbia University and his Ph.D. from Polytechnic University of NYU. He specializes in the design of analog and mixed-signal integrated circuits and has taught graduate and undergraduate courses in integrated electronics and electroacoustics. Student work under his guidance, including a novel high-efficiency mixed-signal integrated power amplifier, has won numerous awards. His industrial positions include Technical Manager at Bell Laboratories. His portfolio has spanned the design of audio ICs for Air Force One to RF ICs for wireless cell phones, and his innovations have earned 14 patents. He is a Senior Member of the IEEE and has frequently served as chairperson for technical and panel sessions at IEEE conferences. He has been a member of the AES signal processing technical committee and has been Technical Editor for *Audio Critic* and *Sensible Sound*. He is the head of the music committee of the Bethlehem Chamber Music Society.

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