A BRIGHT IDEA

I have one comment on the excellent article ("A Low Noise Measurement Preamp," April '07) by Mr. Colin. The diodes selected for the input circuit protection are not optimal. The input impedance is specified as 3.6MΩ (from Table 3) but the circuit shows a 10MΩ resistor in parallel with two protection diodes and the gate of a JFET transistor. You should be able to have much higher input impedance than 3.6MΩ.

The culprits are the protection diodes selected for this function. The 1N4148 diodes are switching-type diodes, which conduct significantly, compared with a 10MΩ resistor, even for the low input voltages that are within the linear range for this amplifier. The input linear range depends on the gain but is either from -20mV to +20mV or from -100mV to +100mV (from Table 3 again). The current in a 10MΩ resistor with 100mV applied is 10nA.

The typical current for a forward biased 1N4148 diode at 275mV is about 1µA, taken from Fairchild specification sheets. The curve is quite linear, on a linear-logarithmic scale, and you can extract from it the following ratio; for an order of 10 change in forward current you need a change of 112mV in forward applied voltage. The input JFET used has a specified maximum gate current of 200pA. With a 50mV input you will have about 10nA in the diode or 50 times the JFET gate current plus the 5nA that flows in the resistor giving you about 3.3MΩ equivalent input impedance.

A better diode for this application would be a red LED, kept in the dark; i.e., painted over and kept inside an opaque box. LEDs are reversible process devices—they convert electric energy into light energy and light energy into electric energy. So to keep the current generated by light hitting the LED from interfering with the signal current coming from the circuit under test, you must optically shield the LED from external light sources.

I did some tests using DC signal as the excitation to compare the two diodes, but without the JFET, and I got the following results (**Fig. 1**). The test setup is in **Fig. 2**. The graph shows the input voltage to the divider, horizontal scale, versus the output from the divider, vertical scale. Because I used a 10MΩ source resistor, the straight line with a 0.5 slope is the circuit without any protection diodes.

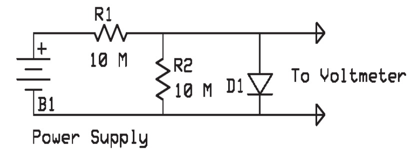

Figure 1

The curve of the measurements done with the LED is so close to the curve without any diode it is plotted over it. The lower curve on the graph is done with the 1N4148 diode. I used a very high input impedance voltmeter, greater than 1GΩ, so as not to load the circuit, just as the JFET will do with its 200pA maximum bias current. With a red LED you can have a 10MΩ input impedance and keep it within 10% of that value for a signal up to approximately 1.3V peak.

This change should improve the low-frequency input impedance by making it not only higher but also by making it linear and constant against changes in ambient temperature.

If distortion measurements were to be done with a high impedance source, they will most certainly show high levels of distortion due to the protection diodes acting up. The red LED should cure that. Why red? Well, the forward characteristics of LEDs depend on the physics of the semiconductor, mostly doping, and affect the forward characteristics and the color of the light generated. A red LED has a reasonably high voltage for a significant current flow, is low in cost, and is easily available.

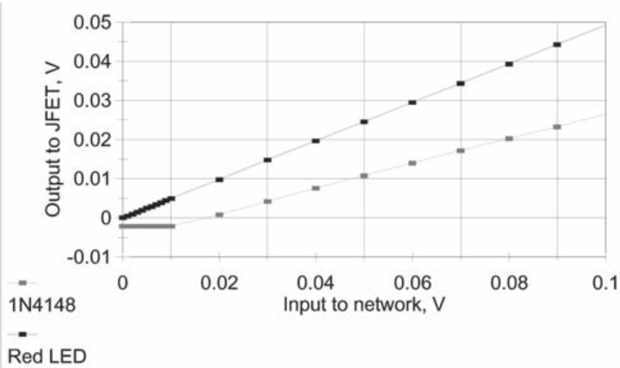

Figure 2

For more information on the particulars of diodes and other intriguing aspects of electronics I refer you to the book by Robert A. Pease, *Troubleshooting Analog Circuits*, 1991, Newnes, 217 pages, ISBN 0750694998, about $48.

TABLE 1: Characteristics of 1N4148 and two red LEDs at +21° C.

		1N4148 diode	Lumex SSL-LX5093SRC/E Digi-Key 67-1612 660nm super red	Lumex SSL-LX5093HT Digi-Key 67-1104 695nm Hi-efficiency red
photoelectric effect	V into 10MΩ	0.7mV	1.44V	10mV
1000 fc white light	I into short	70pA	11.4µA	1nA
reverse current		3.2nA at -0.2V	35pA at -1V	25pA at -1V
equivalent leakage R		62.5MΩ	29GΩ	40GΩ
forward current vs. voltage	0.2V	200nA	<0.1pA	2pA
	0.4V	11µA		
	1.1V		80nA	
	1.4V		5.3µA	20nA
	1.5V		30µA	70nA
	1.6V		290µA	710nA
	1.7V		2.26mA	11.2µA
	1.8V		6.22mA	260µA
	1.9V		11.2mA	1.62mA
	2.0V		17.3mA	3.95mA

I hope Mr. Colin tries this simple modification on his amp and reports whether it affects any other characteristics negatively or positively.

Daniel Dufresne
Ville Saint-Laurent, Québec
Canada

Dennis Colin responds:

Thank you for your excellent idea of using a red LED. I think only one would be needed, with its cathode connected to the JFET gates (to clamp negative spikes), because the gate is a diode to the source. However, in case this junction diode can't safely absorb positive (forward conducting) spikes, you could use two back-to-back optically-blocked LEDs.

I recently built a phono preamp using this JFET/AD797 input stage (called the LP797, article forthcoming), and at first I didn't include protection diodes. But I was careful about discharging any static charges on the turntable cables before plugging them in.

For the noise measurement applications I originally designed the preamp for, I didn't need an input Z higher than 1MΩ. But you brought up a good point about the 1N4148s causing nonlinearity with high source impedances, even at low input voltages, so I will replace them with red LEDs, in both the measurement preamp and my phono preamp.

As I write, I just finished the measurements in this letter's **Table 1**. The Digi-Key 67-1612 is a very bright red LED (2800mcd at 20mA); the 67-1104 red LED is more "ordinary," much less bright. Some notes:

1. Photoelectric effect: even the 1N4148 has a small amount, 0.7mV into 10MΩ, with 1000 foot-candles (fc) of white light (equivalent to outdoor lights under mildly overcast skies; the light from a desk lamp is about 100 fc). But notice that the 67-1612 LED generates 1.44V with 1000 fc of light—you could use it as a solar cell!

2. With a forward voltage of 200mV, the 1N4148, with 200nA, looks like a 1MΩ resistor as far as equivalent leakage. But the 67-1612 LED conducts less than 0.1pA at 200mV, equivalent to a 2 tera-ohm (2 million megohm) resistor! With a *reverse* voltage of 1V, it draws 35pA, equivalent to a 29G resistor. At the forward voltage of 200mV, this LED has one two-millionth the leakage of a 1N4148!

Needless to say, I'm convinced! Thank you very much for the idea, the useful information, and your interest.

LISTENING TESTS

In the April '07 Letters column, James Hoover asked for an article on listening tests not involving test equipment. Mr. Hoover, I think your letter couldn't be more appropriate. I, like many others, am guilty of focusing on the "technical minutiae (that) doesn't communicate the worthwhile immediacy any audiophile felt (or not) if they'd been sitting right in front of these Scott tube amps," where Mr. Hoover refers to the Scott 222C/222D mods performed by Charles Hansen and me.

It's all too easy to devote disproportionate coverage to "if I can just get one more half-dB out of that driver," rather than "the improved driver resulted in less collapse of the soundstage when the amp was mildly overdriven." I remember a speaker review in which about ten pages were focused on topology and parts criticism, but only two sentences described the sound!

One problem is that while measurements are well-defined, precise, and repeatable, attempts at sound quality description are usually none of these. This is because of variables both subjective (which of many deficiencies is the least objectionable to a given listener?) and objective (the quality, or lack thereof, of one's recordings and other associated playback components besides the one evaluated).

Ed Dell has asked me to write about my various experiences and methodology regarding listening tests. I recently submitted an article [to be published later this year—Eds.] entitled "Intrinsic Fidelity Testing," in which a component's output versus input signals (precisely level matched) are compared. This eliminates many of the above variables. Also, I've just completed building an A/B/I switch box (the "I" is for "In-

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trinsic Fidelity"). See the article on p. 6 of the June '07 issue.

The box allows precise (0.01dB) level matching, uses OPA627 ultra-high quality op amp output buffers/headphone drivers, and uses a manual or automatic controlled relay to switch between the outputs of two components (A/B) or between the output and input of one component (Intrinsic Fidelity Test). The box allows "blind" or "sighted" comparison via switchable A/B status lights.

I completely endorse your use of analog tapes, and the importance you give to high-quality recordings. I use SACD material because the glare and graininess of 16/44 CDs can cause misleading component preferences. Two of my best SACDs are "Super Artists on Super Audio" (Channel Classics CCS SA SEL 3404), and "The Very Tall Band" (Telarc CD-83443-SA), with Oscar Peterson, Ray Brown, and Milt Jackson, live at the Blue Note, 1998. The first has the most natural recorded violin sound I've heard (Haydn's Clock Symphony), and the second has absolutely first-rate vibraphone playing and sound.

With the intrinsic fidelity test, I've so far heard one power amp and one phono preamp (preceded with a stereo pair of Inverse RIAA networks) in which the output sounds indistinguishable from the input, even using the extremely resolving Sennheiser HD650 headphones. I've heard some components in which the output sounds better than the input. Some magic distortion cancelling? No —I think the component generated some effect that partially compensated some recording (or other system component's) deficiency—the "expensive tone control" effect!

Thank you for your letter—I hope this stimulates some much-needed discussion of the relation between technology and sound, such as used to appear in *The Audio Amateur* and *Glass Audio*.

Dennis Colin
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VOLTAGE QUADRIPLER

I hope that the Voltage Quadripler in **Fig. 1** will enable salvaged solid-state power transformers to be put to work in many tube amplifier projects.

Typically, most power transformers used in solid-state amps and receivers have voltages ranging from 60-100V AC, too little voltage for a high-quality tube amp, when using the usual half-wave, full-wave, or voltage doubler supplies. The voltage quadripler, so named because it quadruples the peak-to-peak value of the input voltage, actually multiplies the better-known RMS voltage five times or better. This would enable a 75V AC transformer to provide 375V DC, enough for an amp such as the Bruce W. Brown 6L6 "Junk Box" amp in *aX* December 2005.

As detailed in **Fig. 1**, the Quadripler actually consists of two voltage doublers connected in series. It works well with 100μF electrolytic capacitors, but you would do well to use higher value caps, if you can find them. The voltage rating or

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WVDC of C1 and C2 should be at least twice that of the AC input voltage, while the WVDC of C3 and C4 should be at least three times the AC input voltage.

To ensure proper results, the transformer connected to the Quadripler should have a 2A or higher current rating. You would do well to use a power transformer from a 45W per channel, or higher amplifier. Most solid-state transformers are nice-looking and extremely rugged, and last for years.

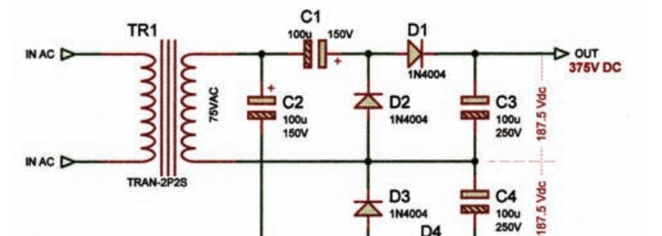

Figure 1: Voltage Quadripler

If the transformer powering the Quadripler has a center-tap terminal, leave it empty. If it has a center-tap lead wire, shrink-tube the end and put it aside. You can also solder it to an unused terminal on a lug strip. If you ground the center-tap, you will apply AC voltage across C4, which will blow up the cap!

In conjunction with the power transformer you use with the Quadripler, you will need to add a 6.3V AC heater transformer. If a solid-state power transformer has a 6.3V winding, it usually has a current rating of less than 1A—enough to power a few dial scale lamps. Some had 8V dial scale lamps. Have fun!

Neal A. Haight
Castro Valley, Calif.

DISC PLAYER MODS

In a recent letter ("Xpress Mail," May '07, p. 58) I detailed my modifications of a Sony DVP-NS500V SACD/DVD/CD player and an Oppo-digital DV-970HD universal disc player. I replaced the main two-channel output dual op amp (originally a 4558 in *both* cases) with an AD828. The results were quite gratifying, as I stated in the letter.

Well, I *finally* have been able to replace the stock electrolytic coupling capacitors in each unit. Sticking to the stock values (47μF/16V in the Sony and 10μF/16V in the OPPO unit), I substituted "Black Gate" electrolytics ("Standard" types sourced from Michael Percy Audio and very decently priced at $1 each to just under $2 each) and thus replaced the originals in each unit.

The results (done first in the OPPO player) were immediately apparent—a more open and revealing sound. A week's worth of listening convinced me that Panasonic bypass capacitors (applied to each of the electrolytic coupling capacitors in question), which I already had on-hand—0.022μF/50 polypropylene types from Digi-Key—would help further.

They did, and decisively so. I then applied the same mod to the Sony unit—and the results were just as gratifying. The sound quality from each unit is even more enhanced and dramatically revealing with SACD and 24/96 DVD discs (such as the Classic Records series from 1998-2000). With the OPPO unit, DVD movie discs are also better-sounding—assuming LPCM mode. Because I don't really use the Sony unit in a TV-oriented system, I can't honestly comment on it, except that it should perform better in that mode as well.

I *did* discover that the OPPO player required *two* capacitor changes per channel (one just after the DAC and another after the output op amp—for *each* channel. See datasheet for the CS4360 six-channel DAC chip). Anyway, I consider these recent changes to be almost as important as the op amp substitution (4558 -> AD828). The combination of the two upgrades is irresistible.

R. LeBeck
Kirkland, Wash.

P.S. I still do not possess any DVD-A discs, but intend to procure some for further listening tests. Naxos (and a few others) will be a good-enough source. The new 24/96 and 24/192 series from Classic Records promises to be of great interest, too. *aX*

CONTRIBUTORS

Steve Mowry ("Editorial, "The Silent Information Revolution," p. 6) is president of SM Audio Engineering, has a BS, Business Administration, from Bryant College, and a BS and MS, Electrical Engineering, from URI with highest distinction. Steve has worked in R&D at BOSE, TC Sounds, EASTTECH, and P.Audio. Steve is currently an independent consultant/lecturer in project management/transducer and system design. His website is www.s-m-audio.com.

George Danavaras ("Analog Bass Control For Magnepans," p. 10) graduated from National Technical University of Athens, Greece in 1986 with a degree in Electronic Engineering. He currently works in the R & D division for a Greek Telecommunication company. His hobbies include design and manufacturing of audio crossovers, amplifiers, and loudspeakers.

Atto Rinaldo ("Matteo: A 10W Integrated Amplifier," p. 18) is an active retiree after being employed at IBM for 32 years. He has experienced various managerial job responsibilities in Italy, the US, and other parts of the world. He received his radio techniques diploma 48 years ago, when vacuum tubes were the technology. Joining IBM in the mid-60s, he witnessed the phase-out of vacuum tube computer production which was replaced by transistors and integrated circuit technology. He enjoys getting back to playing with tubes again.

Dennis Colin ("Tweaking An Inverse RIAA Network," p. 24 and "Optional Stages for Minimal Distortion," p. 50) has demonstrated the audibility of phase distortion at Boston Audio Society, and has designed the "Omni-Focus" speaker (bipolar coincidental with phase-linear first-order crossover), ARP 2600 analog music synthesizer, 1kW biamp and PWM supply at A/D/S, and Class D amps.

Daniel Schoo ("Calibration of The Hickock 539C Tester," p. 30) collected radios and learned to repair them growing up in the mid 1950s and 1960s. After graduating from college in 1973 with a Bachelor's degree in Electronics Engineering Technology, he accepted a position at the Fermi National Accelerator Laboratory, a national laboratory for research in high-energy physics, where he continues to work. His interests cover many facets of electronics and antique radio technology.

Bill Christie ("Cascoding National's LM12 for 140W," p. 38) developed an interest in electronics at the age of 6 after his father helped build his first crystal set. Since then he has built numerous kits and started building amplifiers from scratch while still in high school, starting with a mono tube amp designed by Mullard. He graduated from the University of Akron with a bachelor's degree in physics. He is a retired electrical engineer from Goodyear Tire & Rubber Company after serving 35 years designing controls and instrumentation for manufacturing.