MAINS ANALYZER

I have researched the shunt current sensing method used in "A Mains Analyzer part 1" by Iain McNeill in 11/07 *aX*. I contacted engineers I worked with at the electric company, and at a major engineering-construction company where my brother works. While not specifically addressed in the National Electric Code (NEC), they all agree it is a bad practice to use shunts for AC current sensing on any AC line application. Only current transformers are mentioned as AC current sensors in the NEC.

My personal practice is to use current transformers to meter current flow for AC voltages above nominal 48V, or Hall-effect devices for high voltage DC. Shunts do not provide galvanic isolation from the power conductors. Small 5VA Class 1 current transformers are readily available on eBay at reasonable prices, in current ratios from 30:5 up to 200:5.

Shunts do not provide galvanic isolation from the power conductors; they are in essence bare conductors and are directly connected to external measurement equipment. This is why the power utilities use current transformers exclusively to monitor AC line currents. Aerospace electric power follows the same practice. I am particularly concerned where the proposed Mains Analyzer might be built and used by a novice unfamiliar with safety regarding the AC line. Admittedly, I have not seen how Mr. McNeill has packaged his analyzer. He may have totally precluded contact with the AC line voltage by the user.

Another issue for me is the use of the LM324 for sensing the small mV shunt current signal. Even at a line current of 20A (the maximum for a 120V AC circuit), there will only be 40mV of signal available from the 25A shunt. The offset voltage for the LM324 is ±2mV, or 5% of the maximum shunt signal.

At lower current levels the Vos will become a proportionally greater part of the signal error. The two leads from the shunts to the op amp circuits will see very high magnetic fields proportional to the load current. These leads would need to at least be twisted together in an attempt to prevent a large 60Hz error voltage from being impressed on the sense circuit, and perhaps twisted-shielded pairs would be required. Also the DC output of wall adapters WW1 and WW3 are not supplied with a voltage regulator, and the PSRR for the LM324 is only 65dB. Much better quad op amps are available.

Consider the specific failure mode effects for various failures in the design of Fig. 1 on page 10 of the *aX* article.

1. If the mains-side neutral is open, the line current shunt will be elevated to full AC line voltage through whatever load is connected to the outlet sockets. There will be no power from any of the wall warts. The line current op amp will have AC line voltage on its inputs with no ±Vcc to the circuit and the LM324 will fail (note that the use of Vdd and Vss in Figs. 2, 4, 5, and 6 is incorrect for an op amp). The situation is not as bad for an open mains ground, depending on the chassis ground configuration of the load and the amount of load imbalance on the two 120V AC sides of the 240V AC service entrance power.

   The line current shunt will be elevated to full AC line voltage through whatever load is connected to the outlet sockets. [I should have added here this would only happen with ungrounded, 2-wire power cords.] There will be no power from any of the wall warts. The line current op amp will have AC line voltage on its inputs with no ±Vcc to the circuit and the LM324 will fail.

   Applying the AC line to the inputs of the LM324 with no V+ rail DC, yet still having an inductive/capacitive path through the wall wart back from its grounded substrate back to the AC line, may cause current flow from substrate out to inputs. The 1k4 resistors may not limit the substrate current flow to 50mA and can damage the LM324 (see Notes 3 and 7 of the NSC Data Book). I have, in fact, seen this happen in the 400Hz AC systems I have worked with, where the older voltage sensing circuits used lower value wirewound resistors than we use today.
2. If R68 opens, very high voltage will be impressed on the primary of the T1 audio transformer, causing it to fail, perhaps catastrophically. There may then be a short between the two windings and anything connected to the J3 monitor output could see full line voltage. My suggestion is to use a small step-down power transformer with its primary directly connected to the 120V AC line for the monitor output.
3. With R68 or R67 open, the Glitch Detector circuit and Line Voltage DPM inputs will see full AC line voltage and will fail.

Only fireproof resistors should be used where directly exposed to AC line voltage. This includes the input resistors to the sensing circuits, due to the failure modes just described.

Power engineers are required to monitor at least to the 13th harmonic for line voltage distortion products. That would require a flat response to 780Hz for the 60Hz line, so Mr. McNeill's filter cutoffs of 340-400Hz won't give him the full power quality picture; of course, he is not running qualification on a piece of electrical equipment either. The third harmonic is generally considered to be the worst, due to electromagnetic loads such as transformers and motors (see my three-part series "AC Power Line and Audio Equipment," *audioXpress* Sept.-Nov. 2001).

As an aid to Mr. McNeill's Glitch Circuit detection settings, ANSI C62.41 1980 (IEEE Std. 587-1980) "Guide On Surge Voltages in Low-Voltage AC Circuits" calls out the time-voltage limits for AC line transients. "Low-Voltage" here refers to less than 1kV, including 120/240V AC residential AC power. I wrote a Power Line Monitor project article in the April 1998 issue of *Popular Electronics* with four distinct detectors for Outage, Sag, Surge, and Spike levels based on what was then ANSI/IEEE C6.41. It latched LED indicators after detection of any of these events. With modern microchip controllers, you could place the number of detected events into memory for later analysis.

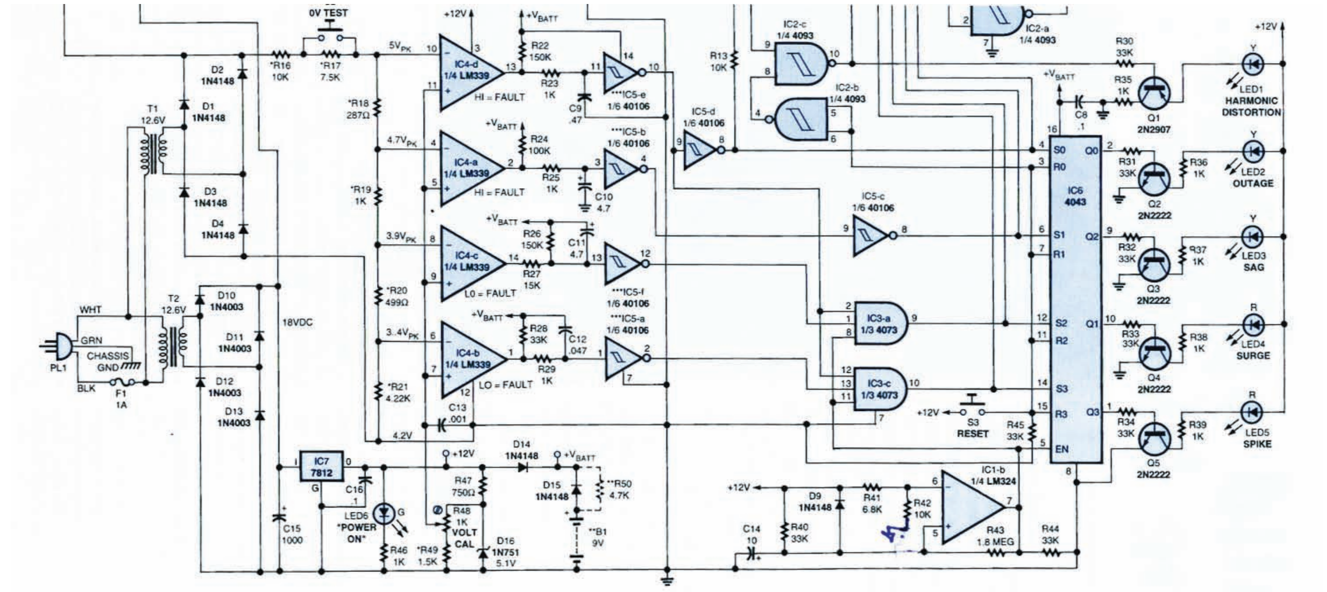

Figure 1: Voltage fault sensing circuit from *Popular Electronics*.

Figure 1 shows the voltage fault sensing circuit from the *PE* article (Schematic note: I used only "T" intersections for line connections in my supplied artwork. When *PE* re-drew the schematic they used crossing intersection dots for some of the connections. This is not permitted by ANSI/IEEE standards.) If I were to do this project today, I would include current fault sensing as well.

I hope I am not sounding too critical of Mr. McNeill's work. His basic concept is quite good. I just want to point out these few safety issues from my experience as a power engineer in both the aerospace and electric utility industries. I look forward to Part 2.

Chuck Hansen
Ocean, NJ

Iain McNeill responds:

I would like to especially thank Charles Hansen for taking the time to review and comment on my article. I have read and learned from Mr. Hansen's articles for many years, so it was quite an honor to have him comment on my work. And don't worry, you can never be too critical when it comes to safety.

Maybe I should reiterate how safety is achieved in my design. All live circuits are completely enclosed in a plastic enclosure and all exposed metal parts have galvanic isolation from the live mains circuits to withstand voltage of 1500V AC achieved through the use of air clearance and/or insulating layers. Exposed metal parts include switches, connectors, and mounting screws.

I suspect the exclusive use of current transformers in the power industry is to do with lightning surges and other fault transients on installed equipment; this device is not intended for permanent installation. I think it is important to separate safety issues from reliability issues here. I believe this device is safe, as I have ensured that there is basic and supplementary insulation from the mains circuits as is common in consumer electronics products. I didn't go to the lengths of addressing regulatory compliance or ensuring fault condition tolerance because the device was intended as a DIY project for those comfortable working with high voltage.

Checking my design notes on the LM324 offset question, I don't see this as a significant problem. The output is DC blocked in all cases and so all the offset voltage does is reduce effective headroom. For the line current meter, my calculations show worst case output DC offset at 71.43 * 0.002 = 0.143V. Supply voltage is +4.75V worst case minus 0.143V offset minus another 0.7V for output transistor Vcesat yields 4.05Vpk (2.86V RMS) worst case maximum output, which equates to a 40mV input signal equivalent to the target 20A.

I completely agree with Mr. Hansen that there are much better op amps available than the LM324, which has been around for over 25 years, as far as I remember. I didn't want to use my good (expensive) op amps on this utility application and the 324s were what I had lying around. I was actually feeling quite pleased with myself for finally clearing them out. I went back to check accuracy on the line current meter and found that the accuracy has a dome shape having good accuracy at the extremes (as you would expect for the zero/cal setup) and peaking at +5.5% at 13A as shown in **Fig. A**.

The accuracy below 2A is pretty appalling due not only to the offset problem outlined by Mr. Hansen but also due to low level signal nonlinearities in the precision rectifier. For me, this is quite adequate because I'm only looking for an indication that a circuit's capacity is being approached. For those with higher accuracy needs, substituting a better op amp will help.

I twist signal pairs together as a matter of routine and did so here also, as you recommend. There probably is some induced error in this wiring, but I was able to compensate adequately using the zero and cal pots, so I wouldn't personally call it a "large" error. The PSRR issue is moot because the LM324 is fed from a regulated supply, a fact which Mr. Hansen could not know as the complete schematics are in part 2—my apologies. I should have re-written the article somewhat after we decided to split it into two parts.

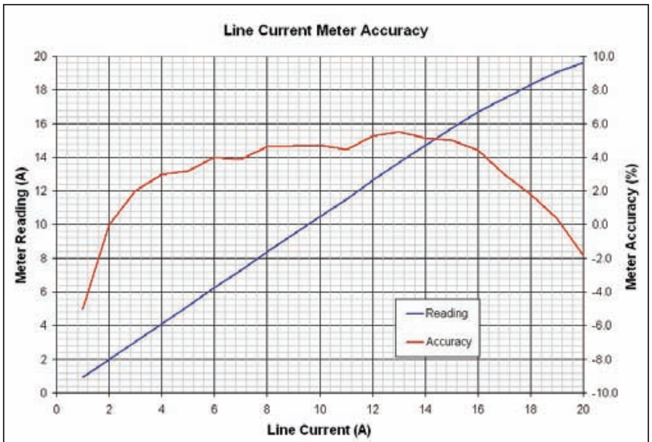

Figure A

Regarding the failure modes you cite:

Open Neutral: I don't think this is a problem. As you say, the line current shunt will be pulled up to line voltage, pulling the measurement circuit and wall-wart secondary supply up with it. However, the wall wart primary is also only connected to the live conductor. There could be some small leakage current flowing to ground through parasitic capacitance which, even if it were 100pF, would only amount to 4.5μA.

Just to be sure, I tried this with a 100W bulb plugged into the outlet and the incoming neutral conductor disconnected. As you would expect, all the displays were blank, but the red neutral-ground neon and amber live-ground neon were illuminated indicating the fault condition. When I replaced the neutral conductor everything worked as normal.

Open R68: As designed, R68 is in parallel with the transformer primary for a combined impedance of 21Ω. With R68 out of the picture we're left with just the transformer primary impedance of 37Ω. There is under 3mA of current flowing in the chain in both cases although with R68 open, all 3mA will flow through the transformer primary. The voltage across the primary will increase from 60mV to 110mV. Neither of these is particularly challenging for the audio transformer, and, with its 1500V AC withstand rating far exceeding the 205V AC worst case maximum mains voltage, I don't believe there is a safety issue here.

Open R67: You are quite right. If R67 were to fail open, 120V AC would be connected to the line voltage and glitch detector circuits, albeit current-limited by the 40kΩ resistor, R66, and would probably destroy the entire line current/voltage/glitch detector section. Having said that, it would take some pretty severe over-voltage to cause this to happen, and my calculations show that R66 would blow first. R66 reaches its 500mW power rating at 3.5mA, where the power in the 125mW R67 is only 10mW.

The use of flameproof resistors is a good idea to make this project even safer. I believe the common metal film leaded resistors today are flameproof.

Regarding monitoring to the 13th harmonic: I used an audio transformer for the monitor output for exactly this reason, and this gives me bandwidth far in excess of the 13th harmonic at 780Hz. In fact, as you can see from the spectra in Part 2, I'm seeing mains-borne noise all the way up to 10kHz. I still haven't gotten around to measuring the RF spectrum on the mains, but I suspect that there is significant noise well past the audio band.

Thanks for enclosing a copy of your mains monitor project from *Popular Electronics*; it was interesting to review and compare. I see your design as more of a long-term "sentinel" device and as such requires higher precision and consideration of reliability factors. However, my motivation in designing this project was for a quick and easy sanity check that would highlight possible problems for further investigation and as such it has been a very handy tool that I have used many times in the year since I built it.

This letter is in reference to Iain McNeill's "A Mains Analyzer—How Clean Is Your Juice? Part 1," (*aX* 11/07, p. 8). I'm highly interested in this topic of power quality and gladly welcome such a project (even though excellent, off-the-shelf solutions already exist from Dranetz and made affordable by eBay).

However, I found the article lacking for several reasons: No photos. (Which makes me wonder if this prototype was ever finished?) Safety: The author talks the talk, but I think he missed the boat. For some reason, he ignored the universal requirement for overcurrent protection. It's generally required by insurance underwriters for all line-connected equipment to have a fuse, breaker, thermistor, or thermal cutout in the primary circuit unless the circuit is inherently current-limited as in a small step-down transformer. (His wall-wart supplies would fall under this exception.) For some reason, he rules out fuses early on, but doesn't say why. (Perhaps, he was trying to use a fuse as a cheap shunt?)

I would also recommend he use current transformers instead of those 25A shunts. This would provide isolation from the power line and should allow running the digital meters directly off a single DC supply. (I know, lab-standard current transformers are quite expensive, but, you can get service-grade ones that provide ×1/×10 ranges designed to work with clamp-on ammeters quite cheaply.)

Failing that, the shunts should be placed before the neon bulb indicators, so that an open shunt would be indicated immediately. He should also move the shunt from the neutral leg to the hot leg, because an open neutral stops the flow of current, even though the tester and downstream equipment is still hot to the chassis! (Likewise, fuses and switches should only be placed in the hot leg.)

To measure line voltage safely, he could simply use a 12V step-down transformer and set his meter multiplier for 10.

Finally, to derive an isolated scope output, he could float the scope power off an isolation transformer, because I've found that the waveform becomes severely clipped if you float the signal. I'm guessing that's caused by an impedance mismatch. (It also clips if you use a voltage divider shunting the line.) But, because the power line has a characteristic impedance of 25Ω, a 12.5Ω dummy load (since we're only seeing half of the 240V pole-mounted transformer) would dissipate 1100W continuously and piss off Al Gore tremendously.

Jerry Nutter
audio.carp@verizon.net

Iain McNeill responds:

I'd like to thank Mr. Nutter for his interest in my article. I suspect many of his questions have been answered by part 2 of my article. I designed and built the analyzer about a year ago and have been using it regularly since then in many applications. My need for such a device predates that, and, as I mentioned in the article, I performed a fairly extensive search on the Internet before deciding to "roll my own."

On your recommendation, I looked at the Dranetz products and couldn't find one that was as simple to use as mine or had the same features. All the Dranetz products appear to be designed for site monitoring in a permanent installation. I wanted something that would give me a reading in minutes without the use of tools. However, repeating my search today, just to see whether the landscape had changed, I did find a product that includes most of the features of my analyzer from Extech (their part number 380803) retailing for around $700.

With regard to safety, I spent much time thinking through the various failure scenarios before starting the design and originally intended to fuse the device. However, as I explain in the article, my concern was that I couldn't guarantee that the mains circuit I was connecting into was correctly wired. I have encountered swapped live and neutral conductors in several residences where the homeowner has incorrectly replaced outlets, and if a fuse in the (assumed) live conductor failed, due to power-on surge, for example, then any equipment plugged into my analyzer could conceivably float up to line voltage. The logical solution is to use a breaker that would interrupt both live and neutral in the event of overcurrent, but these are large and expensive and there is always one of these in the customer service panel.

As long as the mains circuit in the analyzer is designed to greatly exceed the 20A maximum residential circuit current, everything is safe; the analyzer works much as an extension cord in this sense. I would also point out that the load part of the analyzer, as you mention, is inherently current limited. This includes the neon indicators, GFCB test circuit, and voltage sense resistor divider. Anything plugged into the analyzer will have its own overcurrent protection.

The use of current transformers is an equally valid choice in my mind and would allow the use of a pair of wall warts (the DPMs still need a floating supply). It so happened that I had a huge pile of wall warts available and the cost and design simplicity of shunts was more attractive. As with many consumer electronics products today, isolation is provided by the use of a plastic enclosure.

My decision to place the neon indicators upstream of the current sense was so that their currents, admittedly small, would not be included in the load current measurement. I would argue that an open shunt would be indicated by 0V on the voltmeter display, but now we're splitting hairs; I firmly believe that the service panel breaker will trip before these 25A shunts fail open.

Your comments regarding the correct placement of current sense shunts, fuses, and switches are valid as long as you can guarantee a correctly wired outlet; this is not the case in my experience. One of the first tests I performed on this unit was to verify the analyzer operated correctly under all miswiring conditions including live-neutral swap and neutral-ground swap. I am glad to say I have never encountered a live-ground swap, but the analyzer will safely alert you to this lethal condition as long as you plug the analyzer into the wall outlet first before plugging equipment into the analyzer.

The problem with using a stepdown transformer for the voltage sense functions is that they are optimized for 60Hz operation. (This is also why I used an audio transformer for the monitor output.) My concern was that a simple 12V step-down transformer wouldn't preserve the voltage ratios of the harmonics to the 60Hz fundamental.

For the glitch detector to provide a valid indication, I needed a wide bandwidth sense voltage, and resistors are a cost-effective way to achieve this. Once again, safety isolation is provided by the enclosure.

Finally, I don't think floating the scope power off an isolation transformer is an acceptable solution to the isolation problem. If I remember correctly, this was a practice used back in the 50s and 60s for working on televisions with hot chassis. Fortunately, this design technique is no longer used, so floating test equipment off the mains supply is not necessary and the integrity of safety ground can be maintained throughout.

My implementation, using a wideband audio transformer to provide an isolated, single-ended monitor output, works just fine as you can see from the figures in part 2. I suspect the clipping you have seen may be due to ground loops and/or leakage currents conducting in input clamping devices, but without examining the actual conditions I can only guess. Impedance matching is only important where you need to control reflections, and while this may be important in the solution of the high frequency mains-borne harmonics problem, it is, as you point out, highly inappropriate for 60Hz mains power delivery.

Thanks again for allowing me to discuss my design decisions, and I hope you enjoyed the final part of the article.

GOOD-LOOKIN' HORN

Concerning Ed Simon's Combination Horn from January '07 (p. 10), I am wondering whether we could have more dialogue about new developments with the speaker system. It appeared to have many positive attributes, although Ed found some shortcomings. I would like to further explore this system, which has a higher WAF than my current hi-fi setup. His other articles have been equally impressive and useful for our hobby.

Kevin Tuttle
Durant, Okla.

MIDRANGE ID

I would like a clarification concerning project # 10, Mr. Bones (*Speaker Building 201*, by Ray Alden, p. 133). In the general description of this project and in table 11.9 as well, it is stated that the Morel MW113 midwoofer is being used; however, in the description of the midrange section of the crossover and also in the accompanying schematic, it seems that the Morel MW114S is the one that's being used. Which is the driver that has actually been used?

Dimitris Katramados
Athens, Greece

Ray Alden responds:
I would like to thank Mr. Katramados for pointing out this discrepancy. To immediately answer his question, it is the Morel MW113 that is being used, not the MW114S. The MW114S is mentioned in error in the crossover schematic on the bottom right of p. 134. I suspect that, because graphic designers had to draw this diagram independent of my manuscript, this error crept in and went undetected during my final reading.

It can be a great disappointment to authors who provide designs of complete speaker systems in their books that parts, in particular drivers, go out of production so soon after publication. Personally, I tried to choose drivers that had a long shelf life, and happily many in *Speaker Building 201* are still available. Morel, a company founded in 1975, focused on using advanced materials such as rare earth magnets and hexagonal-shaped wires in their voice coils. In fact, the MW114-S midrange is the immediate replacement for the MW113; it used a neodymium magnet system instead of the double-magnet ferrite used in the MW113. If you wish to read a detailed PDF spec sheet for the MW133 go to: www.madisound.com/catalog/PDF/morel/mw113.pdf?osCsid=0412d63acb55ada0160a06190bef627f

If you wish to purchase the MW113 midrange for use in this system, I have discovered that Madisound still has 13 available; they can be found on the Internet at: www.madisound.com/catalog/product_info.php?manufacturers_id=141&products_id=597

"Mr. Bones," so named because of its more skeleton-like construction, is a very fine system that I hope more builders will come to enjoy.

CIRCUIT CONNECTIONS

I read Alex Arion's "Greek Baroque System" (*aX* 12/07) with interest. I have been a professional electronic circuit designer for more than 55 years, going way back to the tube days and continuing into the transistor and IC days. I am still active at it.

I looked at his circuit diagram (p. 52) and something caught my eye. I know that in a long-tailed pair of triodes connected as phase inverters, the undriven triode (the common cathode part of the pair) has somewhat lower gain than the driven triode. To compensate for that, you usually use a somewhat larger plate-load resistor in that stage than in the driven stage.

In his diagram, this is not the case at all. The plate load of the driven side is much larger, more than double the value of the undriven side. This must be wrong; otherwise, the output-stage will be totally unbalanced AC wise.

Then I noticed that the long-tail resistor R26 is connected to the output transformer secondary, in some form of feedback configuration. This cannot be a correct connection, because the bottom of the long tail is a nonlinear input to the amplifier. You want negative feedback to a linear input to the amplifier, not a nonlinear input.

There is an attempt at negative feedback by connecting V3B grid back to the input, but because of the long-tail connection this feedback is to a large extent cancelled. Not only that, but because the author needed to decrease the plate loads on the wrong side of the long-tailed pair to balance the drive to the output amplifier, the feedback must effectively be positive rather than negative feedback.

The result of overall positive feedback in an amplifier is that the gain is increased. This is often OK, but harmonic distortion is increased as well. The frequency response of the amplifier becomes worse as well. In addition, the output of the amplifier as seen by the speaker load increases as well. With a pentode-connected output stage, the output impedance is pretty high to start with, and by adding positive feedback it becomes even higher.

You can only imagine what this does to the overall performance of the amplifier-speaker connection, but you know one thing—that this amplifier would not care about what kind of speaker cables you would use. Any speaker-cable impedance would be totally swamped out by the huge output impedance of the amplifier. It has become a current source rather than a voltage source, as required by most loudspeaker loads.

Next oversight is present in the preamp circuit on p. 54. R14 and R15 on Fig. 2 serve no purpose whatsoever, and R14 should be removed, while R15 should be replaced with a short. The circuit will work better that way, and will be circuit-wise more correct.

My last objection is to the schematic for the power supply, which shows D2 as being a 215V zener diode. That must be a misprint for a 21.5V zener diode. The regulator cannot possibly work with a 215V zener diode. According to my calculation, the output voltage wants to be more than 5000V using a 215V zener diode. That is not possible with the components shown on the schematic. Also, the filament connections of the rectifier tubes U11 and U12 are shown incorrectly; they should obviously not be shorted together at the tube-base as shown on the drawing.

Hans J Weedon
Salem, Mass.

Alex Arion responds:

Thank you for your letter. Unfortunately for me, you are right in all your observations regarding the "Baroque Amp." So, in the power stage (p. 52) R31 is 100Ω, not 100kΩ! In this case, all the problems you indicated about the nonsymmetry and the negative feedback will disappear! Of course, the OTR's secondaries should not be shorted to ground, but only the downer side. The upper side (8Ω) should go to the speakers.

About the preamp (p. 54), here I wanted to divide the DC (direct coupling) to not use the cathode follower before its lifetime. Of course, it will work OK with your simplifications. Now, in your last objection (the power supply), of course you are right that the zener diode is 21.5V, and the filament connections for the two rectifiers are shorted! Mea culpa, all the mistakes are mine, because I'm not good at computer graphics, but I will improve myself everyday!

Once again, I thank you for your competent observations that only a man belonging to our generation, having huge experience in tube construction, could make.

Alex Arion's "A Greek Baroque System" is one beautiful piece of art, and I can only imagine that it is a beautiful-sounding system. Many thanks for sharing it with the world!

Jon Geissinger
Elliottsburg, Penn.

CORRECTION

Rickard Berglund's article, "The Many Uses of a Hybrid Van Scoyoc Circuit" (Oct. '07), has a major problem—the circuit as shown won't work. Instead of cross-coupling, the schematic has each feed from the source followers going to the grid and cathode of the same side. The signals will largely cancel out. I suspect a drawing error.

A version which I modestly think is a bit more elegant uses p-channel JFETs to accomplish the same task. For a bit of extra gain, the biasing resistors can be bypassed. I've built versions of this circuit using a wide variety of tubes; because the AC balance of a cross-coupled inverter is equal to (mu + 1)/mu, a high mu tube (e.g., 6SL7) is preferred. FETs can be selected for best DC balance—they're cheap.

Stuart Yaniger
yaniger@sbcglobal.net

Rickard Berglund responds:

Yes, there is an error in the cross-coupling section. The idea of using p-channel FETs is very elegant. *aX*

CONTRIBUTORS

Ari Polisois ("A Double-Ended Two-Channel Amp," p. 6) resides in France. He previously wrote "High Power SE 6C33C Amp," in the July 2004 issue of *audioXpress*.

Claudio Negro ("Driver Induced Vibrations," p. 16) is a retired commercial airplane pilot, and has been interested in speaker building since the age of 13 when he built a zero offset three-way speaker with a self made tweeter acoustic lens. He also became interested in electronics, building a mixer based on a Radford preamp and a Marantz MM pre-schematics, with separate PSU enclosure. In 1985 he was classified sixth in an Italian magazine DIY speaker contest, after which he took a long break from DIY audio. His other interests are listening and playing hard rock music, photography, computers, and online car racing.

Paul Loewenstein ("Dynamic Microphone Soundcard Amplifier," p. 22) has a BA in 1971 from the University of Cambridge, MA in 1974, and Ph. D in 1994. His early career at Schlumberger in the UK and France involved analog systems from high-frequency IC amplifiers, vibrations of thin shells, and transients on high-voltage power lines. His professional activity has been purely digital since his move to the US in 1981, working for Schlumberger, National Semiconductor, Mitsubishi, and Sun Microsystems.

Hiroshi Obama ("7W Power Amp with Cathode NFB," p. 26) was born in 1943 in Tokyo, Japan. After having mastered economics, he joined the airline industry, where he met several colleagues who were audio enthusiasts and taught him to design and build amps. He enjoys restoring old audio equipment as well as building his own amps, including solid-state units.

Are Waagbø ("Shunt or Not," p. 30) resides in Norway. This is his first article for *audioXpress*.

David J. Weinberg ("AES Multi-Tracks in New York 2007, pt. 1," p. 38) is an engineering consultant and technical journalist on audio, video, and film technology. He provides audio and home theater engineering consultation and professional on-location digital audio recording services to companies, radio stations, and individuals. He brings to his work an MSEE, a First Class Radiotelephone license, and over 40 years of continued study and active involvement in the audio, video, and computer industries. He is Vice Chairman of the Audio Engineering Society's DC section, a manager in the Society of Motion Picture and Television Engineers' DC section, and membership officer of the Boston Audio Society (www.BostonAudioSociety.org).

Julian Bunn (Review: Speaker City's PS10 Subwoofer Kit, p. 42) is a member of the Professional Staff at the California Institute of Technology (Caltech), where he is engaged in researching computing solutions for the next generation of CERN's particle physics experiments, investigating contaminant dust particle motion from a future Mars lander, and simulating the motion of the Basilar membrane in the human cochlea. In the early 90s he wrote the AIRR and WinAIRR applications for loudspeaker measurement, which are sold by audioXpress. Recently he formed his own company, Bofinit Corporation (www.bofinit.com), which specializes in development of audio applications for the Pocket PC. In this context, he formed a strong relationship with Ivie Technologies (www.ivie.com), where he holds the position of Senior Scientist. He is the main software architect of Ivie's IE33 audio measurement device. In his spare time he has recently built a 70s vintage Minisonic 2 synthesizer, a SE tube amplifier, and a four digit Nixie tube clock. Julian has a lovely wife, Sarah, and three beautiful daughters, Jessica, Georgina, and Isabella.