TITLE: Speaker Of The House

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This is the first of a three-part series on building your own mini audio panel. For some years now, I've been asked why I don't bring out a trivially simple audio panel with just a couple of com switches and not all of the rest of the gingerbread that you find on most commercial panels that sell for lot$ of buck$. I mean, if you are paying a ton of $$$ for a box, you expect bells and whistles, don't you? Herewith an audio panel that you can build yourself that will let you buy a McBurger with the leftovers from a $20 bill. That is, until you start hanging the bells and whistles onto your *OWN* audio panel.

When National Semiconductor gave up making the venerable old LM383 series of audio chip, there just weren't any other devices around that would fill the bill of a simple, inexpensive, reliable speaker power amplifier. Oh, sure, you can find dozens of "bridge" style amplifiers that run from 5 volts, but just a plain old 12 volt battery system speaker amplifier wasn't to be had, one that let you run the normal aircraft style one-lead-grounded speaker configuration.

The pipeline is really running dry on a couple of other oldies but goodies too. The TBA-810x series from SGS used to be a dime a carload. Now, when you can find them, they chew up the better part of an Honest Abe bill each -- and the bottom-of-the-barrel spec units that you can find in the junk markets blow up if you look at them crosseyed.

Thus began the search for an inexpensive yet high-performance amplifier that was stable, easy to use, and almost indestructible. It was not an easy search. What I wound up with, after a couple of months of heuristic engineering (that's geekspeak for "playing around on the test bench") was a circuit that was all the rage back in the days when the Camelot White House was around.

Referring to the schematic, you can see that I blended the old-time idea of a complementary-symmetry output transistor pair stage (Q101/102) with a relatively modern opamp (LM324). This configuration of output transistors works a lot like the Cessna Mixmaster -- you've always got one sucking and one blowing at the same time and adding their powers together. I then stabilized the lot with negative feedback from the junction of R110/111 around the loop back to U101A to close the gain down to a 10:1 voltage amplifier. That is, you put a volt of signal into this amplifier, you get ten volts of audio out into your speaker.

Let's talk about some other things that may not be obvious. All that rigamarole down at the bottom of the schematic is the power supply that makes the thing run. V14 is the +14 volt aircraft system input from your fuse or circuit breaker. In order to get maximum swing at the output of the transistor pair into the speaker, the quiescent ("no-signal") voltage at the center of R110/111 has to be half the supply. R119/R120 does the division by two and then applies this to the reference terminal of U101 to force the loop to drive the output voltage to half the supply.

We also need a relatively clean voltage to power the opamp. Q105 is driven by the zener reference diode D101 to a regulated, ripple-free output of 9.3 volts (V10). We don't quite know why yet, but our intercom circuit (the third part of this series) is going to have to have a reference that is half the 10 volt supply. R124/125 do this division, and C110 makes it a very quiet reference source.

Lined up on the left of the schematic are inputs AS through HS. (A-speaker through H-speaker.) Each input is isolated through a 100K resistor before going to the op-amp and then to the output. Note the little circuit

comprised of S101 and a resistor (R126) called "Termination". A word about termination is in order here. Most audio sources like to be "terminated" in one impedance or another. Speaker amplifiers like to be terminated at their output with something on the order of 4 to 10 ohms. Headphone amplifiers like to be terminated with something between 100 and 600 ohms. "Strollman" CD players like a very high resistance termination. "Line" amplifiers like 600 ohms. What you use for termination depends ENTIRELY on what you are using for your audio source. If you are using the headphone output of a radio to drive this speaker amplifier, I personally prefer a 560 ohm terminating resistor, but you can't hurt this amplifier by playing around with a terminating resistor value of your choice.

C103 is kind of a funny part. It seems that the NPN output device Q101 doesn't like to drive itself into saturation all that easily. Yet we want all the output voltage that we can get, so C103 is called a "bootstrap" capacitor that runs output back to drive Q101 on even harder than it had been turned on by the rest of the circuit. It is sort of like a pure jet engine, the harder it runs, the harder it wants to run, right up to the point where the output transistor is in saturation.

Now, for those of you who have been paying attention, you have already noticed that S101 is a double-throw switch. Down is for speaker. Guess what up is? Did I hear "headphones" from the crowd? Bingo. Next month is the matching headphone amplifier of this little jewel and then the month following turns one channel of the headphone amp into a simple intercom for up to four headsets.

Questions from the group:

Q. Do I have to use those exact parts? What if I've got a bucket of spare 2N1234 transistors and want to use them?

A. The transistors and opamp are completely generic. There are absolutely no critical parts in the design. Any transistor with a beta (current gain) of more than 20 should work just fine. Just be sure to use a PNP for Q102 and NPNs everywhere else.

Q. How do I heat sink the output transistors?

A. Heatsinking the output transistors is not necessary if you use the TO-220 package like I've shown. I've let them run with sine wave output power at full ratings for an hour and they get warm. Not hot. Just be sure not to let the metal tab of Q101 touch any grounded metal surface as it is connected electrically to the collector. Same electrical connection is there for Q102 also, but since the collector is already grounded, it doesn't make any difference.

Q. How do I run this thing in my 24 volt airplane?

A. You build a 24 to 12 volt converter. Oh, you don't have plans for one? Well, howsabout we do a column on that little problem when we get done with the audio panel.

Q. Can I get these parts at The Shack?

A. Unfortunately, The Shack has just about phased out all small components over the last couple of months -- bummer. That's a shame, but I suspect some corporate beancounter took a look at the cost to sell a $1 transistor and the cost to sell a $200 cellphone and found that they were about the same. Now, I can't fault them for that, but it means that you are going to have to get *REAL* chummy with folks like Mouser

(www.mouser.com) and Digikey (www.digikey.com) and a few more of this group of wholesale/retail parts sellers.

A2. It also means, unfortunately, that those of you who wanted to build those little digital panel meters we discussed a few months ago are now going to have to go directly to the manufacturer to get them. The good news is that Trumeter-Florida (www.trumeter.com) will sell them to you for the same price you would have paid from The Shack

Q. I need more (or less) gain than your 10:1 configuration. What do I do?

A. Not a problem. The gain to any one input (AS through HS) is simply the ratio of the input resistor (100K) to R109 (1M). Since 1M divided by 100K is 10, the gain is set at 10. Suppose you want a gain of 20 for input GS. Quite simple. Drop the value of R102 down to 47K and your gain magically jumps up to 20 (21.2 to be exact about it). You want variable gain? Simple. Replace any of the input resistors with variable resistors.

I don't think it is any surprise, now, to find that next month will bring the phones amplifier and the month following will bring the intercom circuit. After that, I promised to do a 24-12 volt converter, and then I want to take you into the world of carbon monoxide detection. After that, we'll let the imagination run wild.

Author's Note: Jim Weir is the chief avioniker at RST Engineering. He will be glad to answer avionics questions for this article or on any avionics subject in the Internet newsgroup rec.aviation.homebuilt. If you are having trouble with newsgroups, go to www.rst-engr.com and click on the "How To Use The Net" link.

Illustration Log --

KpschRevB.pdf The speaker amplifier schematic.

Picture1.jpg Breadboard speaker amplifier

Picture2.jpg Full output on the oscilloscope (2v/div vertical, 1 kHz. input frequency)