AC 2009-1412: AN AUDIO TEST BED DESIGN FOR LAB TESTING AND HIGH-SCHOOL RECRUITING

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Abstract

This paper presents a student-built tool that is used for audio electronics testing in the lab portion of our power electronics course. It is also sometimes used for an exhibit at our open house and high school recruiting events.

Among several other topics, our power electronics course covers the calculation of audio parameters and the design/construction of linear audio amplifiers. The instructor wanted a tool to allow direct comparison between a commercial amplifier and the amplifiers designed and built by students in the lab. Moreover, a set of good quality speakers was needed for sound level measurements. The subject of this paper, the Audio Test Bed, meets both of those requirements.

The article describes how the project got started, how the parts were acquired, and pursuant interaction with local industry donors. It then provides a technical description of what we call the Audio Test Bed, plus how it was designed and constructed by the student. Next is a discussion of the challenges encountered, how we overcame them, and lessons learned during the development and early usage of the Test Bed. Finally, we present a few ideas for possible application of the Audio Test Bed in other courses, along with some corresponding modifications.

Project Genesis

The event that eventually led to this project was a local employer[1] contacting me through one of my students. The employer was interested in starting a "mutually beneficial" relationship with us. He was willing to donate some used equipment to our program and wanted us to advertise openings he periodically had for technical help. I took a tour of his operation, learned about the business, and gained some insight into his need for part-time employees. He was especially interested in hiring a part-time technician to repair old Crown amplifiers, but also hoped to hire help for other business areas in the future as his operation expanded.

I agreed that this could be a mutually beneficial relationship. In addition to helping the local business, it would provide some experience for the students he hired. Although not design, the repair work did require learning about stereo amplifier operation in order to test, troubleshoot, repair, and in some cases upgrade the equipment. Moreover, we are a satellite campus[2] and keeping our equipment and facilities up to date is always a difficult challenge. As such, even used equipment is often attractive.

Periodically, customers who sent equipment to this company for repair decided it was better to replace their old amplifier(s) with new ones rather than pay the sometimes fairly expensive repair bill. Thus, this local employer proposed donating some of these old amplifiers, along with the parts needed for repair, and letting us repair and use them. In addition to returning them to service as amplifiers, it is also straightforward to convert them into fairly high-power voltage supplies (on the order of ±80 V at several amperes of current).

Both ideas were intriguing for the benefits they could bring to our power electronics class. Converting some old Crown amplifiers into high-power voltage supplies would enable lab experiments not possible at the time. A powerful audio amplifier could form the core of a test bed to compare student-built proto-board amplifiers with a professional-grade amplifier, which would be fun for the students and provide a basis for discussing circuit issues like power and distortion.

The instructor set up a directed project course[3] for each of the projects and two students signed up to do them (one for each project). Unfortunately, the student involved in the power supply project moved away before finishing it. The Audio Test Bed (ATB), on the other hand, was completed. The student who built it is an audio enthusiast who also enjoys doing project work.

Audio Test Bed Description

The amplifier around which the Audio Test Bed was based is a Crown CT-410[4], which is designed to mount in a 19" rack. After we identified the bad parts, our local employer donated the resistors, capacitors, diodes, and transistors needed to repair it. Since we wanted the ATB to be portable we used an SKB 6U plastic travel case[5] with an integrated 19" rack. A local sales rep for JBL got his company to donate a pair of their Control 1 Pro loudspeakers[6] to the project. We purchased an inexpensive DVD player locally and ordered some cabling and connectors online. The student was already proficient in mechanical parts fabrication, had several tools of his own, and was allowed to use fabrication tools and a good bit of scrap material from his job site. He fabricated the front panel used for cabling connections and the mounting brackets to secure the DVD player.

The finished ATB is shown in Figure 1. The Crown CT-410 amplifier takes up the bottom two slots, the DVD player is mounted just above it, and the connection panel is at top. The space behind the DVD player and patch panel is used to stow the speakers.

Figure 1: Audio Test Bed, Front View

The inputs and outputs of the amplifier and DVD player are routed to the front patch panel. All component and speaker connections are made at the front panel so components can be swapped in and out easily. For instance, in the amplifier lab of our Power Electronics class we plan to compare student-built amplifiers with the CT-410. For the baseline test the outputs of the DVD player are connected to the CT-410 inputs, and its outputs are connected to the speakers. Then, the cabling is reconfigured so that the student-built amplifiers replace the CT-410. This type of switching can be done very easily from the patch panel.

The rear view of the ATB, Figure 2, shows the cable routing and the cavity on top of the amplifiers. This cavity is used to stow the speakers for storage and transport.

Figure 2: Audio Test Bed, Rear View

Project Challenges and Lessons Learned

We encountered several frustrating problems with this project. For instance, the 19" rack mounting was not as "standard" as we expected. The Crown amplifier, although it appeared to be set up for a 19" rack mount, did not fit in the case. After measuring the case and realizing the width was slightly different between the top and bottom of the rack, we flipped the case and were able to squeeze the amplifier into the rack at the other end of the case.

By far the biggest problem we encountered was repairing the amplifier itself. After my student spent several hours performing repairs the amplifier still did not work. He had the problem narrowed down to a few possibilities, but needed better test equipment to continue his troubleshooting. We ended up asking for help from the company who donated it. After their technician (another of our students) looked at it for a while, he determined that it would be more

cost effective to piece together another amplifier with components they had on hand at the company.

When we powered the system up at school, we discovered it only had one functioning channel. This was quite a disappointment, but proved to be a simple fix. It turned out that the student at our local donor company had not tested it after completing the assembly and, since one of the header connectors had the "key" portion broken off, he mistakenly attached it offset by one pin on the connector. That problem was easily remedied and the amplifier worked well, although it did not produce the sound volume we had expected.

This was the second time we ran into the 19" rack problem. It turned out that the rack mounting tabs on the second CT-410 were different than the ones on the first amp, requiring some additional holes to make it fit.

The DVD player mounting was also challenging, although we had anticipated it. The student fabricated what are essentially five-sided boxes out of 1/8" plate steel, as shown at the extreme left- and right-hand sides of Figure 3. These "brackets" were mounted to the 19"rack. Then the DVD player was held in place and each box filled with expanding foam, the same type commonly used for shipping.

Figure 3: DVD Player with Mounts on Left and Right Ends

The completed system, while portable, is pretty bulky and heavy. It might be called more "luggable" than portable.

In retrospect, the donated amplifier, although a professional grade amp, caused a lot of grief in the project. Its repair ended up taking many hours, its size and weight makes the ATB large and heavy, and it does not produce the sound volume one might expect from such an amplifier. If we were doing this project again today, we would select a new, compact, and inexpensive commercial amplifier so we could design a smaller, more portable system.

On the other hand, there were some significant positive results from the project. With some perseverance, we did end up with an Audio Test Bed that we used for the first time during our spring 2008 open house and plan to use in spring 2009, both for the amplifier lab in our Power Electronics class and for some high school recruiting visits. Moreover, we have a good and ongoing relationship with one of the small companies in the area, which has hired several of our underclassmen in the past few years for part time help. Finally, the ATB has potential to be used for more than amplifier testing.

Other Applications

Since the Consumer Power Electronics course[7] covers audio principles along with linear amplifiers[8], we also plan to use the ATB to do basic sound level testing (e.g., attenuation with the square of the distance from the speaker). If we created a speaker "tower" we could also test/demonstrate the effect of stacking speakers to limit sound dissipation (i.e., attenuation would be proportional to the distance from the speaker instead of the square of the distance from the speaker).

Other possibilities include measuring electrical-to-sound power conversion efficiency and adding a digital signal processor (DSP) to create sound effects, such as reverb, bass/treble boost/attenuation, etc. This would be a fun addition to a course that teaches DSP.

Conclusion

Overall this project experience was positive. Our local department now has a useful piece of test equipment to use in conjunction with some laboratory activities, and it doubles for show-and-tell duties at recruiting events, open houses, etc. It was encouraging to find some small businesses in the area that are very willing to support our program, and the ATB project helped foster a regular and ongoing relationship with one of them.

Conversely, we did encounter some problems completing the ATB. The most frustrating ones centered around the donated amplifier(s). The first amplifier, in fact, proved so difficult to repair that it was eventually scrapped and replaced with a unit in better condition. Neither amplifier was a bolt-in fit to the SKB case, so the mounting brackets had to be modified. These issues would have arguably been less of a problem for a traditional student, but the student doing this project had a full-time job and very limited spare time. Caution would be well-advised whenever considering used equipment in need of repair, even though the donor be well-intentioned.

In retrospect, the idea of using a new and more compact amplifier for the ATB is attractive because it would have saved a lot of grief and allowed a lighter, more portable end product. Nevertheless, it would have cost more money and likely not resulted in the new relationship with a local small business. On balance, we consider the project to be a success, and the lessons learned will hopefully make future projects smoother.

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