Compact 3D-Printed Damped Pipe Stereo 2.1 Loudspeaker Design Project

Updated 4/1/2020

General Specifications: The objective of this project is to design, ~~construct,~~ and test a compact full-range "stereo" loudspeaker system. It will have a built-in Bluetooth interface, signal processing, and class-D power amplifier. It will employ a total of 3 drivers: a single "woofer" for summed left+right signals below 200 Hz (approximately), and separate midrange/tweeters ("twidlers") for each channel that operate at frequencies above the chosen cutoff frequency. The woofer will drive a 3D-printed pipe that is damped to help suppress spurious emissions and vented in a manner that helps suppress turbulence noise. The two "twidlers" will be mounted in small, heavily damped sealed enclosures that are integrated into the 3D-printed enclosure.

Each team will use the same 3-inch woofer (Tang Band W3-1876S, Parts Express #264-909), the same class D 2.1 amplifier module (#320-608), the same miniDSP signal processor (#230-322), and the same Bluetooth receiver module (#320-351). Stock power supplies will also be provided (#129-057 for the BT receiver and miniDSP board, and #120-057 for the power amplifier). Each team will select their pair of "twidler" full-range mini-speakers to complete the design, from a list available at Parts Express.

Primary design/performance goals include optimizing the frequency response (target ±3 dB over the range of 50 Hz to 15,000 Hz), controlling signal arrival times from each driver to optimize "stereo effect" perception, minimizing THD (total harmonic distortion), minimizing turbulence noise, and optimizing the form factor (while minimizing overall size) of the 3D-printed enclosure.

Evaluation: Each team member is expected to contribute in an equitable manner toward completion of this project. Lower levels of participation will be awarded proportionally lower overall scores.

Criteria that will be used to evaluate the completed project are as follows:

- Written report
  - design narrative (tradeoffs considered)
  - measured results (frequency response, THD vs SPL) *will be done by Prof. Meyer*
  - listening tests ("stereo effect" perception) *will be done "virtually" using EARS*
  - activity logs (required for each team member)
  - design documentation (enclosure drawing ~~and tuning/alignment parameters~~)
- Satisfaction of project success criteria (performance-related design goals)
- Form factor optimization – the finished product should be as compact and aesthetically pleasing as possible, while still satisfying the performance-related design goals
- Workmanship (quality of design ~~and construction~~) ~~*Prof. Meyer will (attempt to) print and assemble the enclosures*~~

Since our last class meeting on March 12, all University lab facilities and classrooms have been locked down and, effective March 25, most buildings on campus will be locked as well. It will therefore not be possible to allow students access to the lab to retrieve materials and/or use any of the software and instrumentation as originally envisioned. The project procedures and schedule will therefore be revised as detailed below.

(Tentative)* Revised Project Procedures and Schedule:

1. Prof. Meyer will post feedback for each team's enclosure design on their download portal (if it was not picked up during our last class meeting on March 12) – *note that career account authentication will be required to access the graded material download and submission portals on the course website*
2. The team member responsible for enclosure design should submit files for 3D printing it via the graded material submission portal on the course website JUST INCLUDE THESE IN THE TEAM REPORT YOU SUBMIT
3. ~~Prof. Meyer will *(attempt to)** print the enclosure designs, assemble them, equalize them, and measure their key performance parameters~~ NOT POSSIBLE AT THIS POINT
4. ALTERNATIVE to 2 & 3: If a given team would like to take responsibility for printing and assembling their loudspeaker system, Prof. Meyer will ship the components to the team member identified – once completed, the assembled system should be shipped back to Prof. Meyer for calibration and testing DOUBTFUL AT THIS POINT
5. PLAN C – Prof. Meyer will construct at least one "mock up" of the 2.1 enclosure and produce a video demonstrating its setup and calibration.
6. Photos of the completed design~~s~~, response curves, and THD measurements will be posted on the course website – data that each Team can copy and paste into Section 3 (Measured Results) of their Loudspeaker Design Project Report (*free points!*) NO LONGER NECESSARY
7. Each team should submit a 3-minute (approx.) audio clip (*royalty free, if possible*) of their choosing for the purpose of "virtually" (remotely) auditioning ~~their completed design~~
8. Prof. Meyer will assemble the clips submitted by each team (along with one of his choosing) into an audition sequence that will be used to evaluate the completed systems
9. A high quality binaural stereo recording (using miniDSP EARS) of ~~each loudspeaker system~~ Prof. Meyer's "mockup" 2.1 enclosure vs. the two Bose wave radios (demonstrated previously in class) reproducing the audition sequence will be posted on the course website (the "source" audition sequence will be posted as well, to enable remote "A-B" comparisons) – this will hopefully provide a sense of the stereo image produced by each loudspeaker system as well as a qualitative measure of both the frequency and transient response
10. Each team member should (remotely) listen to the audition sequence reproduced by ~~their design~~ "Bose vs. The 2.1 Mockup" as the basis for completing Section 4 (Listening Tests) of their Loudspeaker Design Project Report
11. For bonus credit, team members can compare and contrast the performance of their loudspeaker system with that of its competitors (include as an addendum to Section 4) DOUBTFUL AT THIS POINT
12. Team members should then collaborate remotely to complete their report (*only one report per team needs to be submitted*)
13. Completed reports should be submitted via the course website no later than April 30*

**subject to further University-imposed constraints not yet in effect and otherwise beyond our control*