Compact 3D-Printed Damped Pipe Stereo 2.1 Loudspeaker Design Project (Updated 4/27/20)

*paste in team picture here, highlighting finished product*

Delete this text box before printing your report. Also, delete all *highlighted instructions* provided in this skeleton file as you edit each section of your report. Do NOT change any of the formatting or page setup.

#### Project Evaluation – Team ID: ??

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| --- | --- | --- | --- |
| Evaluation Instrument | Description | Max | Score |
| Written Report | Introduction | 10 |  |
|  | Design Narrative | 20 |  |
|  | ~~Measured Results (Frequency Response, THD vs SPL)~~ | ~~10~~ |  |
|  | Listening Tests | 20 |  |
|  | Design Documentation | 10 |  |
|  | Technical Content / Writing Style / Professionalism | 10 |  |
| Project Success Criteria | Satisfaction of Performance-Related Design Goals | 10 |  |
| Optimization | Form Factor Aesthetics and Compactness | 10 |  |
| Workmanship | Quality of Design and Construction | 10 |  |
|  | TOTAL | 100 |  |

\* *Activity Logs will be used to determine if proportionally different scores are awarded to individual team members*

##### Instructor comments:

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**Abstract**

*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.*

1. **Introduction**

Outline:

* introduce the team members (separate paragraph written by each team member)
* describe your motivation for taking this course
* describe what you learned from completing this project
* describe any audio/acoustics-related career goals you might have

*Length should be about one page.*

1. **Design Narrative**

Note: Place the *written design narrative* in this section, along with your design documentation (photos, screen shots, schematics, drawings, etc.). Component data sheets and any pertinent reference materials should be included in the appendices.

* Describe the criteria you used and the alternatives you considered when choosing your “twidlers.”
* Describe the process you used (and detail any calculations you performed) to design the damped pipe layout and structure, along with any tradeoffs you considered with respect to the pipe’s length, diameter, tapering, and venting. This discussion should include references to the small signal parameters you measured for your woofer as well as literature citations.
* Describe the process you used (and detail any calculations you performed) to design the sealed compartments in which you mounted your “twidlers”. This discussion should include references to the small signal parameters you measured for the “twidlers” you selected.
* Describe the process you used to optimize the “stereo image” perception produced by your loudspeaker enclosure, ~~both mechanically (i.e. shape of cabinet face) and electronically (signal delays). Assess the efficacy of the procedure you utilized.~~
* ~~Describe any challenges you faced in tuning your system to optimize its frequency response, THD, and turbulence noise. Assess the efficacy of the procedure you utilized.~~

*Length should be about two pages.*

# **Measured Results**

*THIS SECTION IS NO LONGER REQUIRED*

*Calibration and testing of each system will be performed by Prof. Meyer – multiple frequency response curves (to help you gauge the quality of stereo image produced) along with distortion measurements at key frequencies will be posted on the course website. ~~which you can then copy and paste into this section of your report.~~*

Outline:

* Evaluate the performance of your system *quantitatively*, based on its measured frequency response. Indicate whether or not you satisfied the target constraint of±3 dB over the range of 50 Hz to 15,000 Hz (and, if not, what you felt was the primary factor preventing your design from doing so).
* Measure the total harmonic distortion (THD) or your system at different frequencies as a function of SPL. Summarize this information using a chart or plot.
* Measure the size of the stereo image “sweet spot” (i.e. spatial area in which the L and R “twidler” levels are within a few dB over a wide frequency range (e.g. 200 Hz – 10 kHz).

*Length should be about two pages.*

# **Listening Tests**

Each team member should audition the 2.1 MU ~~their completed loudspeaker system~~, as described below. For this purpose, 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. 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 2.1 MU vs the two Bose Wave Radios. ~~all the completed loudspeaker systems.~~

**UPDATE: Just compare and contrast the four audition clips using the “musical adjectives” discussed in Chapter 6 of the text to describe and assess what you heard (e.g., warmth, texture, etc.) and describe which loudspeaker system(s) sounded best for each clip**.

NOTE: Two of the loudspeaker systems are “2.1 variants” per the project specifications, and the other two are Bose Wave Radios (detailed in the report provided to you earlier this semester). Be sure to listen to the binaural recordings using earbuds or headphones.

Outline:

* Evaluate the performance of the 2.1 MU your system *qualitatively*, by listening to the binaural stereo recording made of the 2.1 MU your completed loudspeaker system reproducing the audition sequence (which will be posted on the course website, along with the source). based on listening to different types of music played through it (*your choice, but provide a detailed list of the music you auditioned when evaluating your system*). Use the “musical adjectives” discussed in Chapter 6 of the text to describe and assess what you heard (e.g., warmth, texture, etc.).
* Discuss whether or not your design the 2.1 MU met your “sonic expectations” (e.g., “silky high end”, “in-your-face midrange”, “thunder bass”, “wide soundstage”, etc.) you had envisioned and what you would further “tweak” in your design the 2.1 MU (e.g., change your “twidler” choice and/or tweak delay/EQ tuning parameters) to improve its performance. Compare and contrast the performance of the 2.1 MU with the two Bose Wave Radios.
* BONUS CREDIT OPPORTUNITY: Compare and contrast the performance of your loudspeaker system with that of your competitors.

*Length should be about two pages.*

# **References**

*List any references (e.g., application notes, web sites, individuals) consulted in formulating your design.* ***Be sure to cite these references in your report.***

*Use IEEE or APA format for references.*

**Appendix A:**

**Activity Logs**

**Activity Log for:** <name-1> **Role:** <role on team>

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**Activity Log for:** <name-2> **Role:** <role on team>

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**Activity Log for:** <name-3> **Role:** <role on team>

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**Activity Log for:** <name-4> **Role:** <role on team>

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**Appendix B:**

**Measured Results**

**Appendix C:**

**Design Documentation**