Name: \_\_Replace with your name(s)\_\_\_\_

EID: \_\_Replace with your EID(s)\_\_\_\_\_

Semester: Spring 2025

Course: ECE445L

A) ***Requirements Document:***

1. I have updated my PRD at the end of this lab report to reflect the functionality of my design if I implement one or more extra credit features (Type yes if true): \_\_\_\_
2. Both partners have agreed to the team contract (Type yes if true): \_\_\_\_

<https://docs.google.com/document/d/1b0H_l2s_C3Buwb_I0p0ZEJCIzjKjUqObAgL3oR6PWzI/edit?usp=sharing>

B) ***Objectives*:**

1. In a few sentences, describe the purpose of the lab and the features of your music player.

C) ***Hardware Design Deliverables:***

1. Deliverable 1: Using **KiCad**, create a schematic for your design. Include a screenshot in the space below.

D) ***Software Design Deliverables:***

1. I have pushed my code to GitHub for grading (Type yes if true): \_\_\_\_
2. Deliverable 2: Data flow and call graphs (like Figures 5.10 and 5.11)

E) ***Measurement Data:***

1. Deliverable 3: Time/Frequency domain output, and DAC characterization
2. Deliverable 4: Effective number of bits calculation
3. Deliverable 5: ISR processor utilization
4. Deliverable 6: Output Jitter
5. Deliverable 7: Power and noise characterization
6. Deliverable 8 (15pt EC): Additional Features

F) ***Analysis and Discussion Questions:***

1. Briefly describe three errors in a DAC.
2. Calculate the data available and data required intervals in the SSI/DAC interface. Use these calculations to justify your choice of SSI frequency.
3. Why did you use Freescale mode 1 and not mode 0 (bits 7,6 of SSI1\_CR0\_R)?
4. How is the frequency range of a spectrum analyzer or discrete Fourier transform determined?
5. Notice the audio amplifier had a voltage gain of 1. Why did we not simply drive the speaker directly from the DAC? In other words, what purpose is the TPA731/MC34119?

G) ***Project Requirements Document:***

Included below is the base requirements document for this lab. Modifications to this requirements document are **NOT** required **UNLESS** you do extra credit for the lab. Please make any additions using highlighting, and removals using ~~strikethrough~~. As always, feel free to adjust the syntax and format of your requirements document as you think appropriate. The goal of the document is to provide a clear unambiguous description of what the project does.

1. Overview

1.1. Objectives: Why are we doing this project? What is the purpose?

The objectives of this project are to design, build and test a music player. Educationally, students are learning how to interface a DAC, how to design a speaker amplifier, how to store digital music in ROM, and how to perform DAC output in the background. Your goal is to play your favorite song.

1.2. Process: How will the project be developed?

The project will be developed using the TM4C123 board. There will be two or three switches that the operator will use to control the music player. The system will be built on a solderless breadboard and run on the usual USB power. The system may use on-board switches or off-board switches. A hardware/software interface will be designed that allows software to control the player. There will be at least three hardware/software modules: switch input, DAC output, and the music player. The process will be to design and test each module independently from the other modules. After each module is tested, the system will be built and tested.

1.3. Roles and Responsibilities: Who will do what? Who are the clients?

ECE445L students are the engineers, and the TA is the client. Students are expected to make minor modifications to this document in order to clarify exactly what they plan to build. Students are allowed to divide responsibilities of the project however they wish, but, at the time of demonstration, both students are expected to understand all aspects of the design.

1.4. Interactions with Existing Systems: How will it fit in?

The system will use the TM4C123 board, a solderless breadboard, and the speaker as shown in Figure 5.1. It will be powered using the USB cable. You may use a +5V power from the lab bench, but please do not power the TPA731/MC34119 or the speaker with a voltage above +5V.

1.5. Terminology: Define terms used in the document.

Definitions for the terms SSI, linearity, frequency response, loudness, pitch, instrument, tempo, envelope, melody, and harmony can be found in the textbook. *(Note to students: add any addition terms you feel are needed)*

1.6. Security: How will intellectual property be managed?

The system may include software from TivaWare and from the book. No software written for this project may be transmitted, viewed, or communicated with any other ECE445L student past, present, or future (other than the lab partner of course). It is the responsibility of the team to keep its ECE445L lab solutions secure.

2. Function Description

2.1. Functionality: What will the system do precisely?

If the operator presses the play/pause button the music will play or pause. If the operator presses the play/pause button once the music should pause. Hitting the play/pause again causes music to continue. The play/pause button does not restart from the beginning, rather it continues from the position it was paused. If the rewind button is pressed, the music stops and the next play operation will start from the beginning. There is a mode switch that allows the operator to control some aspect of the player. Possibilities include instrument, envelope, or tempo. *(Note to students: if you use the internal switches you could rename the switches SW1 and SW2 to match the switches you use)* *(Note to students: specify exactly what your mode button does.)*

There must be a C data structure to hold the music. There must be a music driver that plays songs. The length of the song should be at least 30 seconds and comprise of at least 8 different frequencies. Although you will be playing only one song, the song data itself will be stored in a separate place and be easy to change. The player runs in the background using interrupts. The foreground (main) initializes the player, then executes **while(1){}** do nothing loop. If you wish to include LCD output, this output should occur in the foreground. The maximum time to execute one instance of the ISR is xxxx *(note to students: replace the xxxx with the performance measure of your solution).* The maximum sampling jitter is yyyy *(note to students: replace the yyyy with the performance measure of your solution).* You will need public functions **Rewind**, **Play**, and **Stop**, which perform operations like a cassette tape player. The **Play** function has an input parameter that defines the song to play. A background thread implemented with output compare will fetch data out of your music structure and send them to the DAC. Again, feel free to change the functional description to match your design.

There must be a C data structure to store the sound waveform or instrument. You are free to design your own format, as long as it uses a formal data structure (i.e., **struct**). The generated music must sound beautiful utilizing the SNR of the DAC. Although you only have to implement one instrument, it should be easy to change instruments.

2.2. Scope: List the phases and what will be delivered in each phase.

Phase 1 is the preparation; phase 2 is the demonstration; and phase 3 is the lab report. Details can be found in the lab manual.

2.3. Prototypes: How will intermediate progress be demonstrated?

A prototype system running on the TM4C123 board and solderless breadboard will be demonstrated. Progress will be judged by the preparation, demonstration, and lab report.

2.4. Performance: Define the measures and describe how they will be determined.

The system will be judged by three qualitative measures. First, the software modules must be easy to understand and well-organized. Second, the system must employ abstract data structures to hold the sound and the music. There should be a clear and obvious translation from sheet music to the data structure. Backward jumps in the ISR are not allowed. Waiting for SSI output to complete is an acceptable backwards jump. Third, all software will be judged according to style guidelines. Software must follow the style described in Section 3.3 of the book *(note to students: you may edit this sentence to define a different style format)*. There are four quantitative measures. First, the SNR of the DAC output of a sine wave should be measured. Second, the maximum time to run one instance of the ISR will be recorded. Third, you will measure the maximum jitter of the DAC outputs. Fourth, you will measure power supply current to run the system. There is no need to optimize any of these quantitative measures in this system.

2.5. Usability: Describe the interfaces. Be quantitative if possible.

There will be three switch inputs. The DAC will be interfaced to an 8-ohm or 32-ohm speaker. *(note to students: you could use either an 8-ohm or 32-ohm speaker)*

2.6. Safety: Explain any safety requirements and how they will be measured.

If you are using headphones, please verify the sound is not too loud before placing the headphones next to your ears.

3. Deliverables

3.1. Reports: How will the system be described?

The lab report described below is due by the due date listed in the syllabus. This report includes the final requirements document.

3.2. Audits: How will the clients evaluate progress?

The preparation is due at the beginning of the lab period on the date listed in the syllabus.

3.3. Outcomes: What are the deliverables? How do we know when it is done?

There are three deliverables: preparation, demonstration, and report. *(Note to students: you should remove all notes to students in your final requirements document)*.