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# **Software Requirements Specification**

**for**

## **AmpV2**

**Version 1.0**

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**3/14/2021**

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## Revision History

Name	Date	Reason For Changes	Version

# 1. Introduction

## 1.1 Purpose

The software for AmpV2 is used to provide a display interface to allow a user to control different aspects of the amplifier and to receive feedback about audio levels and amplifier status.

## 1.2 Document Conventions

Abbreviation	Explanation
<b>ADC</b>	Analog to Digital Converter – converts analog voltage into digital so that the MCU can read and process that signal
<b>Clip/Clipping</b>	An audio signal is “clipping” when the voltage value of the output audio signal is supposed to be higher than the voltage of the power supply rails. In this case, the voltage of the audio signal is equal to the DC supply rail and “clips” off the peaks of the audio signal
<b>EEPROM</b>	Electrically Erasable Programmable Read-Only Memory – Used to store data and settings when there is no power provided to the amplifier
<b>Fault</b>	A fault state occurs when something has gone wrong inside the amplifier, and the amplifier will need to be reset or power cycled to remove the fault. This can be caused by a few things including overheating, short circuits on the amplifier module, and trying to drive more current into a speaker than the amplifier can output.
<b>FFT</b>	Fast Fourier Transform – A method for displaying a real-time analysis of the different frequencies that make up the total audio signal. Usually displayed on a graph with amplitude in dB on the y axis and frequency on the x-axis on a logarithmic scale
<b>I/O</b>	Input/Output – In this case, used to refer to audio inputs and outputs into the amplifier
<b>LCD</b>	Liquid Crystal Display – A type of display used in this project
<b>MCU</b>	Microcontroller Unit – The processor that controls all the digital functionality of the project
<b>OTW</b>	Over Temperature Warning – This signal shows when the amplifier has reached an unsafe temperature, and the amplifier will then go into a fault mode
<b>PWM</b>	Pulse Width Modulation – In this use case, a method for controlling fan speed
<b>RMS</b>	Root Mean Squared – The (roughly) DC equivalent amplitude of an AC signal

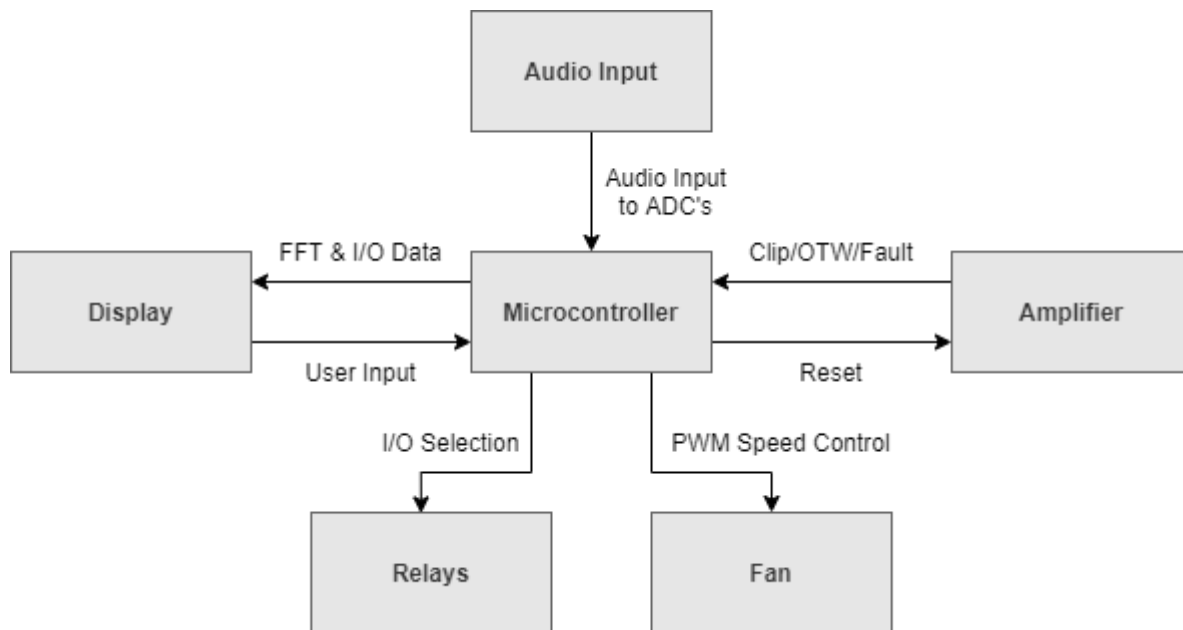
## 1.3 Product Scope

This application will have two major categories of functionalities. Control functionalities include functionalities that cause a state in the amplifier to change. Display functionalities include functionalities that cause information about the amplifier to be displayed on screen.

There is only one type of user, and all user input is done through the touchscreen LCD.

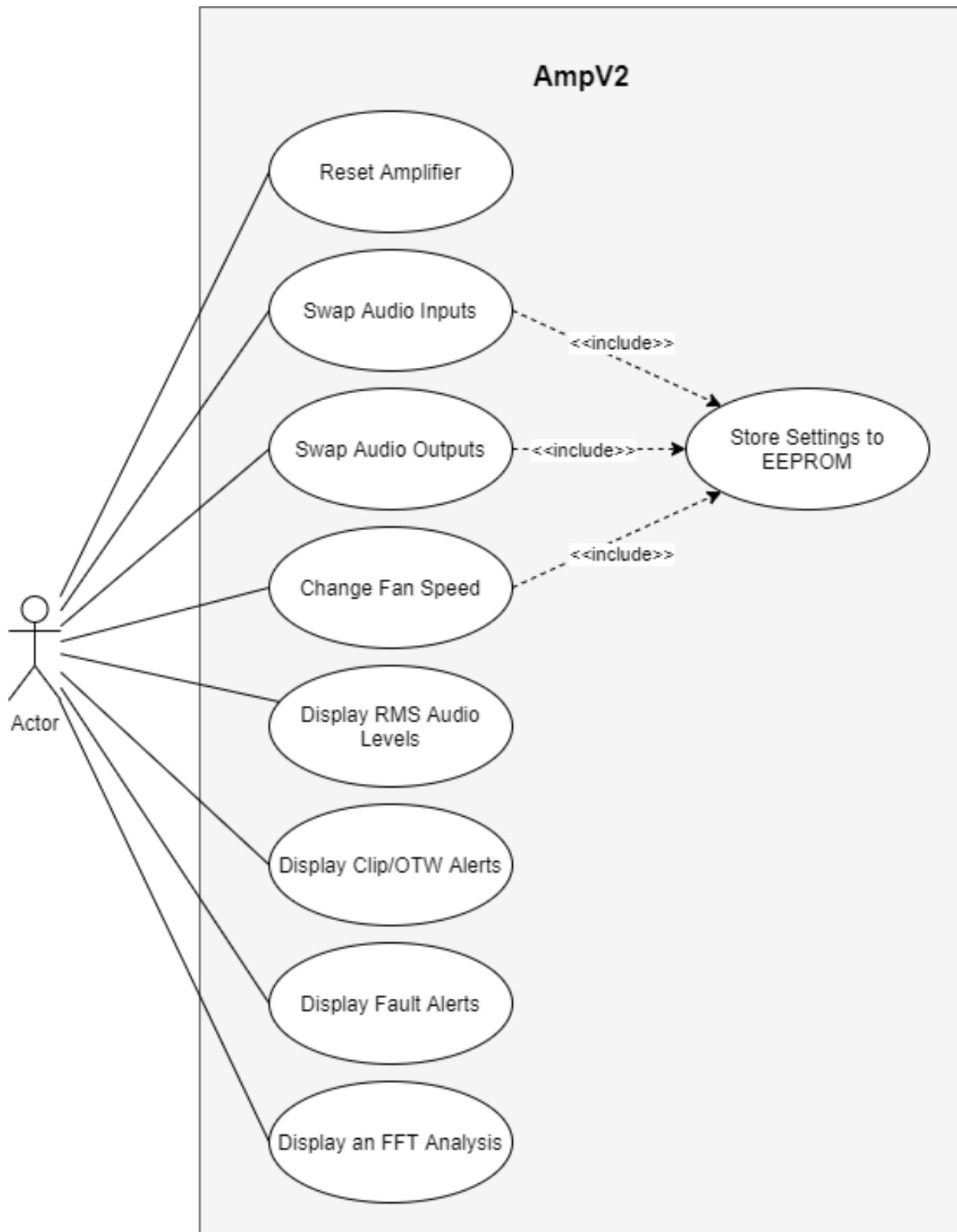
## 2. Overall Description

### 2.1 Product Perspective



All functionalities are processed by the MCU. Control functionalities are initiated by the user from the touchscreen and sent to the MCU, and display functionalities are sent from the MCU to the LCD.

Use Case Diagram:



## **2.2 Product Functions**

Control Functionality:

- Reset the amplifier
- Swap between audio inputs
- Swap between audio outputs
- Control fan speed
- Store settings in EEPROM

Display Functionality:

- Display RMS audio levels on both channels
- Display Clip/OTW alerts
- Display when the amplifier is in a fault state
- Display a FFT analysis of the audio signals

More information can be found in section 4.

## **2.3 User Classes and Characteristics**

There is only one user type. The user directly controls all Control Functionality outlined in section 2.2.

## **2.4 Operating Environment**

The software will be run on a Teensy board. Theoretically, any microcontroller with an I2C port, 2 ADC inputs, and 7 digital pins (3 of which must have interrupt capability) should work. However, only a Teensy 4.0 has been tested. Arduino board with Atmel chips, along with other slower microcontrollers, will run into problems when trying to run FFT analysis on incoming audio signal. Other microcontroller boards may not be exactly pin compatible with the Teensy 4.0 version of the amplifier board.

## **2.5 Design and Implementation Constraints**

The Display uses a program called VisualLCDStudio to program the GUI onto the display. This software currently is only obtainable through the seller of the displays.

## **2.6 Assumptions and Dependencies**

This software depends on the Arduino IDE with the Teensyduino plugin installed in order to program the MCU, and it depends on the VisualLCDStudio to program the GUI to the display.

# **3. External Interface Requirements**

## **3.1 User Interfaces**

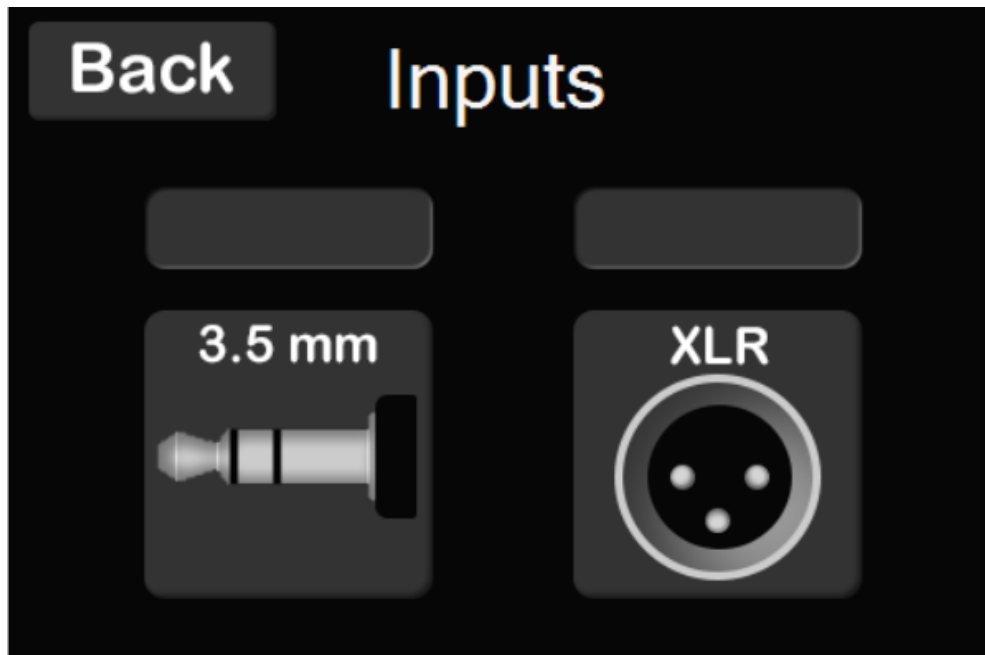
### **3.1.1 Main Page**



The main page has:

- Four buttons on the left to navigate to other pages labeled “Input,” “Output,” “FFT,” and “Fan”
- A button labeled “Reset” to initiate a reset of the amplifier (see section 4.1)
- Two indicators that show when the amp is clipping (see section 4.7) or in a fault state (see section 4.8)
- RMS level meters for both audio channels (see section 4.6)

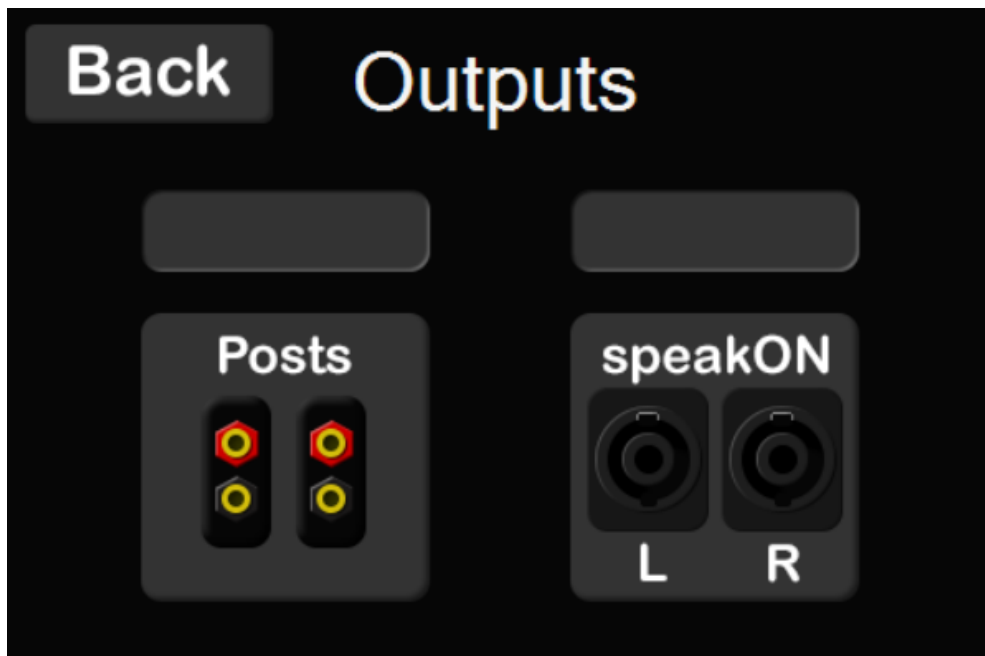
### 3.1.2 Inputs Page



The inputs page has:

- Buttons to select audio inputs labeled “3.5mm” and “XLR” (see section 4.2)
- Indicators above the buttons that light up green to show the currently selected input
- A button labeled “Back” to go back to the main page

### 3.1.3 Outputs Page

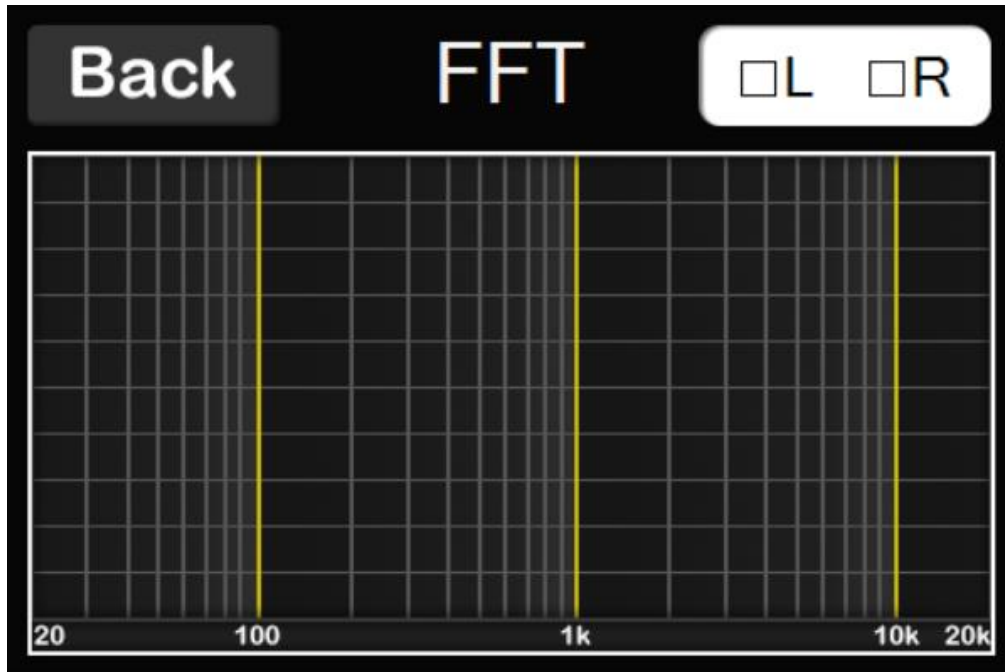




The outputs page has:

- Buttons to select audio outputs labeled “Posts” and “speakON” (see section 4.3)
- Indicators that light up green to show the currently selected output
- A button to go back to the main page labeled “Back”

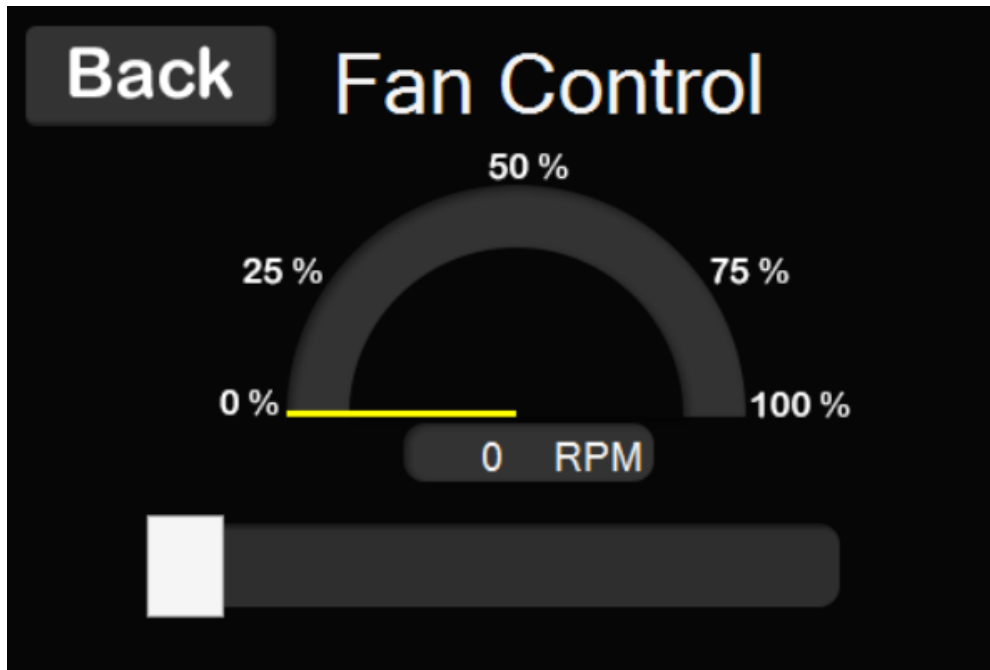
### 3.1.4 FFT Page



The FFT page shows:

- A graph of amplitude vs frequency on a logarithmic scale (see section 4.9)
- Checkboxes used to select which channels are enabled on the graph labeled “L” and “R”
- A button labeled “Back” to take the user back to the main page

### 3.1.5 Fan Control Page



The fan control page shows:

- A dial of the fan speed in percent
- An RPM gauge of how fast the fan is rotating
- A slider to control the fan's speed (see section 4.4)
- A back button labeled “Back” to take the user back to the main page.

## 3.2 Hardware Interfaces

The figure in section 2.1 shows a good representation of the hardware interfaces with the MCU. The MCU can read incoming pins to determine what state the peripheral hardware is in, and it can write out pins to control some peripherals.

## 3.3 Communications Interfaces

I2C is used to send information from Display Functionalities to the display, and it is also used to send commands for Control Functionalities back to the MCU.

# 4. System Features

## 4.1 Reset the Amplifier

### 4.1.1 Description

This pulls the reset pin on the amplifier module low. This causes the amplifier outputs to disable, and it is useful in preventing popping and damage to speakers in certain situations. This can also be used to clear a fault state on the amplifier.

#### 4.1.2 Functional Requirements

- Flow of events:
  - The user must press the button labeled “Reset” on the main page
- Alternate Method:
  - This is also called when a user swaps inputs and outputs (see section 4.2 and 4.3 for more details)
- Exit condition:
  - The amplifier resets for about 500ms

### 4.2 Swap Between Audio Inputs

#### 4.2.1 Description

This triggers the state of the relay that controls if the audio is routed into the amplifier from the 3.5mm inputs or the XLR inputs.

#### 4.2.2 Functional Requirements

- Flow of events:
  - The user must tap on the button labeled “Input” on the main page to get to the inputs page
  - The user must then tap on either of the buttons to select the input they want
- Exit conditions:
  - If the user selects the audio input that is already selected:
    - Nothing happens
  - If the user selects the previously unselected audio input:
    - The green indicator light switches to being displayed about the selected audio input
    - The amp begins a reset to protect the speakers from popping that occurs when switching inputs
    - The relays swap positions to the selected audio input
    - The amp ends the reset and resumes operation

### 4.3 Swap Between Audio Outputs

#### 4.3.1 Description

This triggers the state of the relay that controls if the audio is routed out of the amplifier into either the SpeakON or binding post outputs.

#### 4.3.2 Functional Requirements

- Flow of events:
  - The user must tap on the button labeled “Output” on the main page to get to the outputs page
  - The user must then tap on either of the buttons to select the output they want
- Exit conditions:
  - If the user selects the audio output that is already selected:
    - Nothing happens
  - If the user selects the previously unselected audio output:
    - The green indicator light switches to being displayed about the selected audio output
    - The amp begins a reset to protect the speakers from popping that occurs when switching outputs
    - The relays swap positions to the selected audio output
    - The amp ends the reset and resumes operation

## 4.4 Change Fan Speed

### 4.4.1 Description

Changes the PWM duty cycle value to control how fast the fan spins.

### 4.4.2 Functional Requirements

- Flow of events:
  - The user must tap the button labeled “Fan” on the main page to get to the fan control page
  - The user must tap and slide on the slider at the bottom to change how fast the fan will spin
- Exit conditions:
  - The fan speed changes to the user’s preference

## 4.5 Store Settings to EEPROM

### 4.5.1 Description

Saves settings to nonvolatile memory onboard the MCU.

### 4.5.2 Functional Requirements

- Flow of events:
  - Boot up the MCU to load the previously saved settings
  - Changes to inputs, outputs, or the fan speed result in those setting being saved to EEPROM
- Exit Conditions:
  - Changes are saved

## 4.6 Display RMS Audio Levels

### 4.6.1 Description

Displays the RMS audio level on two bars on the main page. One bar is used for each channel.

### 4.6.2 Functional Requirements

- Flow of events:
  - Navigate to the main page if not currently there
  - Play audio
- Exit conditions:
  - A bar will appear indicating the RMS audio level for each channel

## 4.7 Display Clip/OTW Alerts

### 4.7.1 Description

Displays a yellow circle on the main page when the amp is clipping or overheating

### 4.7.2 Functional Requirements

- Flow of events:
  - Navigate to the main menu if not already there
  - Play audio to the point it clips
- Entry condition:
  - Audio is clipping
- Exit condition:
  - A yellow circle appears on the display until the audio stops clipping

## 4.8 Display Fault Alerts

### 4.8.1 Description

Displays a red circle on the main page when the amp is in a fault state

### 4.8.2 Functional Requirements

- Flow of events:
  - The user must navigate to the main menu if not already there
  - The amplifier must go into a fault state
- Entry condition:
  - Amp is in a fault state
- Exit condition:
  - A red circle appears on the display until the amp is reset or power cycled

## **4.9 Display an FFT Analysis**

### **4.9.1 Description**

Displays a graph with amplitude on the y axis and frequency on the x axis. Bars appear at each frequency band indicating how much of that frequency makes up the total audio signal.

### **4.9.2 Functional Requirements**

- Flow of events:
  - The user must tap the button labeled “FFT” on the main page
- Entry conditions:
  - The user must have checked either or both of the checkboxes to enable FFT for channels
  - Audio must be playing
- Exit conditions:
  - A bar graph will be displayed indicating the amplitude of the frequency components of the audio