Self-Adjusting Volume Pedal

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Problem

- Solo guitarists are unable to change the volume of their amp without interrupting their work
- Before a session or in between songs, the guitarist has to set the perfect volume depending on their venue
- Volume pedals are an alternative, however prevent the player from being mobile

Solution

- Our product aimed to solve this by automatically adjusting volume based on distance from the player
- Allows the volume to be set in advance
- Anywhere in the room, the guitarist would hear the same decibel level

Block Diagram

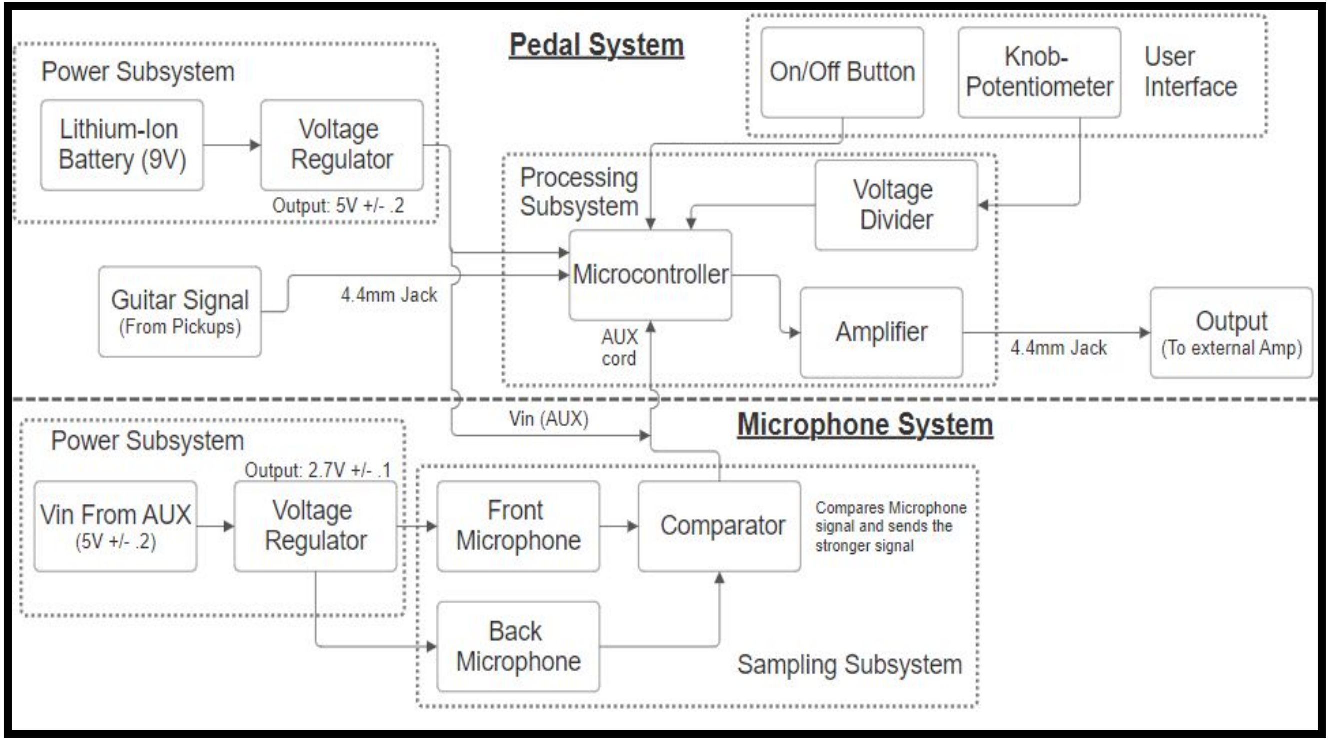
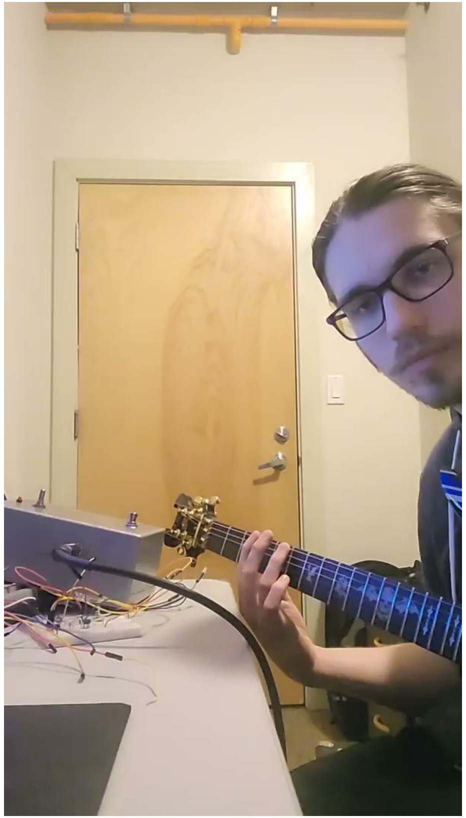


Figure 1: Block Diagram

Video



R&V Tables

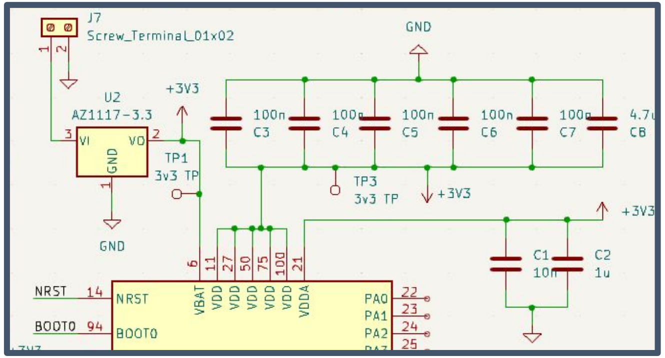


Figure 2: Power Circuit

Requirement	Verification
Must be able to supply rated voltage for each component within a +/- 0.2V tolerance after going through voltage regulators.	• Open up the pedal to expose components. • After each component, verify what voltages are read before the Vcc pins and compare to rated voltage values.
On/Off Button works properly	• Switching this button will accurately turn on and off the voltage in the whole circuit.+

Table 1: Power R&V

Power Subsystem

- 9V Lithium ion battery for external power
- 3.3V supplied to the whole system
- String of Capacitors for decoupling

User Interface

- Push button
  - When on - LED turns on and system alters guitar signal
  - When off - LED is off and signal is unaltered
- Volume Knob
  - 100k Potentiometer used to set desired volume

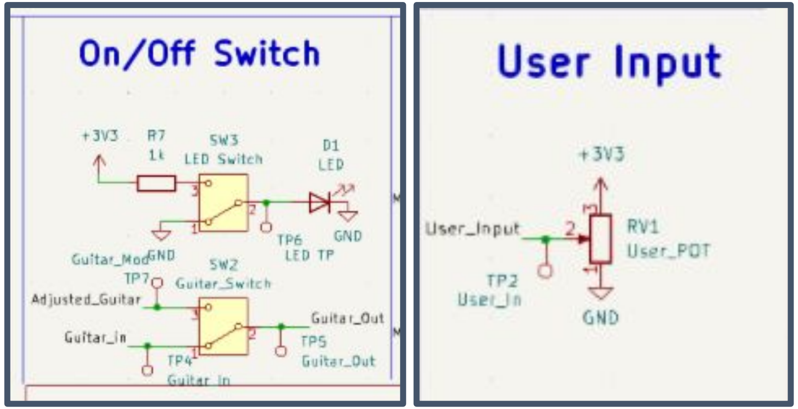


Figure 3: User Interface Old

Requirement	Verification
Knob appropriately sets volume at the user's location to volume within 5% of selected dB.	• User interface will be turned to a maximum value in dB and the guitar will be played stationary. • Using a decibel meter, we will record the decibels at the user's position and compare it to the set value. • We will test the lower bounds of the system next. • Finally we can use a middle position to solidify the accuracy of our device.
On/Off Button works properly	• Switching this button will accurately turn on and off an LED.

Table 2: User Interface Subsystem R&V

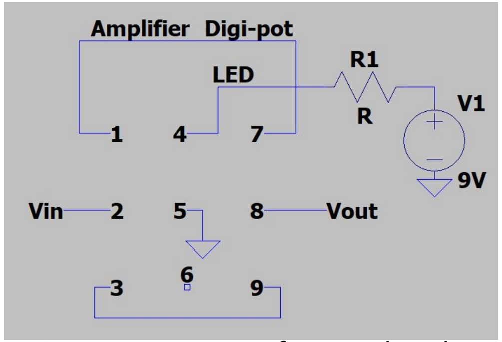


Figure 4: User Interface Updated

Amplifier Implementation

- Guitar Signal must be amplified to allow for larger dB range (Av from 1 to 2).
- Low pass filters must also be added to adjust for any noise created by this subsystem/amplification.
- 3dB cutoff at 8 kHz

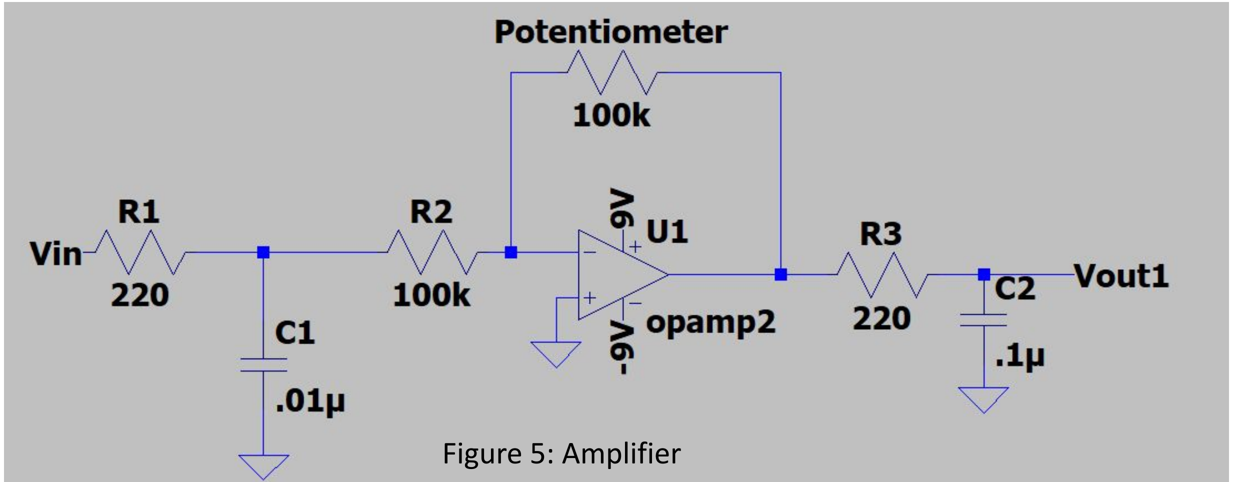


Figure 5: Amplifier

Analog Implementation

- Controlled though microcontroller based on input from microphones on guitar.
- Potentiometer has a max value around 10k Ohms with step resistance (Rs) of 39 Ohms.
- Digi-pot will control the amplitude of the output signal based on set reference voltage.
- BW = Rs(Dn) + Rw ; AW = Rs(256 - Dn) + Rw

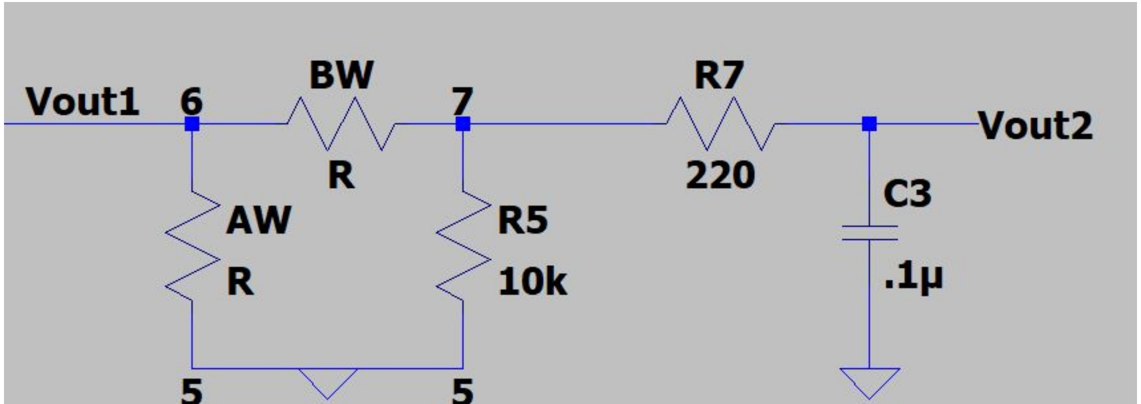


Figure 6: Digi-pot Equivalent Circuit

Digital Implementation

- Set control values depending on 12-bit ADC signal
- Utilize stream of envelope voltages to modify

Output

- Voltage Divider for analog amplification
- 128 control states

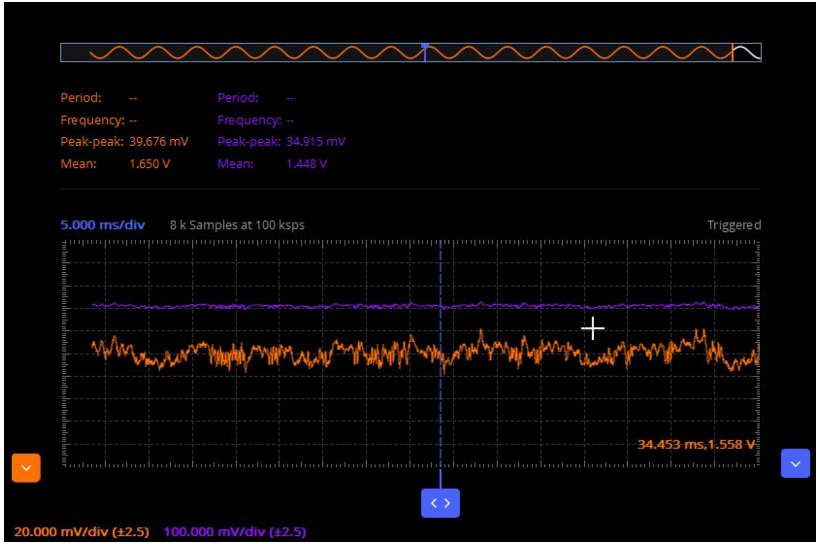


Figure 7.
Orange: Microphone Signal
Purple: Digital Potentiometer VDR

Microphone signal

- The microphone signal is sampled with an ADC (12-bit) on the Microcontroller.
- The signal envelope is calculated to detect changes in data.
- The magnitude of the Hilbert transform of the raw signal yields the envelope

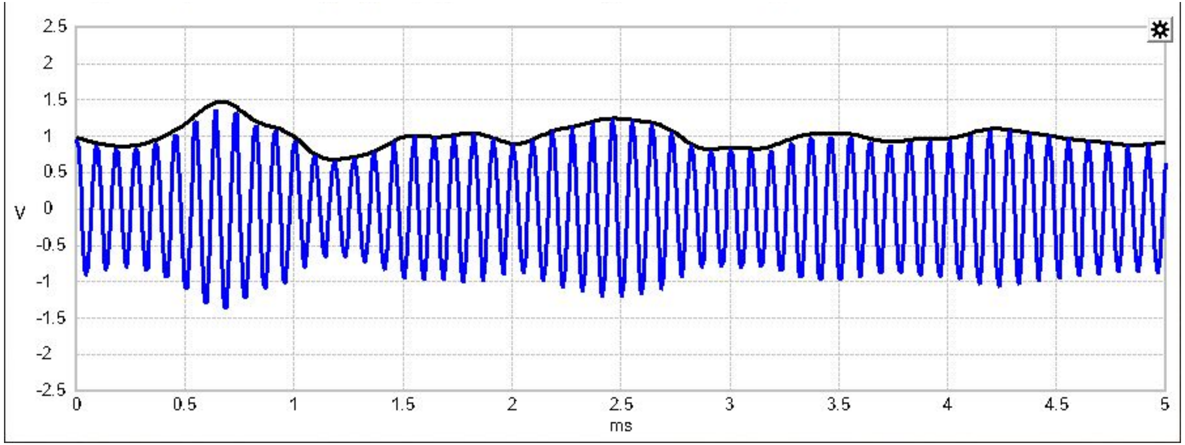


Figure 8.
Envelope of Signal

ADC Sampling

- 12-bit signal
  - Sample Hold Time: 1.5 cycles
  - ADC Conversion Time: 12 cycles
- $f_{sample} = f_{ADC}/(SHT + ACT + 1)$
- f_sample = 14 MHz / (14.5 cycles) = 966 KHz

Filtering

- Bandpass for 80-1500 Hz range
- FIR for simplicity
- Centered at 790 Hz, bandwidth of 1420 Hz

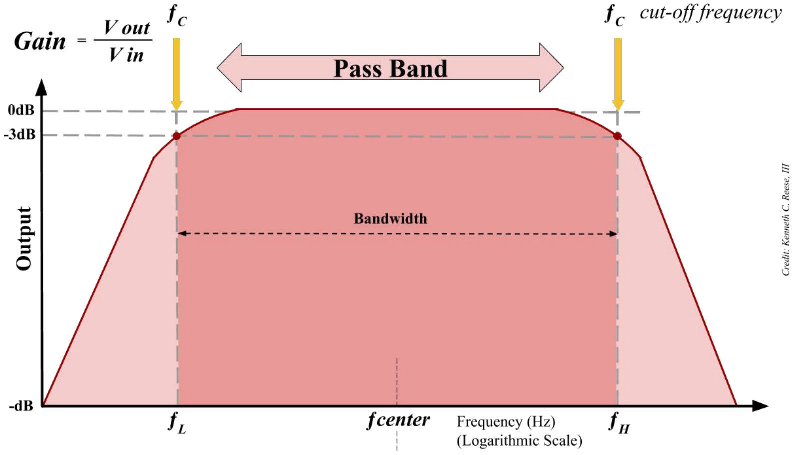


Figure 9.
Band-pass Theory

Microcontroller Unit

Development to PCB

- STM32H723VET6 on PCB
- STM32F103RB on development board
- Pin assignments would be a simple translation

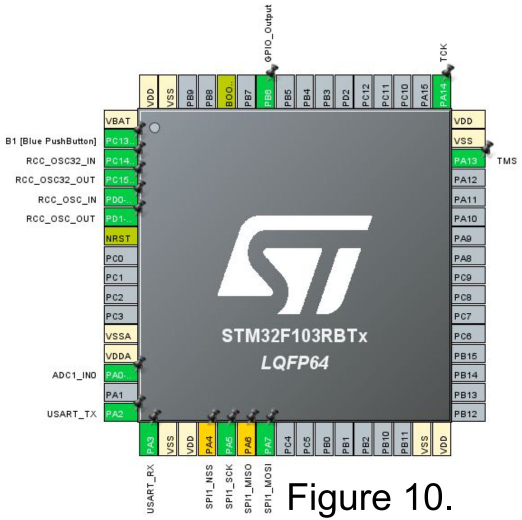


Figure 10.
STMCubeIDE .ioc

MCU	H7 series	F1 series
Core [MHz]	Up to 600	72
Flash Memory [Mbytes]	1	0.128
ADC frequency [MHz]	50	14
ADC resolution	16-bit	12-bit

Table 3.
MCU Comparison

Success & Challenges

Looking Ahead

The Grainger College of Engineering

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN