Metal to the Pedal:
The Design of a Multifunctional Guitar Pedal Using Digital Signal Processing

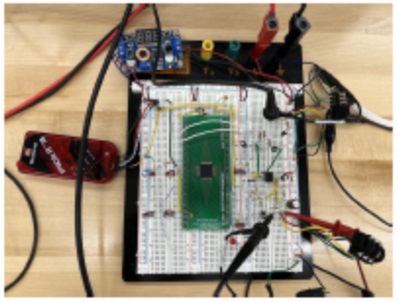
Kathryn Pinkerton, Mitchell Fountain, Jennifer Romero, and Gustavo Hernandez
Department of Physics, Engineering, and Astronomy; Stephen F. Austin State University

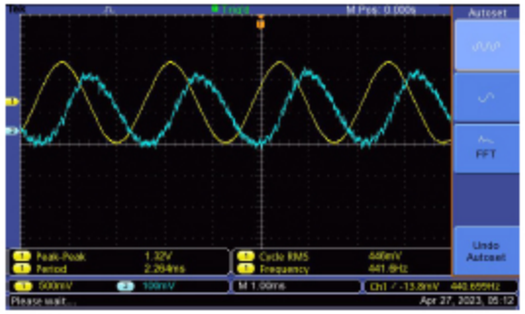
Introduction

This project aims to have a fully functional guitar pedal that will use a Digital Signal Processing (DSP) chip to manipulate signals from a guitar to generate new audio effects. This guitar pedal will benefit musicians and offer an educational opportunity by allowing the user to program and customize the pedal with their own desired effects. The pedal is programmed using C as it is a very user-friendly coding language. The problem we intend to solve is the lack of customizability of guitar pedals while offering the user an educational opportunity.

Prototype Development

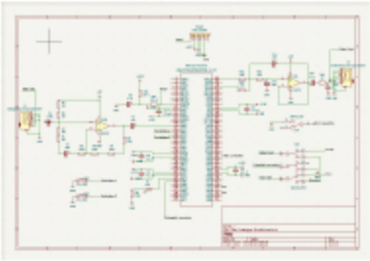
To develop the first prototype, the Microchip was soldered onto a breakout board and then placed onto a breadboard. Around this breakout board the power supply circuit was assembled as well as the filters for the input and output signals. After the prototyping circuit was assembled along with the buck converter, power supply, function generator and oscilloscope, the tests could begin. This prototype development setup was necessary for the development and testing of our code. It was imperative that both circuitry and software worked hand in hand for this project as they are interrelated. Below one can see the breadboard on which all testing took place as well as the input (yellow) and output (Blue) signals from the oscilloscope.

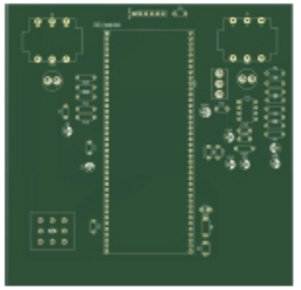




Printed Circuit Board (PCB)

A Printed Circuit Board (PCB) was designed using an open-source, Computer Aided Design (CAD) software called Kicad 6.0. Shown left to right is an evolution from CAD model to the final PCB design

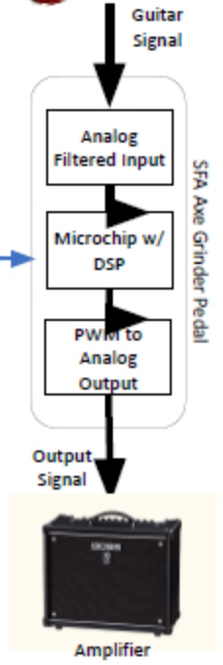




Signal Processing Code

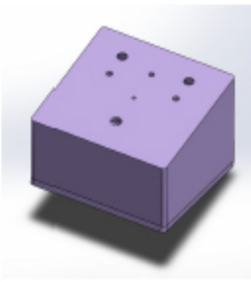
The pedal relies on a Microchip. Diagram below illustrates a basic signal modification. Multiple codes were adapted for the pedal and can be loaded onto the board via USB. Some of the coded effects include clean, booster, tremolo, and distortion.

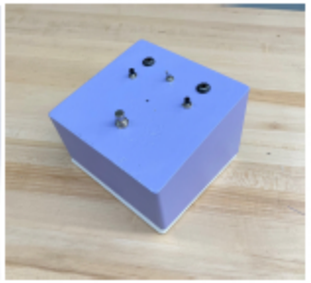
```
int main(void) {
    // Initialize the device
    SYSTEM_Initialize();
    PWM_Initialize();
    ADC1_Initialize();
    ADC1_Enable();
    ADC1_ChannelSelect(channel_AN0);

    while (1) {
        dutyCycle = adcResult();
        changeDC(dutycycle);
    }
    return 1;
}// End Main

void changeDC(int newDC) {
    PWM_GeneratorDisable(PWM_GENERATOR_2);
    PWM_DutyCycleSet(PWM_GENERATOR_2, newDC);
    PWM_GeneratorEnable(PWM_GENERATOR_2);
    __delay_us(10);
    return;
}

int adcResult(void) {
    int conversion;
    //ADC Conversion
    ADC1_SoftwareTriggerEnable();
    ADC1_SoftwareTriggerDisable();
    while(!ADC1_IsConversionComplete(channel_AN0));
    conversion = ADC1_ConversionResultGet(channel_AN0);
    // Scale ADC conversion to 8 bits
    conversion = conversion >> 4;
    return conversion;
}//end adcResult
```



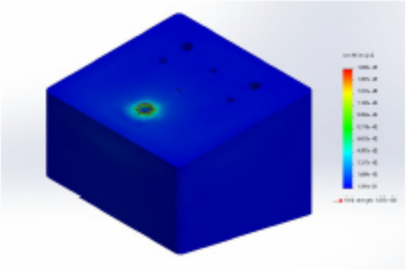
Design of Enclosure

The enclosure was fabricated using SOLIDWORKS. This enclosure was then 3D printed using PLA in an Ultimaker 3. Afterwards, the print was then spray-painted light purple.





A Finite Element Analysis (FEA) was performed on the enclosure designed to house the pedal components using SOLIDWORKS. A maximum loading of 60 lbs is applied at the location of the footswitch. The largest stresses are shown in red near the application of the force.



Conclusion

In Conclusion the final prototype was made for this project. While there are many improvements that can be made, the main goal of having a programmable pedal was achieved. A user can program the guitar pedal by uploading their own C++ code by using MP Lab and then alter the effects according to their liking.

Goals for future development:

- Create an integrated power supply
- Have an aluminum cast enclosure that is more compact.
- Have a PCB that is more compact
- Improve the clarity of the audio output

Contact

Jennifer Romero, Kathryn Pinkerton, Mitchell Fountain, Gustavo Hernandez
Hector A. Ochoa, Professor
Email: engineering@sfasu.edu
Phone: (936) 468-3001

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