

# Guitar Pedal Effects

## 1 Introduction

This document describes the mathematical basis of various guitar pedal effects and provides figures on how to select and configure these effects.

## 2 Common Guitar Effects

### 2.1 Tremolo

The technical name for the tremolo effect is amplitude modulation. This effect is achieved by multiplying a waveform with a triangle wave.

$$y(t) = x(t) \cdot (1 + \sin(2\pi ft)) \quad (1)$$

### 2.2 Distortion & Overdrive

Distortion is a general term for any modification to an audio signal that provides significant alteration. Most distortion effects use clipping and overtones on a signal to alter the input wave. Overdrive works by increasing the gain at specific outputs past the threshold.

$$y(t) = \begin{cases} x(t) & \text{if } |x(t)| < T \\ T \cdot \text{sgn}(x(t)) & \text{if } |x(t)| \geq T \end{cases} \quad (2)$$

### 2.3 FUZZ

This effect takes whatever waveform is input and forces it into a square waveform.

$$y(t) = \text{sgn}(x(t)) \quad (3)$$

### 2.4 DELAY

This is where the waveform is played and then repeated with a lower amplitude.

$$y(t) = x(t) + \alpha x(t - \tau) \quad (4)$$

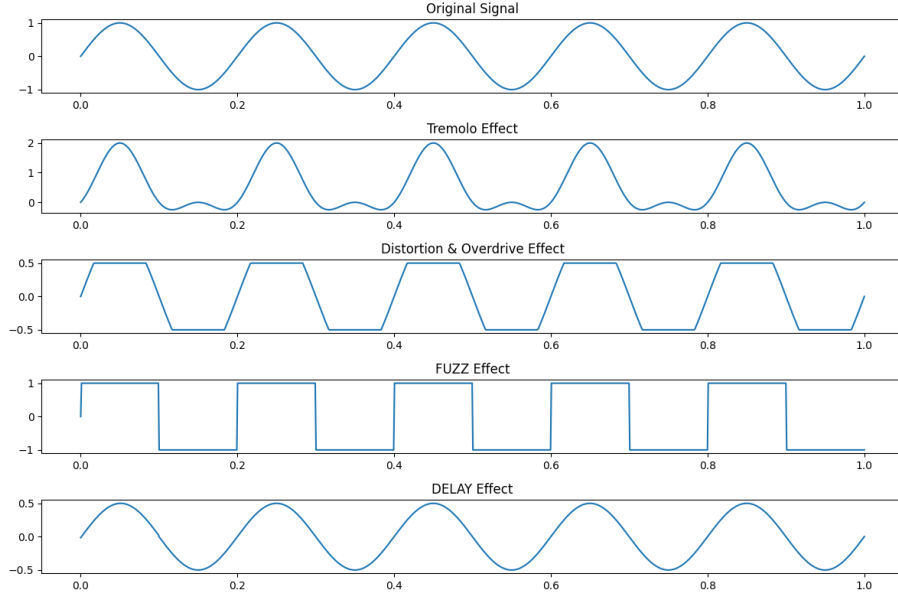


Figure 1: FPGA Waves: This figure shows the waveform outputs for different guitar effects as configured on the FPGA. Each waveform corresponds to a specific effect such as Tremolo, Distortion, FUZZ, Delay, etc., and illustrates how the signal is modified by each effect.

### 3 Implementation Details

The effects were implemented using a combination of a soft-core processor and custom FPGA modules:

- **Tremolo and Delay:** These effects were implemented using a soft-core processor. The processor handles the real-time processing required for these effects.
- **Distortion, Overdrive, and FUZZ:** These effects were implemented as custom FPGA modules. The FPGA handles the high-speed processing required for these effects.

### 4 Effect Configuration

- All effects are configured with switches 0-3.
- To add an effect to the effect chain, flip switch 9.
- To clear the effect chain, flip the clear switch to the 1 position (see Figure 1).

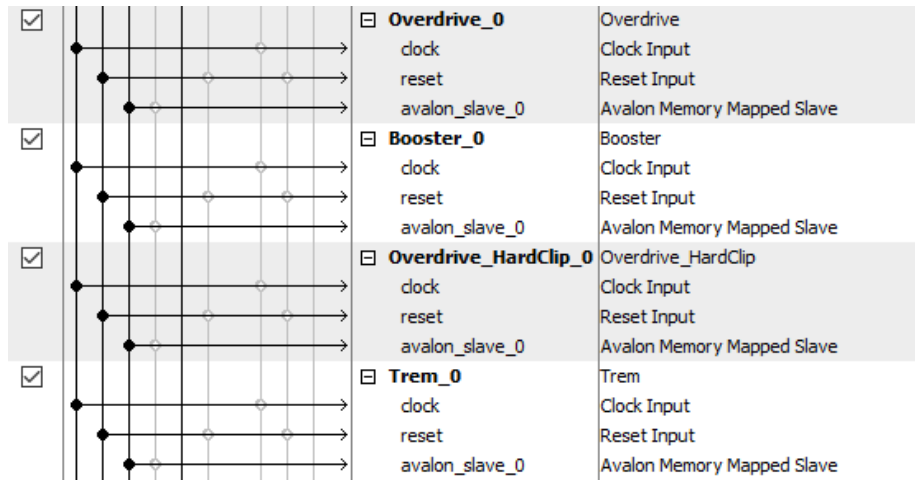


Figure 2: Enter Caption

- The effect properties are changed using KEY3 and KEY2 to lower or raise the value (see Figure 4).
- The 0's and 1's next to the effect name correspond to the positions of SW0-SW3 (see Figure 5).
  - **0000 – Tremolo:** Amplitude modulation frequency changed with buttons 3 & 2.
  - **0001 – Distortion:** Cut off amplitude changed with buttons 3 & 2.
  - **0010 – Booster:** Volume boost configured with buttons 3 & 2.
  - **0011 – FUZZ:** Cut off amplitude changed with buttons 3 & 2.
  - **0100 – Overdrive:** Cut off amplitude changed with buttons 3 & 2.
  - **0101 – Delay:** Length of delay ranges between 1 second and 1/10 second.
  - **0110 - Reverse Queue:** Length of queue ranges between 1 second and 1/10 second.

## References

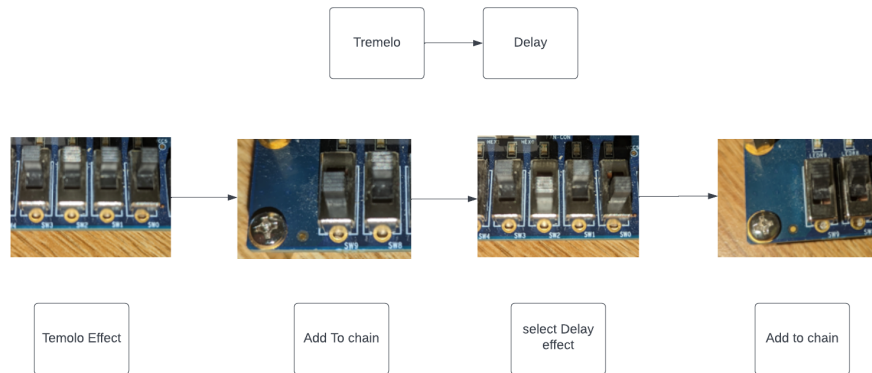


Figure 3: Example sequence of effect configuration.

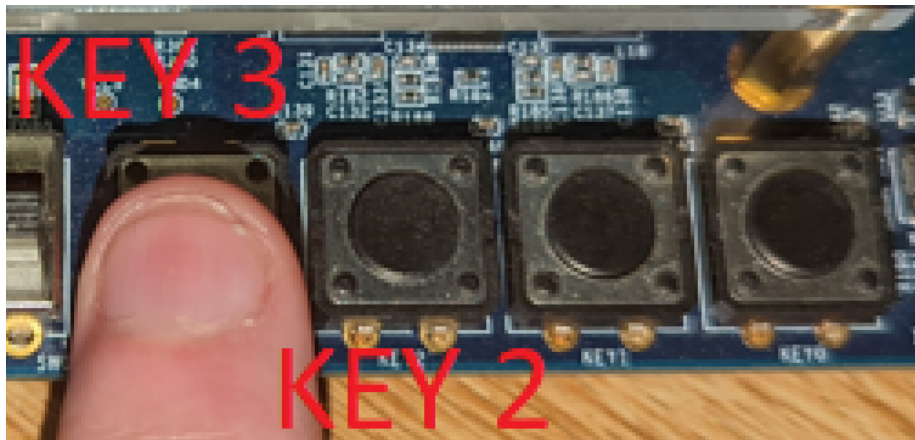


Figure 4: Effect properties are changed using KEY3 and KEY2.



Figure 5: Controls for keys and switches.

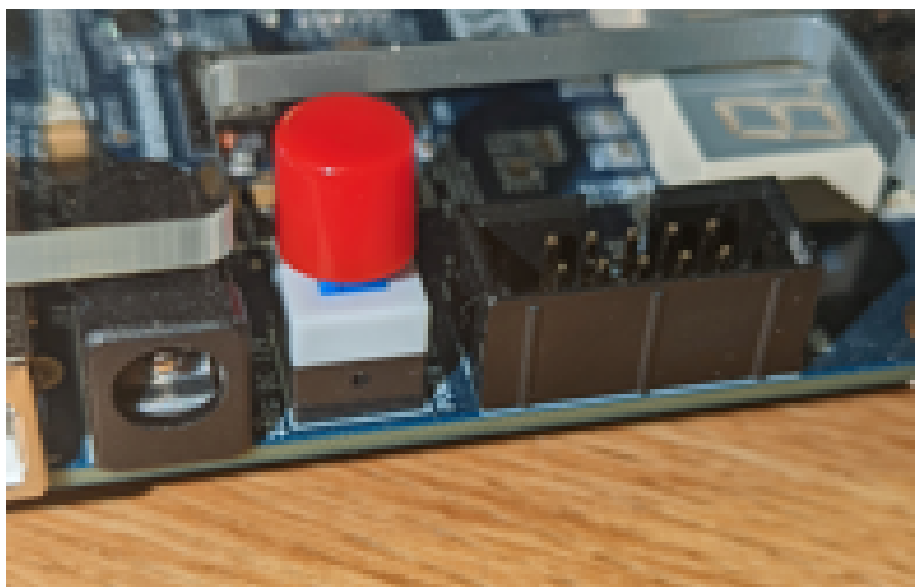


Figure 6: Power button configuration.

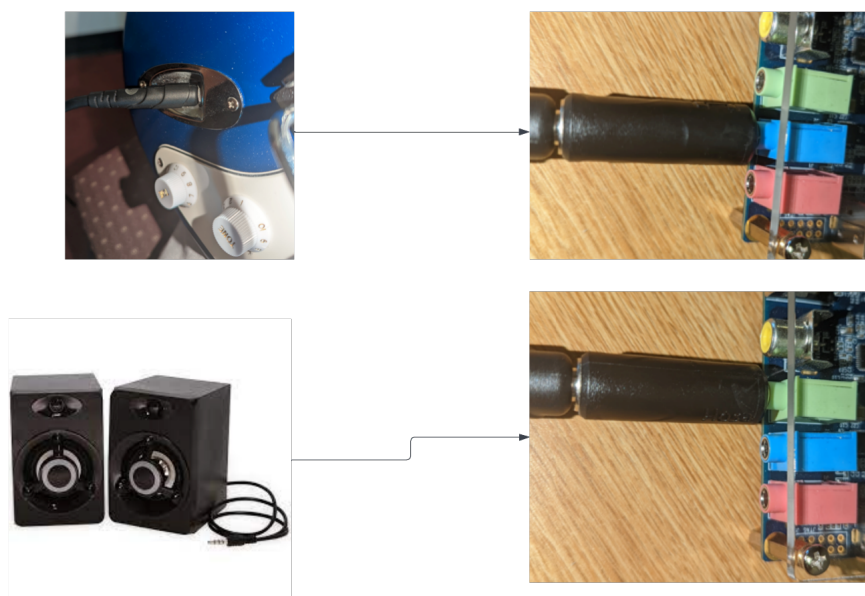


Figure 7: Audio input and output configuration.