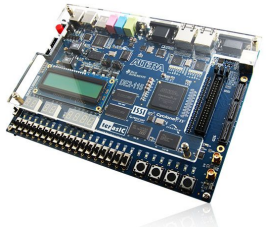
Final Presentation - Guitar Effects Pedal

Team 11

Introduction

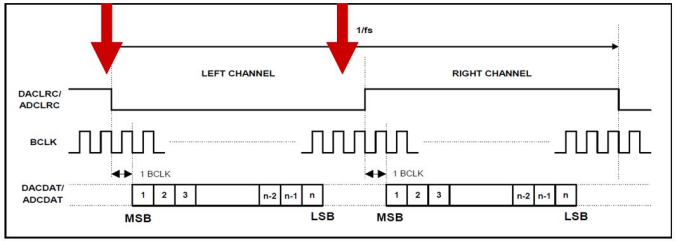
Our Setup

preamp:
for impedance matching

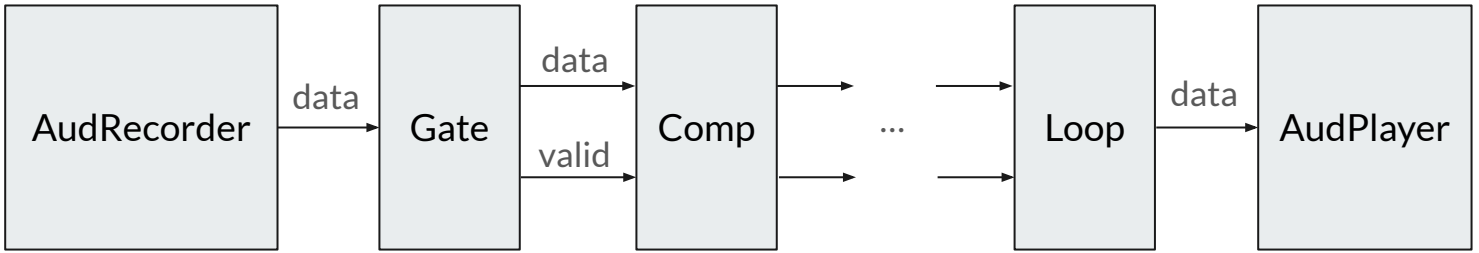


FPGA:
analog -> digital
effect pedal simulation
digital -> analog

Effect Pedal Chain



- Used i_AUD_BCLK as main clock
- There are multiple cycles between samples, we need a signal between modules to indicate that these 16 bits are valid during this cycle

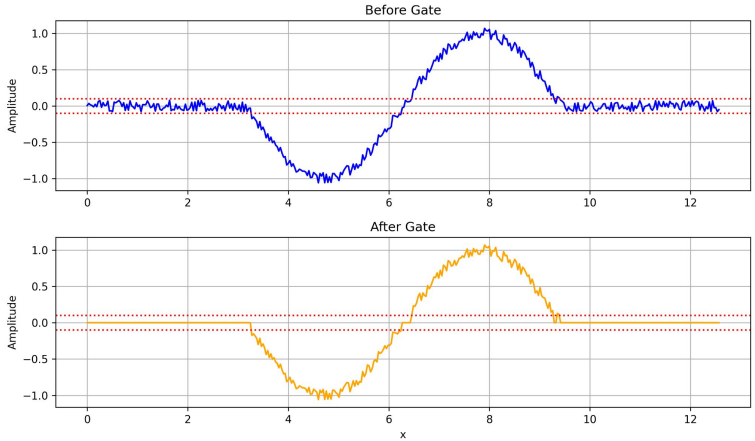


Effect Pedals Implemented

- Gate
- Compressor
- Distortion
- Equalizer
- Tremolo
- Delay
- Loop (layer0)
- Loop (layer1)

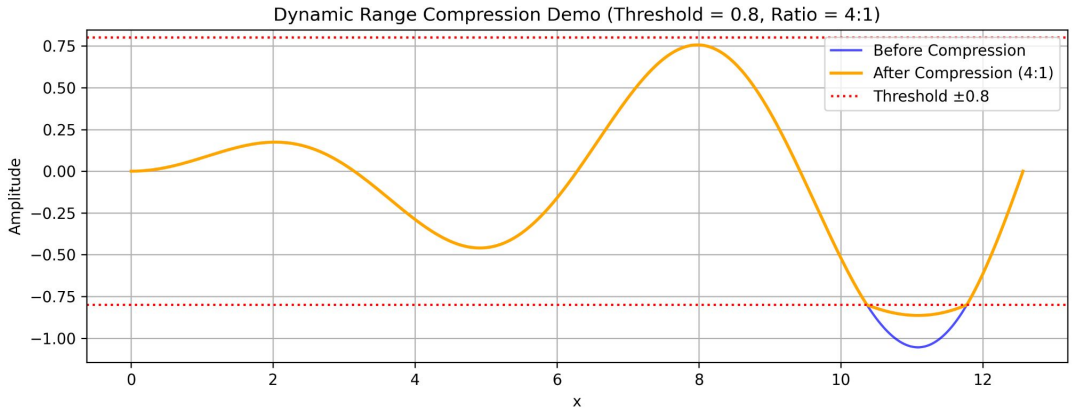
Effect: Gate

- Hard-clipping of noises under an user-defined threshold
- Remove unwanted buzzing



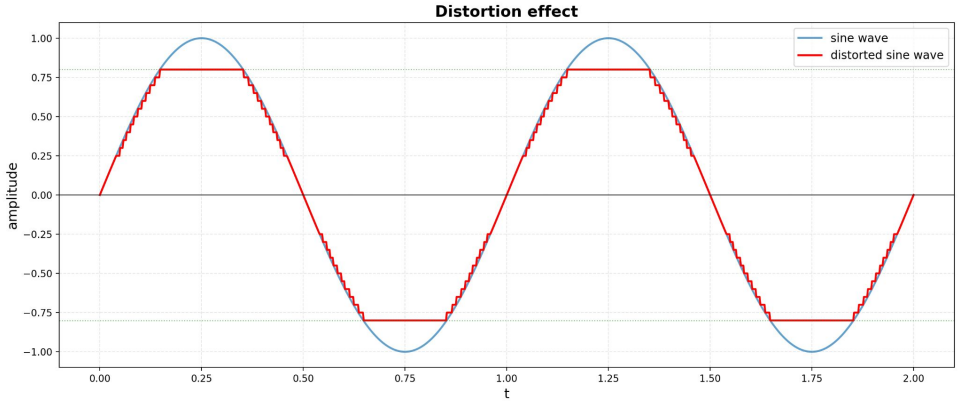
Effect: Compressor

- Reduces dynamic range (largest peak to smallest part)
- Reduces the audio part that exceeds the user-defined threshold by ¼

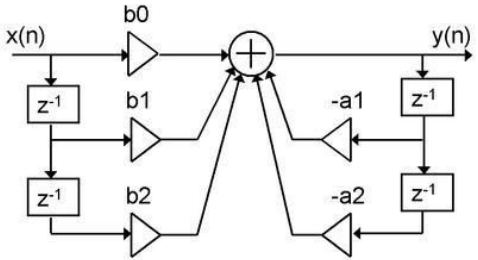


Effect: Distortion

- Modifies the signal to produce a gritty tone.
- A piecewise function is used with an adjustable parameter, level, which determines the maximum threshold.

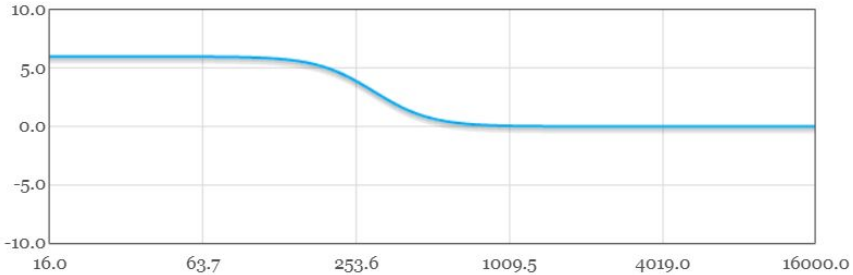


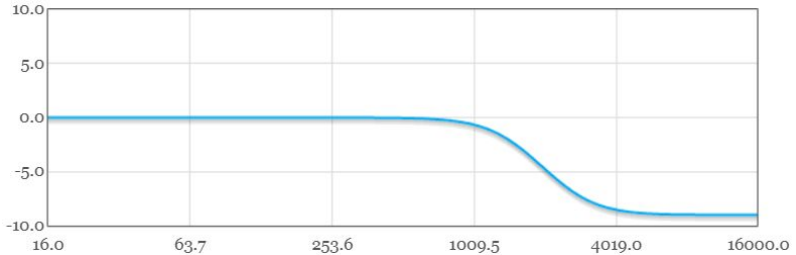
Effect: Equalizer



$$H(z) = \frac{b_0 + b_1 z^{-1} + b_2 z^{-2}}{1 + a_1 z^{-1} + a_2 z^{-2}}$$

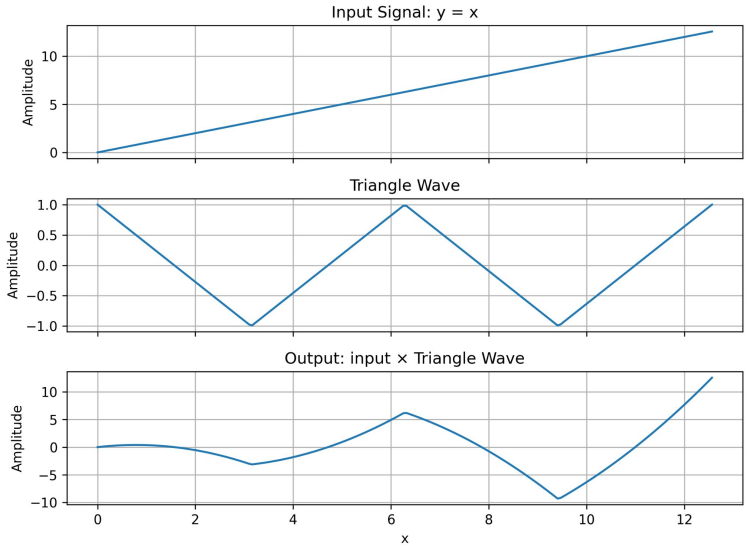
- Let the user amplify/attenuate the treble/bass signals from +9 dB to -12 dB
- Implemented by passing the audio through a low shelf filter then a high shelf filter
  - Both filters are implemented using biquads
- Corner frequency: 250 Hz / 2.5 kHz





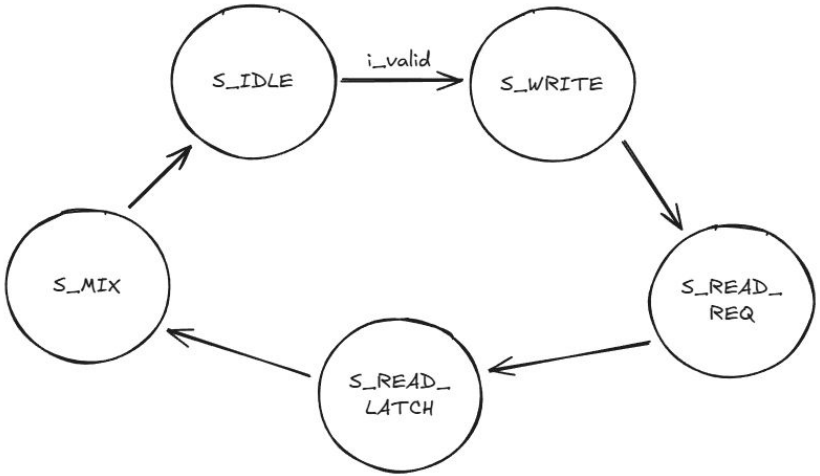
Effect: Tremolo

- Multiplying input with triangular wave
- Used fixed point Q8.24 to have enough precision



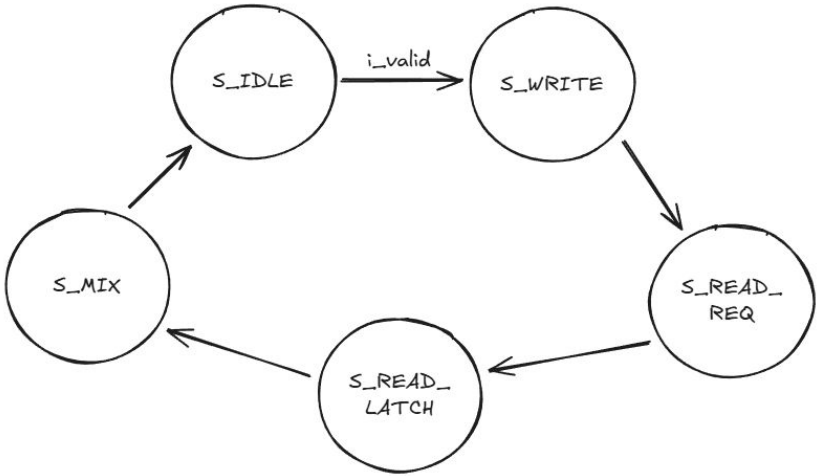
Effect: Delay

- By storing input signal into SRAM and read back after a specific time lapse, an echo-like delay effect is obtained



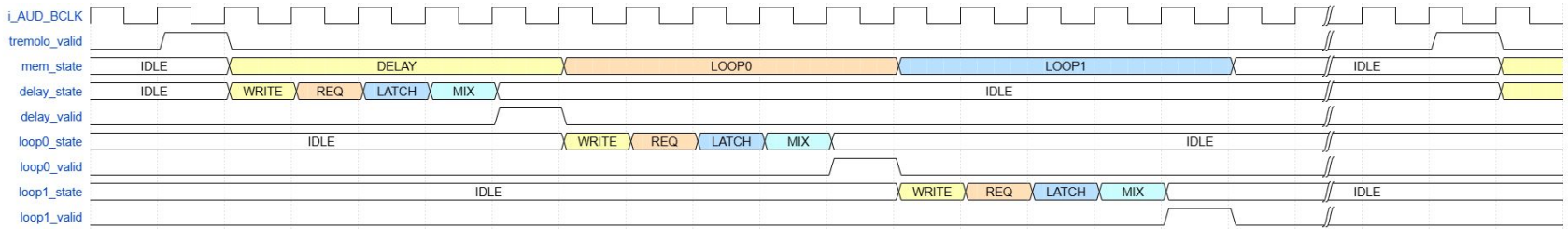
Effect: Loop

- Similar to delay, uses SRAM to store signal for loop, and play the loop while also passing through the live input



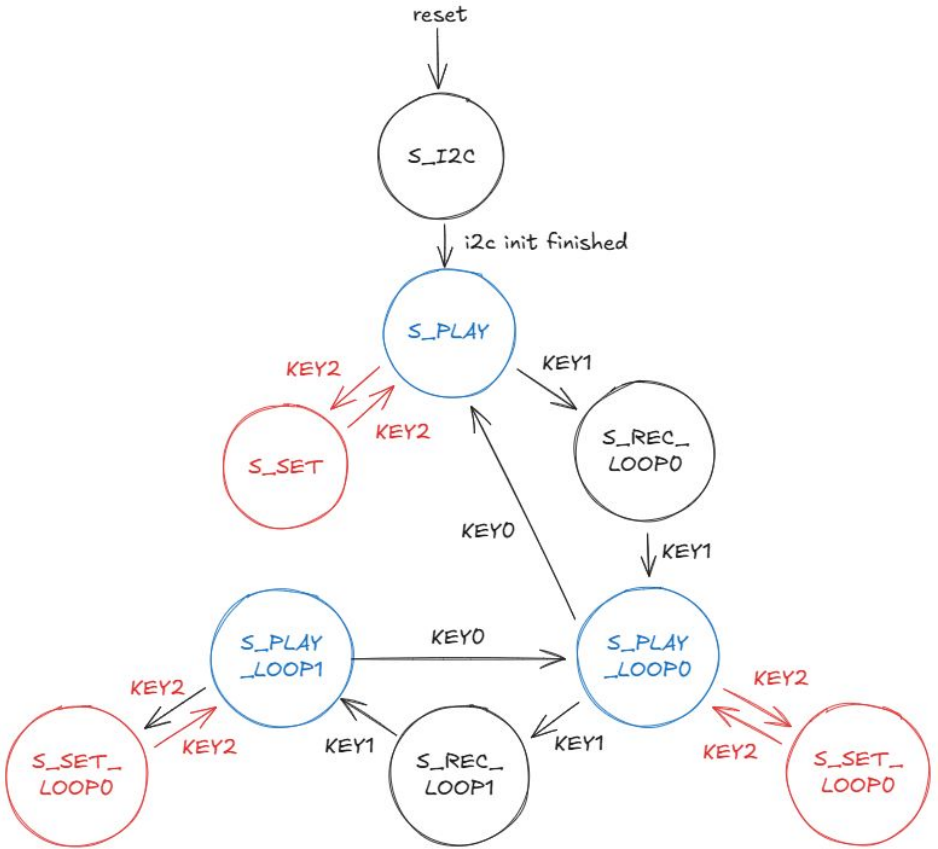
Memory Time-Multiplexing

- The are at least 32 BCLK cycles between each audio sample
- All the memory-using modules need to access memory inside this period



Finite State Machine

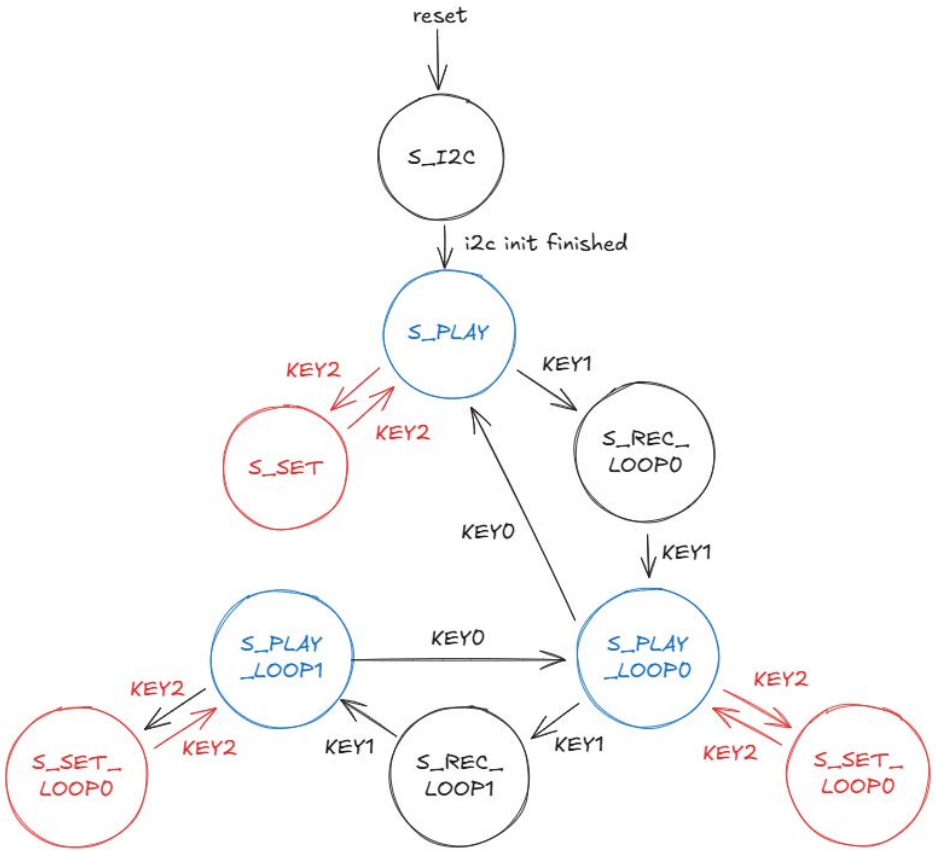
- PLAY
  - processing and playing audio in real-time
- SET
  - configure pedal parameters
- REC
  - loop recording



LED and Hex Displays

- Green LEDs
  - Shows current FSM state
- Red LEDs
  - PLAY: shows the effects that are enabled
  - SET: shows the effect chosen by the switches to be configured
- Hex
  - Shows the state (0-7) of the chosen effect during SET

Demo


reset
S_I2C
i2c init finished
S_PLAY
KEY2
KEY2
S_SET
KEY1
S_REC_
LOOP0
KEY0
KEY1
S_PLAY
_LOOP1
KEY0
S_PLAY
_LOOP0
KEY2
KEY2
S_SET_
LOOP0
KEY1
S_REC_
LOOP1
KEY1
KEY2
KEY2
S_SET_
LOOP0

Demo

- 180 bpm
- Loop0
  - gate 2, bass 5
  - bass
- Loop1
  - gate 2, treble 6, delay 3, loop 3
  - arpeggio
- Solo
  - dist 3, loop 4
  - solo