Reinventing the Electric Guitar

All-In-One Printed Circuit Board for Guitar Electronics

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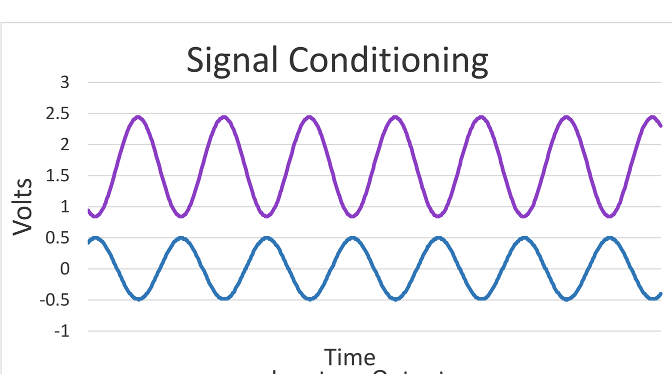
Introduction

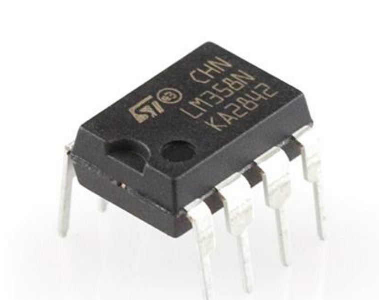
The proposed device is a novel printed circuit board (PCB) with sensing, signal conditioning and processing functions for a musical instrument. The device comprises a transducer (pickup), a pre-amplifier, CPU and a physical user interface. All signal bearing media on this device is confined to the footprint of the PCB.

This electric guitar design is a departure from traditional art and represents growing cultural acceptance of digital technology as a tool for musical expression.

Hardware Overview

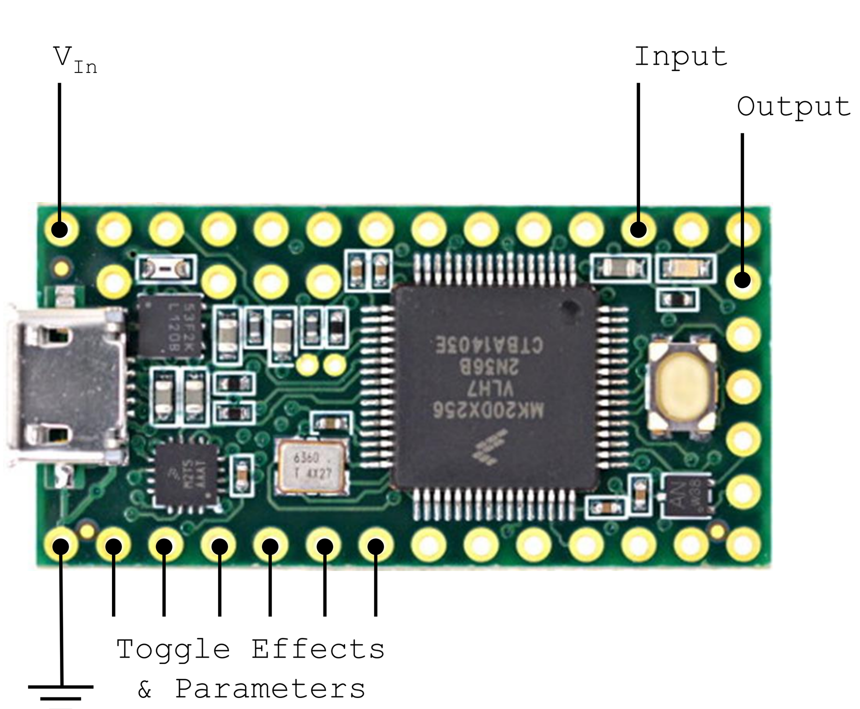
The signal path begins with the raw output of the pickup which is conditioned by a LM358 pre-amp circuit that *amplifies* and *biases* the signal into the acceptable voltage range readable by the CPU.





The output of the pickup is centered at zero volts. The acceptable voltage range for the CPU is (0V, 3V). This amp biases the signal by +1.5V and amplifies it at 1.6V/V

The subsequent signal is interfaced with the CPU in an analog signal port (input below).



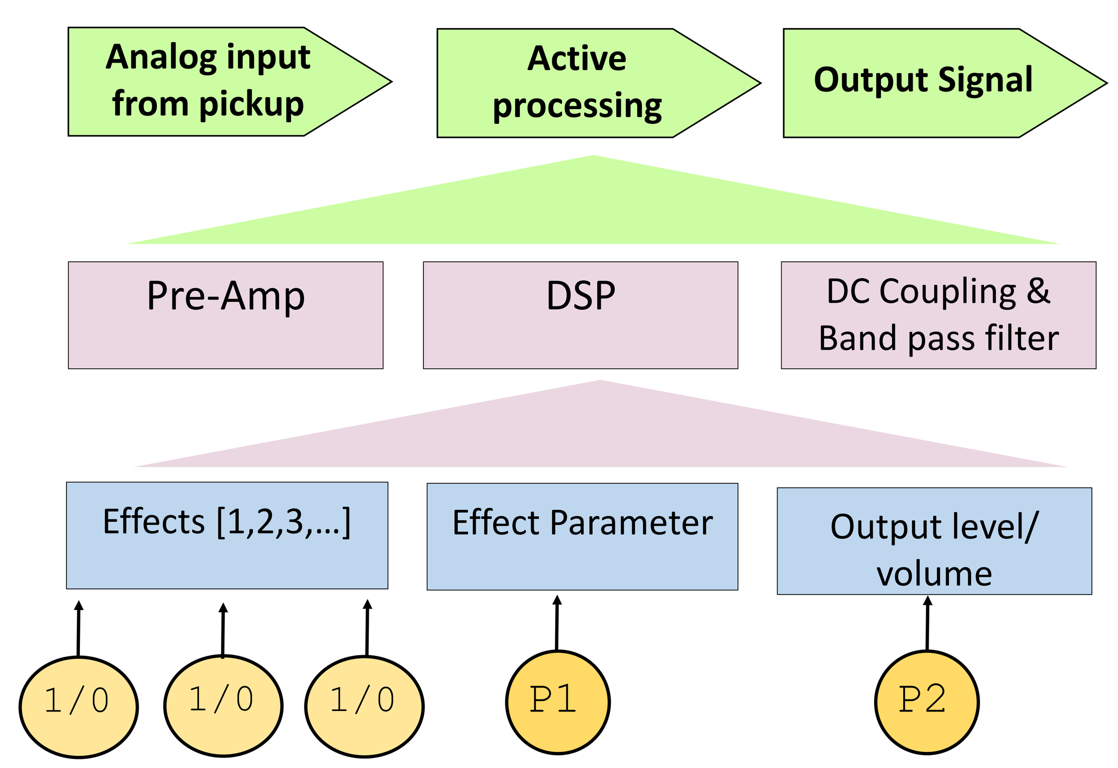
The CPU performs signal processing, effects and modulation. Effects are toggled by an on-board physical user interface.

Novelty and Prior Art

The programmability of this device opens expansive possibilities for signal modeling and effects. Current art in high end modeling occurs mainly with desktop PCs and off board pedals/ units. The spacious PCB form factor presented here can incorporate enough computer hardware to make this possible directly from the instrument.

Digital modeling in music is gradually gaining acceptance in the community as a competitor to the analog specifications long valued by music enthusiasts.

System Summary



Program

```
int sensorValue = 0;          // value read from the Pre-Amp
int outputValue = 0;          // value output to the PWM (analog out)

void setup() {
  Serial.begin(38400);          // initialize serial communications at 38400 bps:
  analogWriteResolution(12);    // resoloution for DAC
  pinMode(13, OUTPUT);          // pin 13 is analog output
  pinMode(1, INPUT);            // pin 1 is analog input
}
```

Initializes sample rate, write resolution and pin assignments.

```
void loop() {
  // read the analog in value:
  sensorValue = analogRead(analogInPin);
  outputValue = sensorValue;
  // map it to the range of the analog out:

  //Apply effects: 4 bit Bit Crush
  int selectBitCrush = digitalRead(1);

  if (selectBitCrush == HIGH) {
    outputValue >>= 4;          // bit shift
    outputValue <<= 4;          // bit 'crush'
    digitalWrite(13, HIGH);     // toggle effect if pin 13 is on
  }
  else {
    digitalWrite(13, LOW);      // ignore if pin 13 is off
  }

  analogWrite(A14, outputValue); // write to the DAC (output)
```

When the switch is on (pin 13), bit crushing effect is activated. This process uses bit shifting to reduce the signal resolution which produces a distortion effect. Multiple effects or models can be toggled at the same time. The analog output function is written to the DAC and output (pin 14)

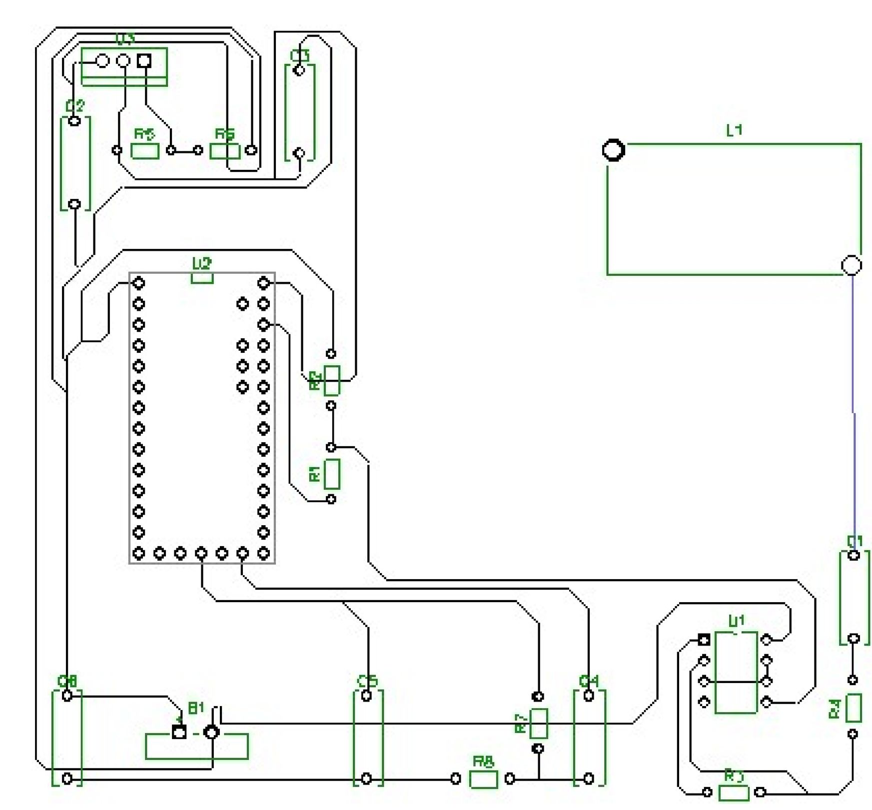
Manufacture

The guiding constraints of the manufacturing process are to:

1. Construct as thin a device as possible.
2. Confine all signal bearing components to the footprint of the PCB.

Components and manufacturing methods are chosen in order to meet these constraints while remaining within the project budget and timeframe limitations.

The Teensy 3.2 was chosen as the processing element due to its small footprint and lack of extraneous connectors which give it a thin profile. A non-mainstream pickup, the FlatCat was also chosen for its thin profile.



The PCB editing software DipTrace was used to configure the component layout and wire runs.

For manufacture, through-hole mounting on a custom PCB was chosen for ease of manufacture. The drawbacks of this are loss of precision and thinness that could be attained by surface mounting components and outsourcing PCB etching.

Future Work

Future plans for the project include programming more effects into the CPU providing more options to the user. Other plans include improving the aesthetics of the device and experimenting with different transducers, hardware configurations and user interfaces in order to arrive at a device that adds as much value to the user as possible.

Planned work includes upgrade to PC grade processor, implementing blue-tooth for wireless programmability and function, piezoelectric pickups and all surface mounted manufacture.

Rendering of prototype in Sketchup

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