

Guitar FX: the Market Gap

Guitarists use effects to enhance the sound of the guitar. This is done using *analog pedals* or *digital processing*, but each has some major disadvantages:

Analog Pedals

Hot: cheap, portable
Not: one effect each; more effects mean more cost, more bulk



Digital Processing

Hot: powerful, can do dozens of effects
Not: expensive; bulky hardware and processing delay means no live shows



The SIGMA Solution:

Use portable, powerful digital signal processing hardware and modular, updateable code to execute dozens of effects in real time in an all-in-one live effects solution.

It would be **the best of both worlds** in a **billion-dollar** music market.

Design Goals

Effects: bigger, better, more

- ✓ Full library of guitar effects in C programming language.
 - Time-domain FX: overdrive, echo, flanger, tremolo, and more
 - Frequency-domain FX: filter, wah-wah, equalizer, autotuning
- ✓ Multiple effects can be chained
- ✓ Multiple instruments with different effects for each

Customizability

- ✓ Full control over effects sequence and parameters
- ✓ Give users the ability to make and save new effect sets

Real-time performance

- ✓ Effects should never sound "delayed" (<20ms latency)

Easy to use

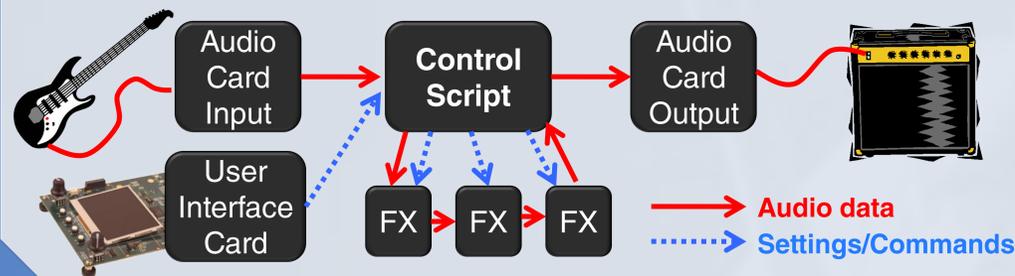
- ✓ Buttons, knobs, and LCD display for intuitive setup
- ✓ Foot pedals for quick and easy control live

Travel-ready

- ✓ Portable enough to easily move and carry to shows
- ✓ Accident-proof, durable enough for intense environments

Control and Workflow

Computation on the OMAP-L137 hardware is divided between:
ARM processor: interprets user commands, regulates audio flow and FX settings
DSP processor: math-intensive effects computation, processes audio samples



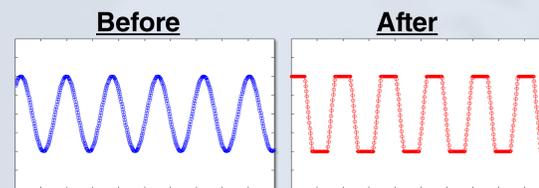
Implementing Effects

All effects were implemented in C language. **Some examples:**

Effect

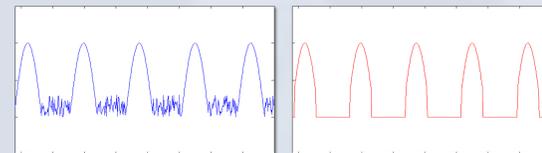
Overdrive

Amplifies and "clips" signal for loud crunchy sound. The most popular effect in rock.



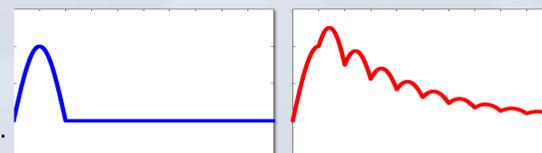
Void cut-out/noise cancellation

Silences low-volume signals. Hides buzz from poor guitar technique.



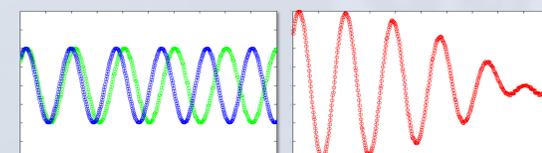
Echo/Reverb

Delays and repeats a signal. Short delay for a "concert hall" feel. Long delay for surreal layered sound.



Flanger

Echo with changing delay time to create phase shifts. Makes swooshing, warbling sound.



Simple effects in time domain (<1ms delay)

- Overdrive
- Void cut-out
- Echo
- Flanger
- Reverb
- Tremolo
- Buzz
- Metal distortion
- Muffle

Complicated effects in frequency domain (5-10ms delay)

- Autotuning
- Pitch shifting
- Vibrato
- Harmonizing
- Auto-chord playing
- Auto-bass guitar
- Wah-Wah
- Phaser
- Filtering
- Equalizer

Hardware: T.I. OMAP L137

TI OMAP L137 Eval Board

- Floating-point DSP processor
 - 40,000 FFT/sec in tests, more than fast enough.
- ARM926 processor
 - Hosts our control script
- USB, SD card interfaces
 - Rapid configuration
 - Future user storage, online connectivity



Multi-Channel Audio Add-On Module

- Four stereo inputs/outputs 24-bit, 96kHz audio
 - Supports multiple instruments in parallel
 - Studio-quality audio

User Interface Add-On Module

- 2 push-knobs, 4 pushbuttons, LCD screen
 - Allows simplicity, freedom in UI development
 - Home-made external UI expansions will add pedals, additional controls

Results and Analysis

- ✓ Working effects on guitar and pre-recorded audio
- ✓ Six effects implemented to demonstrate viability, several more (e.g. frequency domain) in simulation.
- ✓ Demonstrated stable effects control handling, compatibility for future integration
- ✓ Multiple instruments in parallel
- ✓ Simple effects average delay of <1ms
- frequency effects delay of ~5ms by design
- ✓ Basic switching UI, easily expandable
- ✓ Transitory memory limitations hamper some FX
- ✓ Est. production price \$300, marketable in \$500-\$1000 field with similarly-capable but non-modular products.

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