Amped Up

An Augmented Guitar Amp Experience

Team

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Project Goal

To create a system that attaches to an amplifier and controls its knobs in order to provide musicians with a more powerful interface to control it and create new sounds

Background - Many Types of Amplifiers

Fender Hot Rod Deluxe - a basic and extremely popular tube combo amplifier

Line 6 Modelling Combo Amp - popular beginner amplifier with digital processing to achieve gain and effects

Hughes and Kettner TriAmp Mark 3 Tube Amp Head - Expensive and premium amp head with programmable presets and variable wattage - requires speaker cabinet ($4000!)

What are Tonal Parameters?

- Most amplifiers contain a set of similar tonal parameters
- These include (but are not limited to):
  - Volume
  - Equalization
  - Gain/Distortion
  - Reverb/Specific effects
  - “Presence”

- The amp that we have access to has 8 knobs to represent the above

Interviews

- Met with 10 People (8 Interviews and 2 filled questionnaires), Questioned about what types of amps they used and what they like/disliked about amps in general
- During live play, it is desirable to be able to just “plug and play” without having to fight with knobs
- During practice, “tone exploration” seemed more common and was described as a positive experience
- Most people are disinclined to buying another amp, so something that attaches to an existing one is ideal

Background - Tone Shaping

- Vacuum tubes are preferred for their vintage clipping behavior
- Solid state clipping has become popular in certain genres of music but fails to create the authentic tube sound
- Digital modelling amps use DSP to attempt to recreate vintage drive, to widely varying degrees of success
- Modern solutions offer conveniences like presets and external control
- In the end many guitarists chose to stick with older, authentic amplifiers

*** Effects pedals are a different tool that go before or after the preamp in the signal chain in order to offer a specific desired quality like echo, reverb, octave change, custom gain profiles *and hundreds more* …

Interview Quotes

- "... [favorite amps] all have a different tonal flavor. They take the characteristics of your guitar, and they do their own thing with it, without compromising the identity of your guitar. That's what really makes a great amp."

- "In a live situation, it's not so easy to make adjustments [to parameters]"

- "[tweaking] can take a while because there's a lot of trial and error... it's kind of hard to know exactly what it'll be. And then if you change one thing then it will change the original thing you were happy with... they're all codependent on each other."

Problem Statement

Guitar amplifiers typically feature a number of parameters that musicians can adjust to change the sound of their guitar. Existing amplifiers present these settings to users as a static interface, with a set of knobs to control each parameter. Because of this, guitar amplifiers are unable to react to the signals they receive and recalling presets is a feature rarely seen on vintage or cost effective amplifiers. Our solution will address these issues by acting as an electromechanical bridge between an existing amplifier and a remote user interface.

Preliminary System Specifications

- Is compatible with existing amplifiers, allows manual override
  - Electromechanically can control at least 8 knobs
  - Able to respond(adjust a knob) in at most 80 ms from extreme to extreme
- Controls tone shaping parameters for guitar sound, including:
  - Gain
  - EQ
  - Post-amp Effects
  - Volume
  - Channel Selection
- Supports locally saving and recalling user configurations (10+ configurations)
- Can produce dynamic sounds by modulating the amplifier's tone shaping parameters in real-time
- Supports arbitrary automations to control the amplifier parameters according to:
  - Guitar signal volume
  - Guitar signal frequency
  - Mathematical functions
  - Expression pedal
  - Generic footswitch
- Features user interface to interact with customizable functions
  - Must be robust enough to adequately control all features of the amplifier

Competing Solutions: Hook Wizard

- Tube amp head with motorized knobs
- Saves and recalls static presets
- Accepts MIDI control
- Robust cabinet simulation interface
- 2,850 Euros (including VAT) equivalent to $3,350

Image Source: https://hookamps.com/product/wizard/

Competing Solutions: Black Spirit 200 Floor

- 2, 20 and 200 watt selectable solid state amplifier
- Proprietary “Bionic Spirit Tone Generator” - uses analog circuitry to replicate tube characteristics
- 128 programmable presets
- Remote control via iOS and Android app
- MIDI, Bluetooth, Aux inputs
- $1,119 USD

http://hughes-and-kettner.com/products/spirit/black-spirit-200-floor/

Competing Solutions: Chase Bliss Automatone Preamp MKII

- Foot controlled floor preamp
- Motorized faders
- Accepts expression pedal for fader control
- Adjusts features automatically based on 30 presets.
- Variable diode clipping control
- Requires power amp and cabinet for live play
- $750 USD

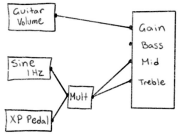
https://www.chaseblissaudio.com/shop-pedals/preamp-mkii

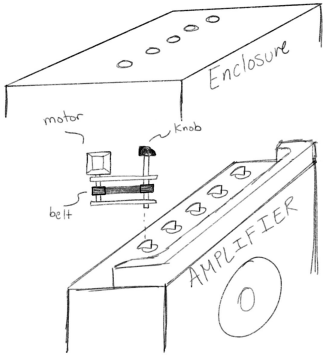
Competing Solutions: Recap

	Storable Presets	Works with Existing Amp	Custom and Dynamic Tone Adjustment	Reactive Tone Adjustment	Comprehensive User Interface
Hook Wizard					
Black Spirit 200 Floor					
Automatone Mk II					
Our Design					

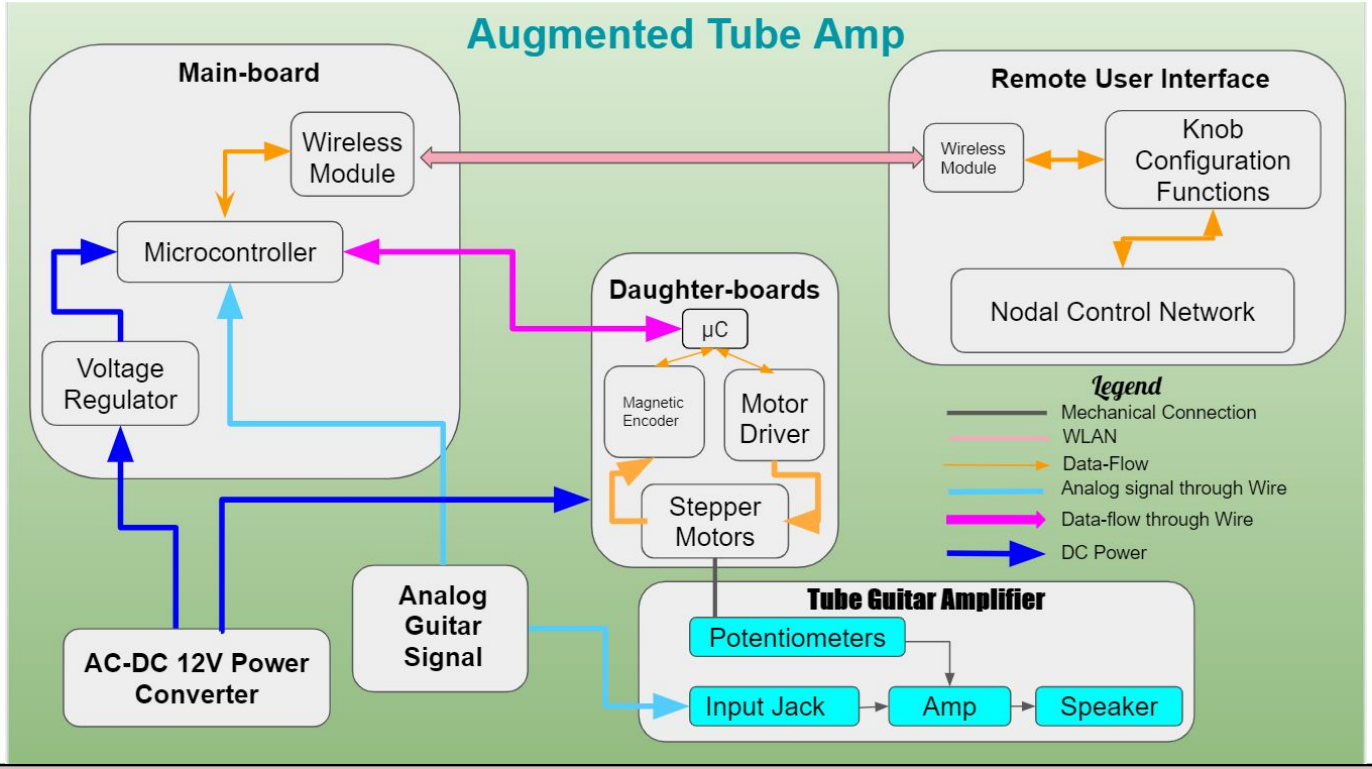
Our Solution

- Create an electromechanical bridge between software and hardware to automate the parameters of a guitarist's existing amplifier
- Implement a remote user interface that compiles user-specified nodal networks to describe the positions of each dial in response to a range of parameters
- Create a generalized modular system whose operating principles could be easily adapted to fit a wide range of amplifiers





Design Diagram

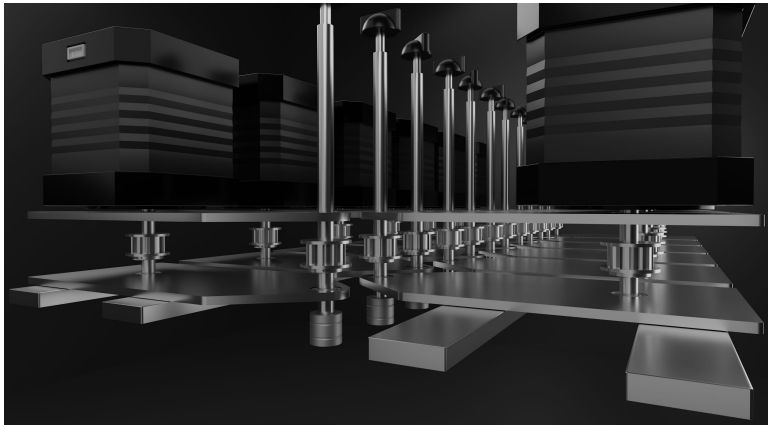


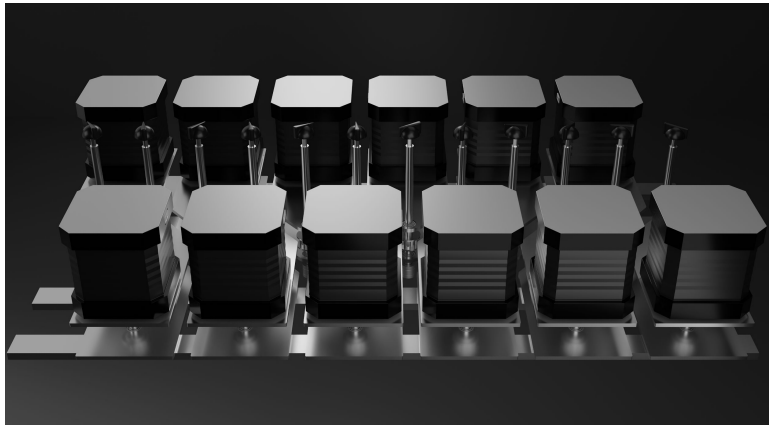
Significant Custom Hardware Design

- Main-board will serve as a shield for the Teensy 4.1, complete with wireless communication and voltage regulation
- Custom Designed Daughter-boards will connect to each stepper motor and control them individually with data received mainboard/teensy
  - Closed loop stepper motor control with current monitoring, a magnetic encoder chip, and an ATtiny microcontroller will be used.

Amplifier Interface

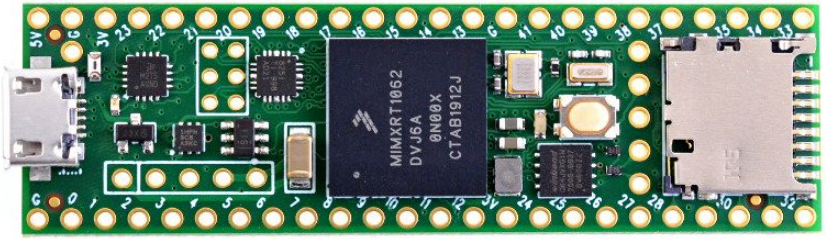
- Modular mechanical system to support amps with different number of knobs and buttons
- Allow for unrestricted arrangement of motor units
- Include modular unit for pushing amplifier buttons (servo motor)
- Completely enclosed and placed on top of existing amplifier
- Custom daughter boards for motor drivers and encoder calibration with current monitoring
- Knobs are placed on top of shafts and remain accessible for manual override





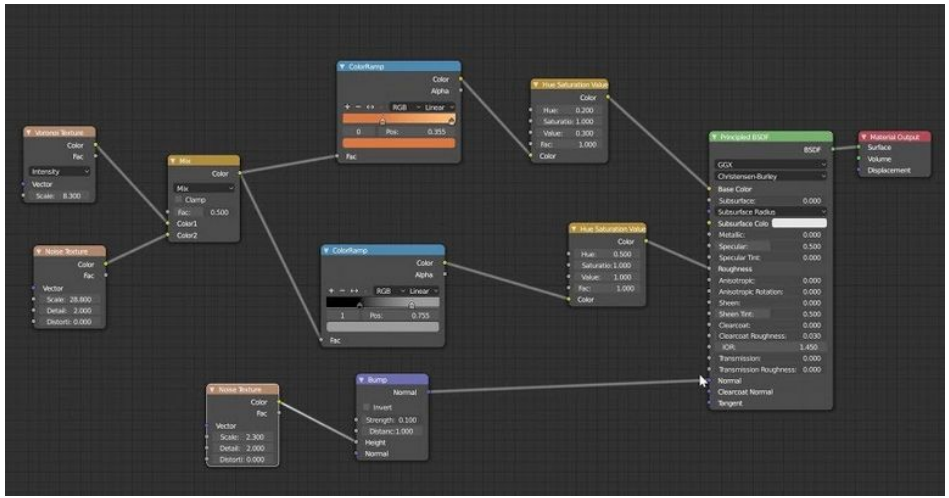
Processing

- Handled on Mainboard, most computing performed locally on Teensy 4.1 ARM Development Board
- Solve for Knob configurations based on input parameters, time functions, and feedback configurations based on nodal control network preset
- Also allows for at least 10 of locally stored node presets on micro-sd storage



Nodal Control Network

- Node Graph Based API for sound customization
- Can be used simply for static knob configuration or real-time variability
- Assign knob control to combinations of input parameters, time functions, and feedback
- Doesn't actually solve for the knob configurations, just allows for function configuration



Think Blender Shader Editor!

Cost Estimate

Item	Predicted Cost
Teensy 4.1	$30
Mechanical Parts(Stepper Motors/screws/rails):	$150
3D Printed Parts(Sourced from M5)	$0
Early PCB Revisions	$170
Final PCB Revisions	$100
AC-DC 12 V Power Brick	$20
Cloud Computing Service	$30
Amplifier(Using team members existing one)	$0
Totals:	$500

Team Member Responsibilities

Aaron Hanley

- Team Coordinator: Communicate with and organize all team members to ensure that the project goes smoothly, and that demonstrations are successful
- On Board Programmer: Develop software to interfacing with the hardware component of the system, interpret commands from user interface, and deploy knob configurations

Remy Yoo

- Altium Design Lead: Design and prototype PCB, work with on board programmer to verify/test electronic system
  - Design both main and daughterboard

Christopher Caron

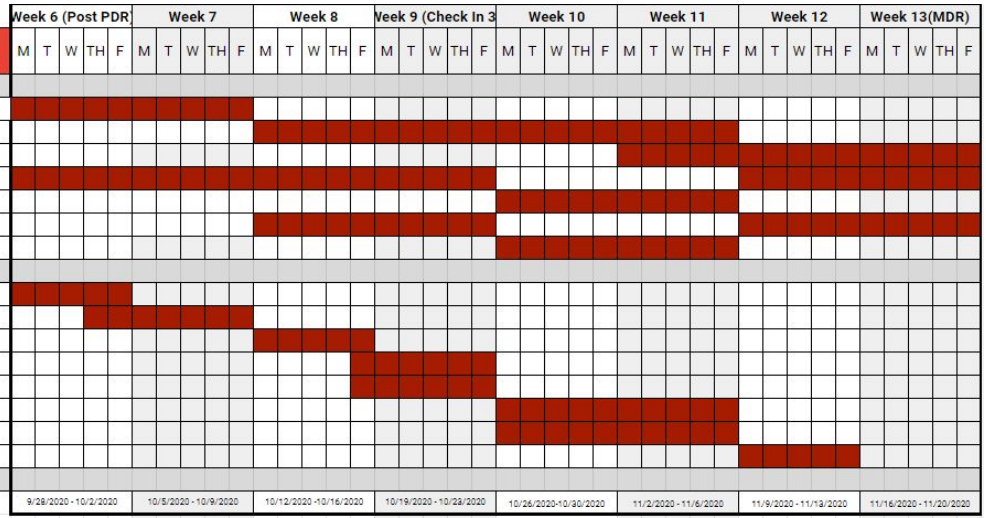
- Mechanical Design/Fabrication Lead: Design the mechanical system that will control the knobs on the amplifier and ensure that it can interface with the rest of the hardware successfully
- Enclosure Design: Draft a rudimentary design for the enclosure of our system

Casey Massar

- Off Board Programmer: Implement the remote user interface and network communication
- Budget Management: Ensure that SDP budget is spent appropriately and in such a way that each component purchased furthers the design.

Gantt Chart

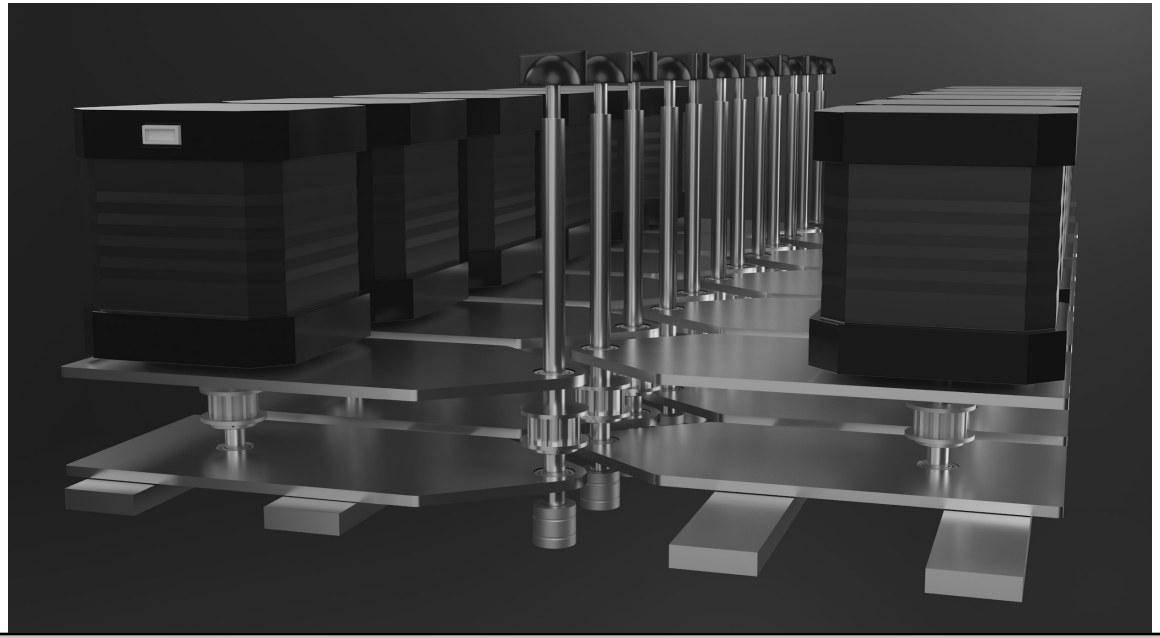
	Task Name	Start Date	End Date	Team Member(s)
Hardware				
	Enclosure	9/28	10/9	**CC**
	Knob control unit prototype	10/12	11/6	**CC**
	Knob control unit semi-final	11/2	11/20	**CC** & RY
	Daughter-board prototype	9/28	10/23	**RY** & CC
	Daughter-board verification	10/26	11/6	**RY** & AH
	Mainboard prototype	10/12	10/23	**RY** & CC
	Mainboard verification	10/26	11/6	**RY** & AH
Software				
	Basic Nodal Network & Design User Interface	9/28	10/2	**AH & CM**
	Develop User Interface	10/1	10/9	AH & **CM**
	Implementation of Knob Config Data Structure	10/12	10/16	**AH** & CM
	Nodal Network->Custom Function Conversion	10/16	10/23	**AH**
	Real Time Processing Setup	10/16	10/23	**AH &** CM
	Communication between amp controller and other device	10/26	10/30	**CM**
	Programming motor controller daughter board	10/26	10/30	**AH**
	Programming Verification	11/9	11/13	AH & CM



MDR Deliverables

- Prototype of knob control unit
- Closed loop stepper motor control daughter board
- Basic nodal network UI design and implementation
- Implementation of preset storage/data structure format

Questions and Answers



Thank you for your time!