eGuitar

GROUP 7

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Administrative Introduction

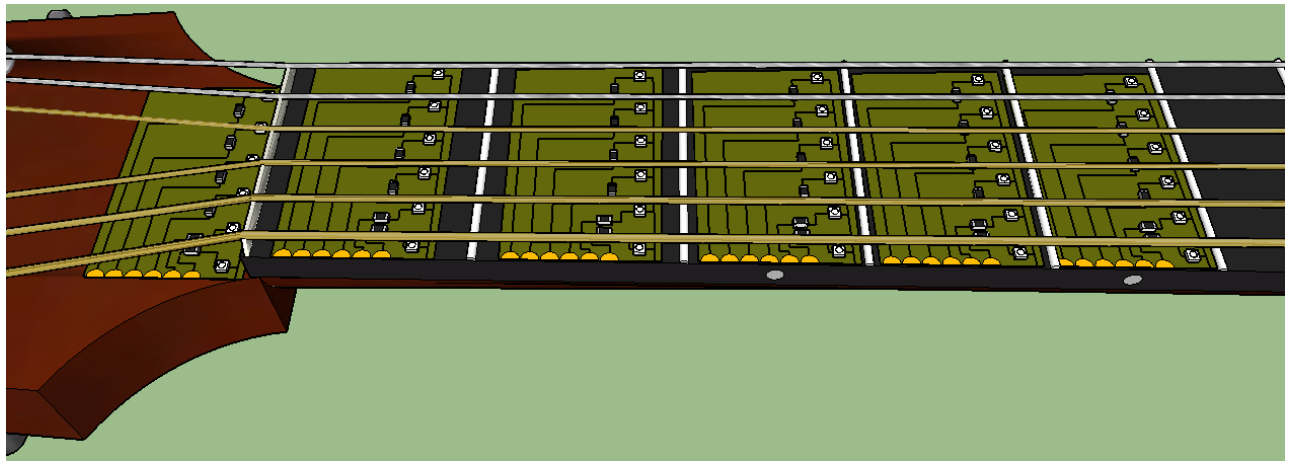
- eGuitar aims to be a portable, easy-to-use guitar assistant
- Improves the way a user learns or further develops their guitar skills
- Through onboard visual indicators, users can learn finger placements in a tactile way
- Experienced guitar players can record their music into guitar tablature (tabs)
- A PC-side standalone application offers tablature modification and transfer to onboard storage

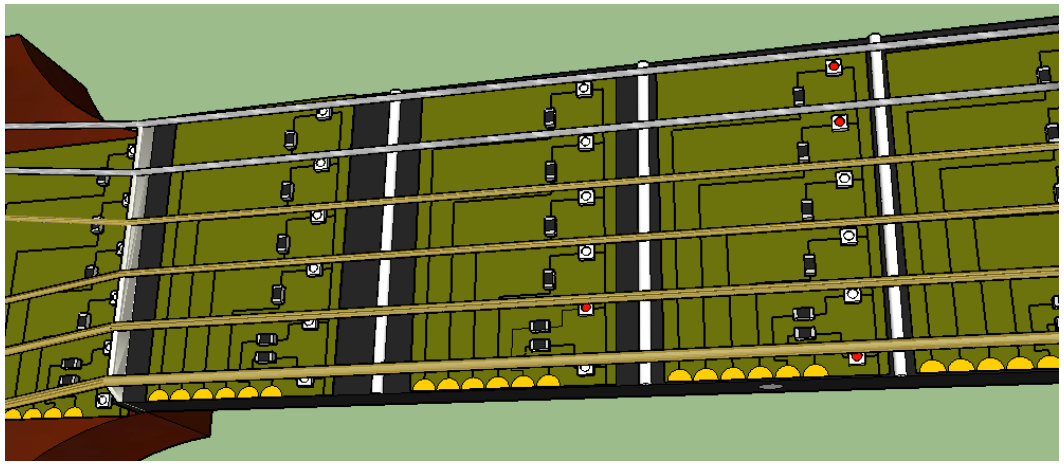
Goals

- Fully additive system – No permanent or damaging modifications to guitar
- Visual finger placement instructions on guitar fretboard
- Untethered tab playback mode
- Tethered (PC-side) DSP for real-time:
  - Tuning
  - Chord detection
  - Tablature creation
- Intuitive PC user interface

Specifications – Fretboard PCB

Component	Parameter	Specification
Under-string Components	Height	< 1mm
Under-string Components	Width	< 3mm
PCB	Material	FR4
PCB	Layers	1





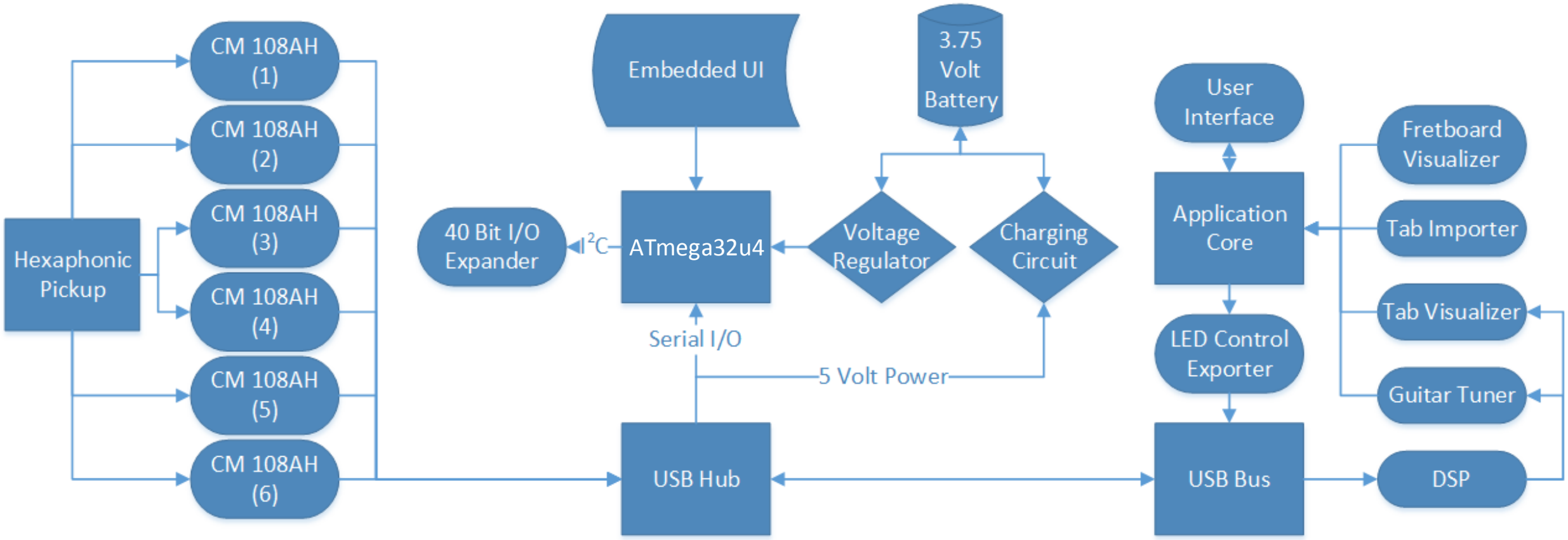
Specifications – Control PCB

Parameter	Component	Specification
Model	Primary Microprocessor	ATmega32u4
Clock speed	Primary Microprocessor	16 MHz
Communications Standard	Primary Microprocessor	I^2C, RS232 serial, SPI
Layers	PCB	2
Outputs	I/O Control	40 (36 in use)
Power Source	Power	3.7V Li-ion Battery
Operating Voltage	Power	5V

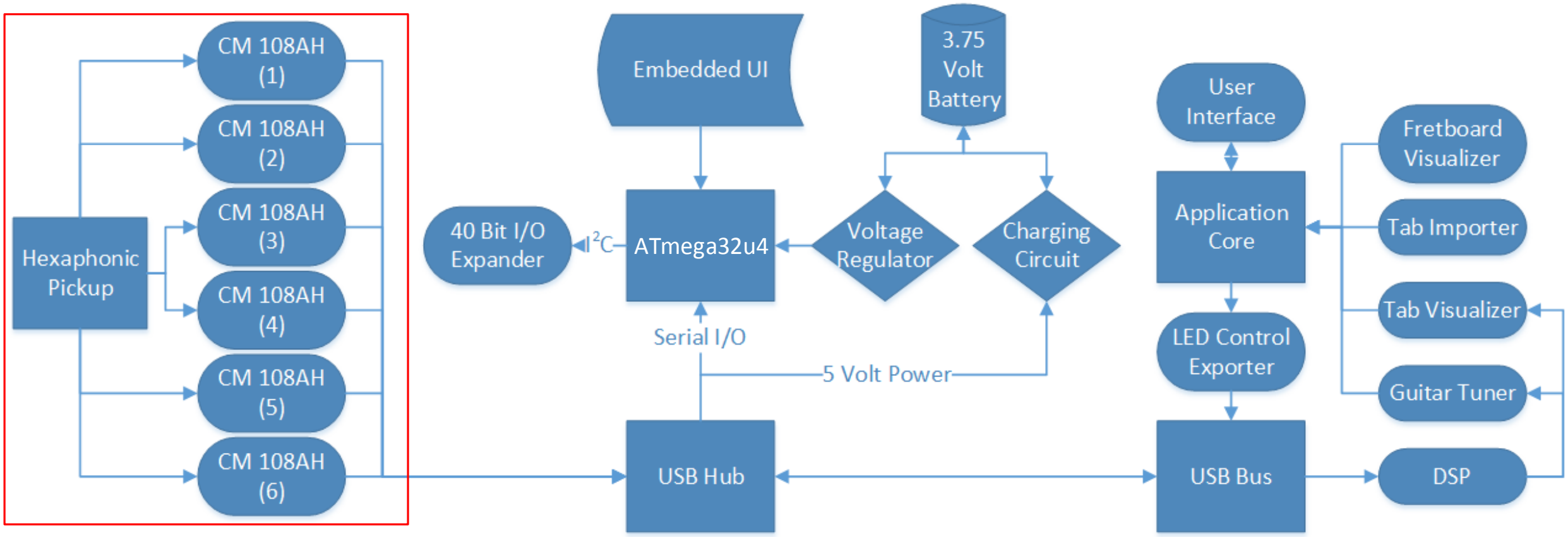
Specifications – DSP

Component	Parameter	Specification
Processing	Host	Windows PC
Processing	Speed	100ms audio processed in <10ms
Notes	Supported frequency range	50 - 1500 Hz (approx. A1 to E6)
Notes	Polyphony	6 Notes on 6 independent channels
Audio	Input Format	16-bit, 44.1 kHz sampling
Audio	Output Format	Midi notes and raw frequency

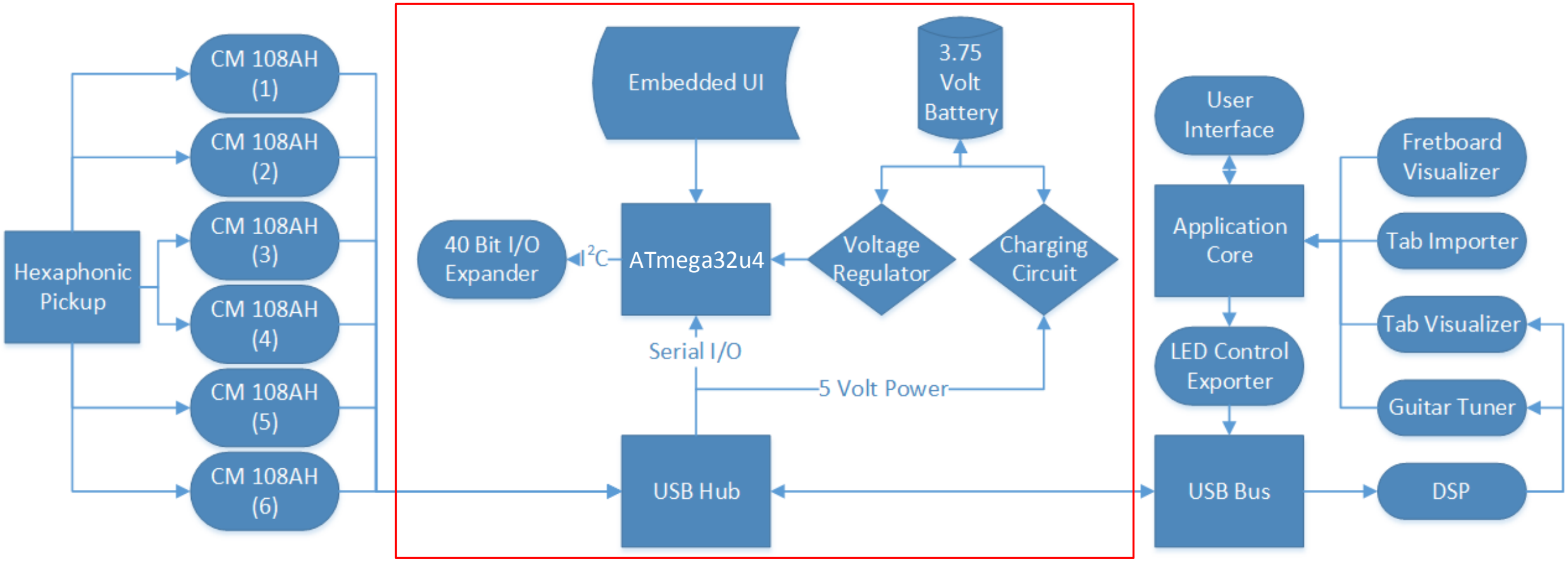
System Block Diagram



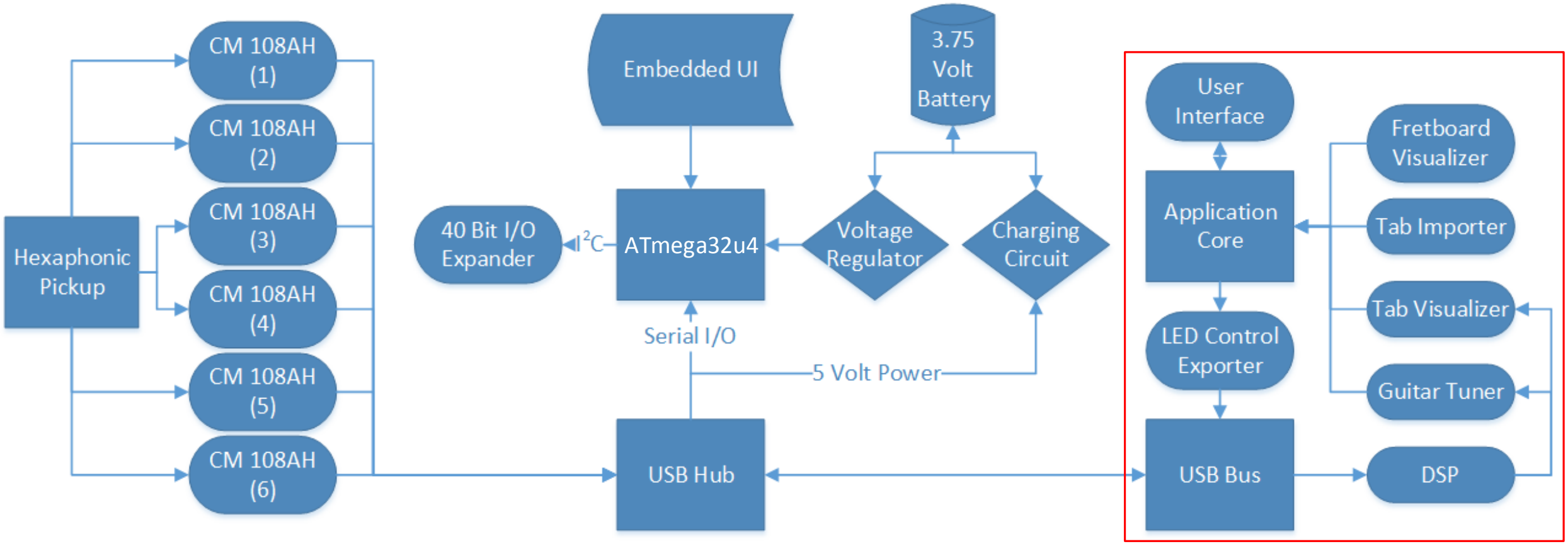
System Block Diagram



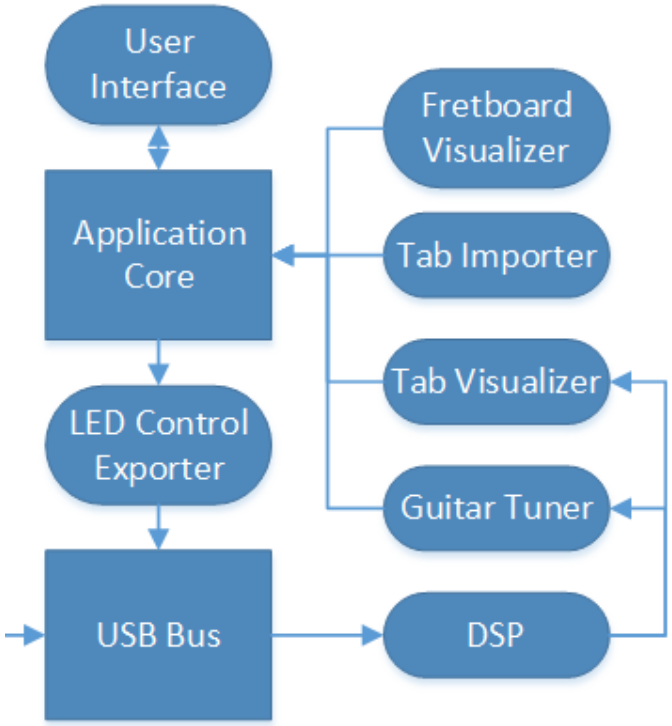
System Block Diagram



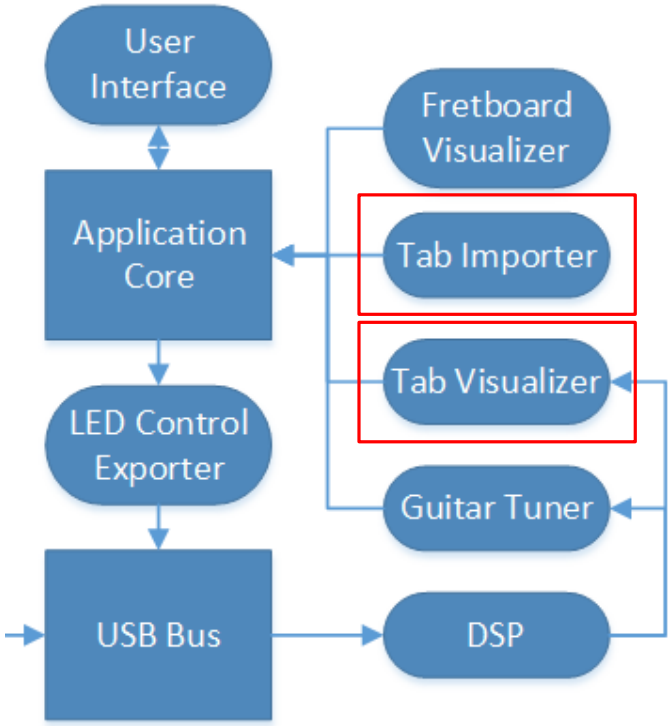
System Block Diagram

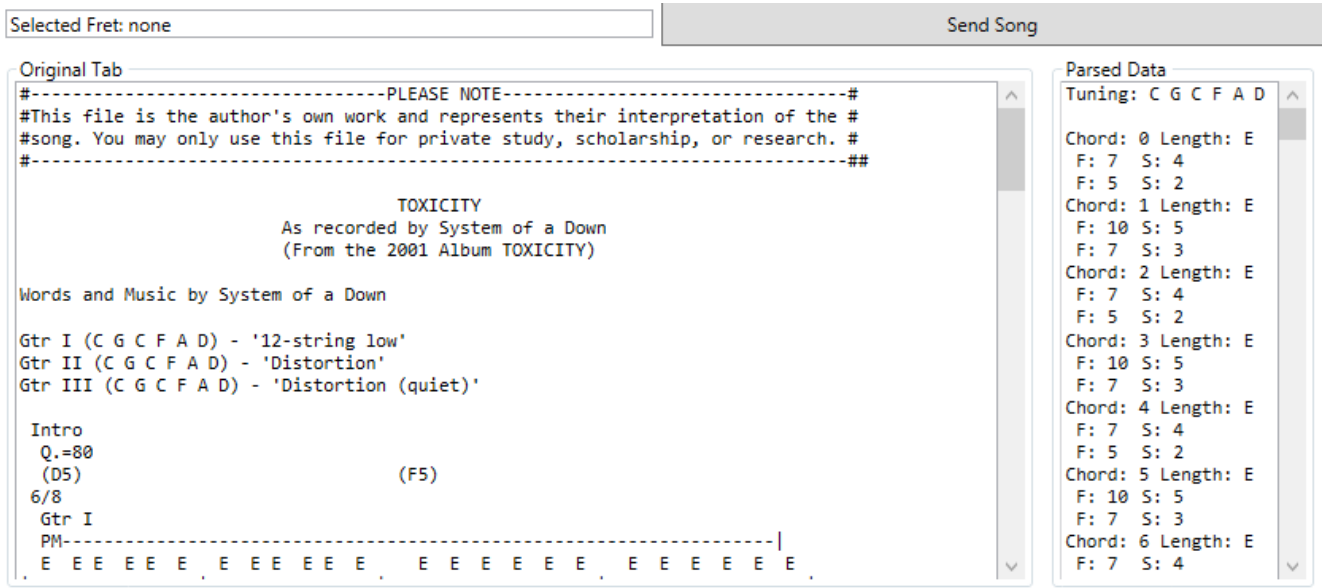


PC Software Architecture Overview



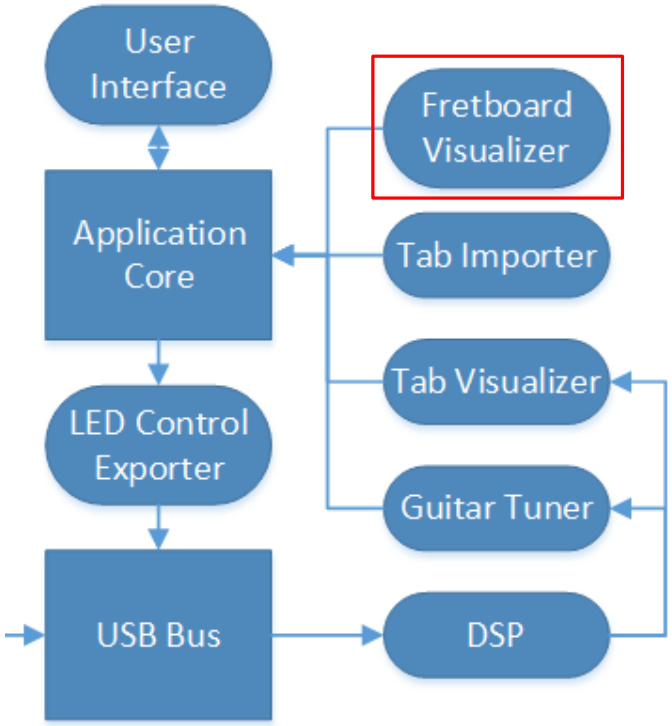
Tab Visualizer

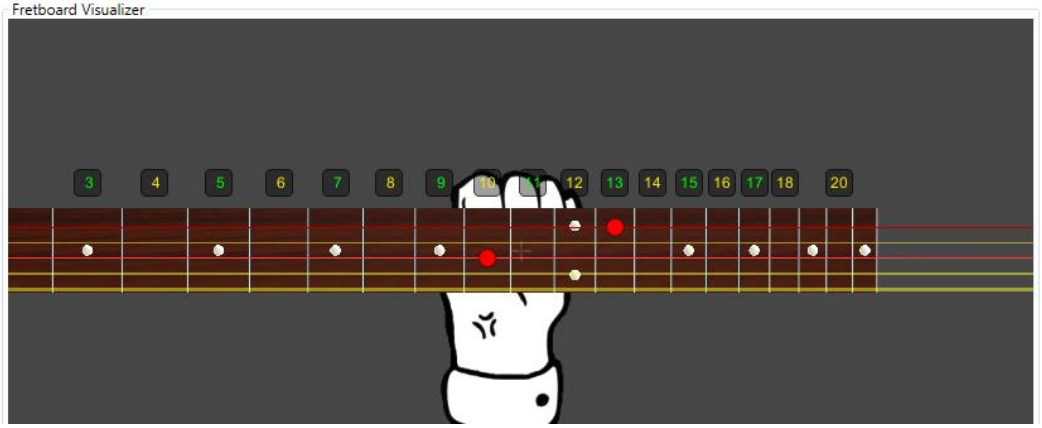




- Displays original tab
- PowerTab ascii exports are parsed into friendly data seen on right
- Send Song button passes data to software fretboard visualizer

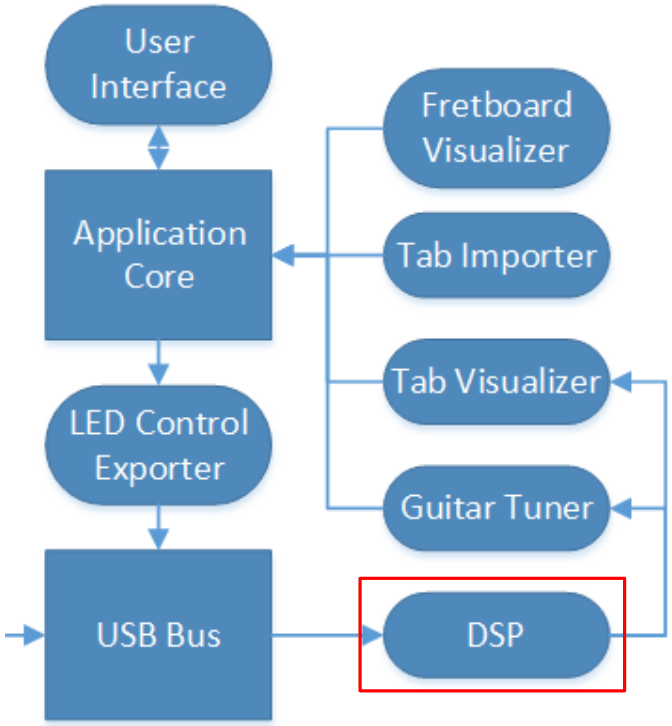
Fretboard Visualizer



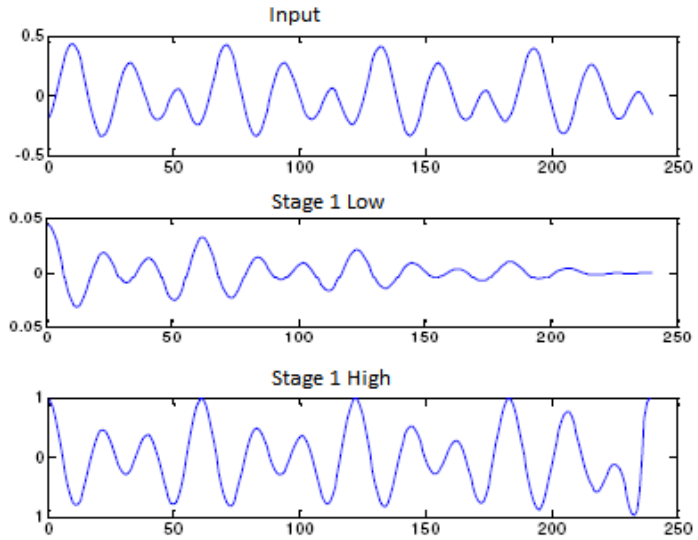


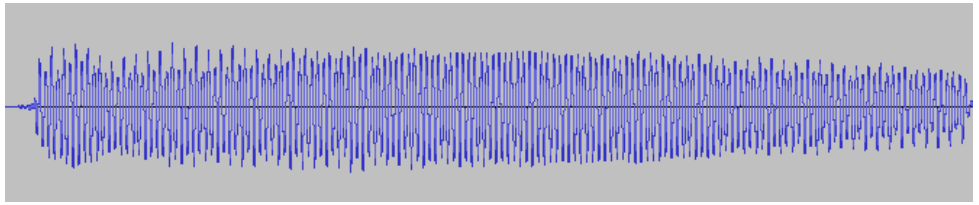
- Playback with finger placement
- Fretboard visualizer is the software equivalent of the LED matrix

Pitch Detection (DSP)



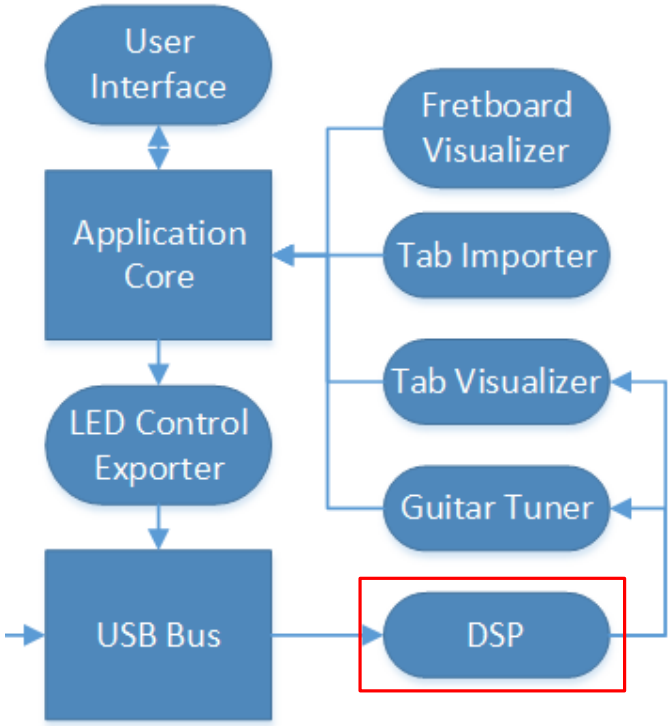
- Utilizes two stage Auto-Correlation
- First stage determines rough frequency range
- Second stage finds exact frequency
- Tolerant of noisy signals
- Fast frequency detection
- Compared against frequency table to determine MIDI note





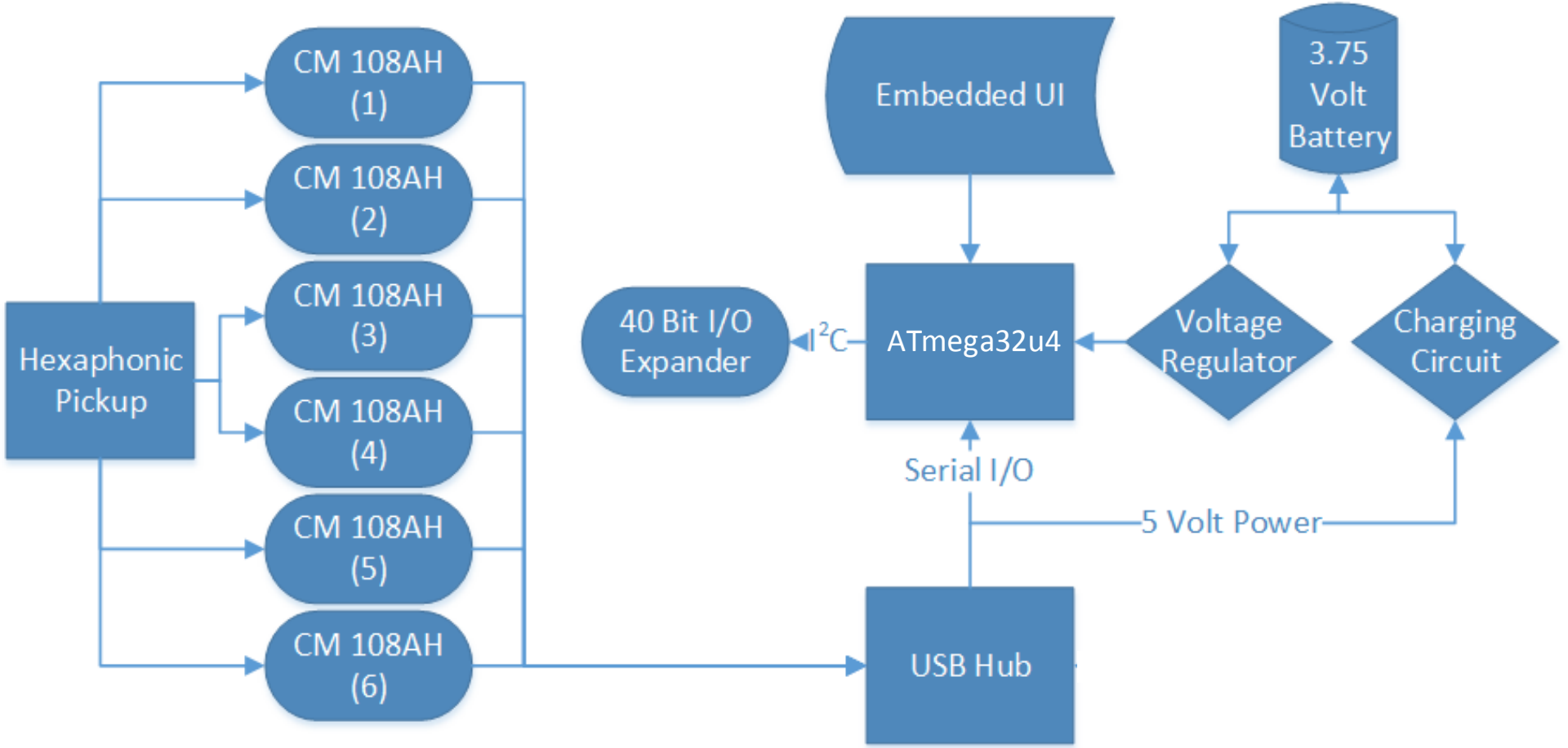
Acoustic Guitar D3

Pitch Detection – Frequency Table

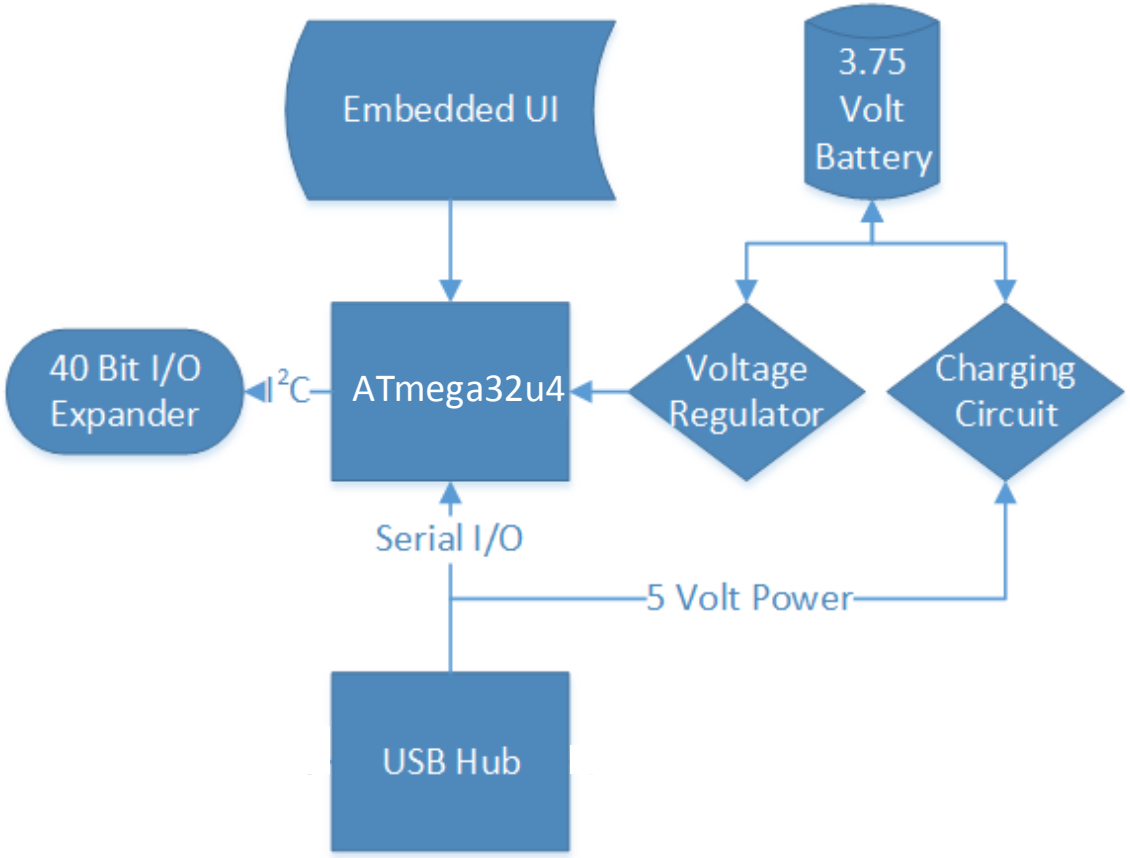


String (Pitch)	Frequency (Hz)
1 (E4)	329.63
2 (B3)	246.94
3 (G3)	196.00
4 (D3)	146.83
5 (A2)	110.00
6 (E2)	82.41

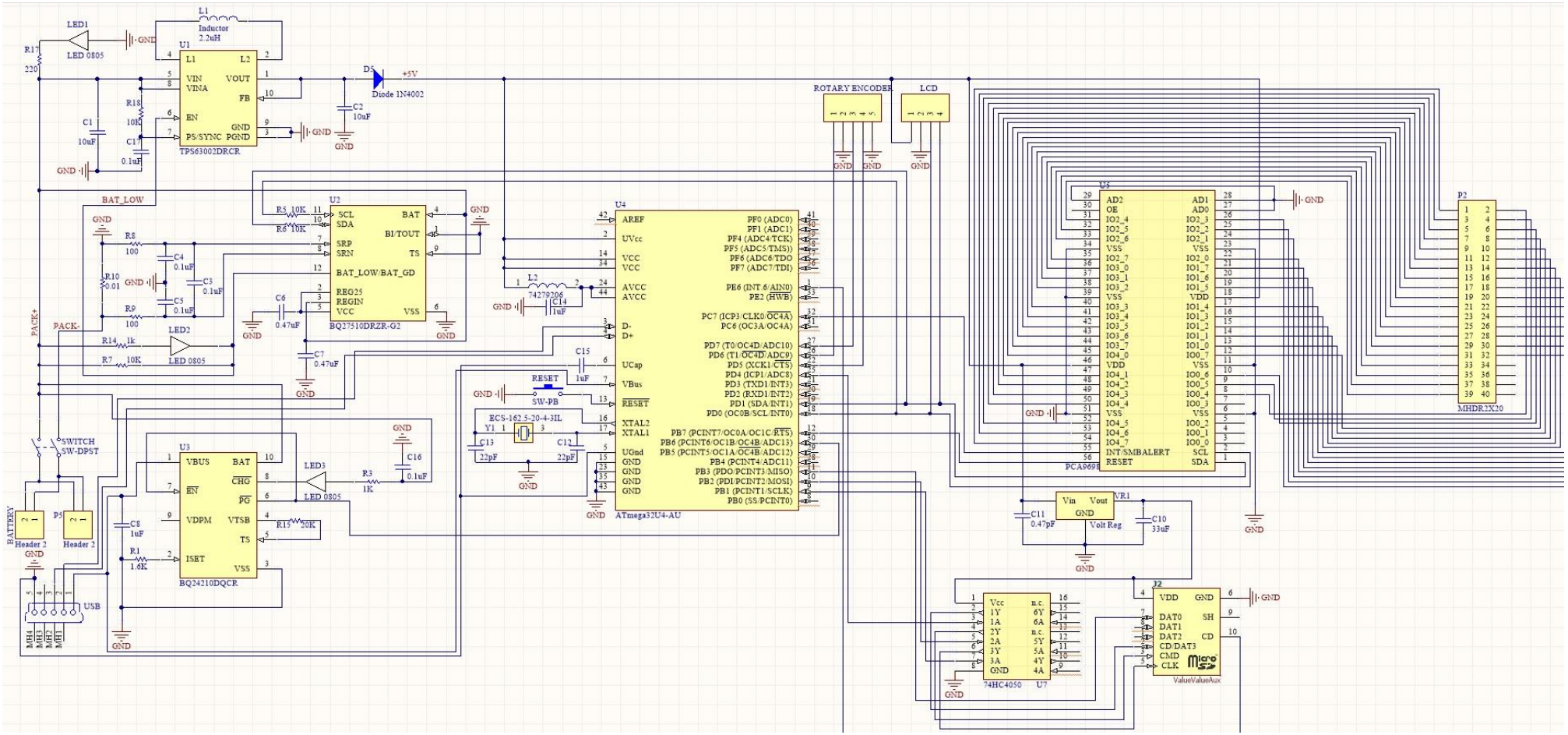
Guitar Hardware Architecture Overview



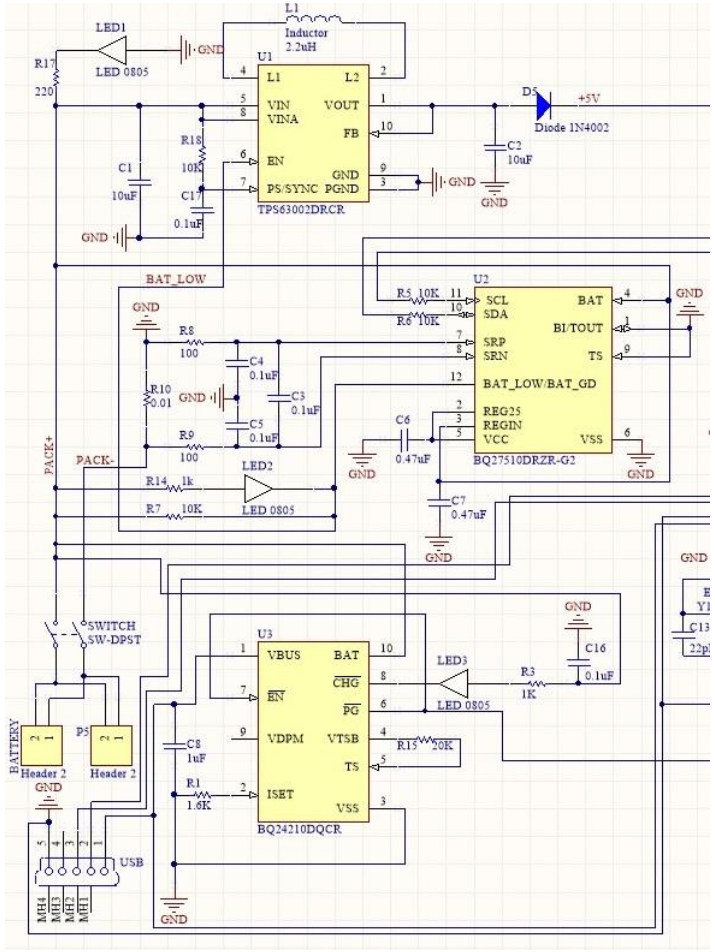
Guitar Hardware – Onboard PCB



Overall Control Board Schematic

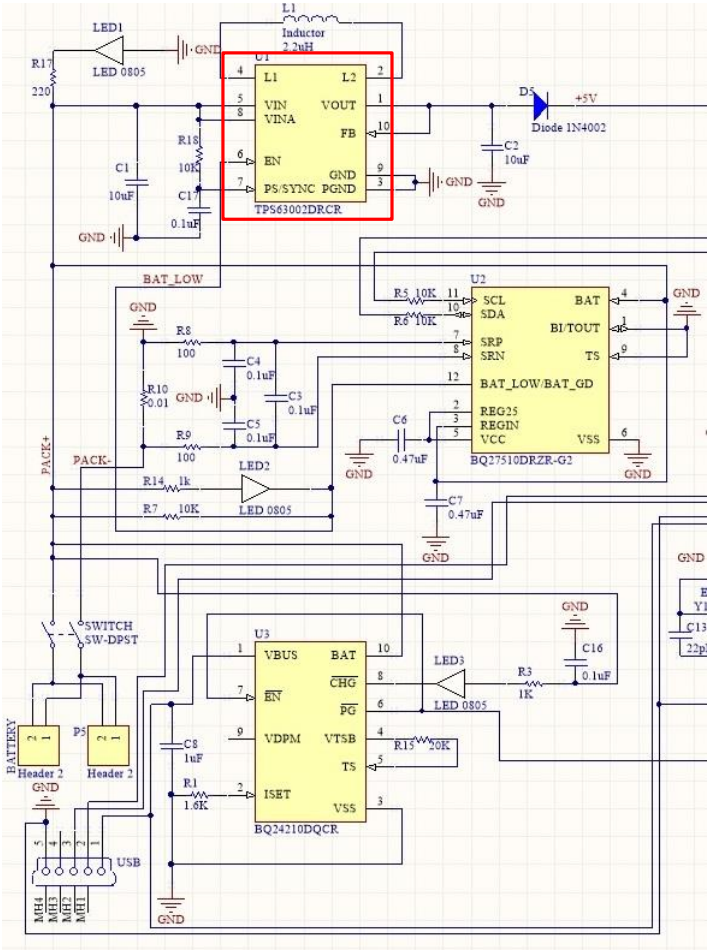


Charging System Schematic



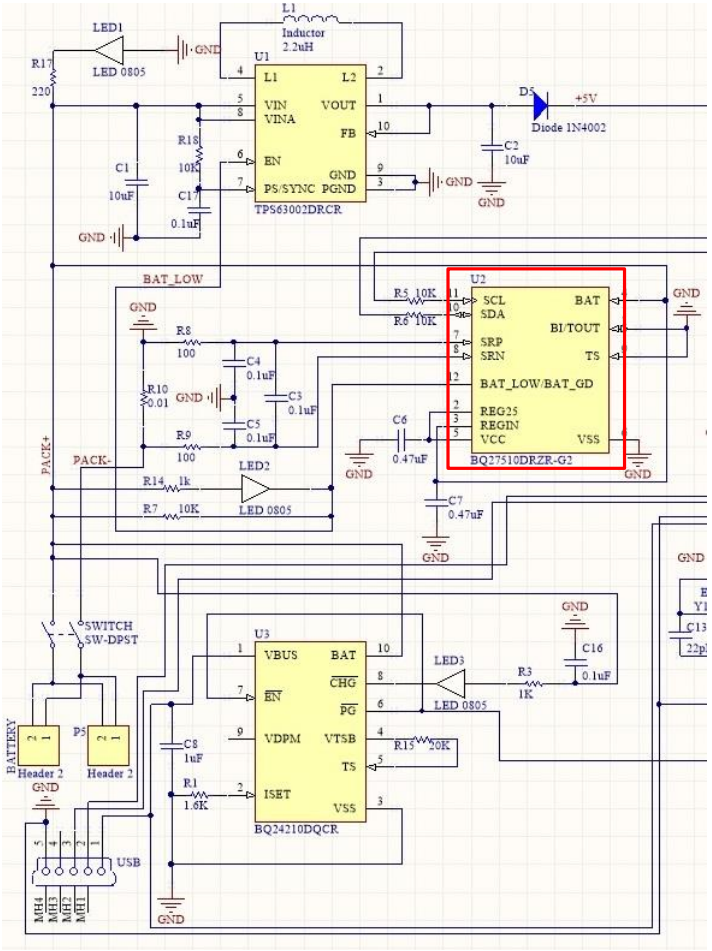
- TPS6300 – Buck/Boost Regulator
- BQ27510 – Fuel Gauge Detector
- BQ24210 – Battery Charger

TPS6300 – Buck/Boost Regulator



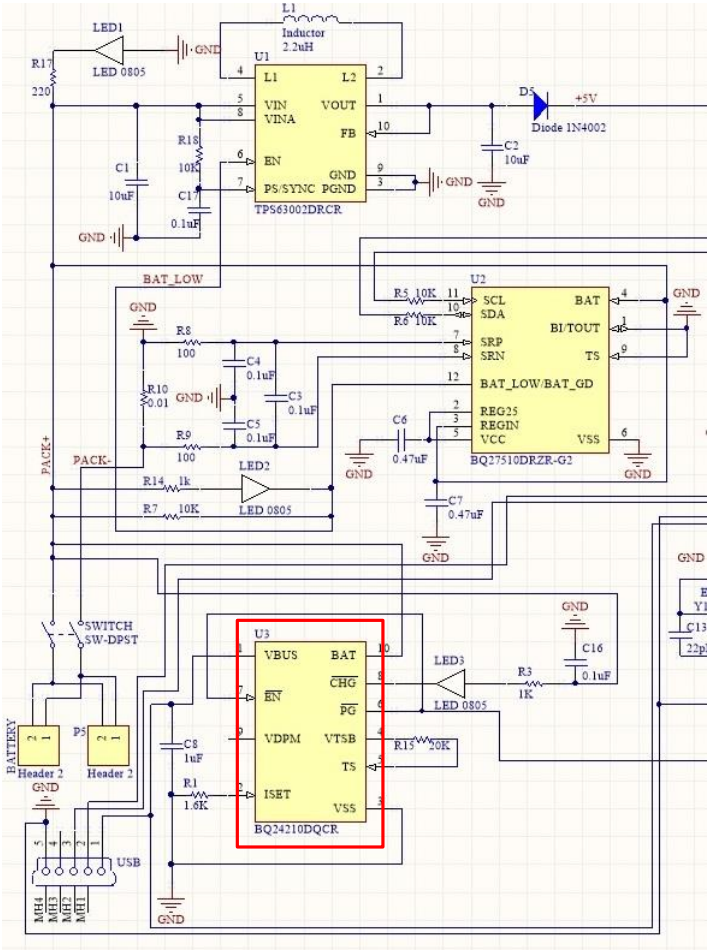
- Acts similar to a voltage regulator
- Has the ability to increase or decrease the input voltage
- Outputs 5V

BQ27510 – Fuel Gauge Detector



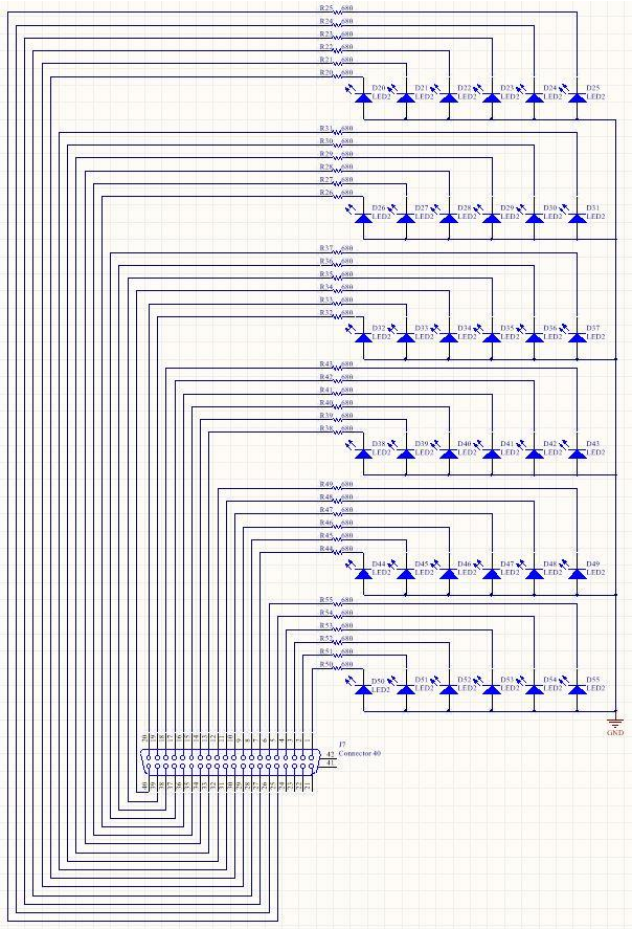
- The fuel gauge measures the cell voltage, temperature, and current
- When battery is low, an LED indicator is lit
- Also monitors charge and discharge activity by sensing the voltage across a resistor (R10)

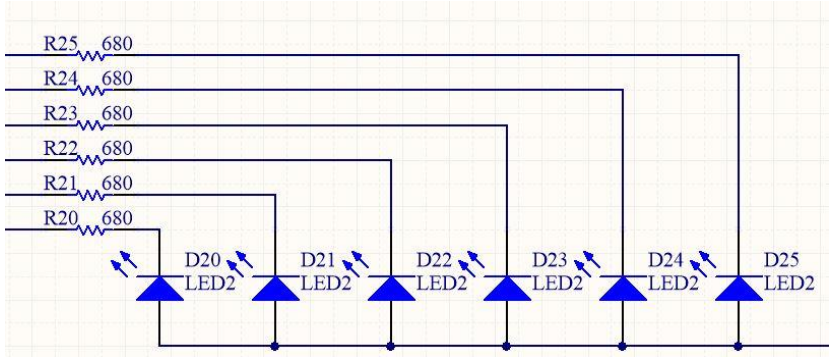
BQ24210 – Battery Charger



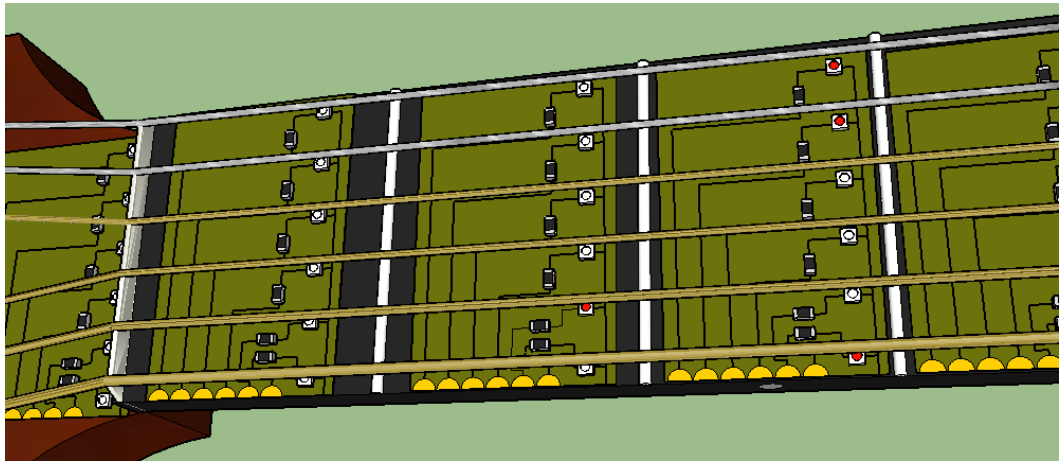
- Charges Lithium Ion battery from USB power cable
- The battery is charged in three phases:
  - Conditioning – Readies discharged battery
  - Package constant current – Fast charges
  - Constant voltage – Safely reaches max charge
- Internal control loop monitors the IC junction temperature and reduces the charge current if an internal temperature threshold is exceeded

Fretboard LED Schematic

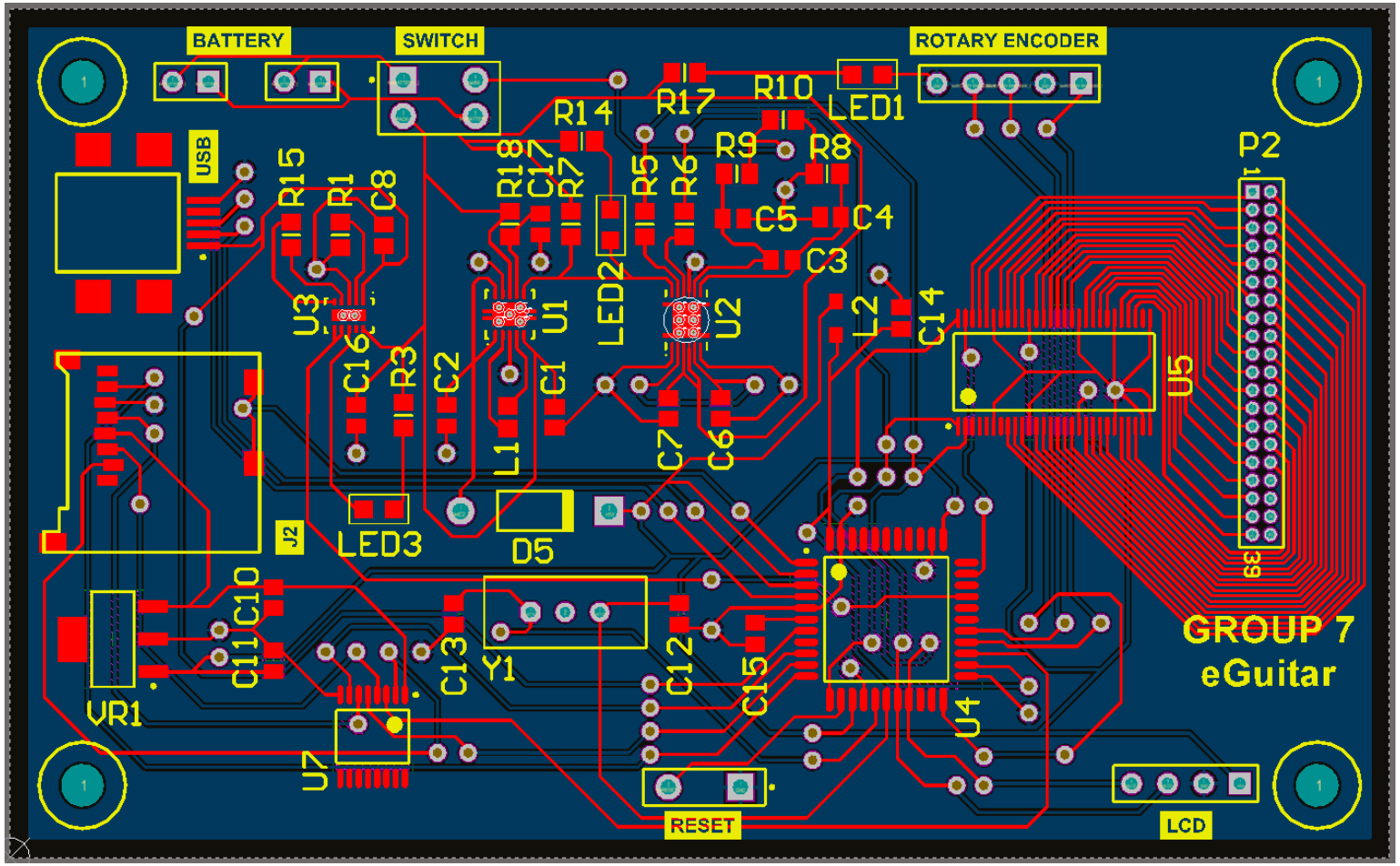




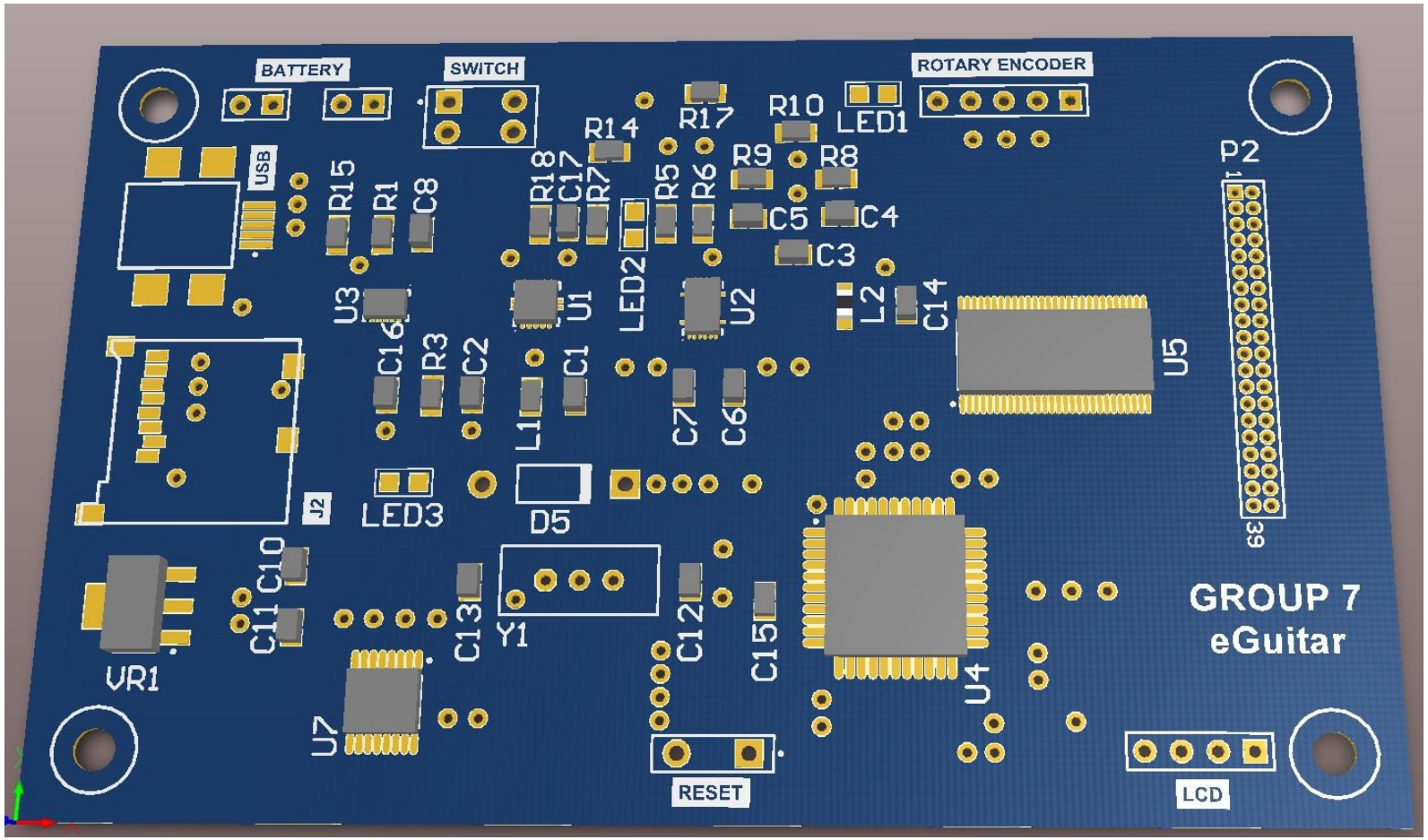
Single Fret



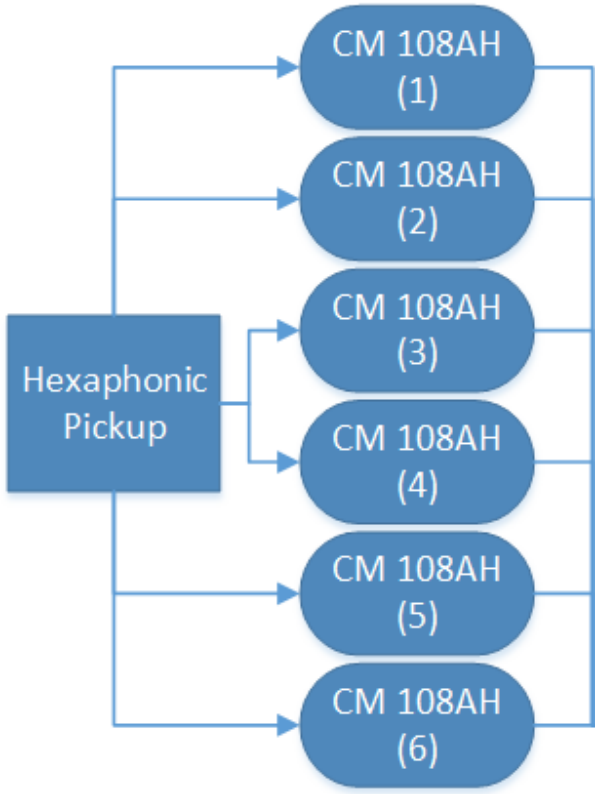
PCB Design


BATTERY
SWITCH
ROTARY ENCODER
USB
P2
LED1
LED2
LED3
D5
J2
VR1
Y1
U1
U2
U3
U4
U5
U7
L1
L2
RESET
LCD
GROUP 7
eGuitar

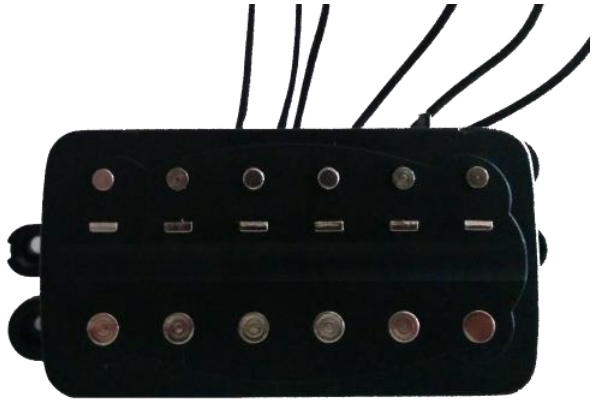
PCB Design – 3D Model



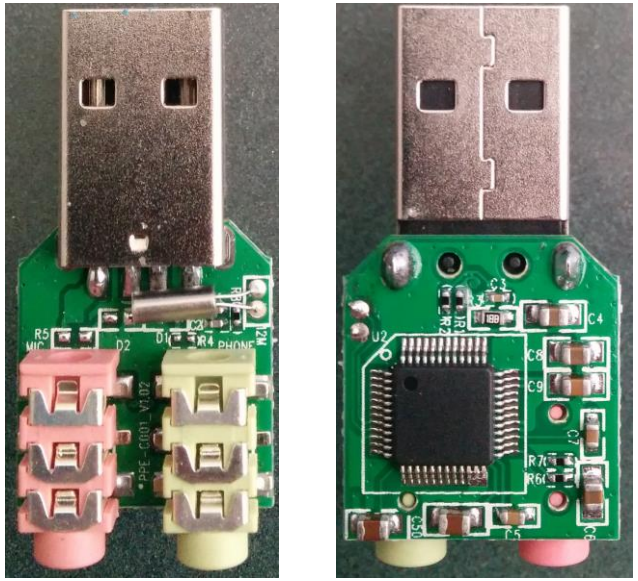
Pitch Detection Hardware



- 6 independent channel (hexaphonic) output
- To be placed in the sound hole of an acoustic guitar for prototyping
- Using the CM108AH chip (on right), we feed each line into the Windows PC



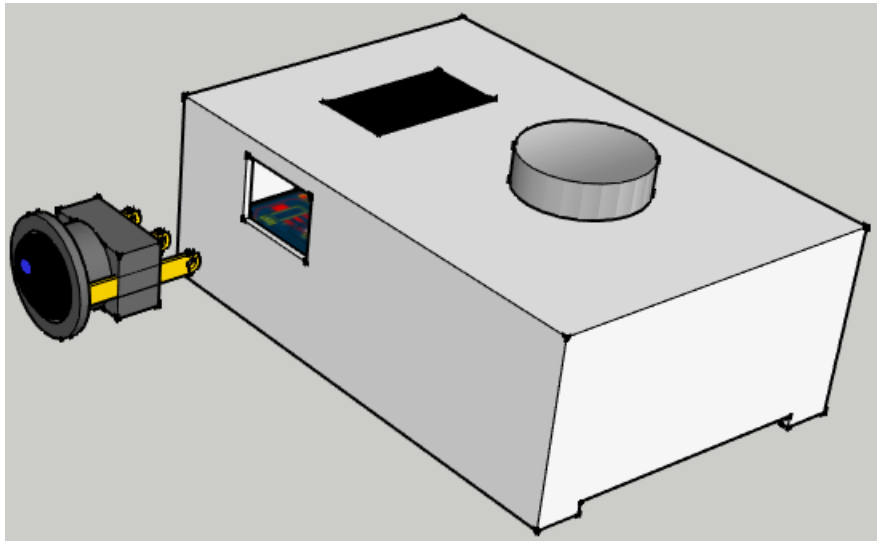
Hexaphonic Pickup

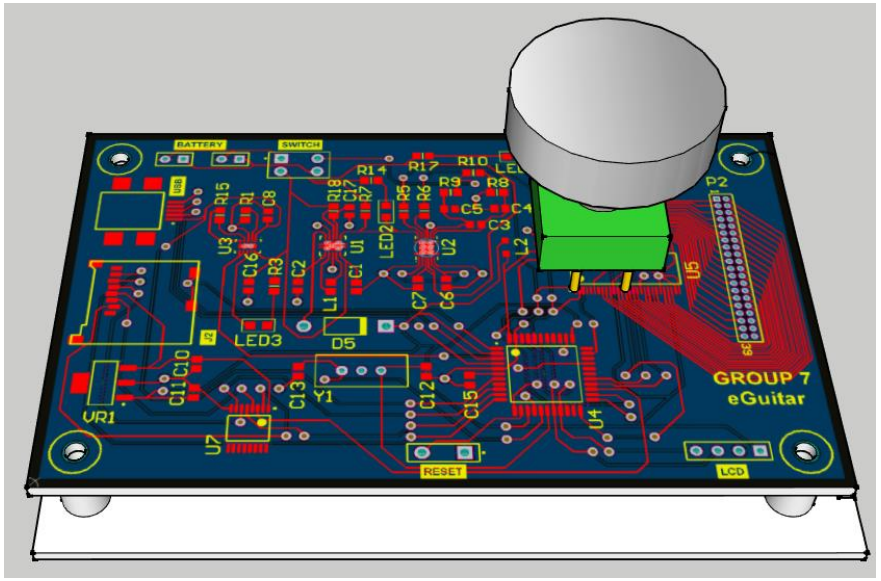


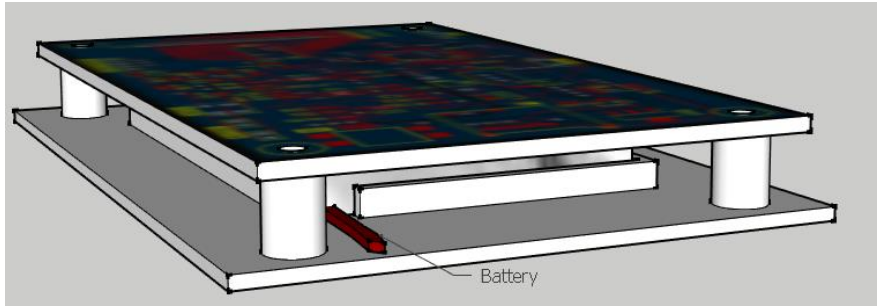
USB Sound Card (CM108AH)

Embedded Hardware

- Power Switch
- Rotary Encoder
- Battery Holder
- Reset switch
- Space for Ribbon Cable







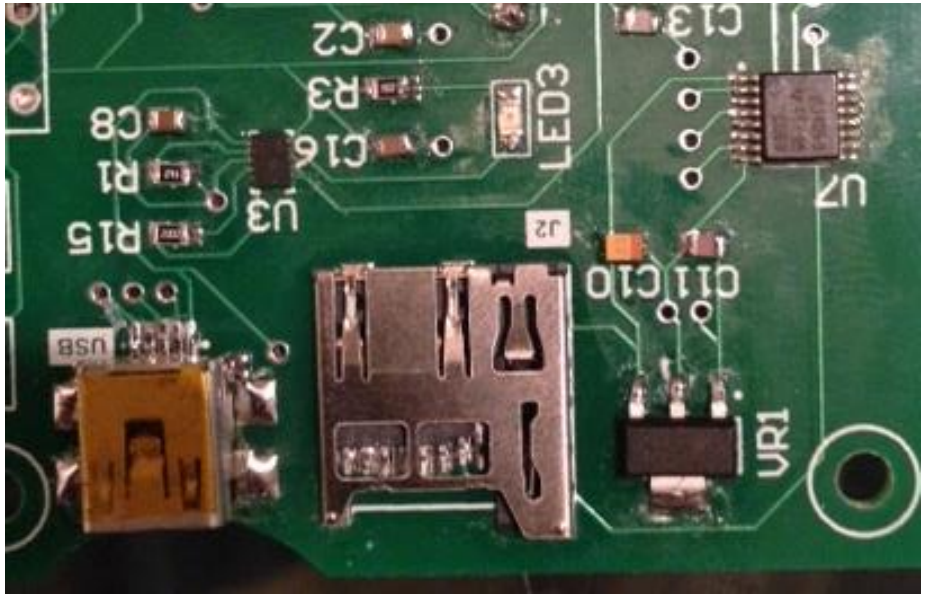
Embedded UI

- Controls untethered functions
- Simple push for play/pause
- Scroll clockwise or counter clockwise to

  speed up or slow down playback

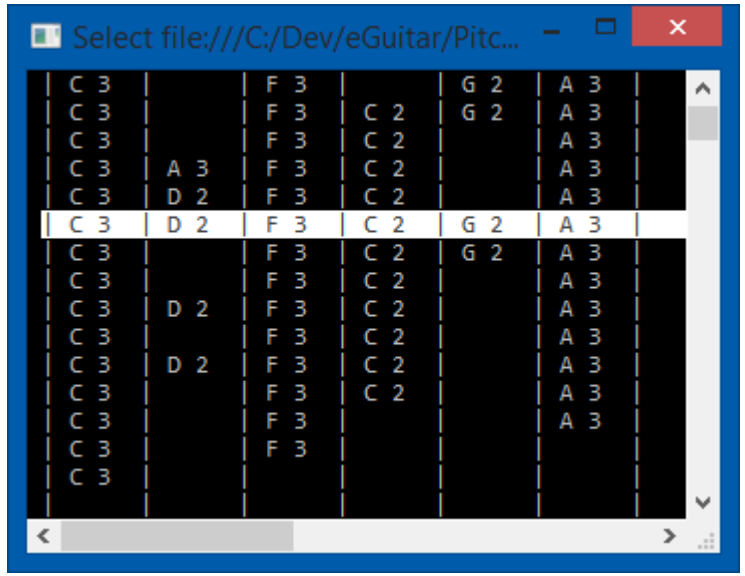
Memory – SD Card

- Used for storing tablature data
- Allows untethered playback of songs
- Utilizes a 74HC4050D Hex Converter
- SD Card communicates using SPI
- 3.3V Operating Voltage



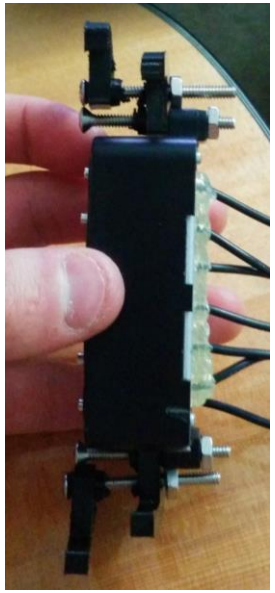
Prototyping

- Elegant* first electric prototype shown on right
- Polyphonic pitch detection.
- Drop C tuning pictured in console output below
  - Out of order because windows arbitrarily orders audio devices

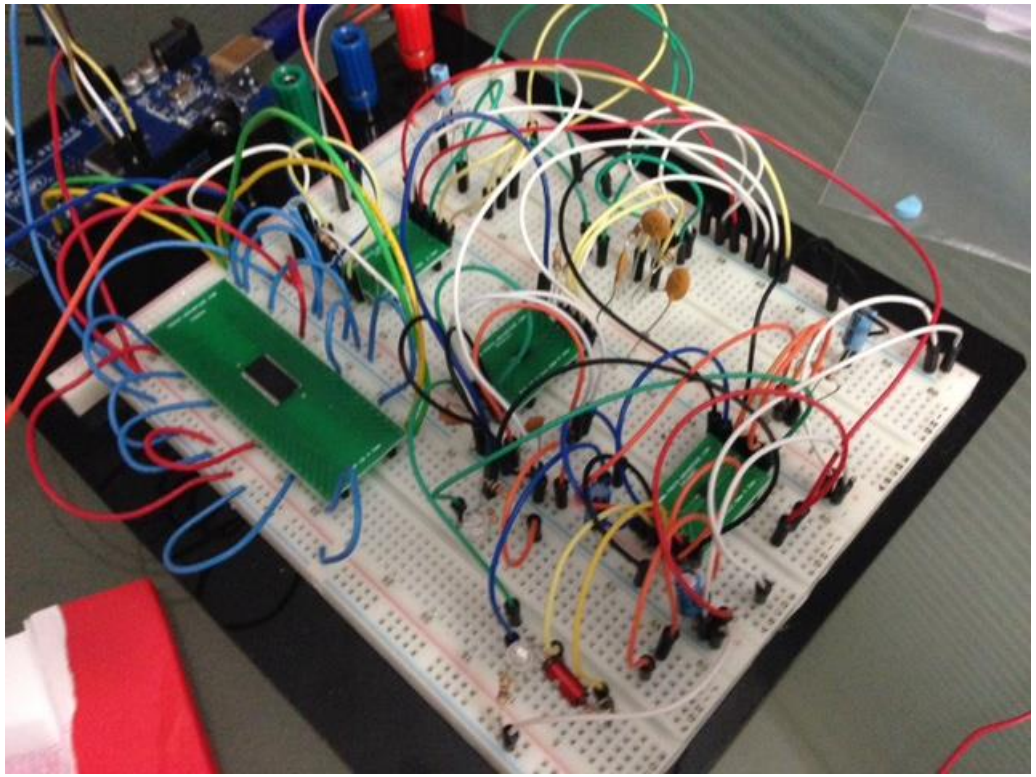


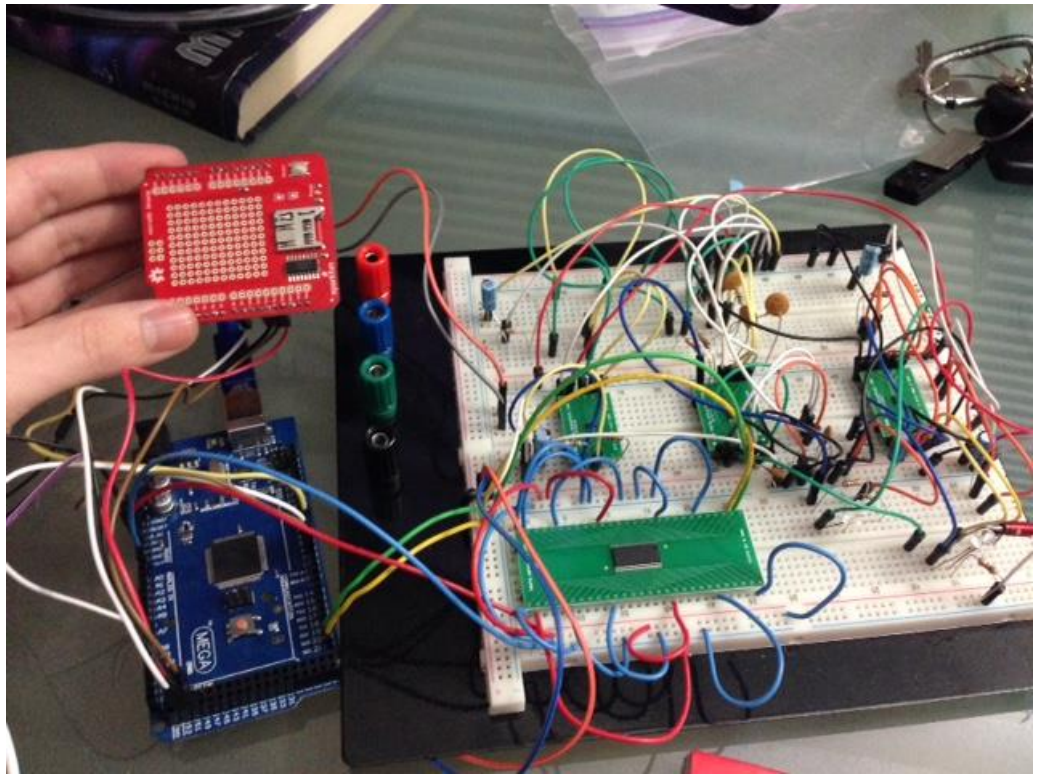
Prototyping (cont’d)

- First acoustic prototype shown on right
- Custom 3D-printed clamping mechanism shown below



Prototyping (cont’d)





Project Roadblocks

- Latency issues with audio pass-through
- Form factor / hardware minimization
  - Placing hexaphonic pickup under guitar strings and independent right/left height adjustment
  - Fitting fretboard LEDs under strings
  - 1 USB sound card per channel, can’t find cheap ones with input only
- Advanced tablature feature parsing
  - Attempting to parse PowerTab ASCII exports makes some assumptions and is thus not 100% accurate
- Embedded pitch detection
  - Issues working with TI ezDSP boards, lots of time wasted.
  - Embedded solutions are expensive and underpowered
- Primary embedded Microprocessor
  - Usability and program memory size issues with TI MSP430
  - Memory issues with ATmega32u4 (Had to remove OLED display)

Project Successes

- Smooth transition from prototype to PCB implementation
- Lithium ion charging circuit working properly
- Multi-channel pitch detection working reliably and with minimum CPU load
- Time management:
  - Staying ahead of things
  - Overall progress
- Accomplished several stretch goals
  - Multi-channel DSP
  - Integrated tuner

Expenses to date

Item	QTY	Cost		Item	QTY	Cost
F.O. Filament, wire, proto board, glue gun	-	$23.00		USB 2.0 Slim Hub	2	$11.98
LilyPad LED White/Blue	10	$11.83		Edimax EW-7811Un	1	$8.99
TMDX5525EZDSP (TI ezDSP Board)	1	$115.53		5V 2A microUSB wall charger	1	$7.99
TSSOP-56 to DIP Adapter	2	$29.98		8GB microSDHC card Class 10	2	$13.98
TSSOP-20 Breakout/Other Supplies	-	$28.58		ODROID-C1	1	$36.95
I/O Expander/ MSP430G2553/ LEDs	-	$48.00		LED Boards – China Build	8	$428.62
Flux Pen	1	$19.84		Control Board	5	$153.11
Radxa Rock Light	1	$69.99		SD Card Shield	1	$26.94
USB Sound Card	8	$66.10		Components for PCBs	-	$182.45
568-1455-5-ND Analog Mux	3	$6.53		Ribbon Cable	1	$36.75
				Total Cost		**$1342.14**

Bill of Materials

Item	Quantity	Cost per Unit	Total Cost
Hex Pickup	1	$60.00 (Salvaged)	$60.00
Charging Circuit ICs	3	$4.00	$12.00
I/O Expander / Atmega32u4 / Components	1	$182.45	$182.45
USB sound card	6	$8.26	$49.58
USB 2.0 slim hub	2	$5.99	$11.98
Printed Circuit Board – LED Fret Board	6	$53.58	$321.47
Printed Circuit Board – Control Board	1	$33.00	$33.00
Ribbon Cabling	1	$45.00	$45.00
Lithium Ion Battery	1	$4.95	$4.95
Surface Mount LEDs	36	$0.56	$20.16
		Total:	**$740.59**

The eGuitar

Questions?