eGuitar

GROUP 7

BRANDON BERK – COMPUTER ENGINEER

WILLIAM REMINGTON – ELECTRICAL ENGINEER

ERIC SOROKOWSKY – COMPUTER ENGINEER

Administrative Introduction

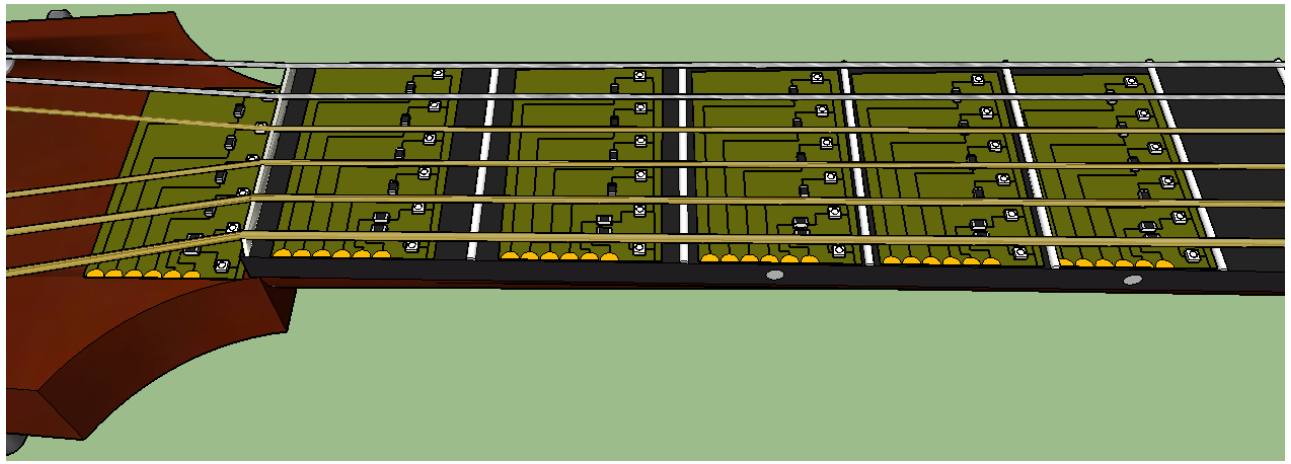
- eGuitar improves the way a user learns or further develops their guitar skills
- Through onboard visual indicators, users can learn finger placements in a tactile way
- Experienced guitar players can record their music into guitar tablature (tabs)
- A PC-side standalone application offers tablature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

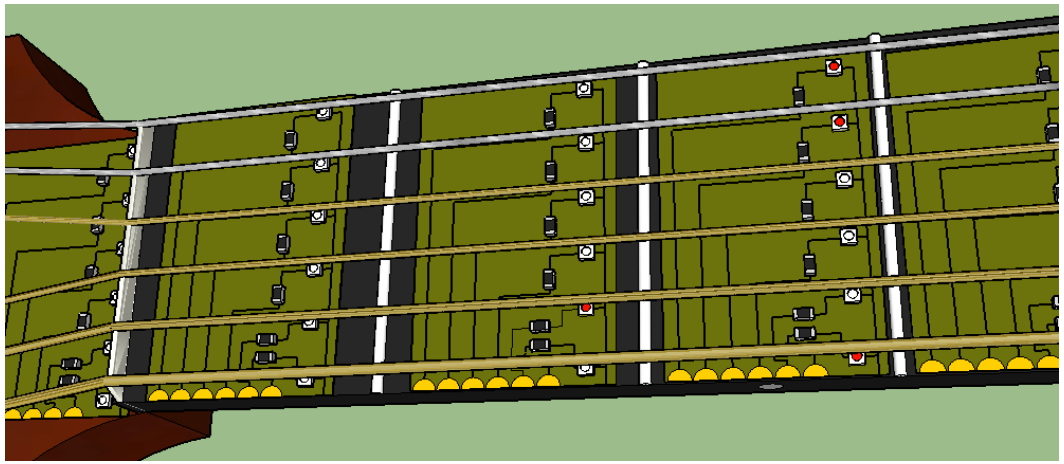
Goals

- 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
  - Performance feedback
- Intuitive PC user interface

Specifications – Fretboard PCB

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





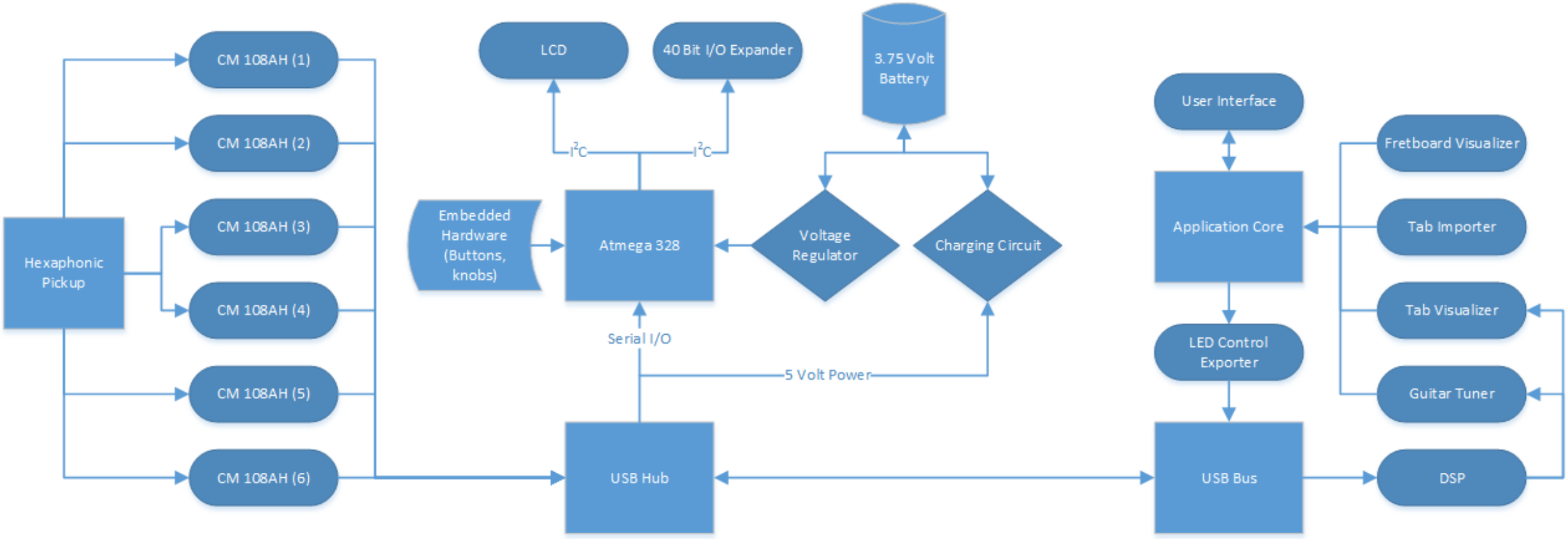
Specifications – Control PCB

Component	Parameter	Specification
Primary Microprocessor	Model	ATmega 328
Primary Microprocessor	Clock speed	16 MHz
Primary Microprocessor	Communications Standard	I^2C, RS232 serial
PCB	Layers	2
I/O Control	Outputs	40 (36 in use)
Power	Source	3.7v Li-ion Battery
Power	Voltage	5v

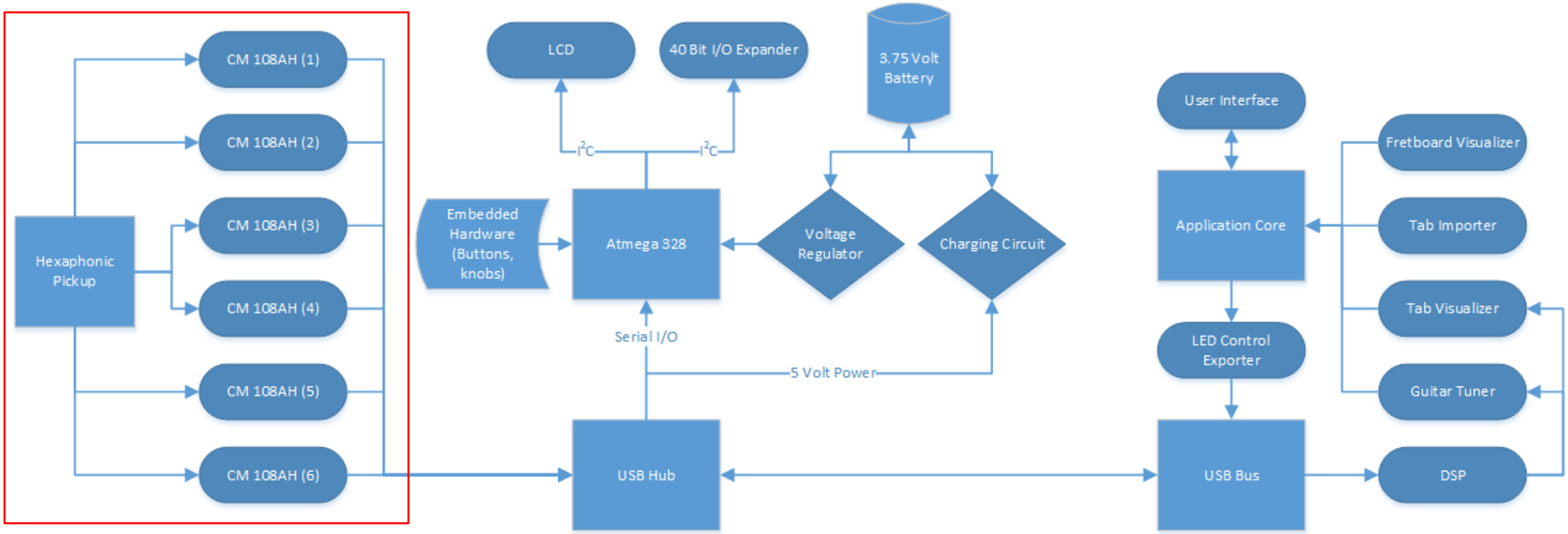
Specifications – DSP

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

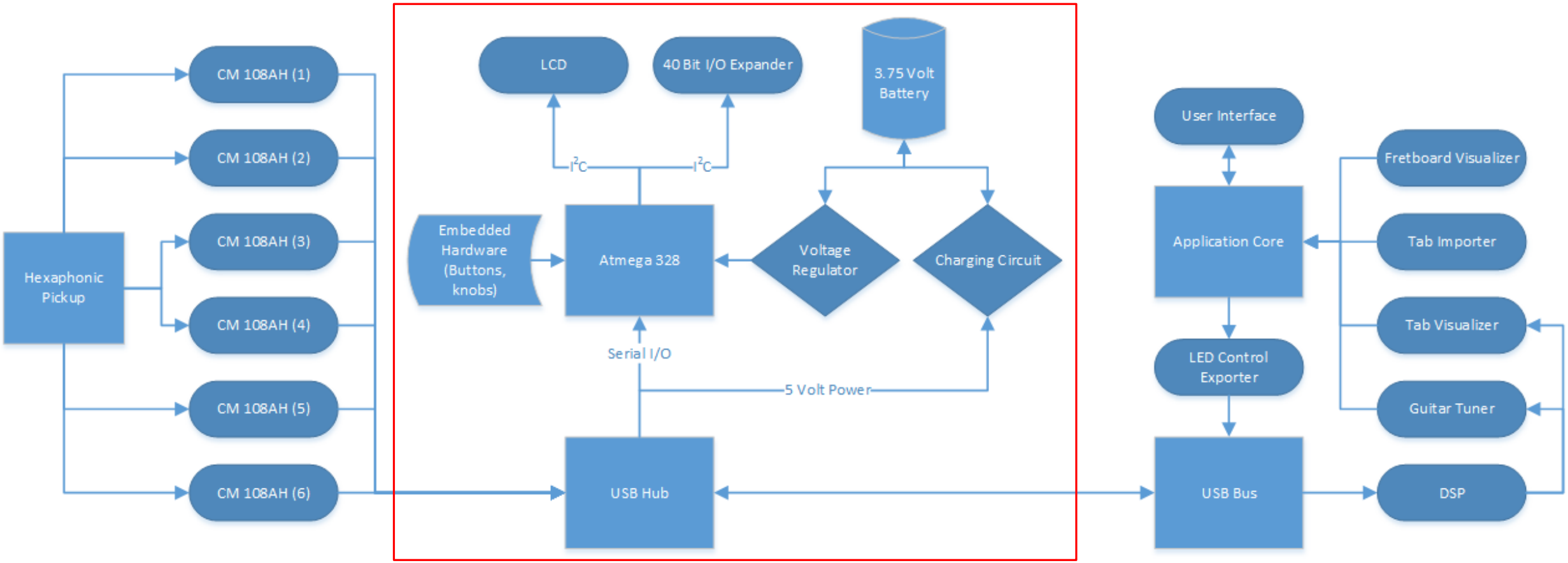
System Block Diagram



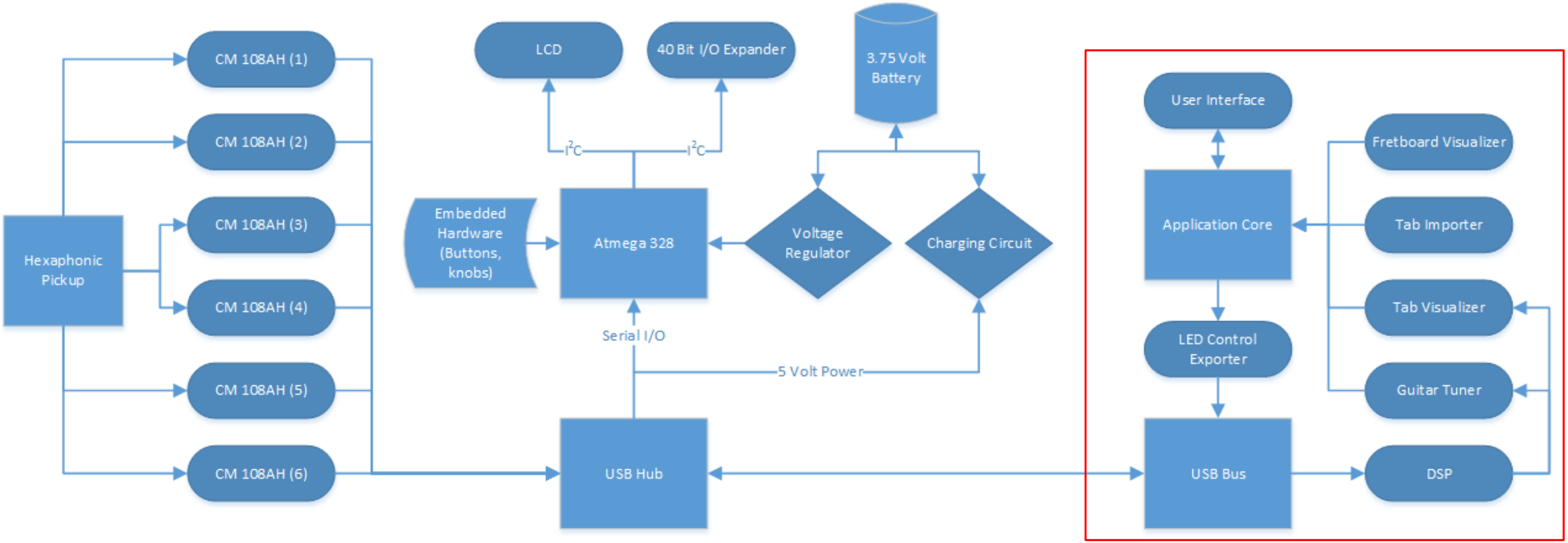
System Block Diagram



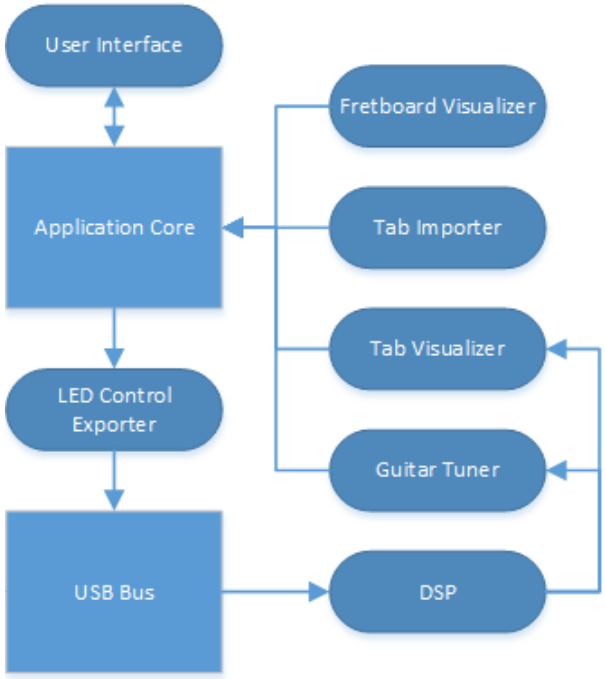
System Block Diagram



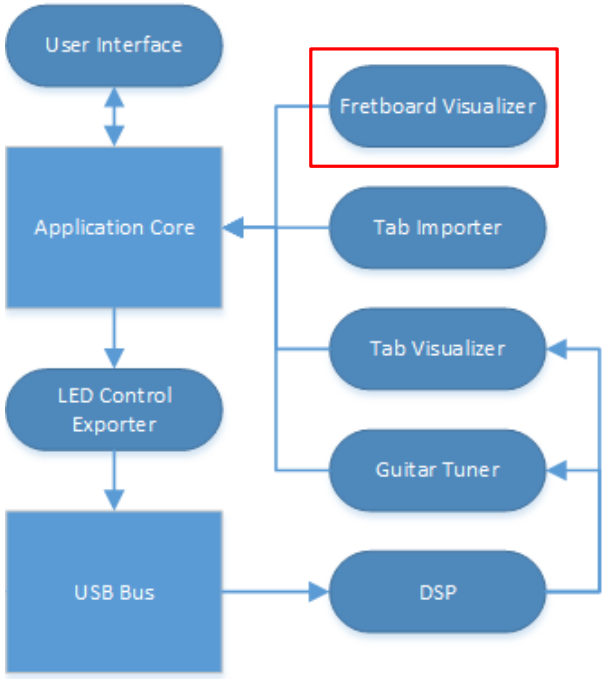
System Block Diagram

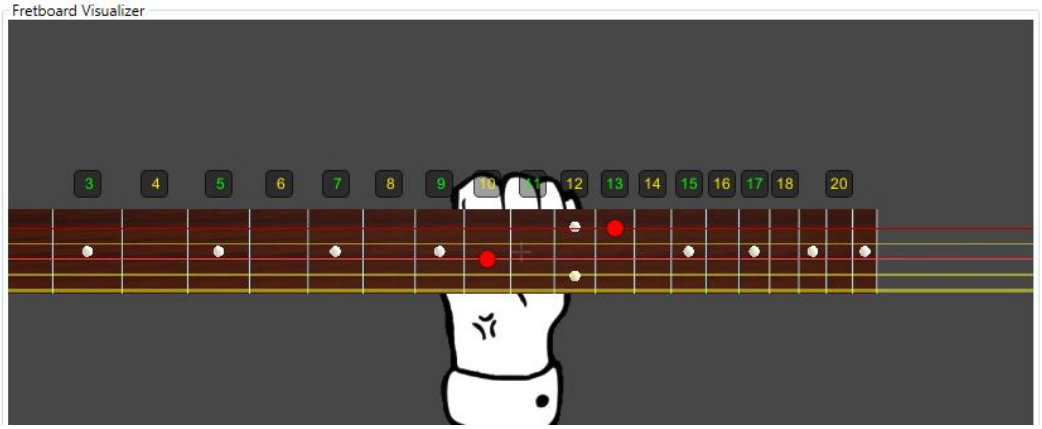


PC Software Architecture Overview



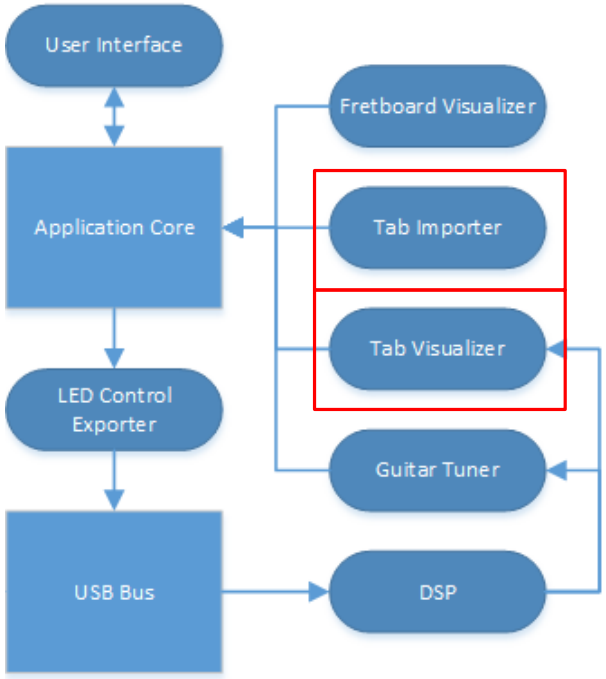
Fretboard Visualizer

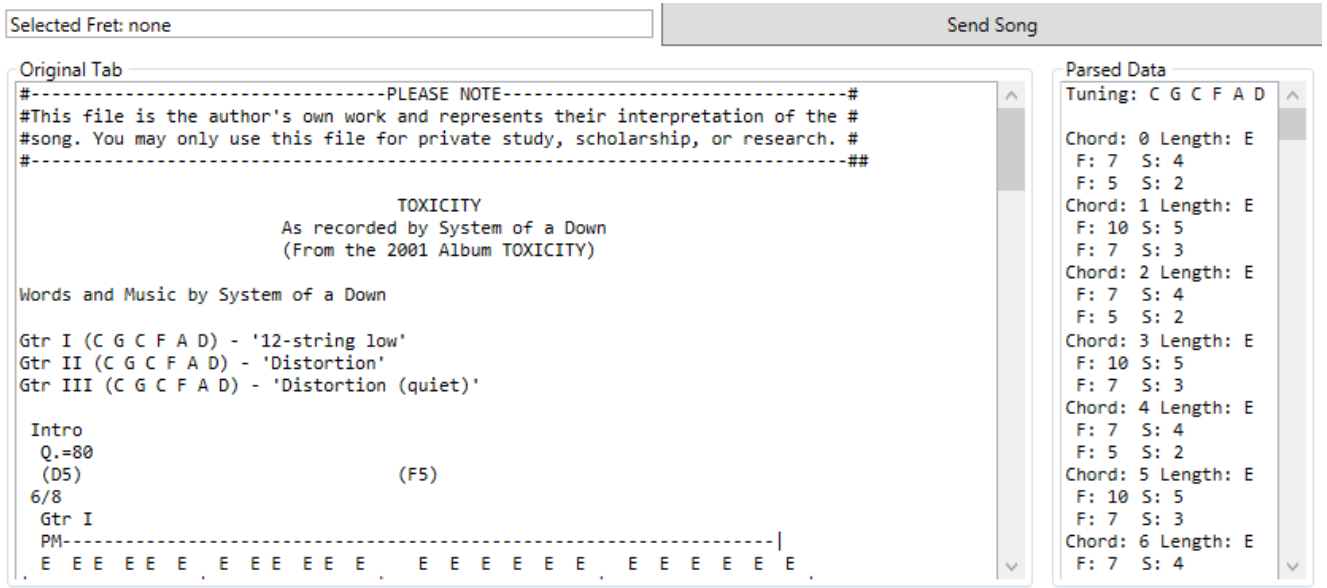




- Playback with finger placement
- Fretboard visualizer is the software equivalent of the LED matrix
- Sine wave audio feedback
  - Should be MIDI instead

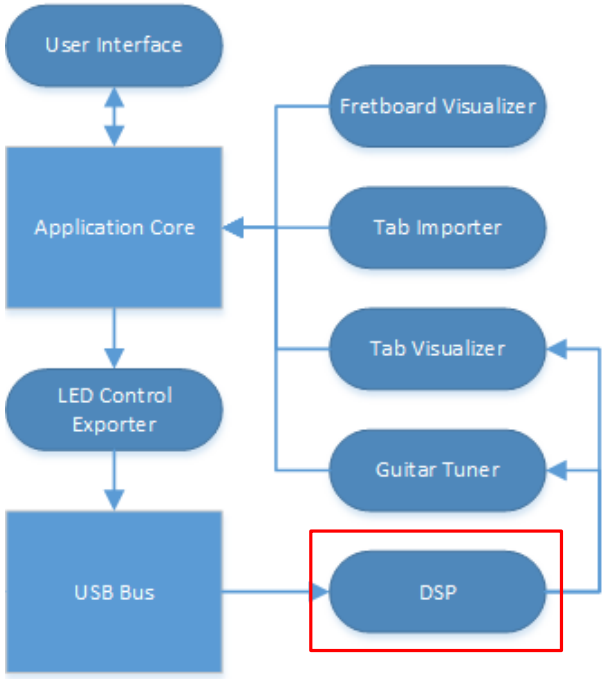
Tab Visualizer



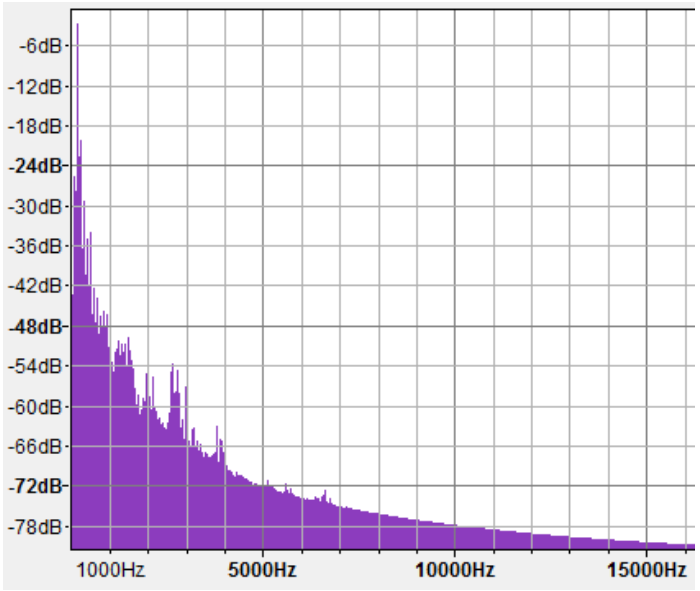


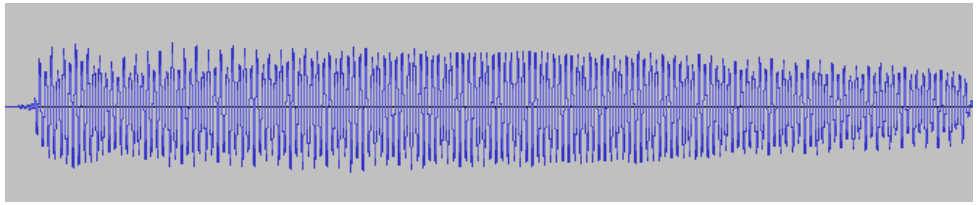
- Displays original tab
- PowerTab ascii exports are parsed into friendly data seen on right
- Send Song button passes data to software fretboard visualizer

Pitch Detection (DSP)



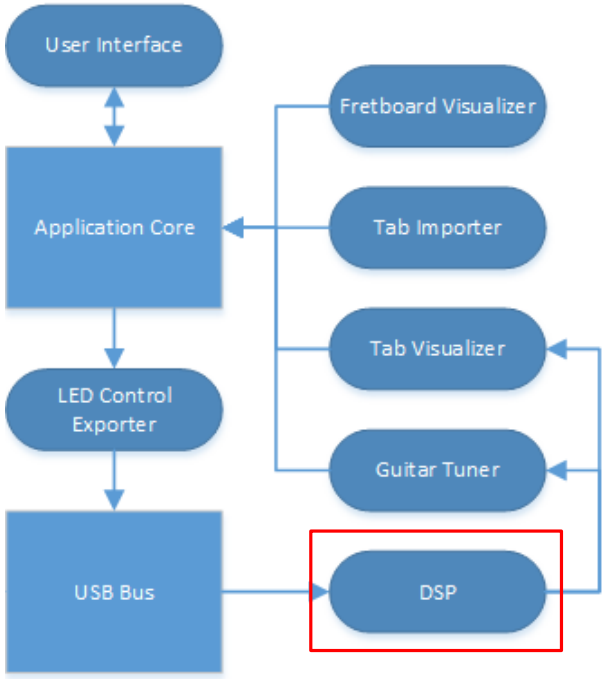
- Utilizes Fast Fourier transforms – Converts time domain signal to frequency domain
- Most prominent frequency is chosen
- Tolerant of noisy signals
- Compared against frequency table to determine MIDI note





Acoustic Guitar D3

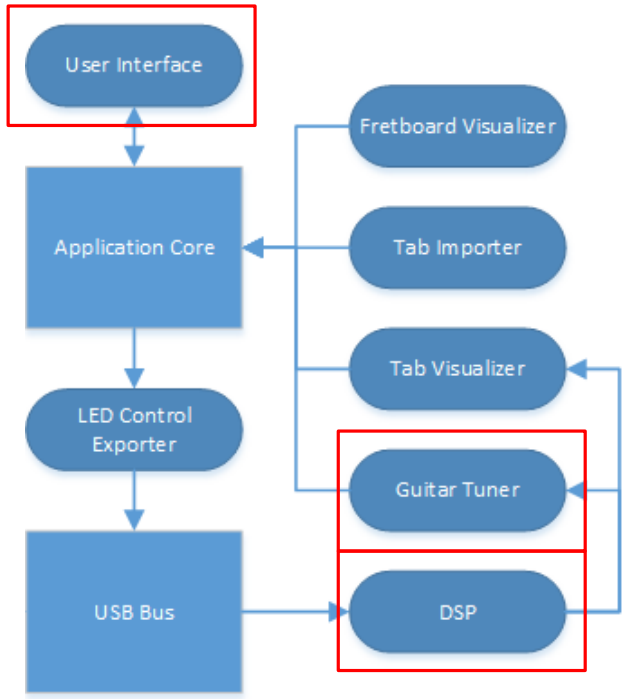
Pitch Detection – Frequency Table



- Correlates frequency to MIDI note

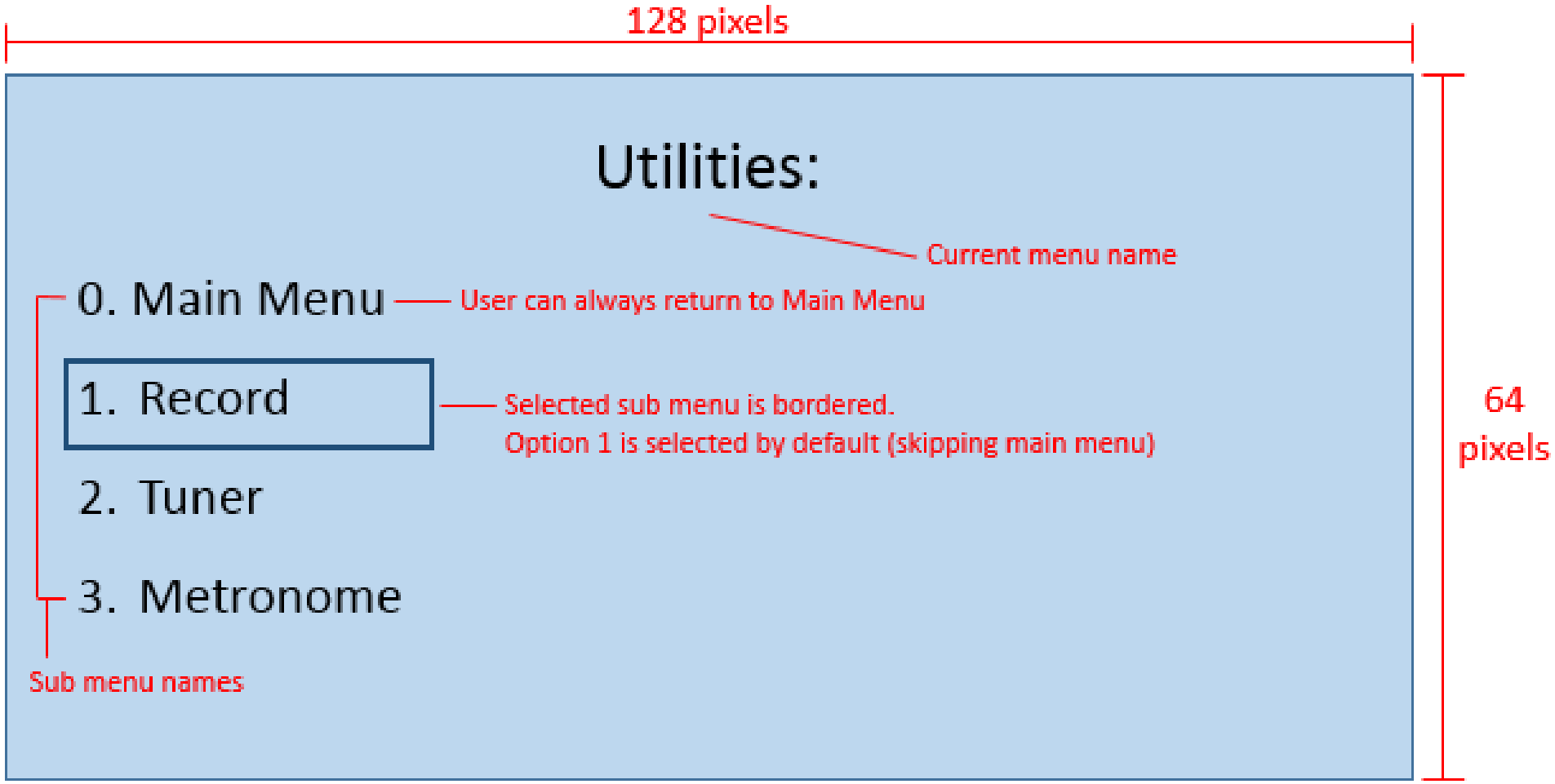
String (Pitch)	Frequency (Hz)
1 (E4)	329.63
2 (B3)	246.94
3 (G3)	196.00
4 (D3)	146.83
5 (A2)	110.00
6 (E2)	82.41

To be completed – Software

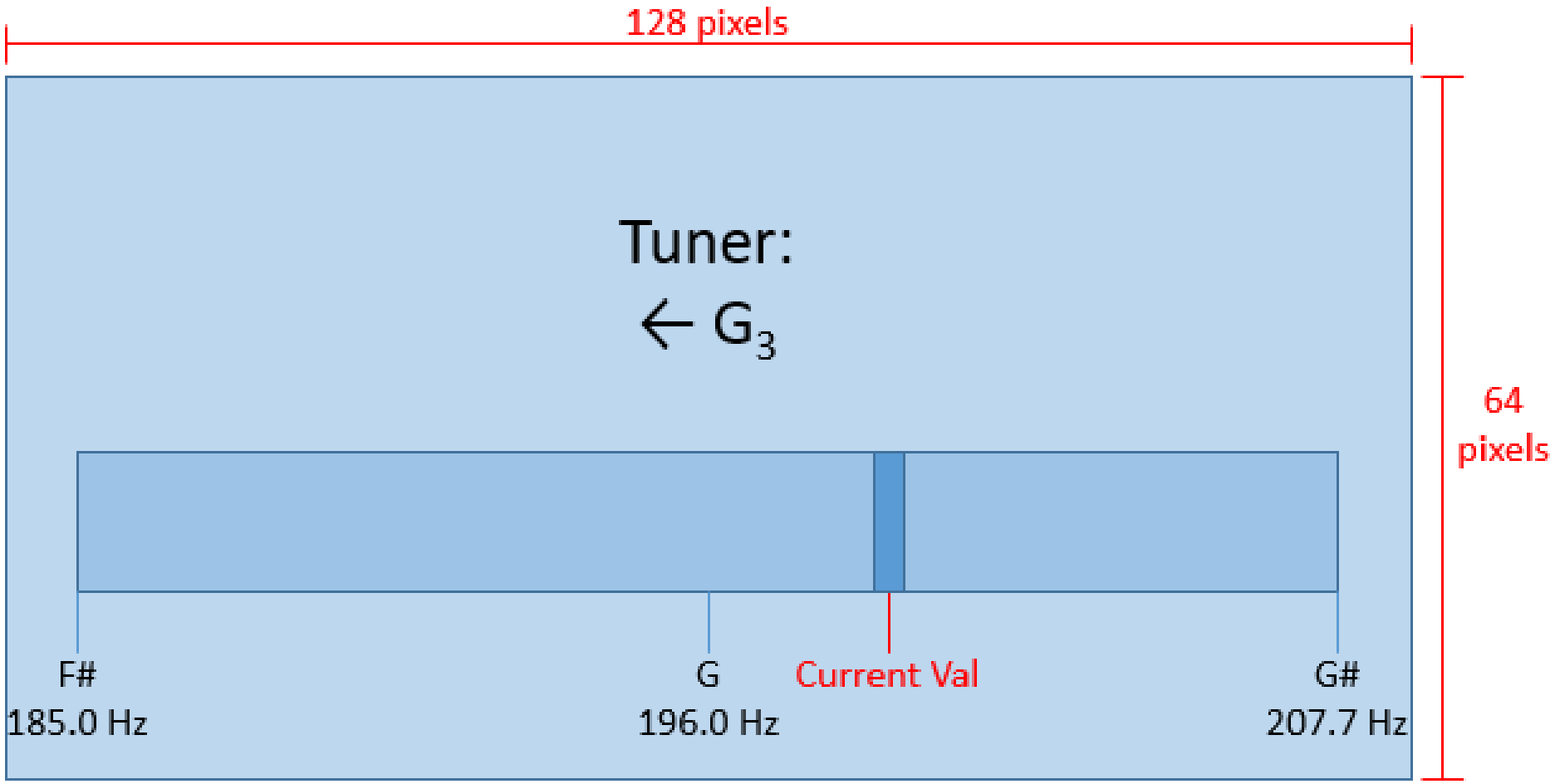


- Embedded User interface mock-ups coming up
- Guitar Tuner (Embedded or PC side?)
- DSP needs to be refined, and perhaps develop into tablature creation

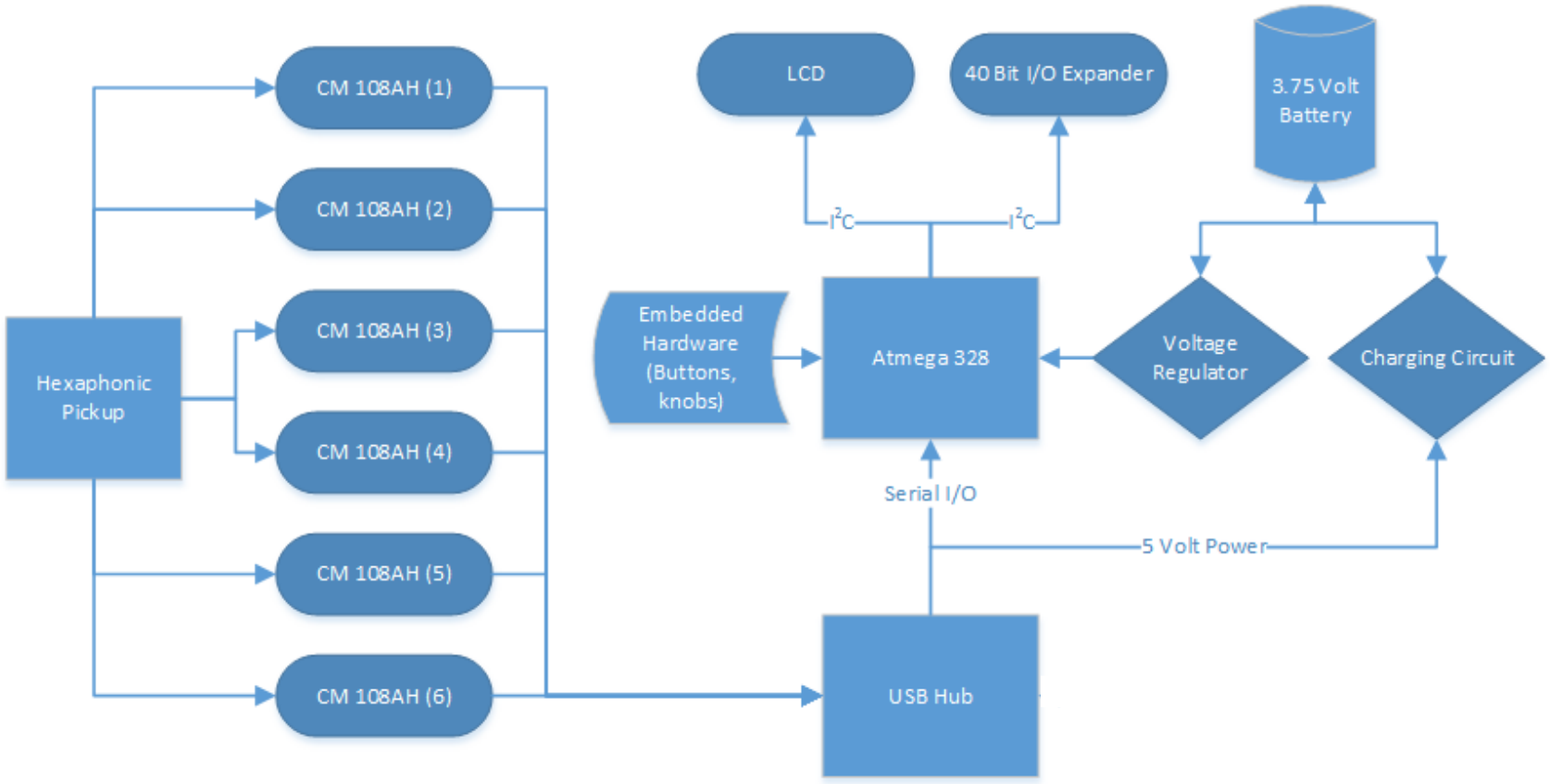
Embedded UI – Menu/File Tree



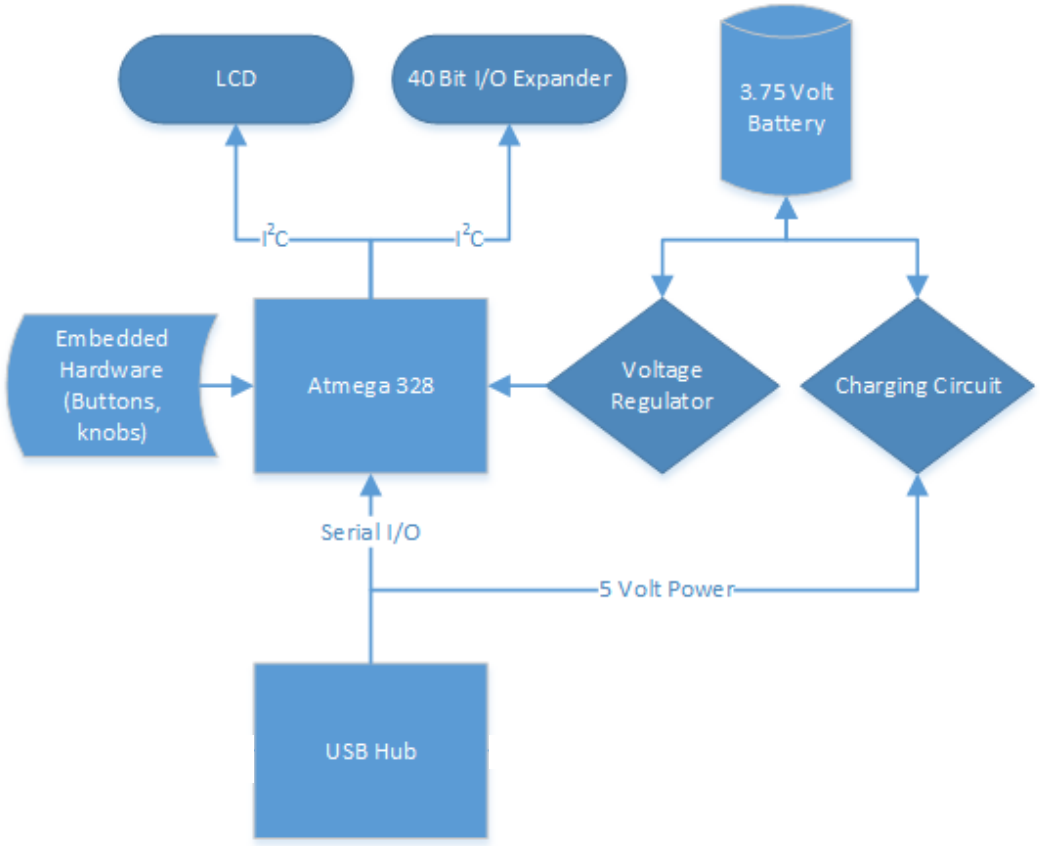
Embedded UI - Tuner



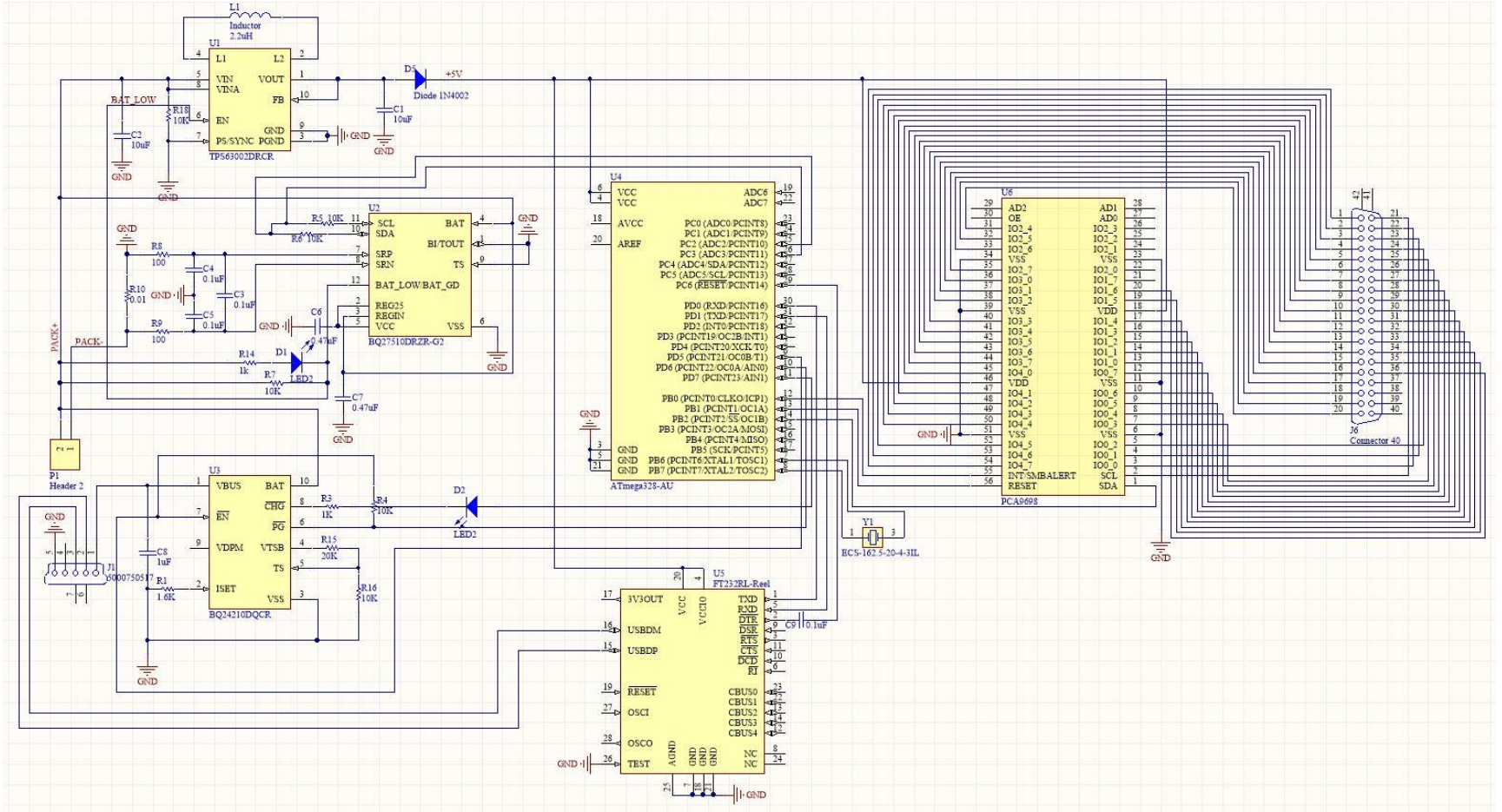
Guitar Hardware Architecture Overview



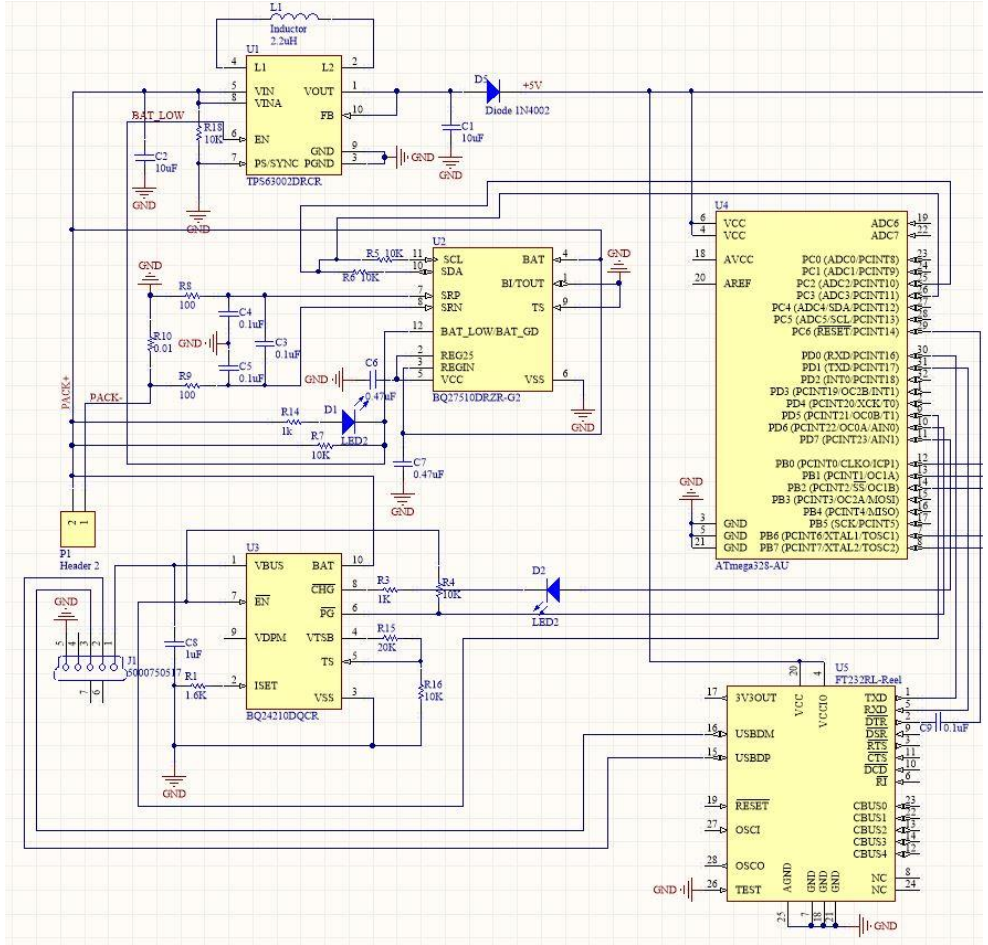
Guitar Hardware – Onboard PCB



Overall Control Board Schematic

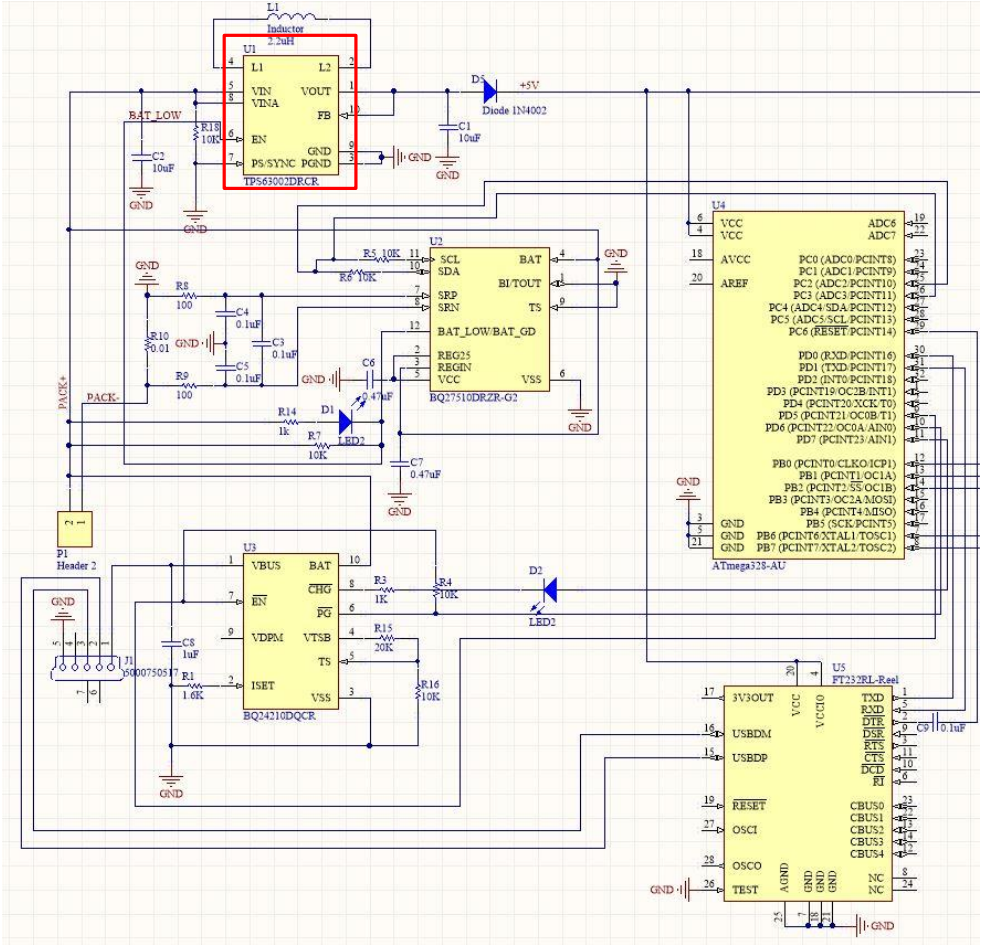


Charging System Schematic



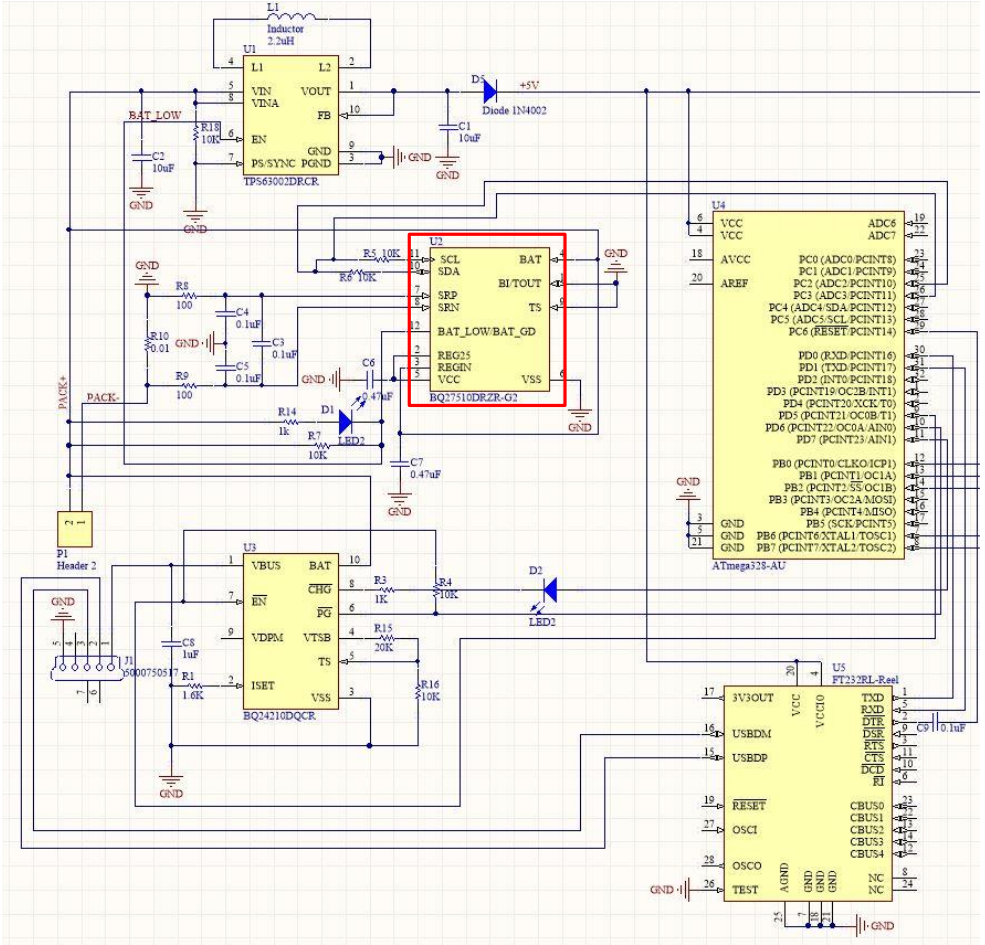
- TPS6300 – Buck/Boost Regulator
- BQ27510 – Fuel Gauge Detector
- BQ24210 – Battery Charger

TPS6300 – Buck/Boost Regulator



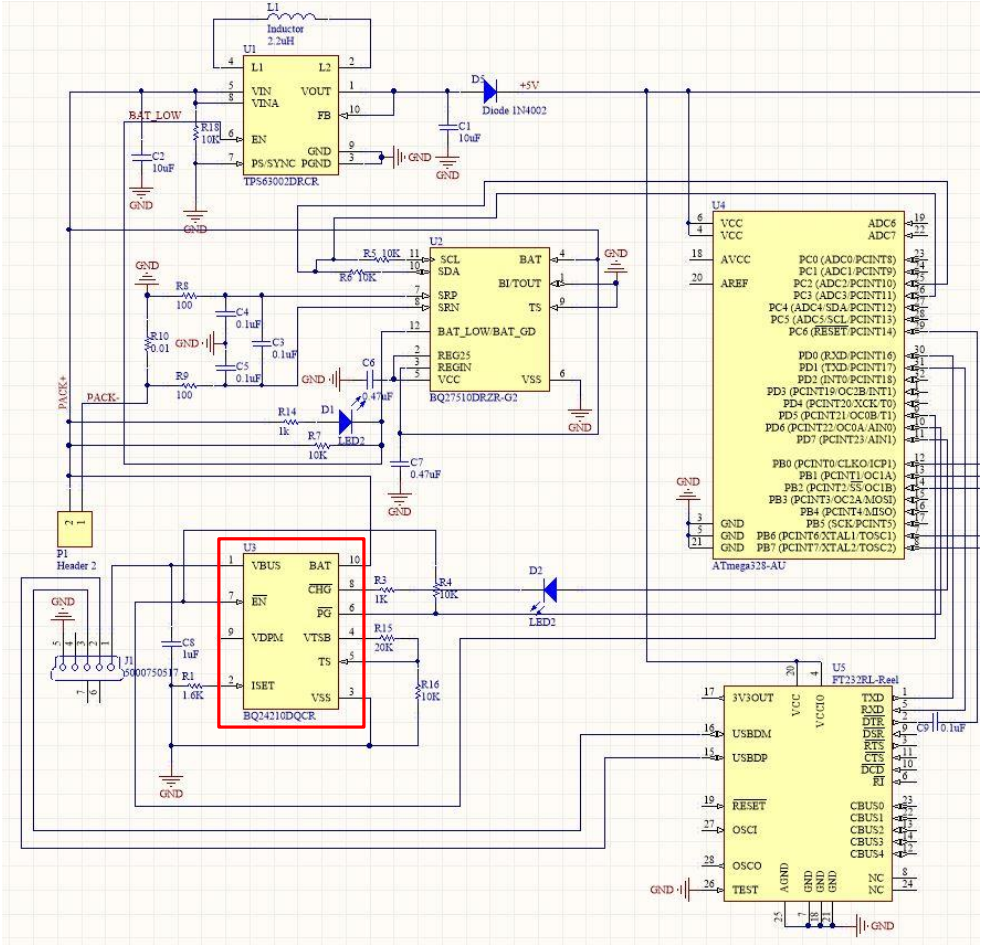
- Acts similar to a voltage regulator
- Has the ability to increase or decrease the input voltage
- Outputs 5V
- EN line is the enable input
  - 1 for enable, 0 for disabled
  - Gets signal from BAT_LOW line from Fuel Gauge Detector

BQ27510 – Fuel Gauge Detector



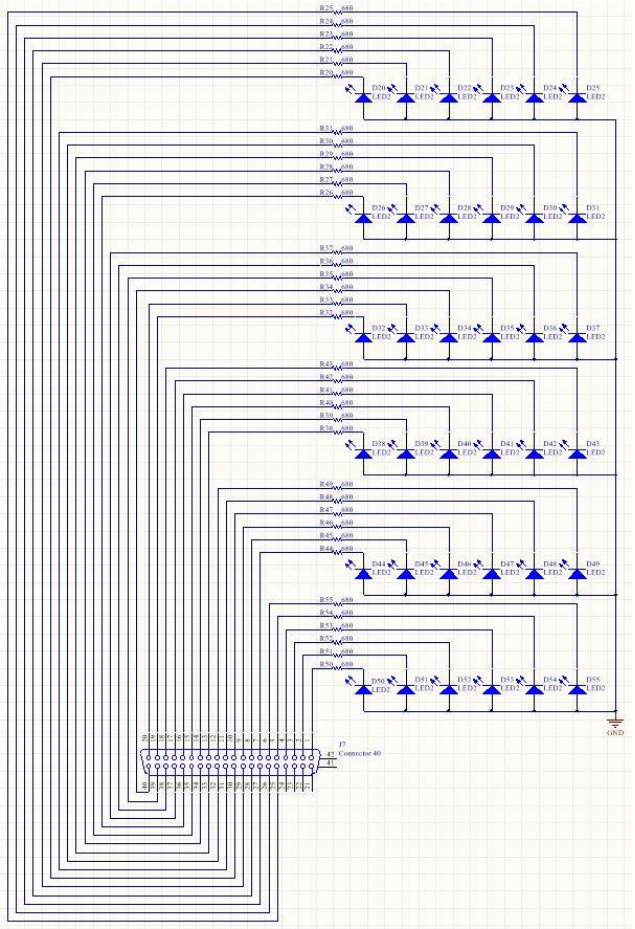
- The fuel gauge measures the cell voltage, temperature, and current
- When battery is low, an LED indicator is lit
- Also monitors charge and discharge activity by sensing the voltage across a resistor (R10)

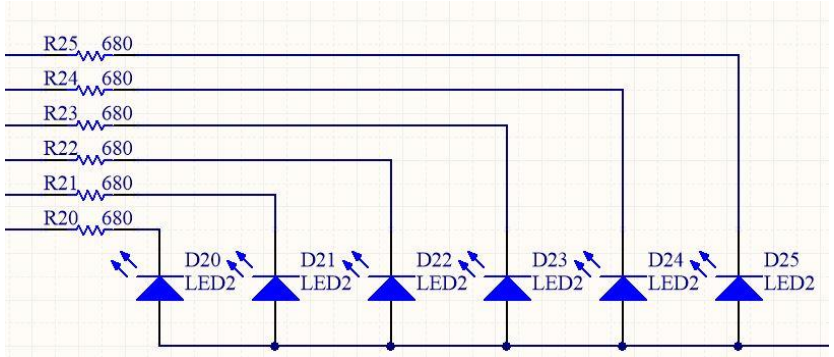
BQ24210 – Battery Charger



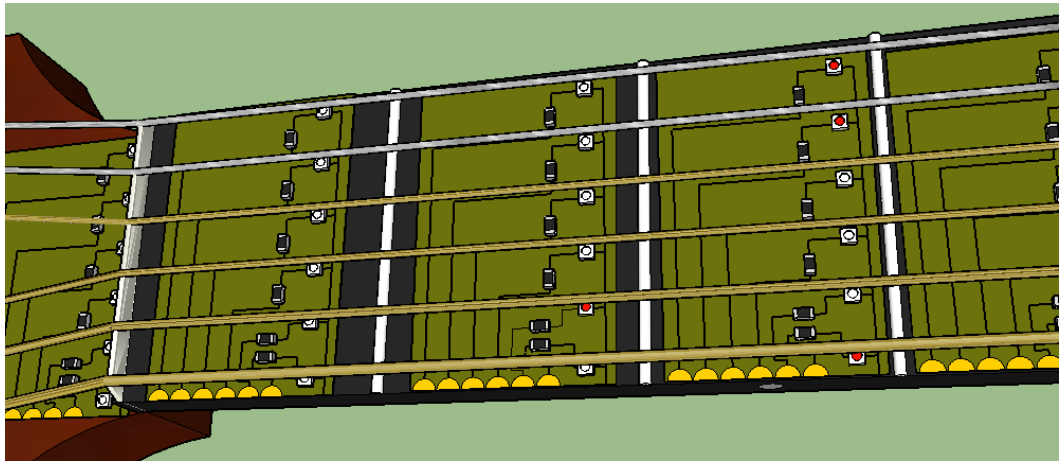
- Charges Lithium Ion battery from USB power cable
- The battery is charged in three phases:
  - Conditioning – Readies discharged battery
  - Package constant current – Fast charges
  - Constant voltage – Safely reaches max charge
- Internal control loop monitors the IC junction temperature and reduces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

Fretboard LED Schematic

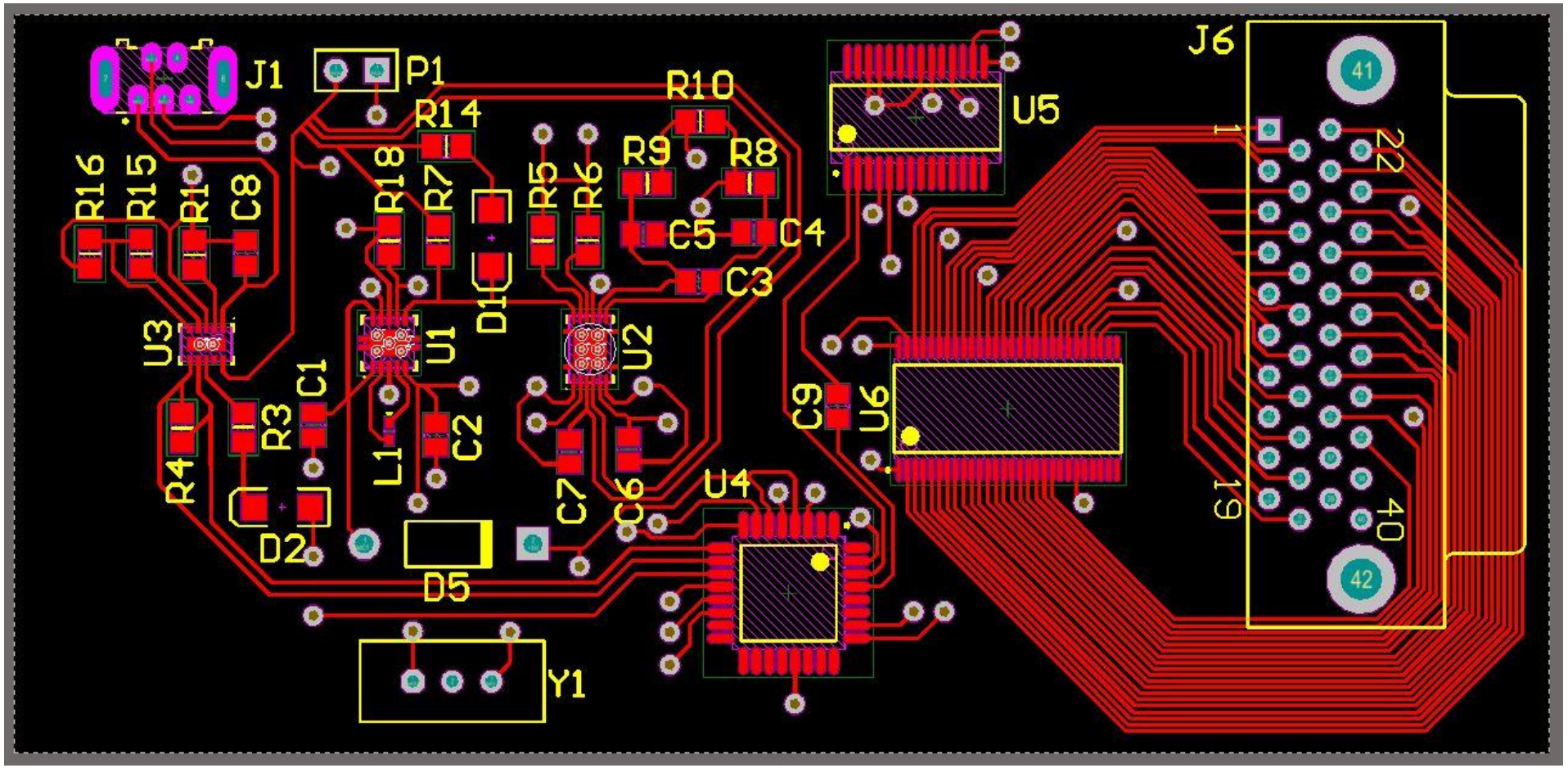




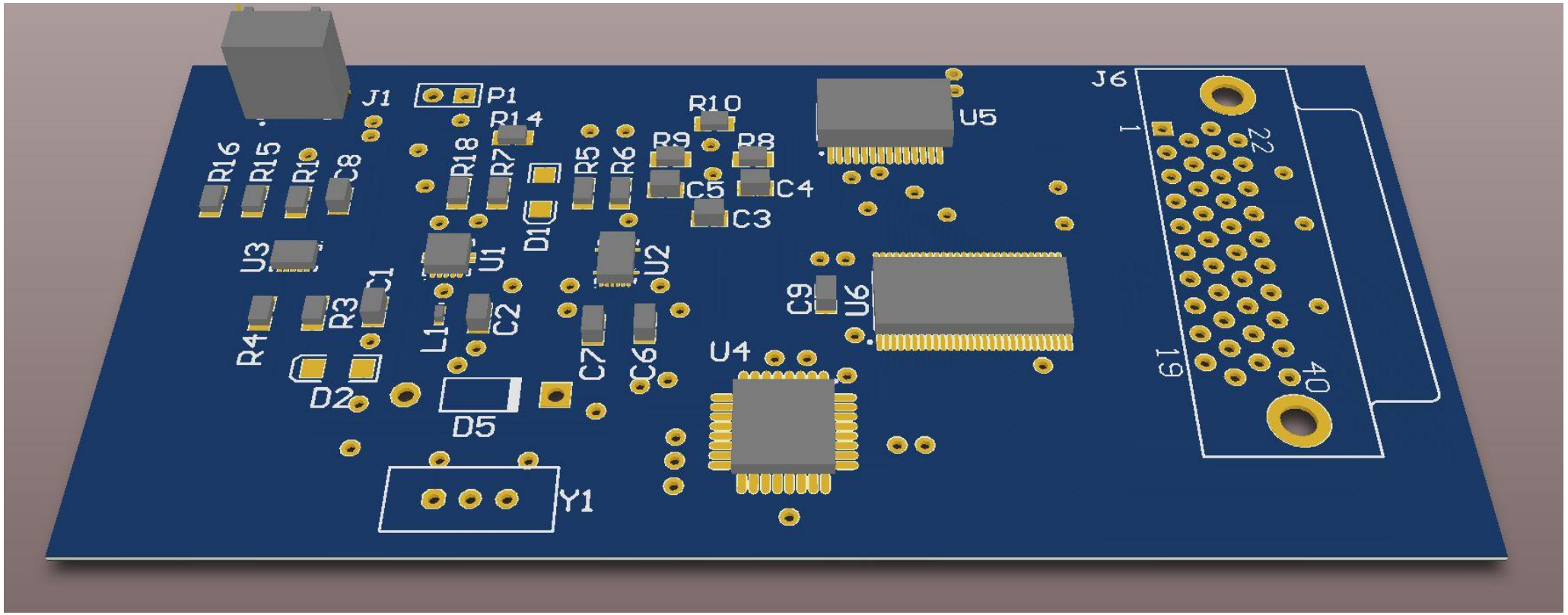
Single Fret



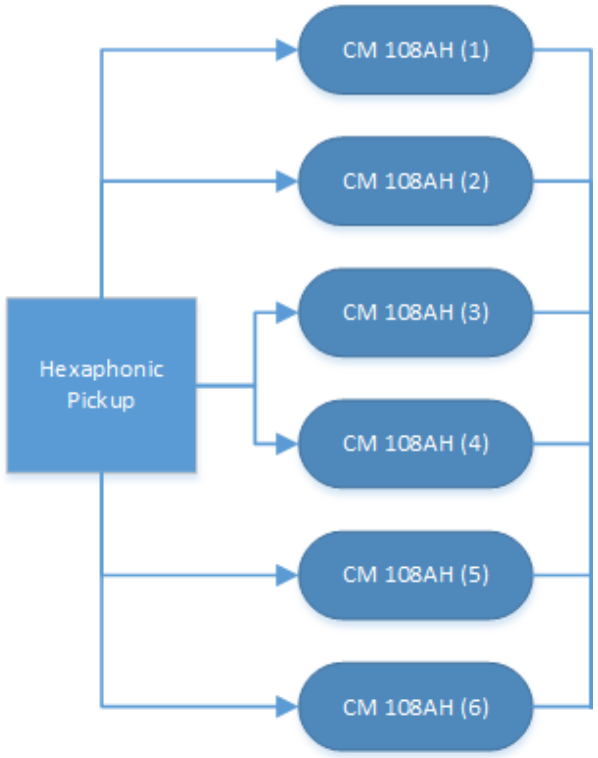
PCB Design (In Progress)



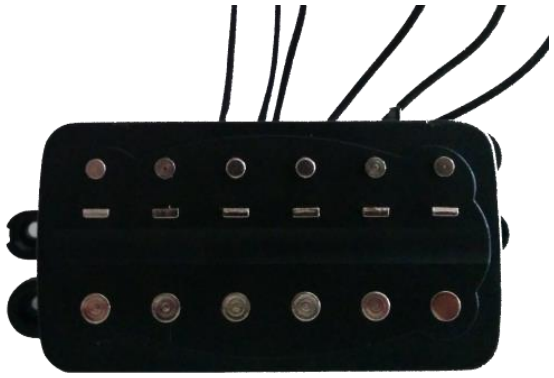
PCB Design – 3D Model (In Progress)



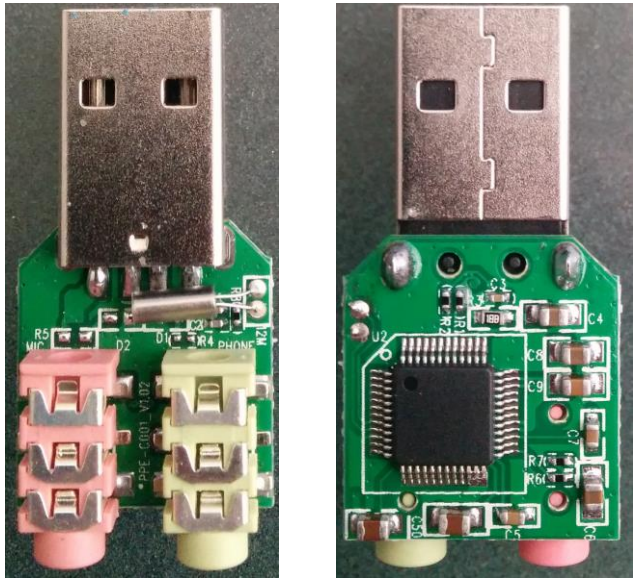
Pitch Detection Hardware



- 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

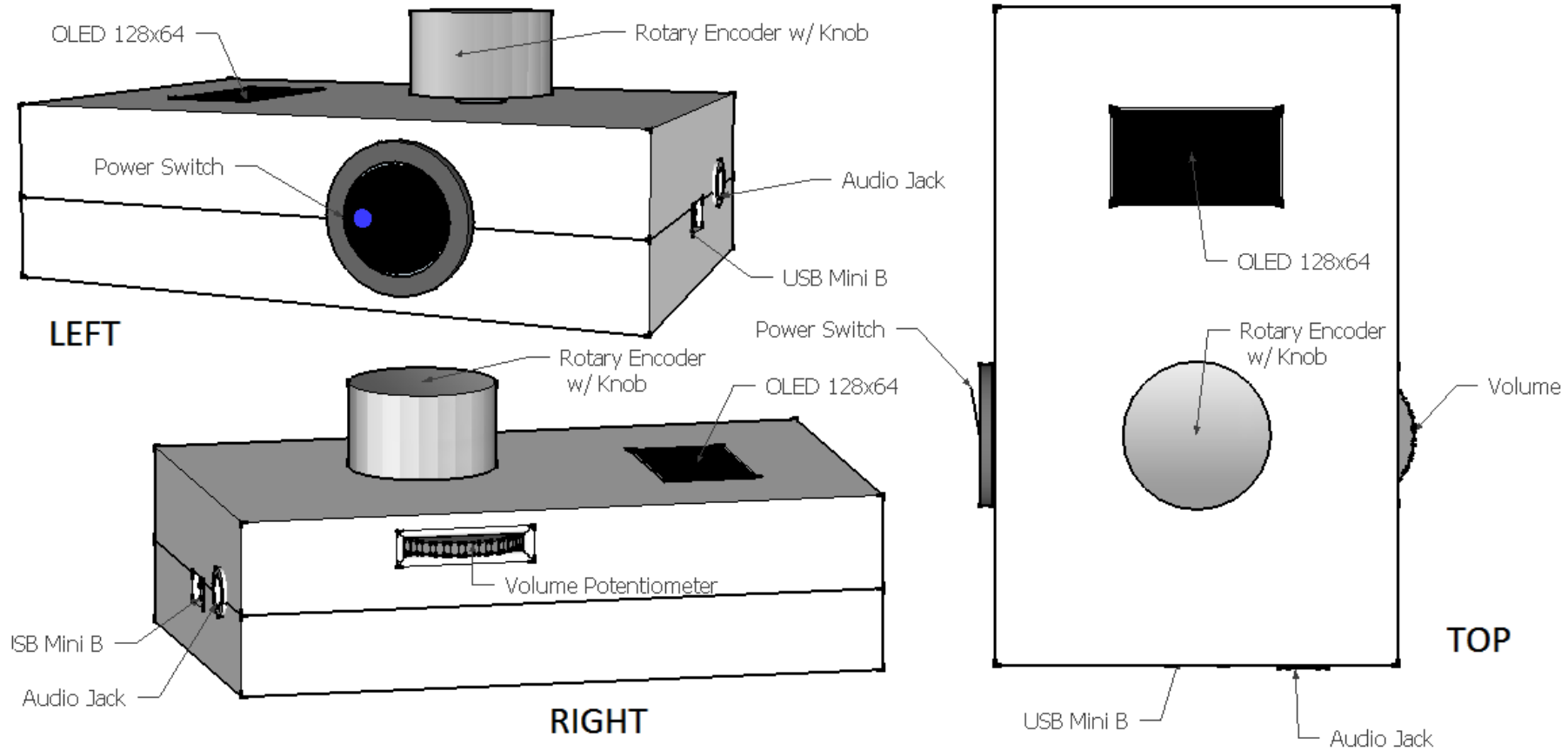


Hexaphonic Pickup



USB Sound Card (CM108AH)

Embedded Hardware Mockup



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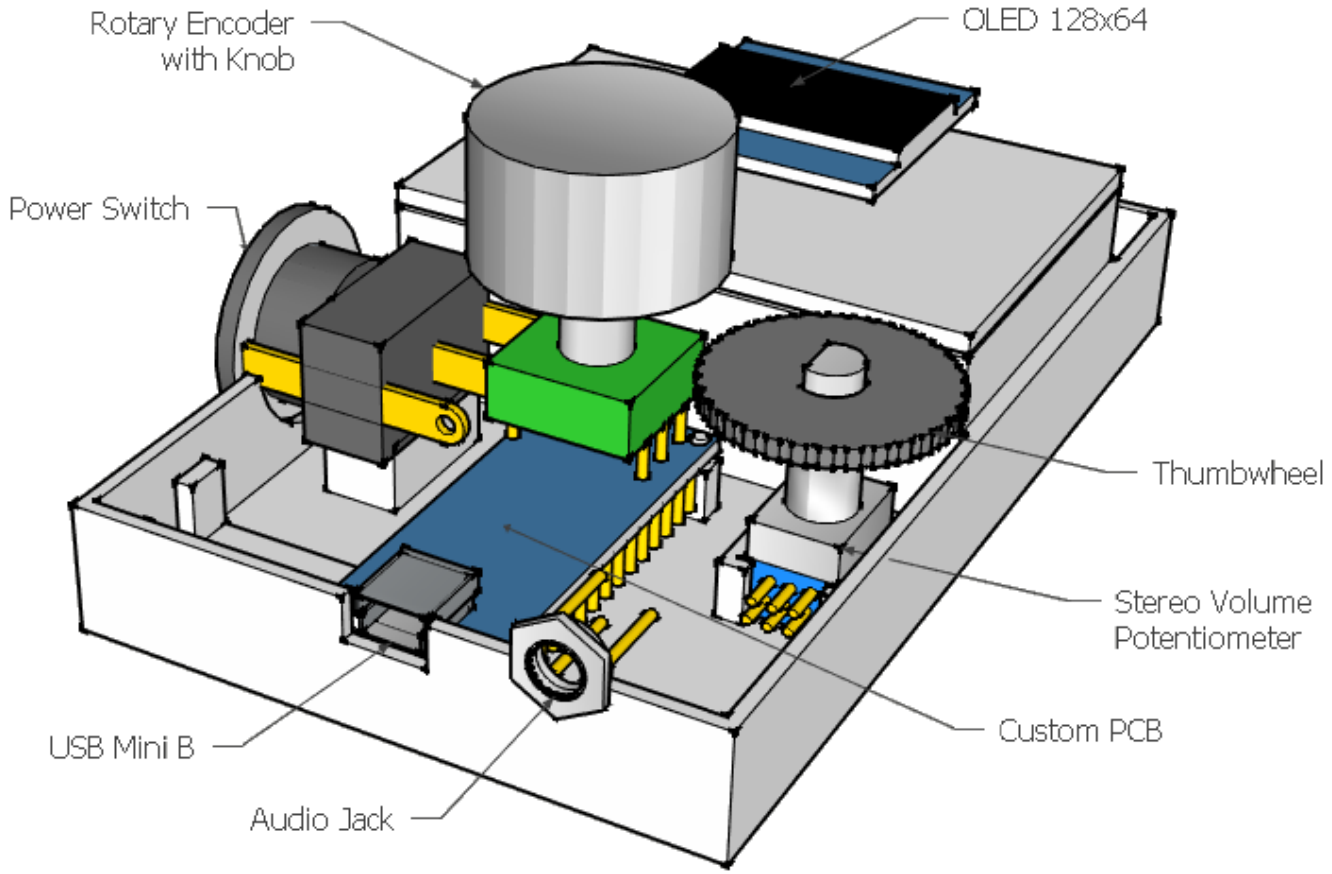
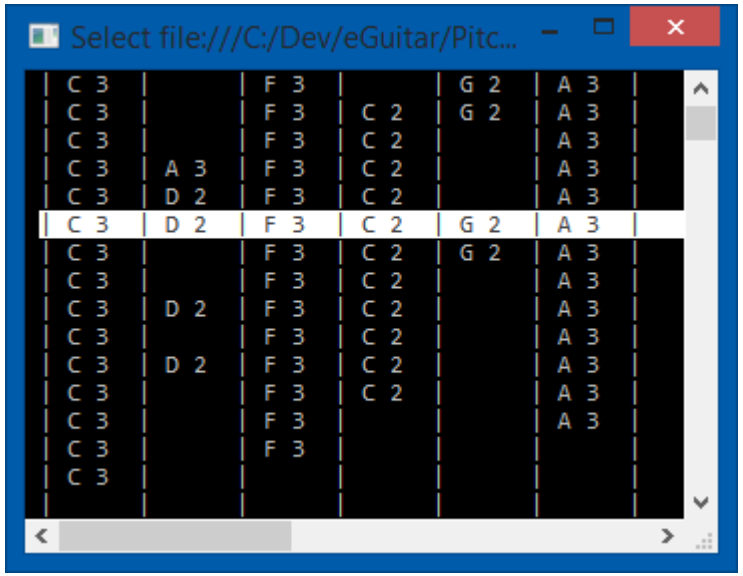


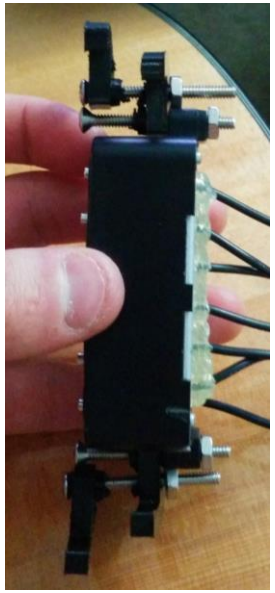
Prototyping

- 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



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

Project Successes

- Software-only subsystems have been successful and reliable
- Basic polyphonic pitch detection. Only needs minor improvements.
  - Initial DSP prototyping has shown feasibility
- Time management:
  - Staying ahead of things
  - Overall progress
- Morale is high and Hilton reservations have not been made

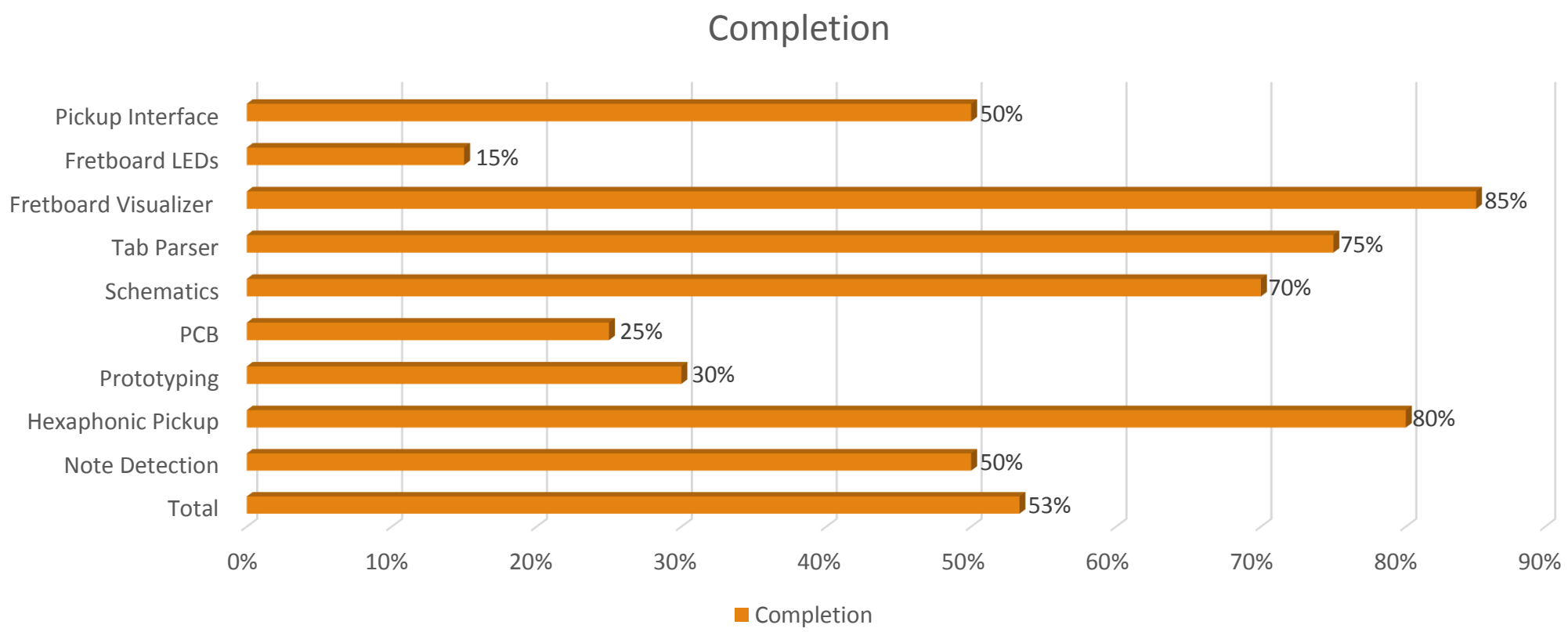
Expenses to date

Item	Quantity	Cost per Unit	Total Cost
TMDX5535EZDSP (TI ezDSP chip)	1	$115.53	$115.53
TSSOP-56 to DIP Adapter	2	14.99	$29.98
TSSOP-20 Breakout / Male headers	1	$28.58	$28.58
I/O Expander / MSP430G2553 / LEDs	1	$48.00	$48.00
Radxa Rock Light	1	$69.99	$69.99
USB sound card	8	$8.26	$66.10
568-1455-5-ND Analog Mux	3	$2.18	$6.53
USB 2.0 slim hub	2	$5.99	$11.98
Edimax EW-7811Un	1	$8.99	$8.99
5V 2A micro USB wall charger	1	$7.99	$7.99
8GB micro SDHC card Class 10	2	$6.99	$13.98
ODROID-C1	1	$36.95	$36.95
		Total:	**$444.60**

Budget – Current Iteration Build 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 / MSP430G2553 / LEDs	1	$48.00	$48.00
USB sound card	6	$8.26	$49.58
USB 2.0 slim hub	2	$5.99	$11.98
Printed Circuit Board	1	$100.00	$100.00
Ribbon Cabling	1	$45.00	$45.00
Lithium Ion Battery	1	$4.95	$4.95
Surface Mount LEDs	36	$0.56	$20.16
		Total:	**$351.67**

Progress


Completion
Pickup Interface
Fretboard LEDs
Fretboard Visualizer
Tab Parser
Schematics
PCB
Prototyping
Hexaphonic Pickup
Note Detection
Total
50%
15%
85%
75%
70%
25%
30%
80%
50%
53%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
Completion

Going Forward

- Untethered Mode
  - SD Card support on PCB
  - Battery/charging prototyping
- Software Improvements
  - Tab complexity support
  - DSP cleanup -- noise reduction and signal isolation
  - Usability and interface tweaks
- PCB Development
  - Get initial Altium designs printed and tested
  - Iterate as necessary