uTune Design Review 1

02/04/19

Contents

Microcontroller

Control peripheral components, compute FFT, motor control

dsPIC33FJ32GS606
    DSP, 40MHz operating frequency, efficient, 10-bit ADCs, PWM outputs

Connections: VDD, VSS, AVDD, AVSS, VCAP, pickit

Operating Voltage: 3.0-3.6V

Pickit: MCLR, VDD, ground, PGEDx, PGECx, and LVP

Different versions of the same chip?

Microphones / Pick-Up

- Accurately capture guitar audio, send to microcontroller
- InvenSense ICS-40619
  - Size: 3.5 x 2.65 x .98 mm
  - MEMS, Omnidirectional
  - Frequency Range: 50 Hz - 20 kHz
  - Supply Voltage
    - High Performance Mode: 2.2V - 3.63V
    - Low Power Mode: 1.52V - 2.0V
  - Supply Current
    - V_{DD} = 2.75V : 165µA - 190µA
    - V_{DD} = 1.80V : 55µA - 65µA
  - Sensitivity: -38 dBV
  - SNR: 67 dBA
  - Acoustic Overload Point: > 129 dB SPL
  - Analog Output, Balanced for Noise Reduction

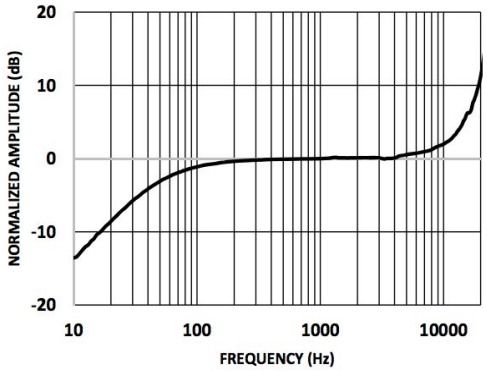


Figure 3. Typical Frequency Response (Measured)

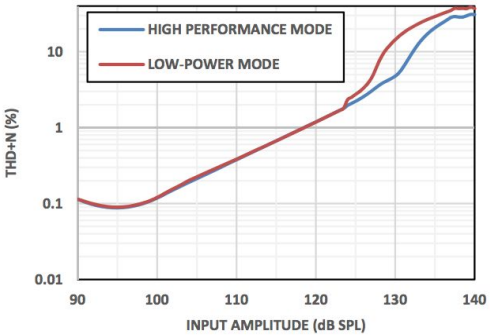
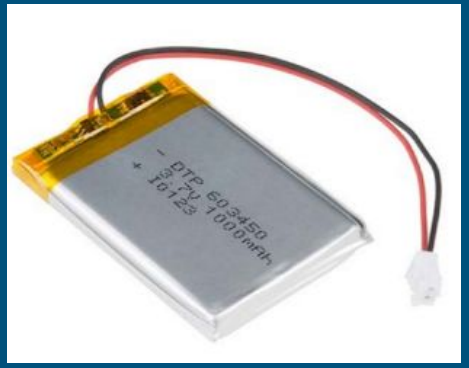
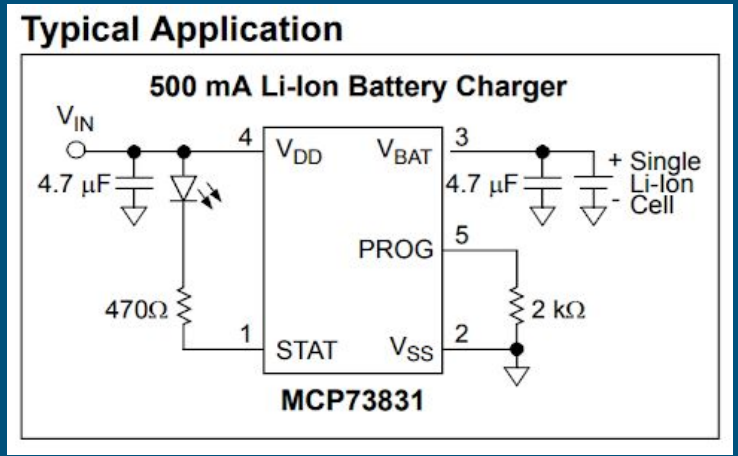


Figure 4. THD + N vs. Input Level

Power Subsystem 1

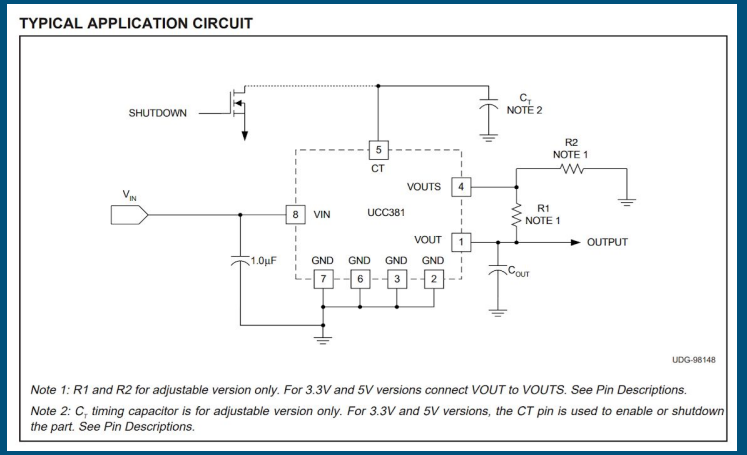


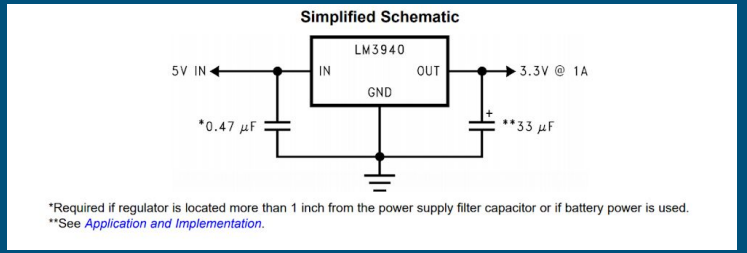
- Lithium-ion battery
  - Power consumption estimate assumptions:
    - Each motor uses 100mA * 5V = 0.5W (conservatively)
    - The rest of the device draws no more than 50mA*5V = 0.25W
    - Perform 100 tuning sequences without recharging
    - Each tuning sequence takes 10 seconds,
    - Implies 3.75Wh of capacity to run the motors.
    - 3.75Wh ~= 1000mAh battery @ 3.7V.
    - If we use 2x 3.7V Li-ion @ 1000mAh = PLENTY
- Linear Charge Management Controller IC
  - Will provide necessary quick-charging solution
  - Programmable output voltage/current
  - Will require additional regulator to achieve what we are hoping for
  - Will work in conjunction with a simple red LED low-battery indicator
  - Will use micro-USB power source



Power Subsystem 2

- Voltage Regulators
  - 5V Regulator
    - Chose fixed regulator with low quiescent current (650uA)
    - High current output capability (>1A with 0.5V dropoff at 1A)
    - Will need to adjust resistor values slightly to set output level
  - 3.3V Regulator
    - Will require a 5V input
    - Designed for low voltage drop off at low current
    - Minimal external components required
    - Can withstand high currents if necessary to supply the non-motor portion of the device with the correct voltages





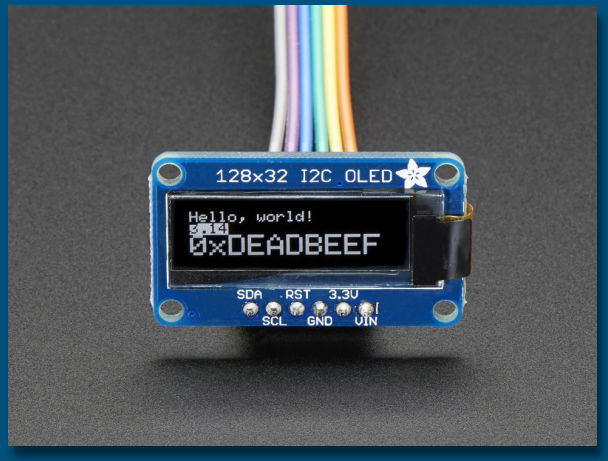
Power: Key Parts List

1. Li-ion Battery: 1568-1492-ND
    a. https://media.digikey.com/pdf/Data%20Sheets/Sparkfun%20PDFs/PRT-13813_Web.pdf
    b. Quantity: 2
2. Recharging IC: MCP73831T-2DCI/OT
    a. http://ww1.microchip.com/downloads/en/DeviceDoc/20001984g.pdf
    b. Quantity: 1
3. 3.3V Regulator IC: LMS8117AMP-3.3/NOPBTR-ND
    a. http://www.ti.com/lit/ds/symlink/lm3940.pdf
    b. Quantity: 1
4. 5V Regulator IC: BD50HC0WEFJ-E2-ND
    a. https://media.digikey.com/pdf/Data%20Sheets/Texas%20Instruments%20PDFs/UCC281-x_381-x.pdf
    b. Quantity: 1

OLED Screen

- Function: allows the user to program and utilize the device without an iPhone, although with limited functionality and options vs. the app.
  - Set and store tuning patterns
  - Initialize or abort tuning procedure
  - See some real-time tuning feedback

- Required Connections:
  - SDA (I2C Data)
  - SCL (I2C CLK)
  - RST
  - GND
  - 3.3V (or use VIN if 5V source)

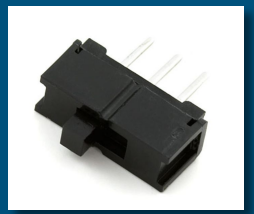


OLED Screen

- Requirements:
  - 3.3 or 5V
  - Draws approximately 20mA of current (depends on display)
  - >512 bytes of RAM on microcontroller

- Programming:
  - I2C *only*
  - Extensive Adafruit support documentation + large GitHub collection of sample projects and code

- Buttons
  - Select/Next
  - Up
  - Down
  - Power



iPhone App

- Serves as the easiest and most general interface between the user and uTune
- User can select or create pre-programmed tuning schemes to be tuned to
- Will also contain a uTune battery indicator
- App will be written in **Swift** (language for iOS apps) through **Xcode IDE**
- During tuning, the app will show a progress display:
  - The 6 target notes will be shown on meters, comparing the current state of tune to the desired state
- **Table Views** will be used to display tuning schemes (Apple iOS standard)

iPhone App: Bluetooth Low Energy vs. WiFi

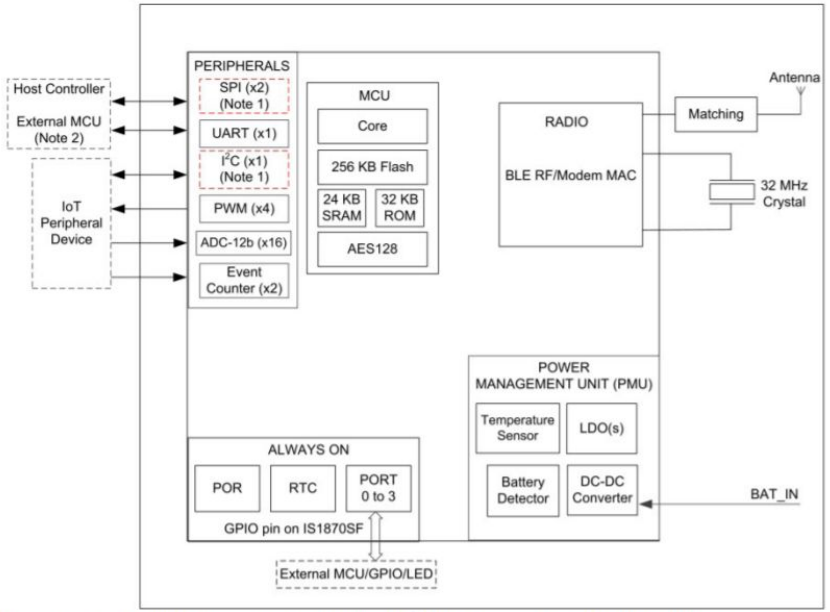
- Bluetooth Low Energy (BLE) provides distinct advantage in terms of power management, which is a concern of ours since we have to drive 6 motors ~simultaneously
- WiFi provides an enormous advantage in speed relative to BLE (100-250 Mbps compared to BLE's 1 Mbps)
    - However, WiFi is better suited for **streaming** or other applications in which a lot of data needs to be sent quickly
    - Because we aren't streaming music, we only need to send a tuning choice before operation and occasional sensor readings (6 numbers for FFT peaks), so BLE makes more sense

iPhone App: Bluetooth Connection

- Bluetooth Chip: Microchip IS1870
  - BLE capability
  - 1.9V - 3.6V operating range (contains same range as dsPIC microcontroller)
  - At 3.0V from battery, average currents:
    - TX: 3.87 mA
    - RX: 3.06 mA
  - Max current out of any pin: 12 mA
- Communication:
  - Uses UART to communicate with dsPIC MCU
  - Communicates with iPhone with Bluetooth LE 5.0 (or 4.2) and Core Bluetooth developer package from Apple
    - iPhone = **Central**; IS1870 = **Peripheral**

Microchip IS1870

FIGURE 1-1: BLOCK DIAGRAM OF THE IS1870 SOC



Note 1: Users can enable other peripheral (SPI and I^{2}C) functions of the IS1870/71 IC by changing the default factory firmware. For more details, contact local Microchip representatives.

2: An external host MCU is required when using the default factory firmware.

Motors

Adjust tuning pegs using 3D printed attachments

Ximimark 360° continuous servo

Connections: power, ground, signal

Operating Voltage: 4.8-6V

Operating Current: 65mA

Control Signal: 50Hz PWM

Unsolved Problems

- Microphones
  - Finding individual string frequencies with single microphone approach
  - Effect of guitar body vibrations on detected signal
- Physical Build
  - Once all major components are acquired the build design will be resolved
- Implementing an FFT on a dsPIC
- Creating iPhone app graphics to allow for a meter display on iPhone
- Best method of safely securing a Li-ion battery to the uTune apparatus

Website Demo

http://seniordesign.ee.nd.edu/2019/Design%20Teams/tuner/index.html