



Bluetooth Stereo Network

ECE 445 – Senior Design Lab

Final Presentation

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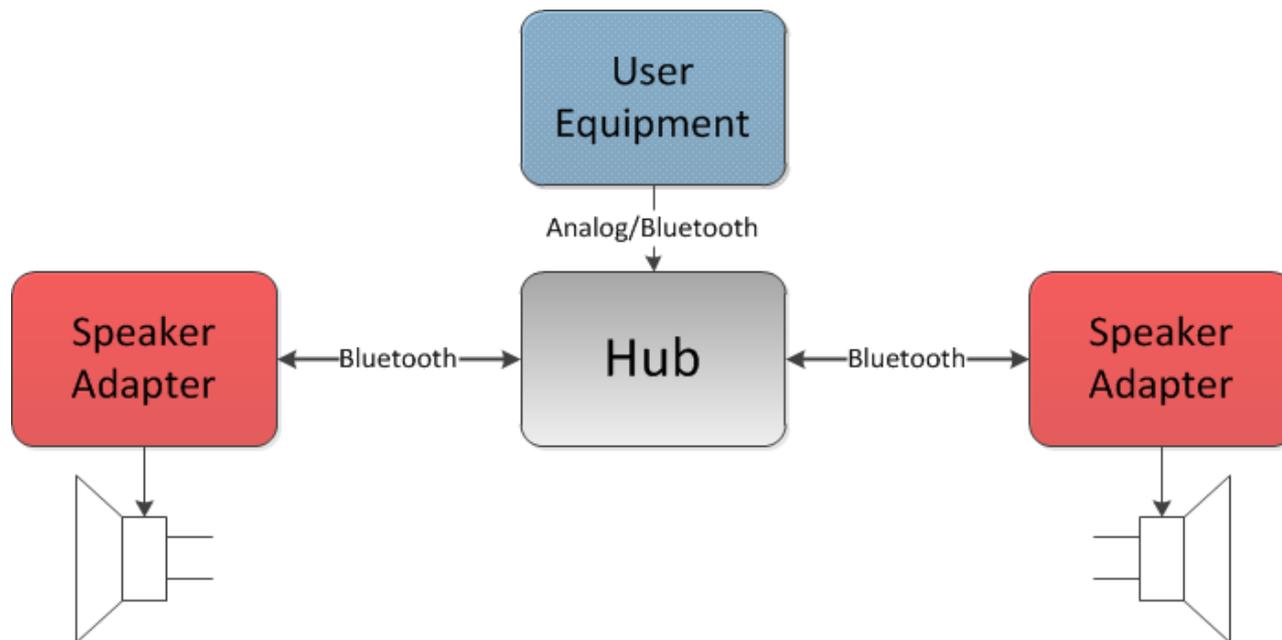
Rishi Ratan

Prof. Andrew Singer, Prof. Brian Lilly

TA: Justine Fortier

Objective

- Network of Bluetooth speakers
 - Play music to speaker closest to user
 - User's device streams to central hub



Features

- Smooth handoff when moving between rooms
- No additional software needed on the phone
- Plug-n-play UX

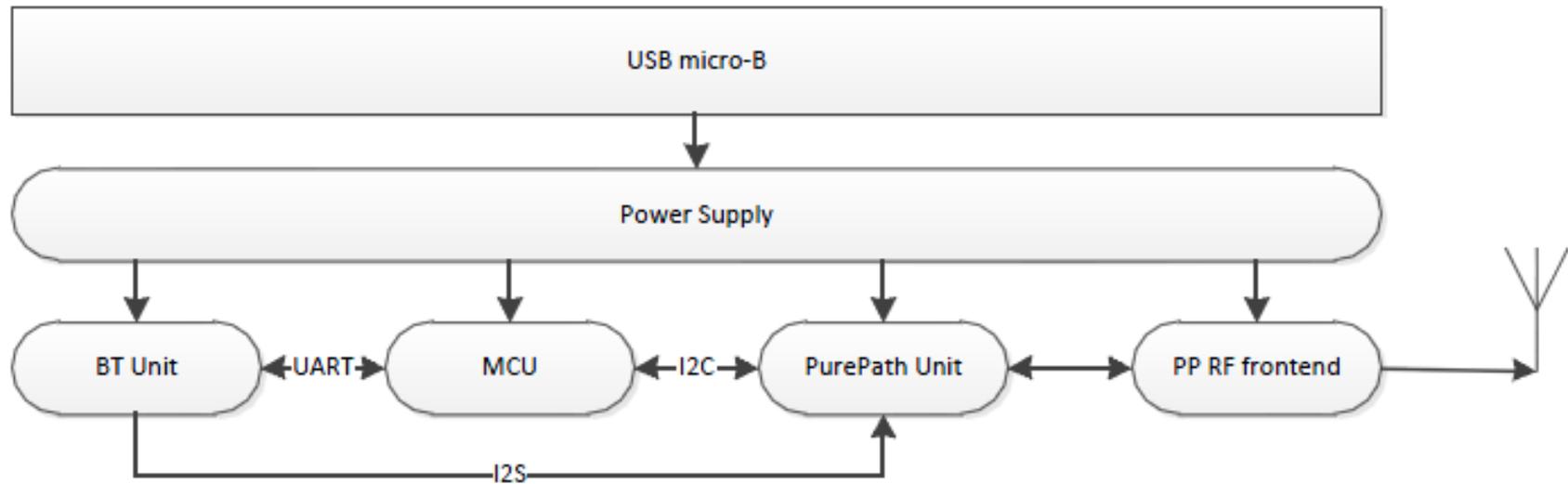




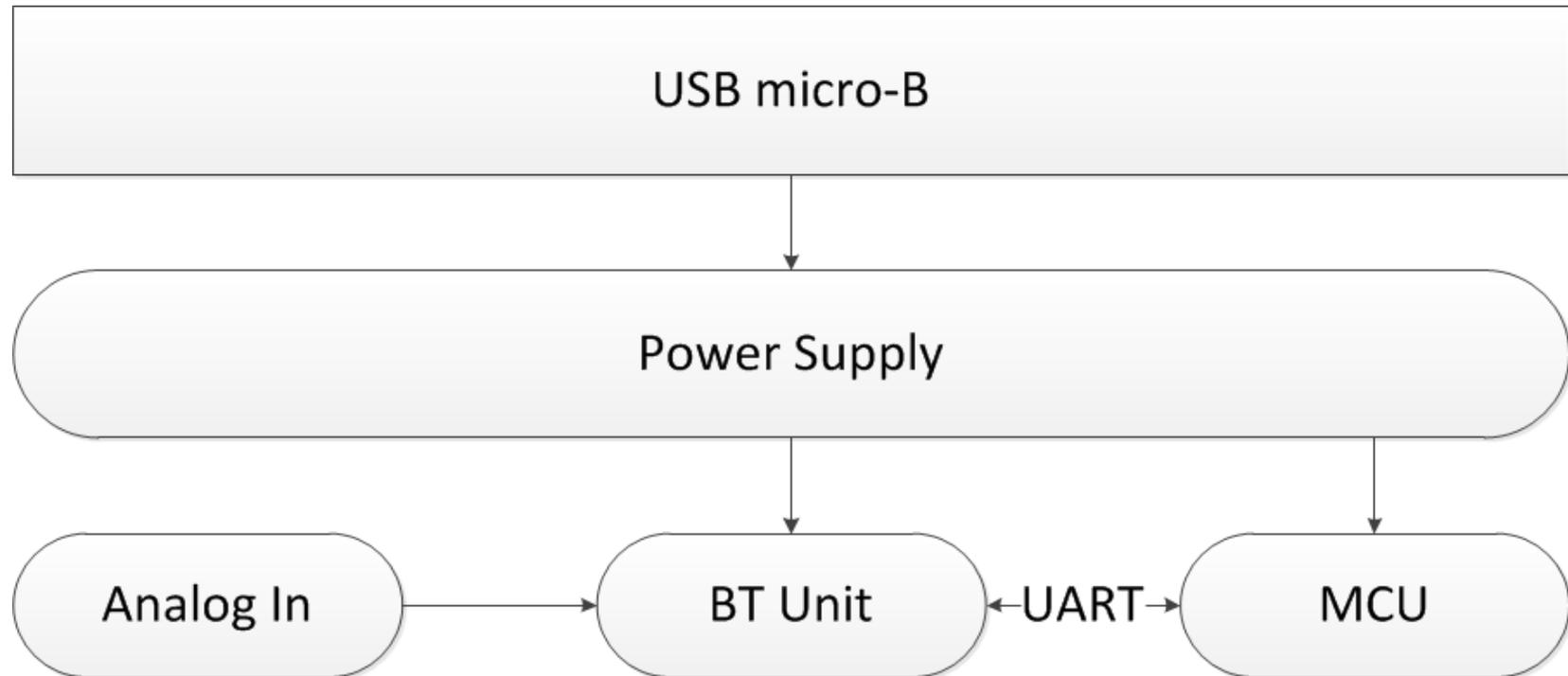
System Overview



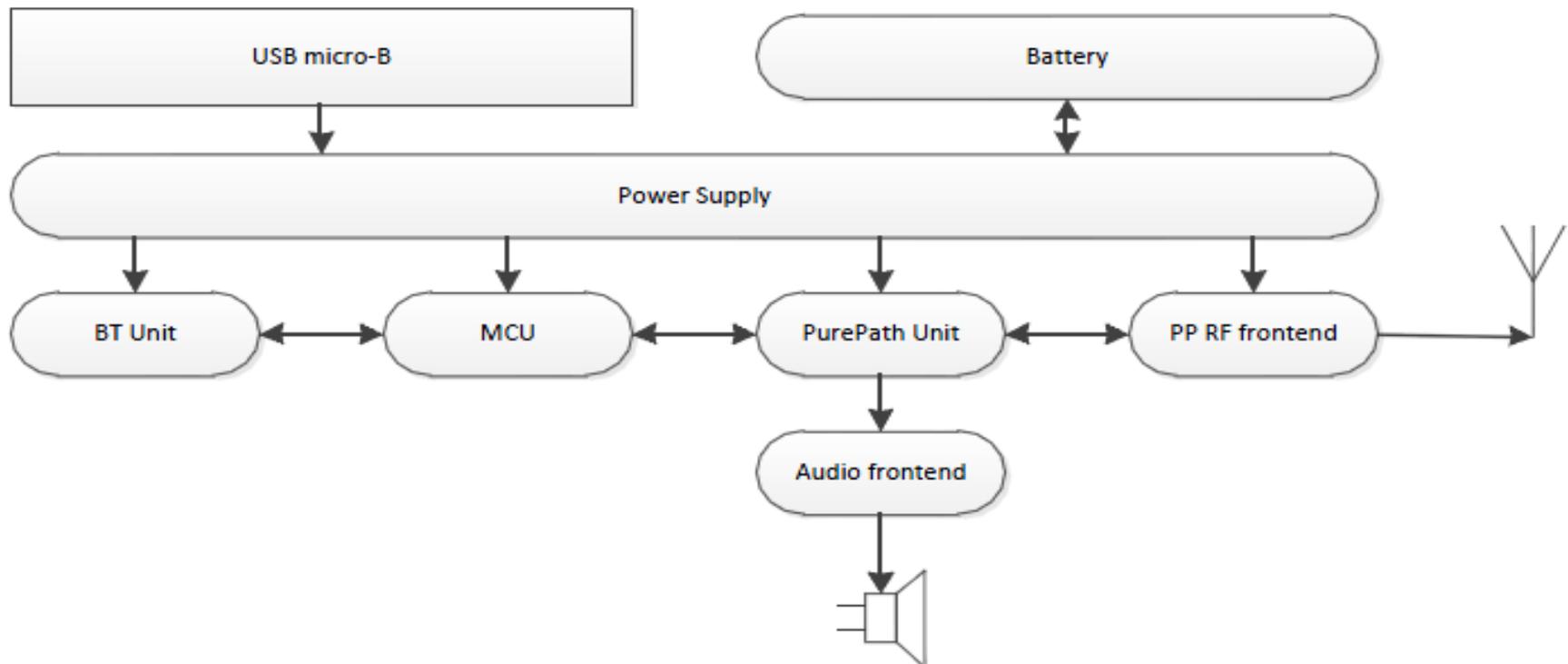
Old Hub



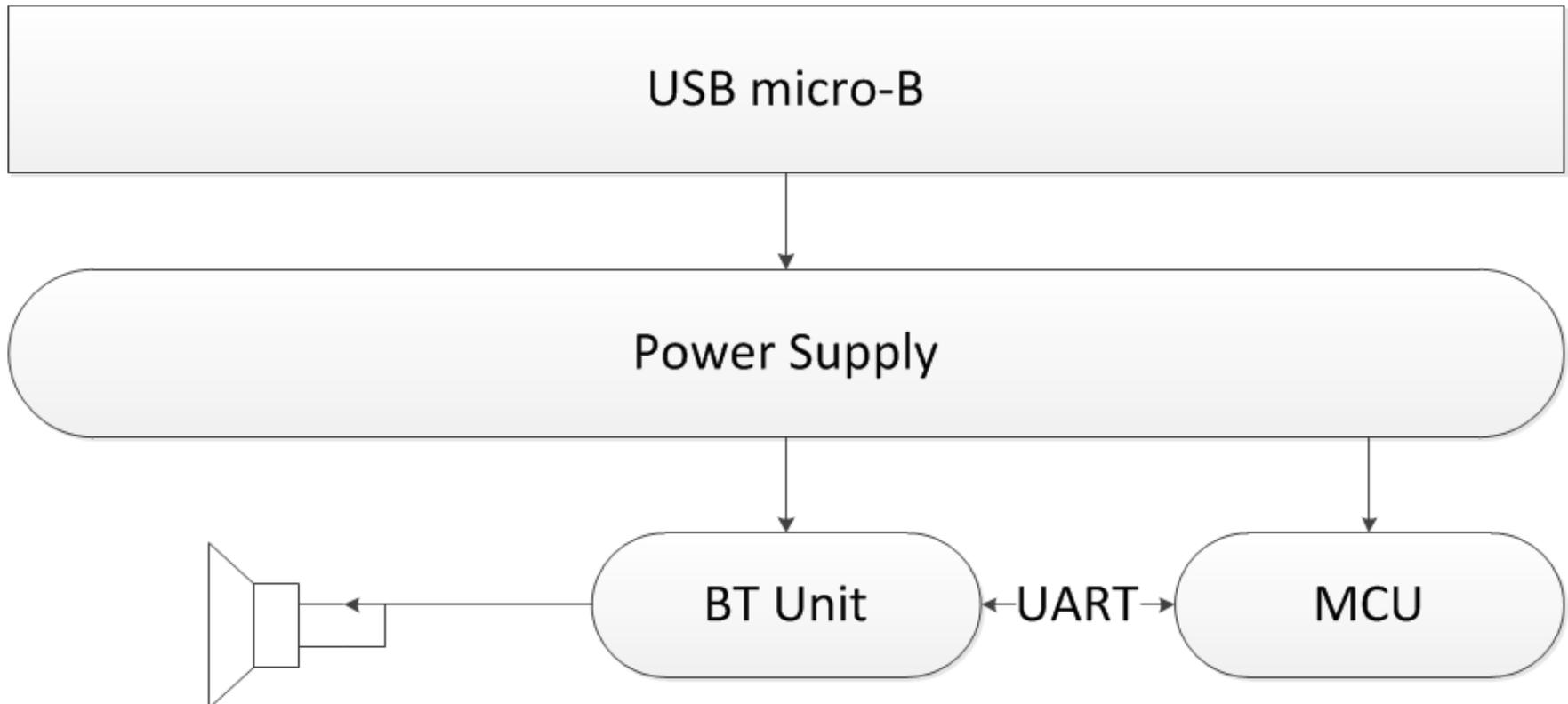
New Hub



Old Speaker Adapter



New Speaker Adapter



Requirements and Verification

Requirements

1. MCU Interface
2. BT IC Interface
3. Receive RSSI values seen by speaker adapters on hub
4. Battery Charger Implemented

Testing

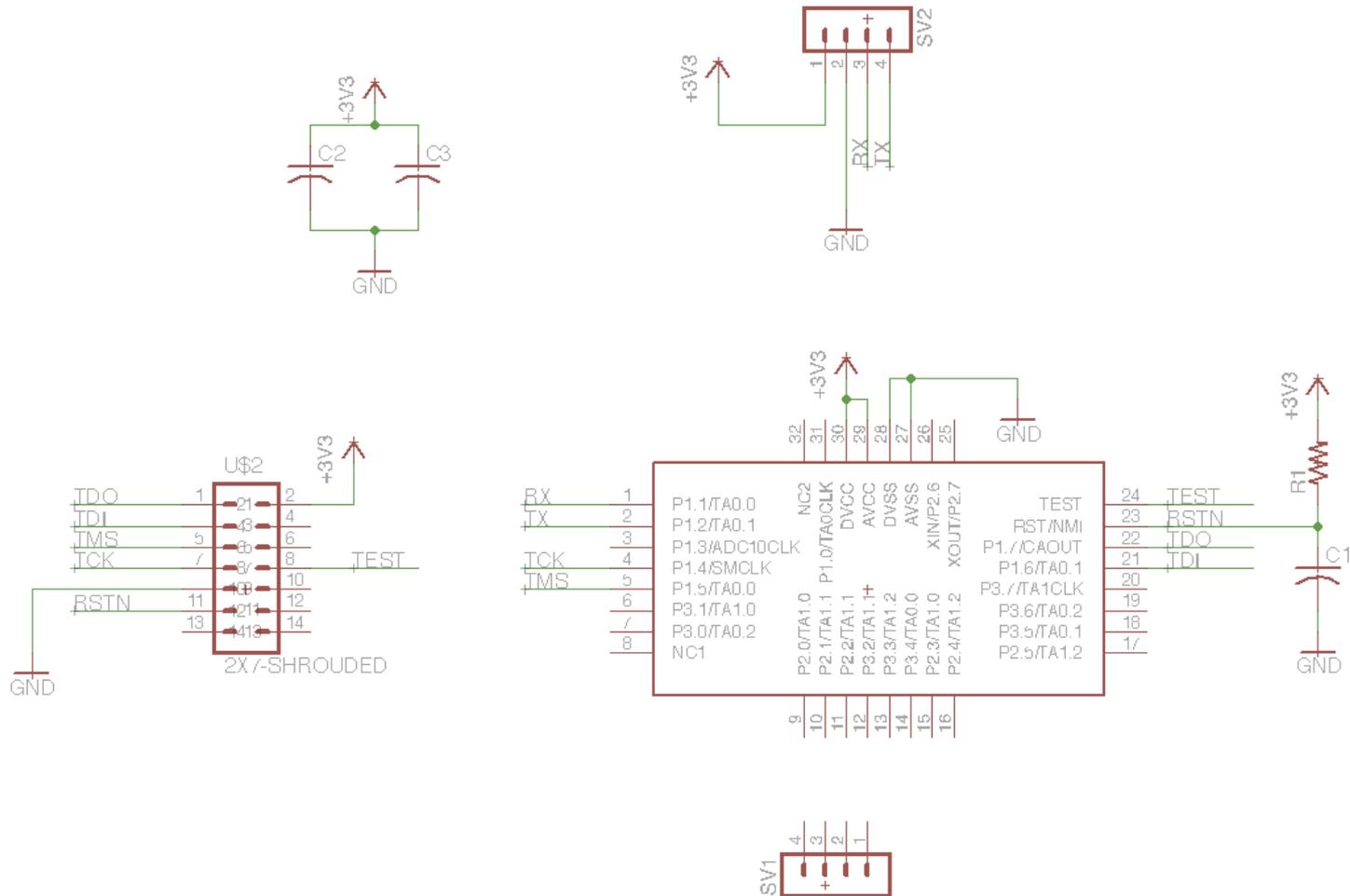
1. Interface with BT IC via UART, observed using BP
2. Test A2DP connection with UE and analog audio playback
3. Observe RSSI data through BP and audio playback switching
4. Tested using oscilloscope current probes



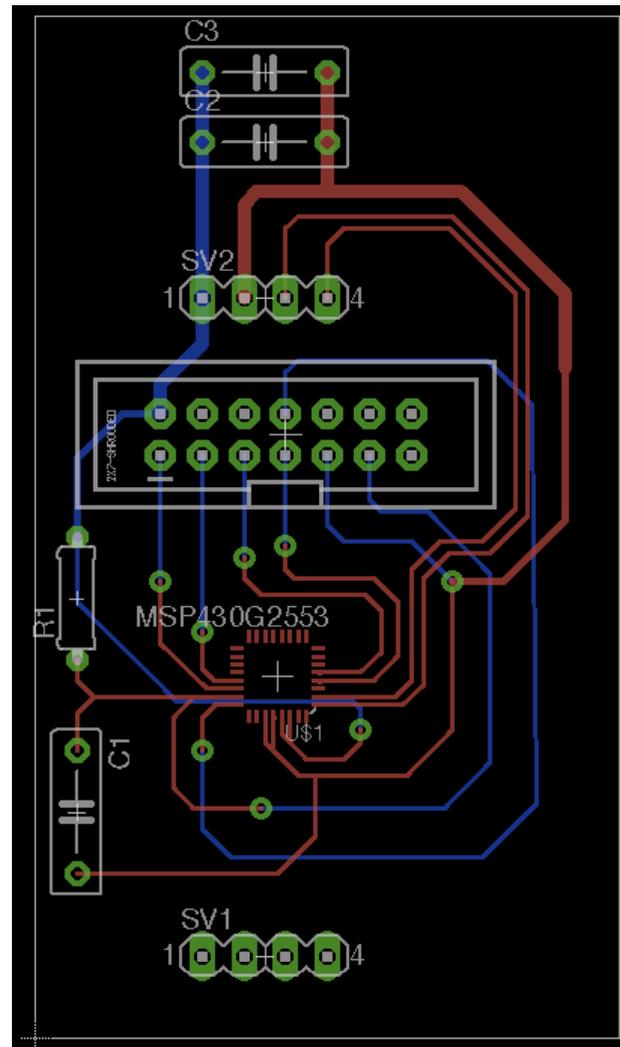
Reqs + Verification Changes

- Removed all PurePath
- Moved battery charging onto BT block
- Removed superfluous analog ASICs

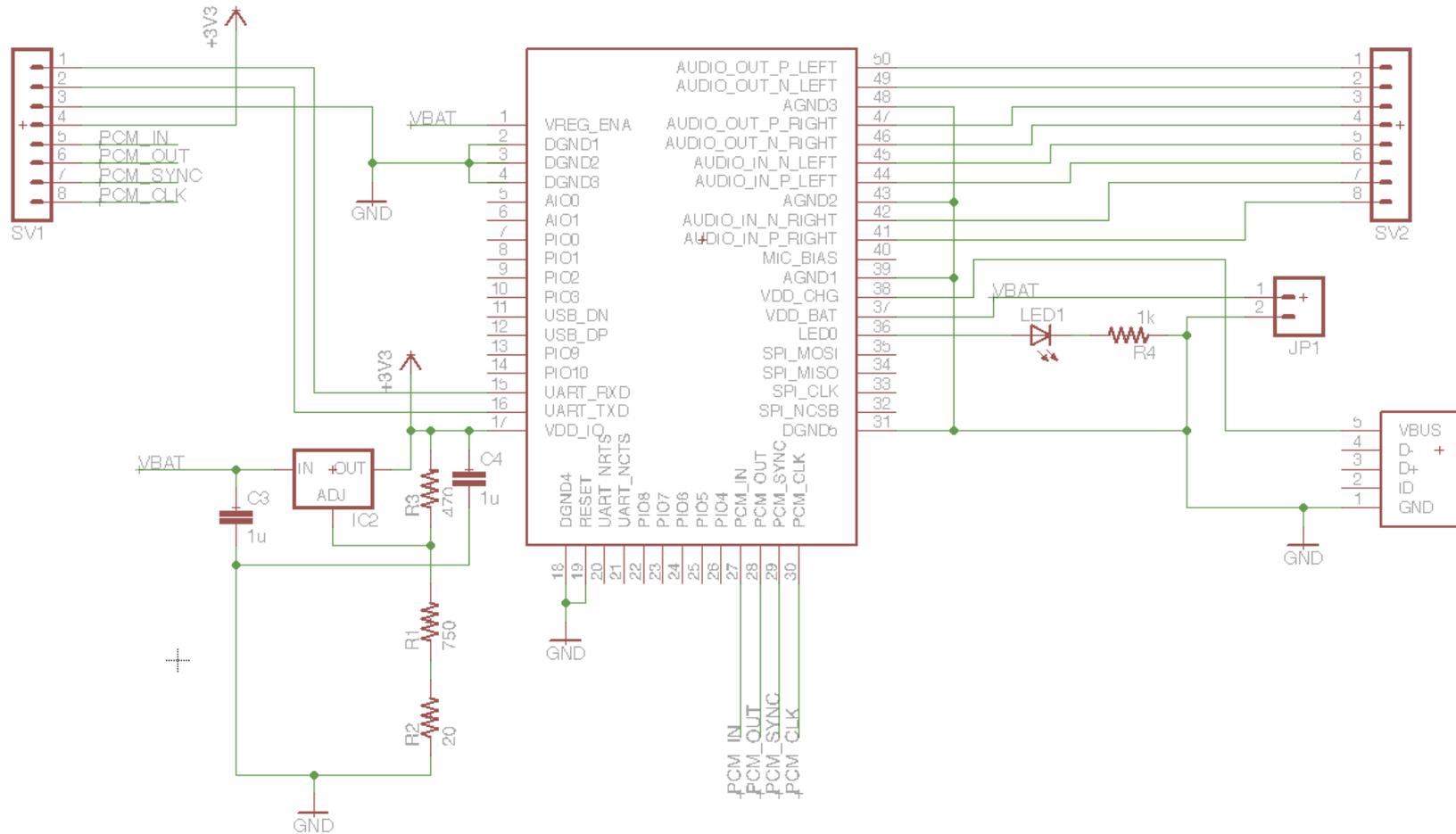
MCU Schematic



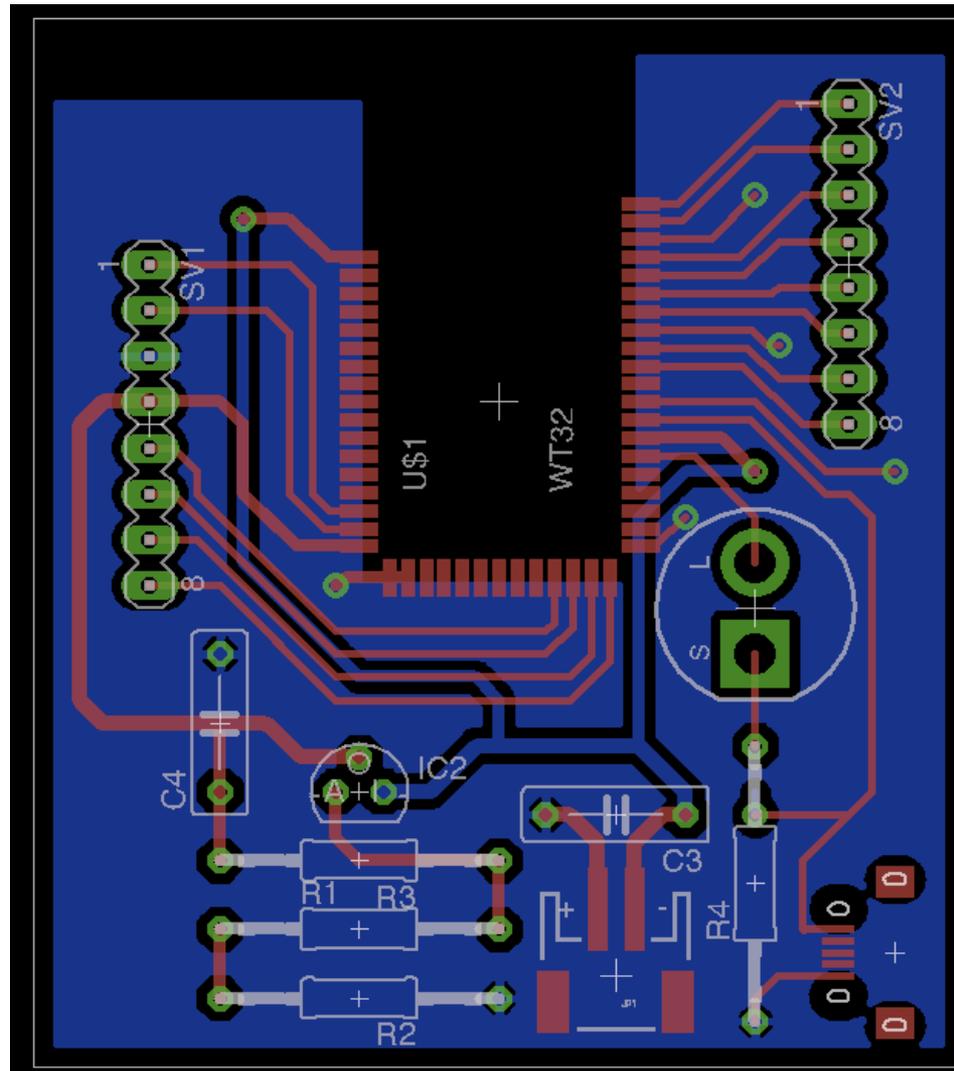
MCU PCB Layout



Bluetooth Unit Schematic



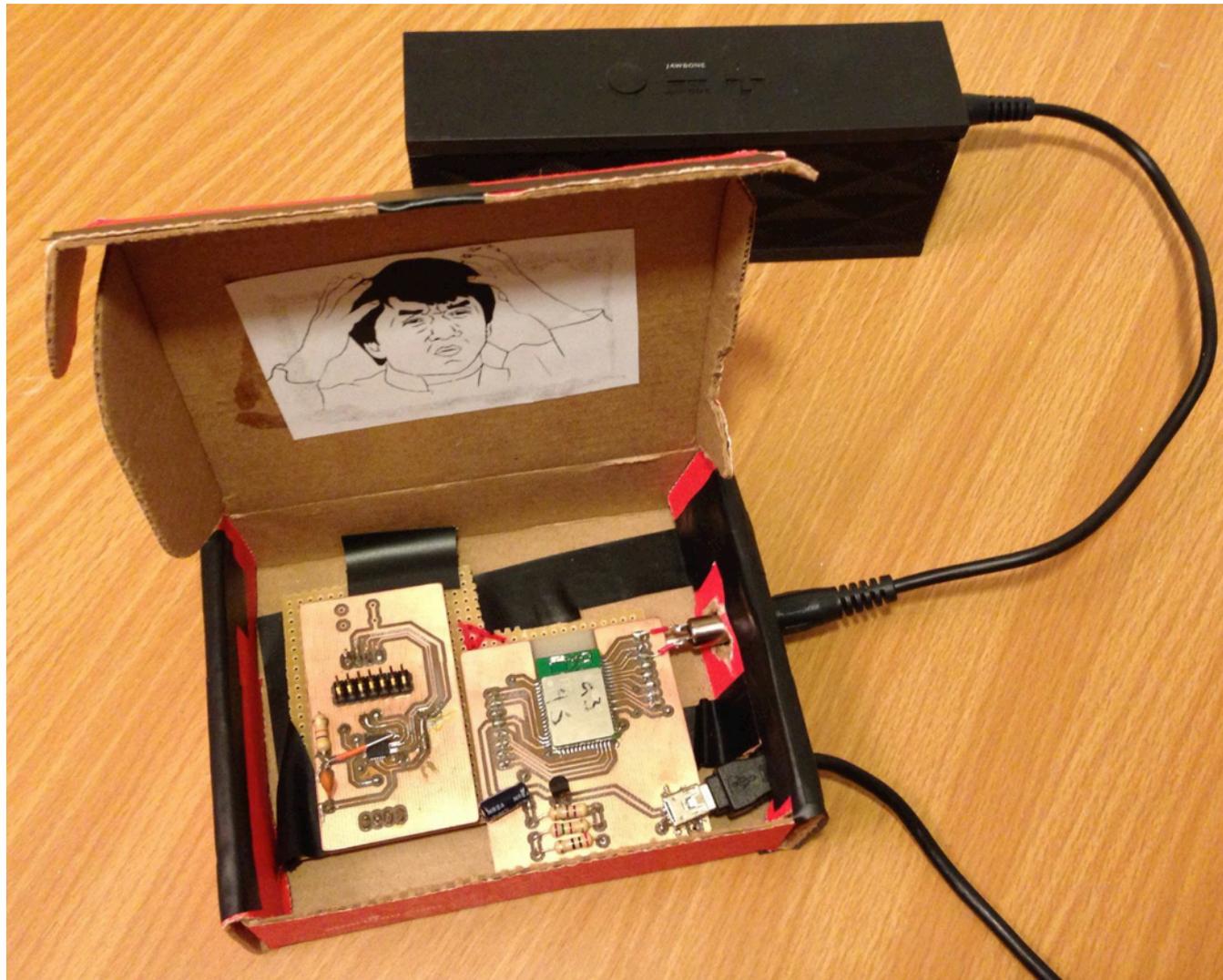
Bluetooth PCB Layout



Hub Construction



Speaker Adapter Construction





Functional Testing

- Developed UART interface test programs in C
 - Speak at binary packet levels
- Verified Bluetooth connectivity with UE like phones, computers
- Update BT IC configurations and observe settings change real-time with other BT enabled devices
- Successful system level testing with OTA audio playback

Component Testing

- Link-Budget Analysis
 - RX Power(dBm) = TX Power(dBm)+Gain(dB)-Loss(dB)
 - Loss = $20\log_{10}(d)+20\log_{10}(f)-147.55$

- Incoming RSSI Data

```
\0xbf\0x01\0x00\0x01\0x44\0xfe  
\0xbf\0x00\0x00\0x01\0x01\0xff  
\0xbf\0x00\0x00\0x01\0x42\0xff  
\0xbf\0x00\0x00\0x01\0x01\0xff  
\0xbf\0x01\0x00\0x01\0x01\0xfe
```

- Confirmed battery charging via current measurement



Successes

Hardware

- Seamless handoff between speakers
- Avoids use of development boards (Arduino, LaunchPad...)
- Recovered "dead" BT IC
- Last minute switch to analog audio in hub

Software

- Inter-IC UART communication
- Automatically picks BT channel upon received RSSI value.
- Developed programs to interface with external HW



Design Challenges

Hardware

- Unreliable MSP programming
- Interfacing with PurePath IC
- 2-layer PCBs w/ no silkscreen
- Soldering analog components
- Importance of bypass caps

Software

- Poor Code Composer UX
- Optimized interrupt handling
- Changing baud rates causes issues
- RSSI collection timing



Recommendations

Hardware

- Integrated single PCB
- I²S between BT ICs on hub
- Discrete audio amplifier
- Integrated battery and exposed power controls
- Mechanical improvements
- Use a discrete antenna

Software

- Minimize 0.4s switching delay between speakers
- Optimize setup time
- Add/remove devices seamlessly
- Audio interface for device status



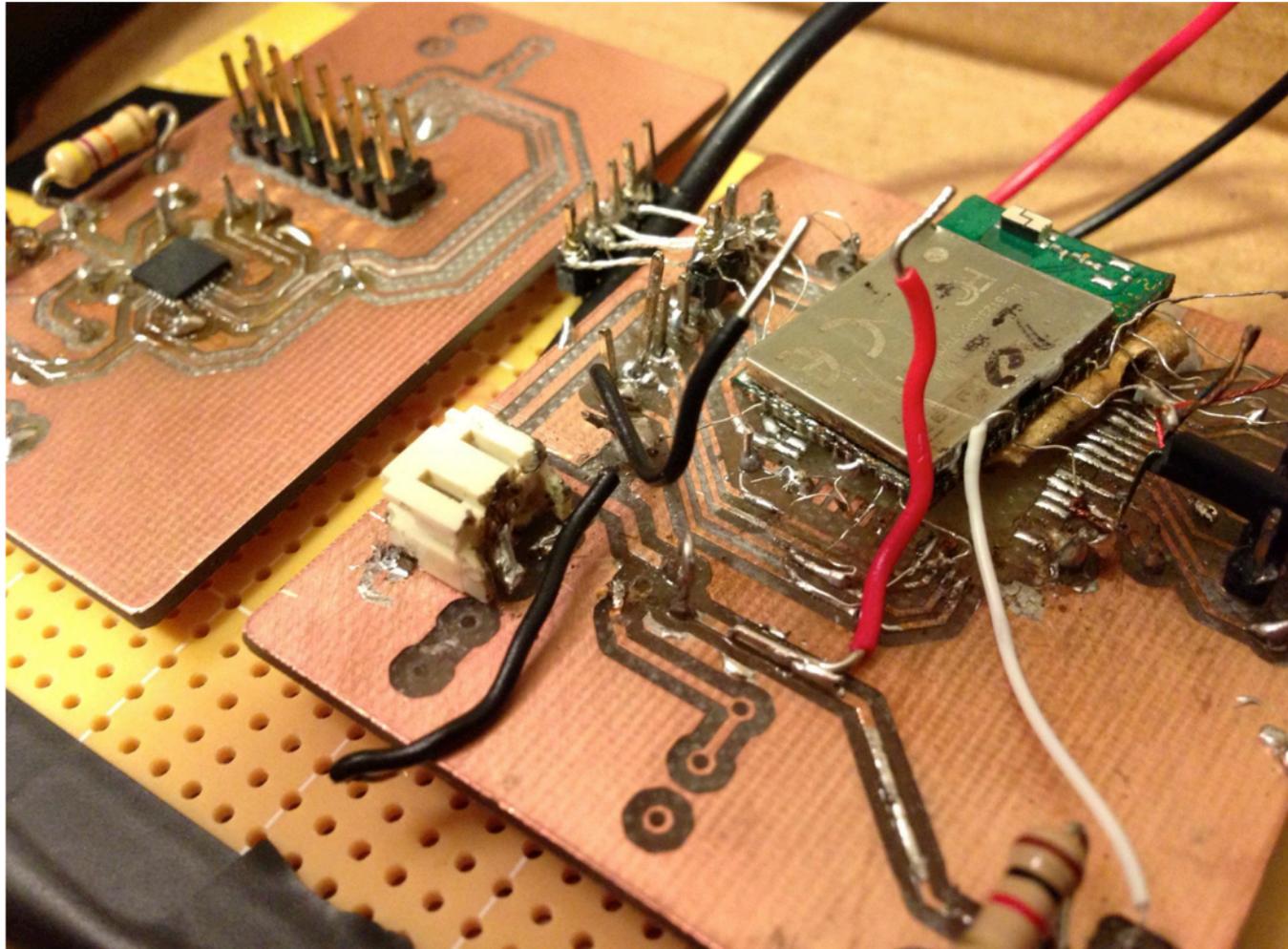
Budget & Marketing

- ~\$40 of components per system block
 - Bluetooth chip is expensive
 - Sell hub + 2 speaker adapters for ~\$200
- Existing products suggest strategy
 - Minimally tech-savvy customers
 - Living in apartments/small homes

Acknowledgements

- Justine Fortier = Best TA 😊
- Mark Smart
- Prof. Singer and Prof. Lilly
- IEEE
- Prof. Pilawa

Appeal for “Design Award”



Questions?

