SoCs for Audio/Biomed Use

## How to Use These Tiny but Powerful Linux Devices

IEEE-Madison ECN-EMB Meeting
August 10th, 2017, Tom Kaminski and Dennis
Bahr, PhD at Sector67

Overview

- Meet the Raspberry Pi SoCs

- Beginning Steps: What you need

- Updating SD memory

- SSH: Necessary Tool

- Updating Debian

- Linux Basics

- Audio Cards

- Audio Systems

- Demonstration

- Real-Time/Low Power Pi Zero Presentation

What is A SoC?

A System on a Chip (SoC) is a method of placing all necessary electronics for running a computer on a single chip. Instead of having an individual chip for the CPU, GPU, USB controller, RAM, Northbridge, Southbridge, etc., everything is compressed down into one tidy package --- Raspberrypi.org
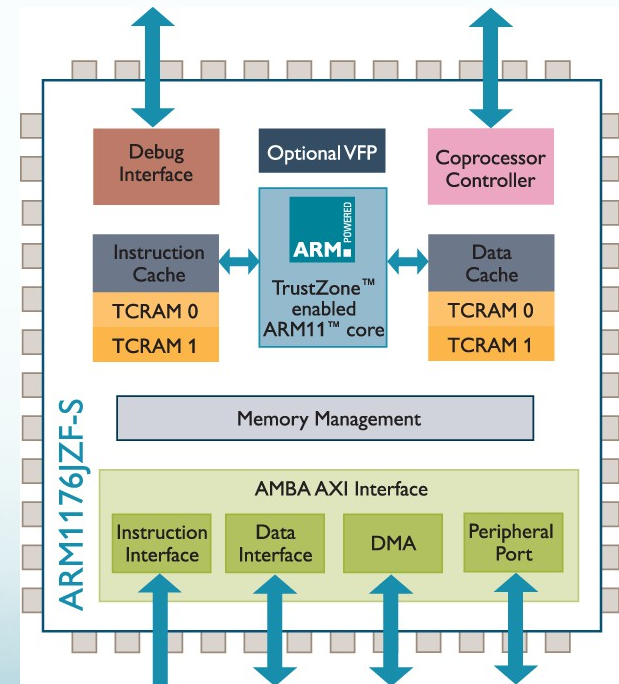
Raspberry Pi Family

Model B

Model A

Compute Module

Model B+

Model A+

2 Model B

Zero

3 Model B

Raspberry Pi 3

- Quad Core 1.2GHz Broadcom BCM2837 64bit CPU
- 1GB RAM
- BCM43438 wireless LAN and Bluetooth Low Energy (BLE) on board
- 40-pin extended GPIO
- 4 USB 2 ports
- 4 Pole stereo output and composite video port
- Full size HDMI
- CSI camera port for connecting a Raspberry Pi camera
- DSI display port for connecting a Raspberry Pi touchscreen display
- Micro SD port for loading your operating system and storing data
- Upgraded switched Micro USB power source up to 2.5A

$35

Raspberry Pi Zero W

- Dimensions: 65mm × 30mm × 5mm
- SoC: Broadcom BCM2835
- CPU: ARM11 running at 1GHz
- RAM: 512MB
- Wireless: 2.4GHz 802.11n wireless LAN
- Bluetooth: Bluetooth Classic 4.1 and Bluetooth LE
- Power: 5V, supplied via micro USB connector
- Video & Audio: 1080P HD video & stereo audio via mini-HDMI connector
- Storage: MicroSD card
- Output: Micro USB
- GPIO: 40-pin GPIO, unpopulated
- Pins: Run mode, unpopulated; RCA composite, unpopulated
- Camera Serial Interface (CSI)

$10
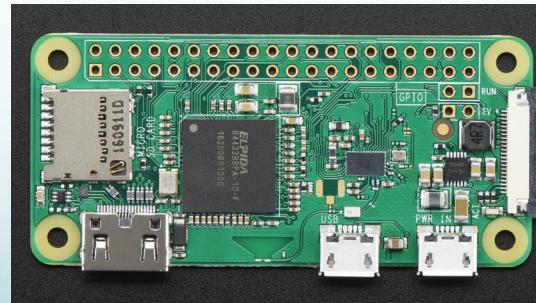
Minimum System

Raspberry Pi 3 or Pi Zero W

- 5V Power Supply
- WiFi Switch/Router/Firewall
- Micro SD (8GByte)

Laptop/Desktop with Monitor/Mouse/Keyboard for programming and configuration.

HDMI Monitor, Keyboard/Mouse for initial setup.

Both Also support SSH (Secure Shell) remote access.

OS Updating

Program The Compact Flash

1. Plug the SD into an adapter and plug the adapter into your computer
2. Download the SD image to flash to a computer.
3. Decompress the image (tool depends on the chip image).
4. Erase the SD using recommended tools.
5. Flash the SD from your computer using the recommended tool.

Place the SD into your SoC and Boot!

Try Other Operating Systems with a New SD

SSH: Secure Shell

Secure Shell, or **SSH**
is a cryptographic (encrypted) network protocol for initiating text-based sessions on remote machines in a secure way.
SSH has replaced **Telnet** as the way we make a connection to a remote computer.

It is available free for most platforms. The client is built in for Linux/Unix/OSX. The most common Windows version is PuTTY.

ssh — OpenSSH SSH client (remote login program)

ssh [-1246AaCfGgKkMNnqsTtVvXxYy] [-b bind_address] [-c cipher_spec]
 [-D [bind_address:]port] [-E log_file] [-e escape_char] [-F configfile] [-I pkcs11]
 [-i identity_file] [-L address] [-l login_name] [-m mac_spec] [-O ctl_cmd] [-o option]
 [-p port] [-Q cipher | cipher-auth | mac | kex | key | protocol-version] [-R address]
 [-S ctl_path] [-W host:port] [-w local_tun[:remote_tun]**] [user@]hostname** [command]

Linux Command Line

Unix/Linux Command Reference

FOSSwire.com

File Commands	System Info
ls – directory listing	**date** – show the current date and time
ls -al – formatted listing with hidden files	**cal** – show this month's calendar
cd *dir* - change directory to *dir*	**uptime** – show current uptime
cd – change to home	**w** – display who is online
pwd – show current directory	**whoami** – who you are logged in as
mkdir *dir* – create a directory *dir*	**finger *user*** – display information about *user*
rm *file* – delete *file*	**uname -a** – show kernel information
rm -r *dir* – delete directory *dir*	**cat /proc/cpuinfo** – cpu information
rm -f *file* – force remove *file*	**cat /proc/meminfo** – memory information
rm -rf *dir* – force remove directory *dir* *	**man *command*** – show the manual for *command*
cp *file1* *file2* – copy *file1* to *file2*	**df** – show disk usage
cp -r *dir1* *dir2* – copy *dir1* to *dir2*; create *dir2* if it doesn't exist	**du** – show directory space usage
	free – show memory and swap usage
mv *file1* *file2* – rename or move *file1* to *file2*	**whereis *app*** – show possible locations of *app*
if *file2* is an existing directory, moves *file1* into directory *file2*	**which *app*** – show which *app* will be run by default

Linux Text Editor

Screen Editors:

LEAFPAD (also runs as remote X window)

Terminal Editors:

VI – System hacker's choice.
NANO -- simple syntax
EMACS – extreme version for coders. Lots of built in syntax checking.

Updating Raspbian OS

Updating Rasbian (Debian) using apt-get

(you must be connected to the Internet for this)

First, update your system's package list by entering the following command in LXTerminal or from the command line:

sudo apt-get update

Next, upgrade all your installed packages to their latest versions with the command:

sudo apt-get upgrade

Audio In Cards

AudioInjector
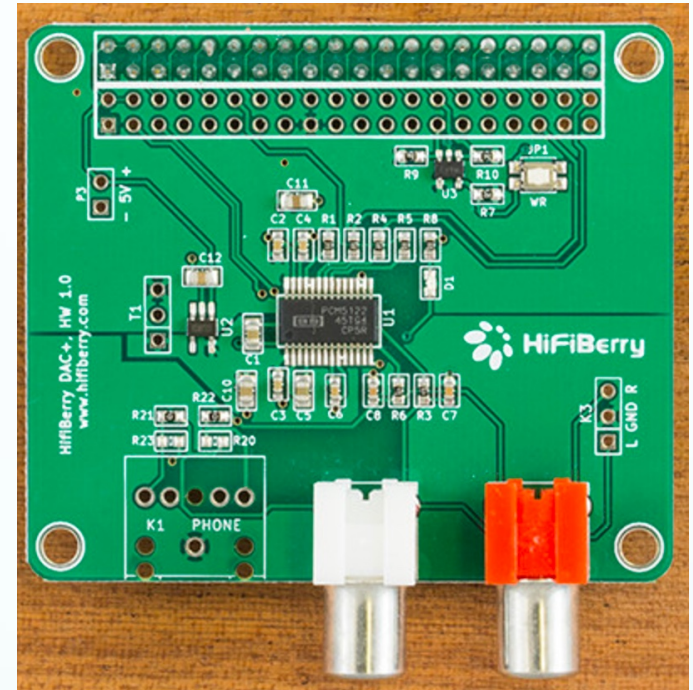
← Stereo Pi

Pi Zero →
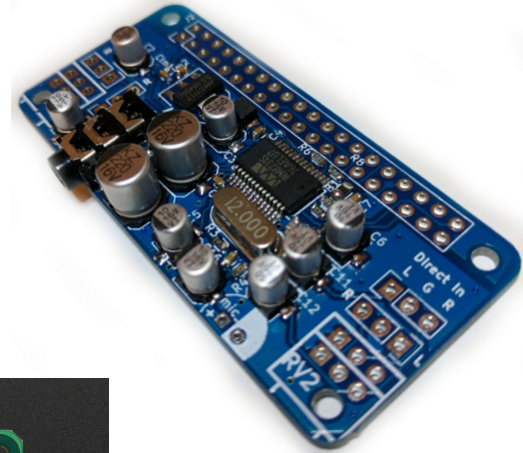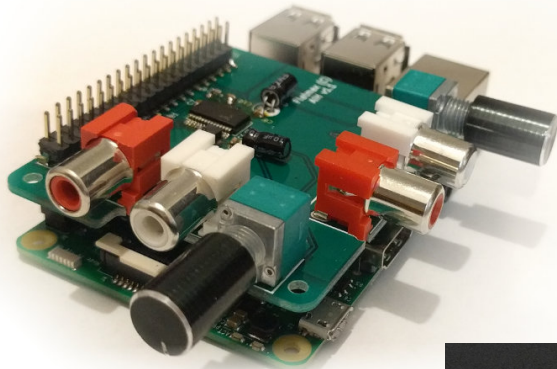
All 24bit ADC
up to 192kHz
Sampling
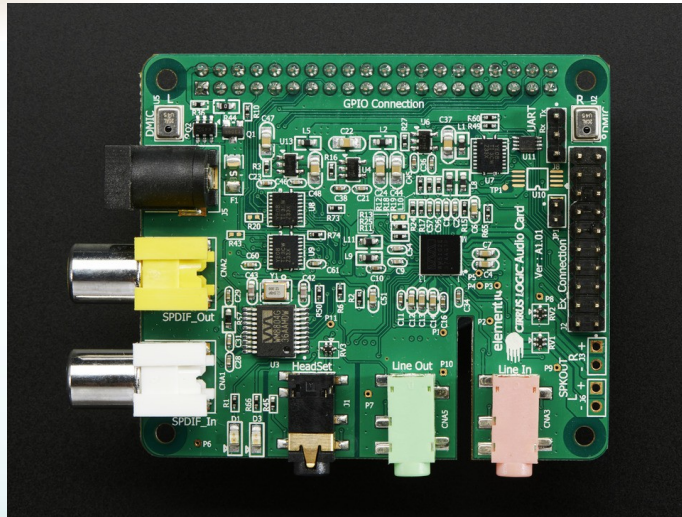
Cirrus Logic/Wolfson (Discontinued)

Audio Out Cards

1.1 Audio Injector
1.2 AudioPhonics
1.3 G2 Labs
1.4 HiFiBerry
1.5 IQaudIO
1.6 JustBoom
1.7 Collybia
1.8 Pi 2 Design
1.9 PiFi
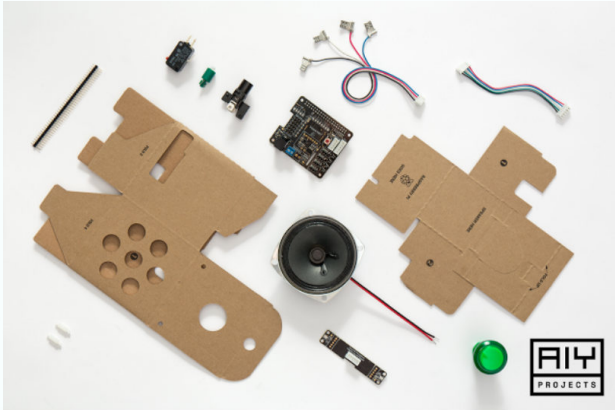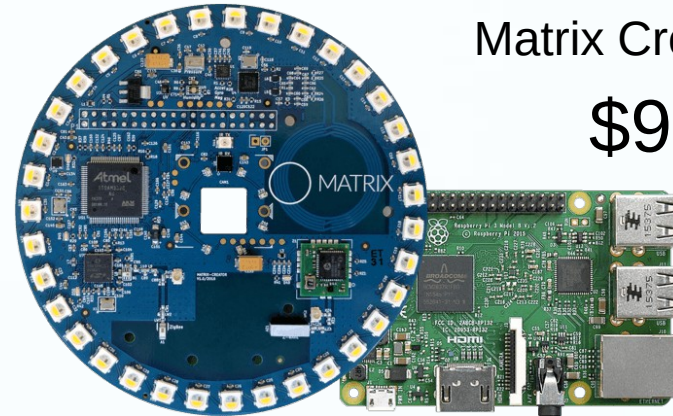1.10 Pisound
1.11 Pimoroni
1.12 Raspyplay3
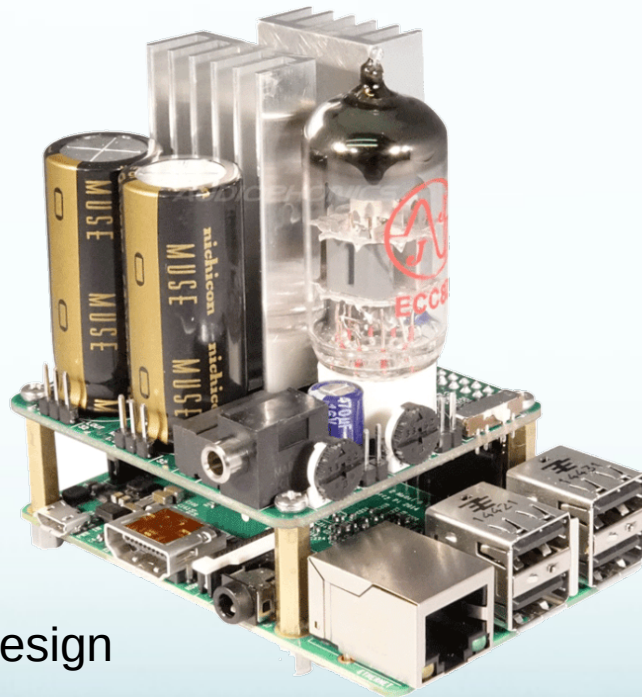
Pi 2 Design

HiFi Berry DAC+

Microphone In Cards

Google AIY Voice Command

$15

Matrix Creator

$99

8 MEMS Microphone
(DIY Amazon Echo)
FPGA (Xilinx Spartan 6)
Microcontroller
(ARM Cortex M3)
Temperature sensor
Ultraviolet sensor
Pressure sensor
3D Accelerometer
3D Gyroscope
3D Magnetometer
Humidity sensor

Android Things Support
Thread
NFC
IR RX/TX
2 ADC Channels
17 Digital GPIOs
ZigBee® (Cert. Pending)
Z-Wave® (Cert. Pending)
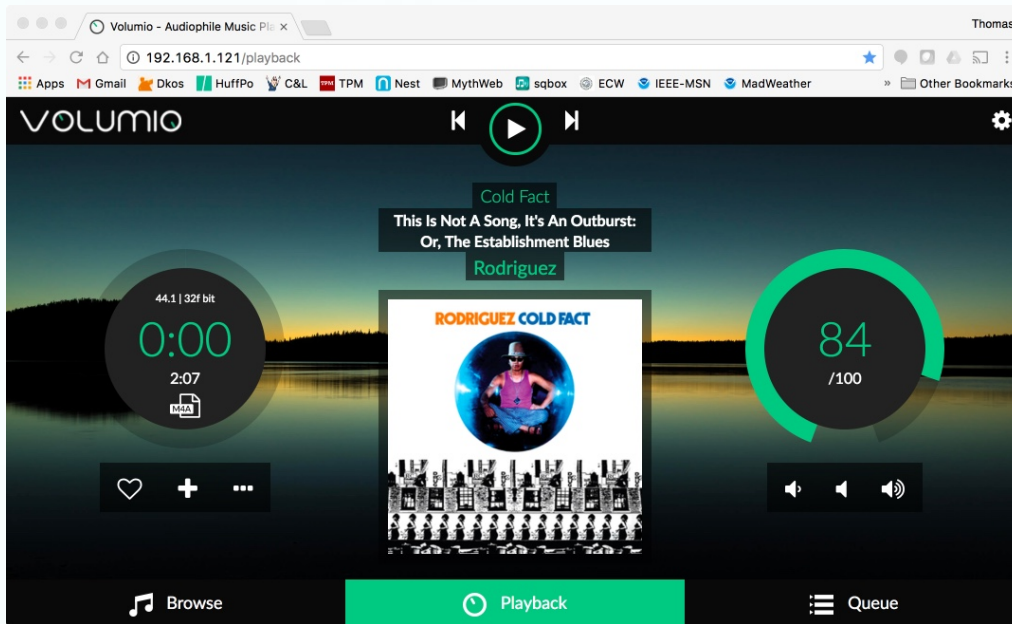SPI
I2C
UART

USB Audio Converters

Behringer UCA222
16Bit CD Quality
Up to 48ksps Stereo
~$20

Behringer UMC202HD
24Bit High Quality
Up to 192ksps Stereo
~$60

Players: Music Playing

Many Players

I liked VOLUMIO best

Volumio: Technologies Used

Node.js as the serverside application framework
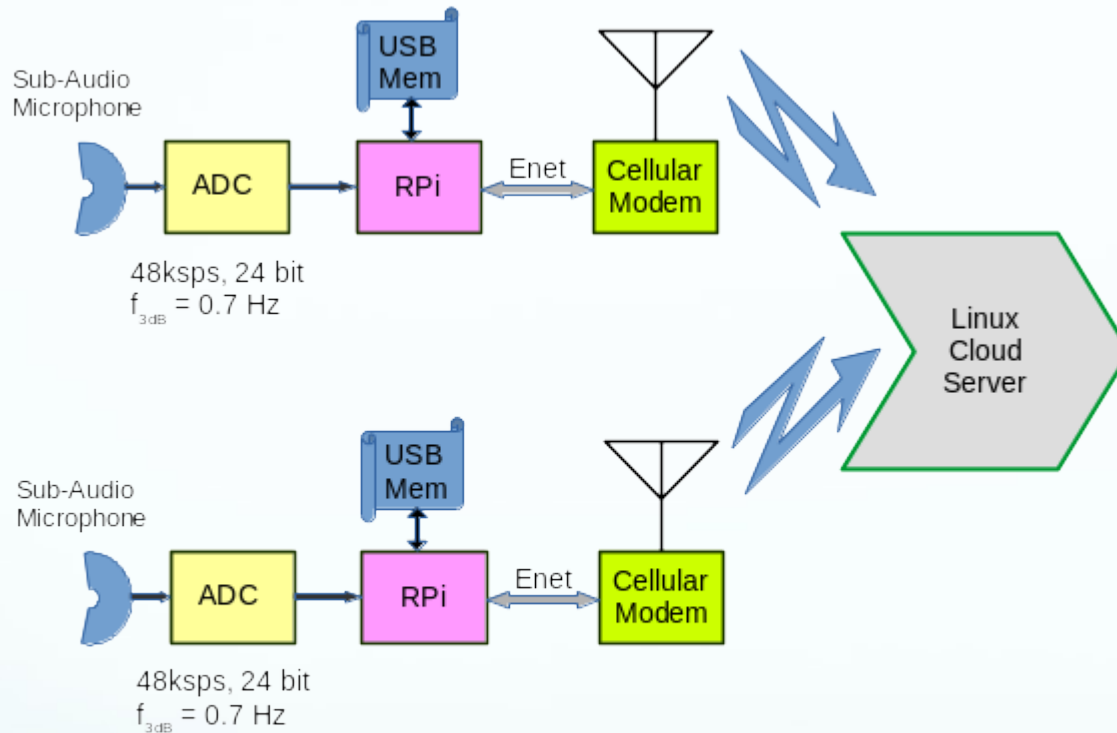**Socket.io** for websocket communication
Express as the HTTP webserver for the Volumio WebUI
Angular as the WebUI framework
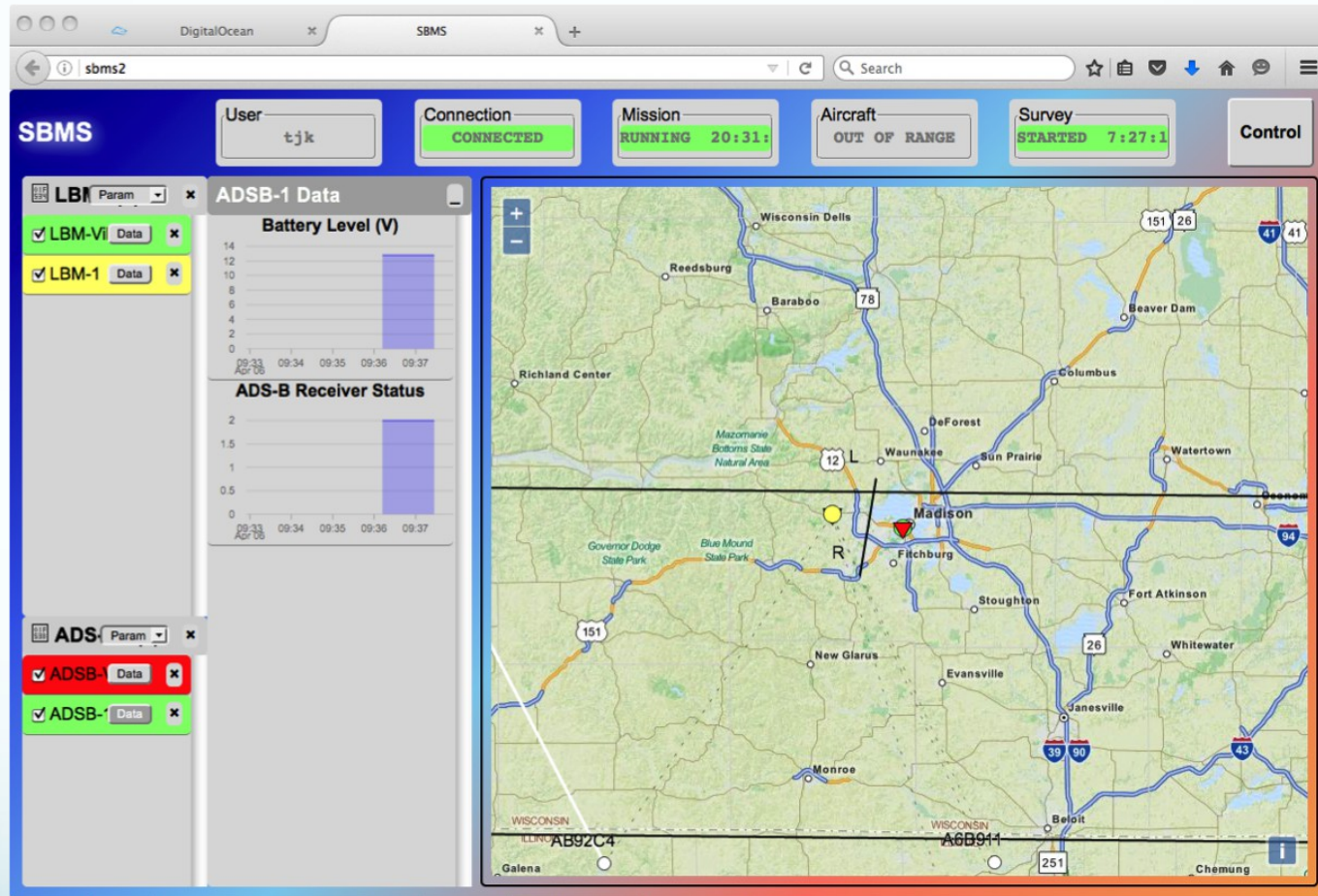**LevelDB** as the persistent database system
Kew to run the promise-based asynchronous execution of code

Sonic Boom Monitor

Geographically Distributed Recorders
Stores 1-minute .wav files
Cloud-Based Server
Node.js + Meteor
Linux Cloud Server

Sonic Boom Server

Sound Level Meter

1. Arecord Digitizes Audio Data
2. Delay routine Buffers Audio Data
3. Sox converts it to single channel
4. Audio Data buffered and written as .wav file in 6000 byte chunks.
5. FFT converts 1-second data to Frequency Spectra
6. 1/3 Octave Power Level Computation
7. 1/3 Octave Power Level data written as .csv file each second
8. Server can start/stop record function
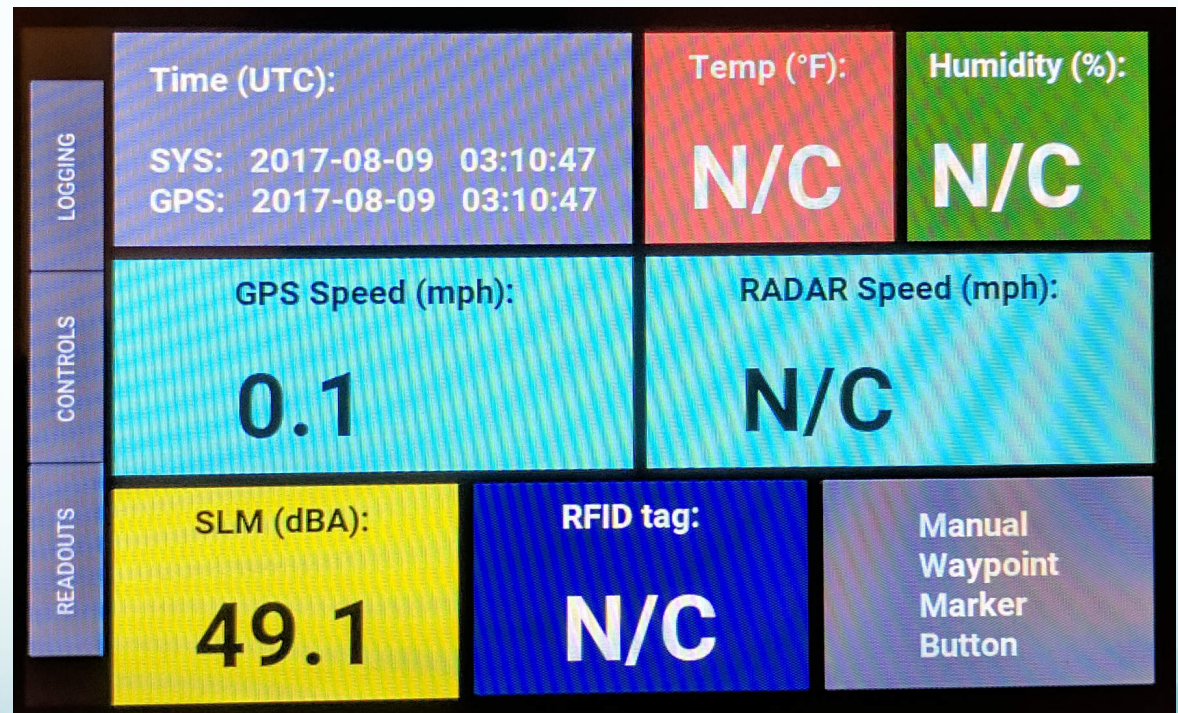9. Wave file data written on minute boundraries

Calibrated Microphone

USB MEM

WiFi or Wired Ethernet

ADC → RPi
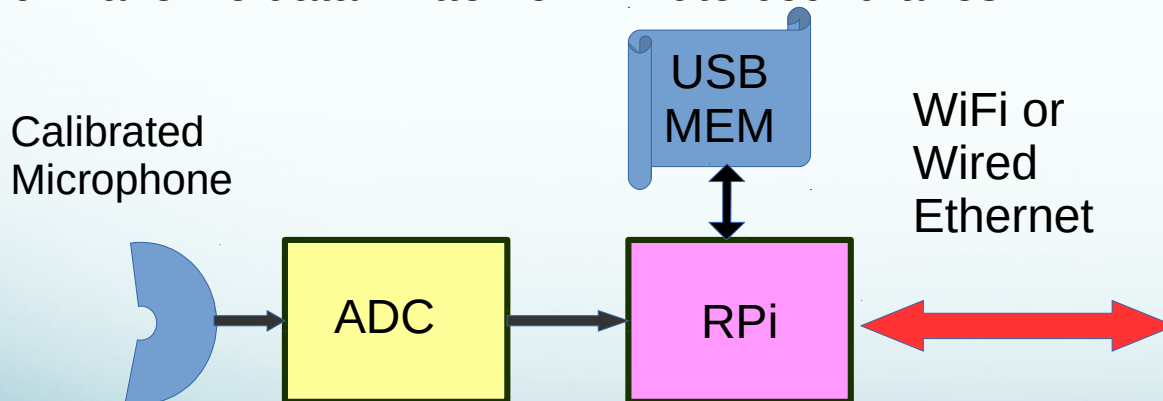
48ksps, 24 bit
f_{3dB} = 10 Hz

Sound Transit System

1. Integrates Devices over Enet and Serial-USB Ports
2. GPS for Time and Position
3. Radar Unit Interface
4. SLM Interface for 1/3 Octave Data
5. RFID Reader
6. KiVi Touch Panel for Display
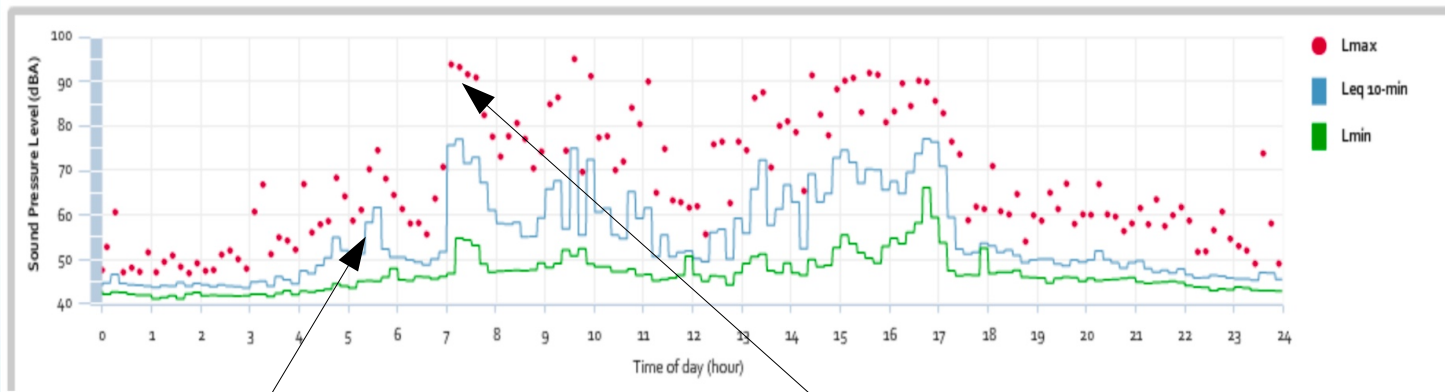7. Temperature/RH

Sound Level Meter Graph

Demonstrations

1. PiDrive Node Zero Booting Graphical Desktop
2. PiDrive Node Zero Booting Simple OS
3. Volumio Web Interface
4. SSH Terminal Access
5. Sound Level Meter Startup
6. Sound Level UDP Application
7. Sound Transit Touchscreen
8. Ubuntu/ROS and Turtlebot (if time)