SONOS Intercom System

UCSB Capstone 2016-2017

SONOS

A company that reinvents home audio for the digital age.

SONOS

A high-fidelity audio company that specializes in seamless audio integration over a home WiFi network.

SONOS Ecosystem

- No compromises on sound quality
- Modern aesthetics
- Durable

SONOS COM:1


for play/pause music and
microphone.


SONOS
SONOS


SONOS
SONOS

Market

- SONOS device owners.
- Families.
- SONOS
  - Research and Development regarding **microphones** and **streaming**.
  - Possibility for voice recognition / personal assistant in the future.

&

SONOS

Benchmark

Amazon Echo Dot

Senic Nuimo

Functionality

- Communication
  - Real time voice broadcasting.
  - Allows user to select which “room” to talk to.
    - “room” = a group of SONOS devices.
- Music Control
  - Play/Pause
  - Next
  - Previous
  - Volume

Music Controls

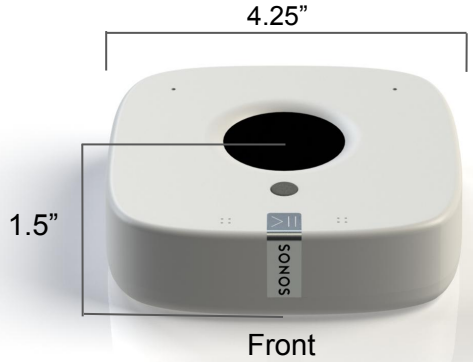
Music Controls

Music Controls

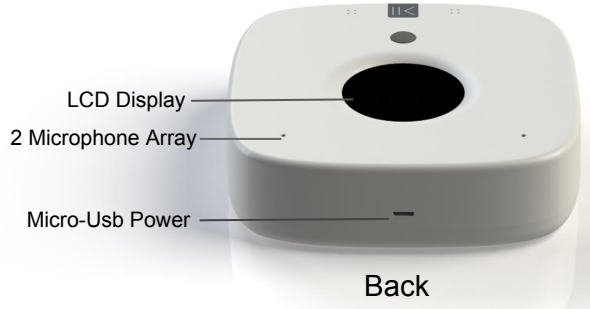
Intercom

Intercom

Technical Details



Front

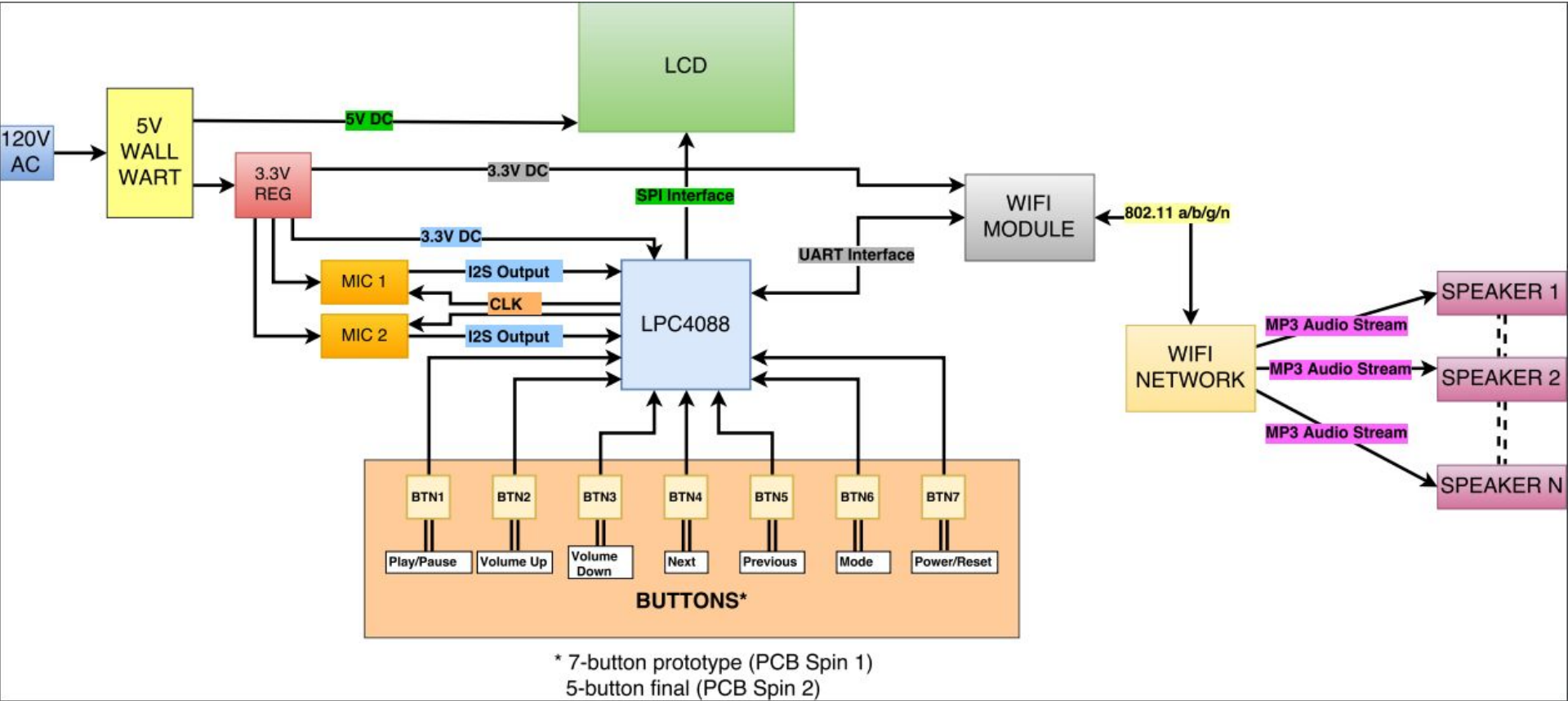


Back

* Actual sizes and weight may vary as project develops

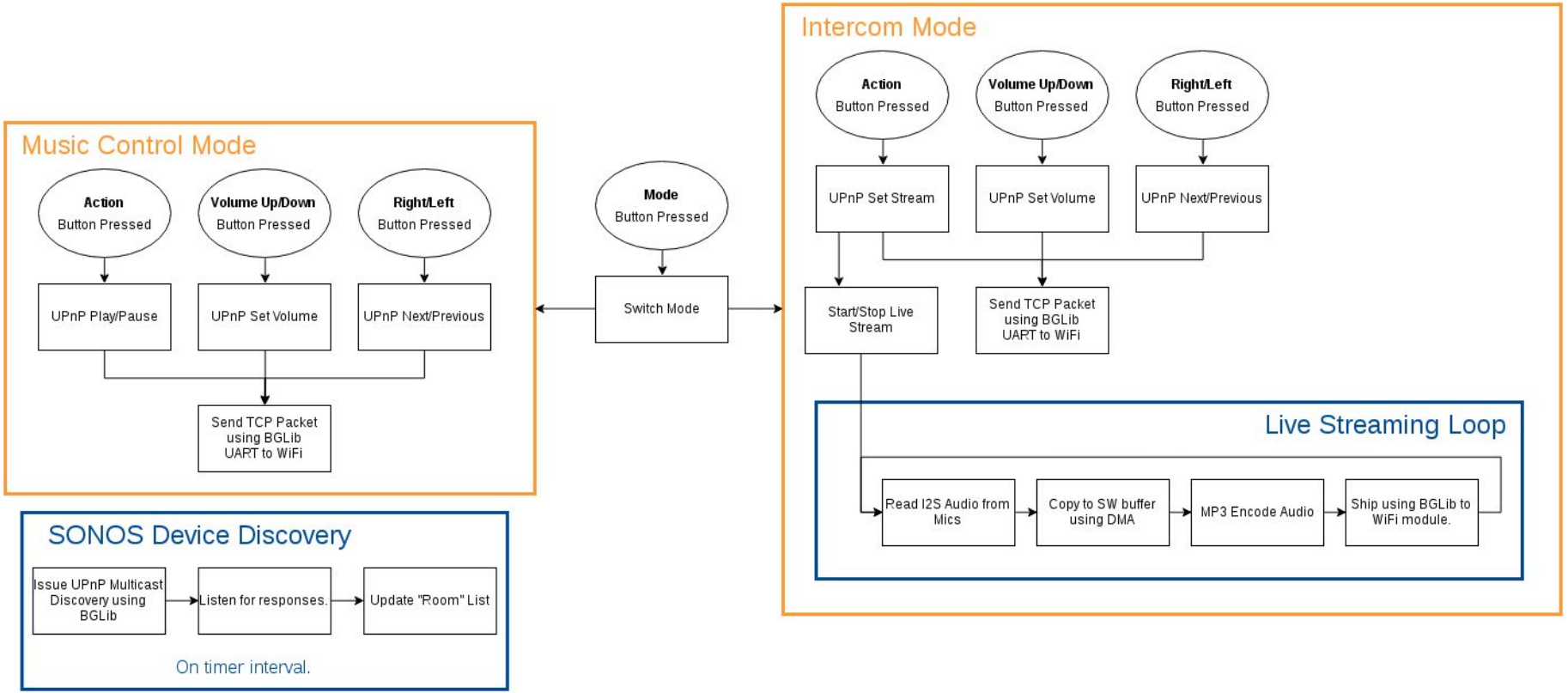
Size*	1.5” x 4.25” x 4.25” (38mm x 108mm x 108mm)
Weight*	6 oz (170 grams)
Screen*	1.5” (38 mm) Color TFT LCD Display
Material	Plastic. Type to be determined.
Wi-Fi Connectivity	Wi-Fi module providing fully integrated 2.4 GHz 802.11 b/g/n radio, TCP/IP stack and a 32-bit microcontroller (MCU)
Audio	Able to seamlessly connect and control your existing SONOS home network
System Requirements	COM:1 comes ready to connect to your Wi-Fi. Requires an iOS or Android device compatible with the SONOS app.
Power	5V Supply via wall wart adapter to micro USB
Operating Temperature	Heat sink temperature about 55°C Shell temperature about 28~45°C
Water Protection	IP 64 (Dust tight and protection against splashing of water)

Hardware Design



* 7-button prototype (PCB Spin 1)
5-button final (PCB Spin 2)

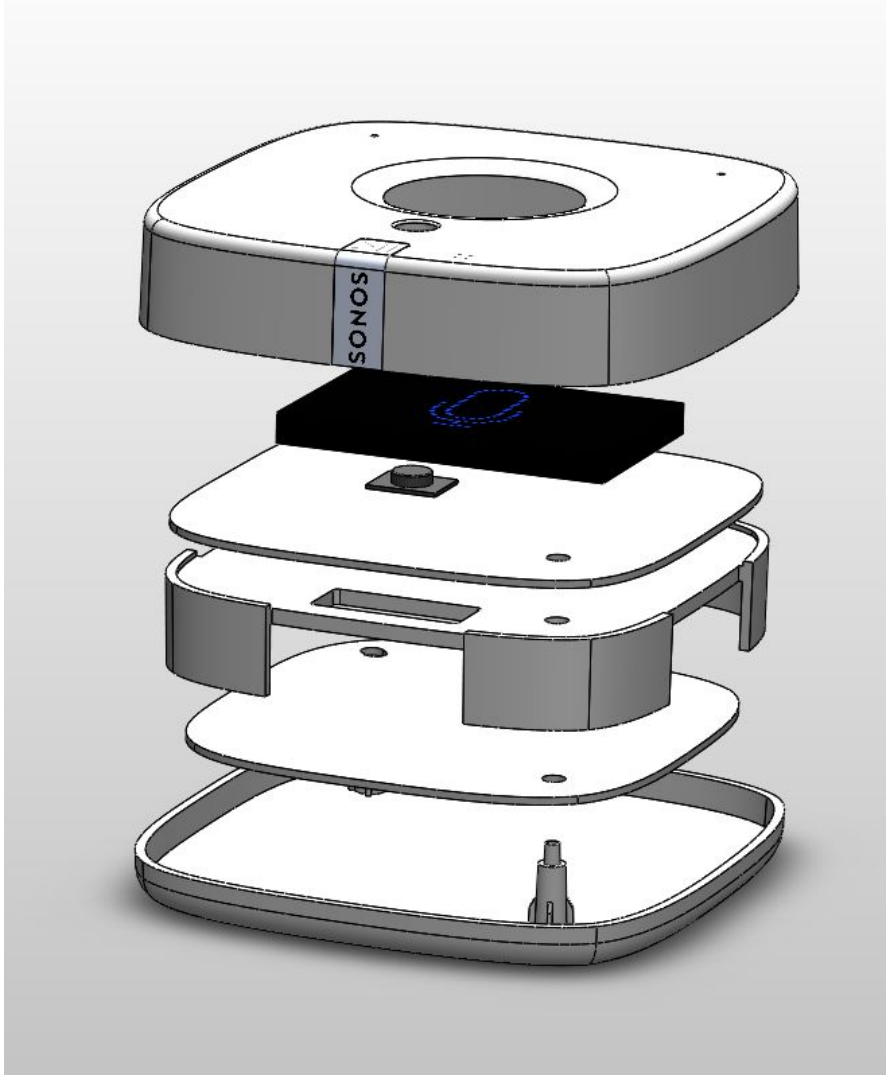
Software Design



What do we have so far?
And What's Next?

CAD Design

- Exploded Shell View



Physical Tests

- Drop Test.
- Water Resistance Test
- Thermal Test

More information in the Appendix

API

- Text files containing example HTTP UPnP packets for the following actions:
  - Get Mute Status
  - Get Track Info
  - Get Volume
  - Next Track
  - Previous Track
  - Play
  - Pause
  - Set Mute
  - Set Volume
  - Set Audio Stream

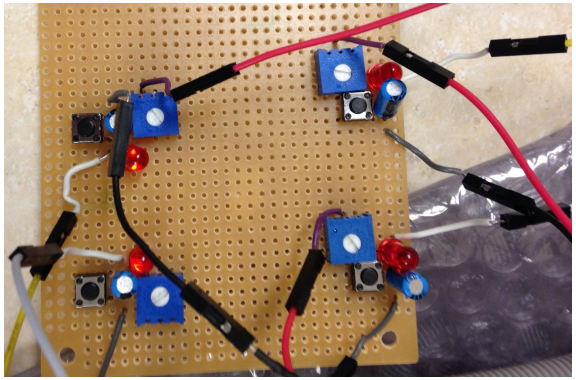
```
POST /MediaRenderer/AVTransport/Control HTTP/1.1
Host: 172.20.10.7:1400
Content-Type: text/xml; charset="utf-8"
Content-Length: 277
SOAPAction:
"urn:schemas-upnp-org:service:AVTransport:1#GetPositionInfo"
Connection: close

<s:Envelope
xmlns:s="http://schemas.xmlsoap.org/soap/envelope/"
s:encodingStyle="http://schemas.xmlsoap.org/soap/encoding">
<s:Body>
<u:GetPositionInfo
xmlns:u="urn:schemas-upnp-org:service:AVTransport:1">
<InstanceID>0</InstanceID>
</u:GetPositionInfo>
</s:Body>
</s:Envelope>
```

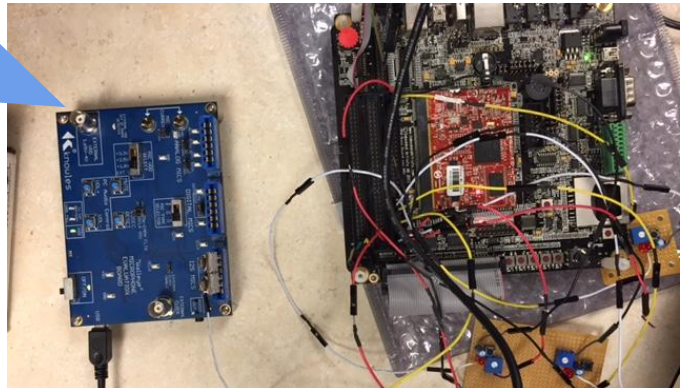
API

- MP3 Audio Streaming Test
  - Live
  - Need to fix delay. (Maybe has to do with buffering?)

Hardware

- Current Prototype
  - Six button GPIO control
    - 1 uF cap with 2.5Kohm
    - LED feedback
  - Microphone Development Board
    - Two I2S Digital Mics
    - Bottom Mount
- Winter Quarter Plans
  - Capacitive touch interface
    - Decrease to four buttons
  - Microphone output to Sonos Speaker





Software

- Basic Functional Structure:
  - Volume up adds 5 to volume, until maximum is reached
  - Volume down subtracts 5 from volume, until minimum is reached
  - Change mode switches from intercom to music
  - Change room simply states next room selected
  - The same button selects next song depending on the current mode
  - Similarly the previous button works based on the current mode

PCB Spins

- This PCB artwork (Gerber Files) will be shipped to **Laritech** to be manufactured and assembled.

PCB Spins

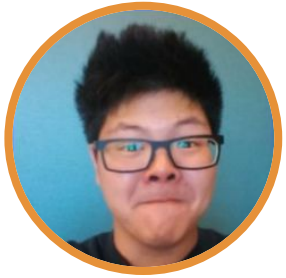
- Prototype vs Final
- Must take enclosure constraints/requirements into account.
- Buttons vs Capacitive touch

Meet the Team

MEs


Kyle Li


Yang Xue


Kenny Wang


Kayden Sung


Yubin Liu

EEs


Yiqin Wang


Luke Bucklew


Jianyang Lu

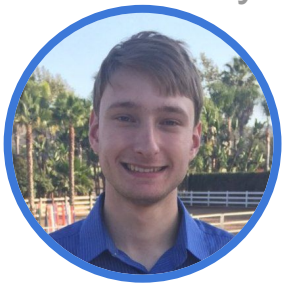
Meet the Team

CEs

Subho Choudhury

Richard Wei

Mohammad Cazi



Brian Sandler

Brenden Fujishige

Marcellis Carr-Barfield

Organization

Discipline Leaders

Thermal/Power

DSP & Mic Array

PCB Hardware

Structure/Design

Software

Appendix

Design Constraints

- Experience
  - Minimize audio latency.
  - Responsive controls.
- Simplicity
- Durability
  - Product should withstand home environment (drop/water proof).
- Affordability
  - $49.99-$99.99 is acceptable for such a simple device.

Water Protection

IP level: Ingress Protection Marking. classifies and rates the degree of protection provided against intrusion, dust, accidental contact, and water.

It contains two digitals: the first for dust protection and the second for water protection.

Dust Protection

Level Sized	Effective Against
0	-
1	>50mm
2	>12.5mm
3	>2.5mm
4	>1mm
5	Dust Protected
6	Dust tight

Water Protection

Level	Protection against				
0	None	3	Spraying water	6	Powerful water jets
1	Dripping water	4	Splashing of water	7	Immersion, up to 1 m depth
2	Dripping water when tilted at 15°	5	Water jets	8	Immersion, 1 m or more depth

Solution for the microphone part: acoustic meshes

ePTFE membrane is the newest generation of breathable membrane which has good waterproof and air-ventilating properties.

Saati Acoustex B090HY

Item Name	Pore size(μm)	Open area(%)	Thickness (μm)	Weight (g/m^2)	Air permeability (L/m^2@20mmWG)	Specific Airflow Resistance[MKS rayls]
Acoustex090	41	24	125	85	2125	90

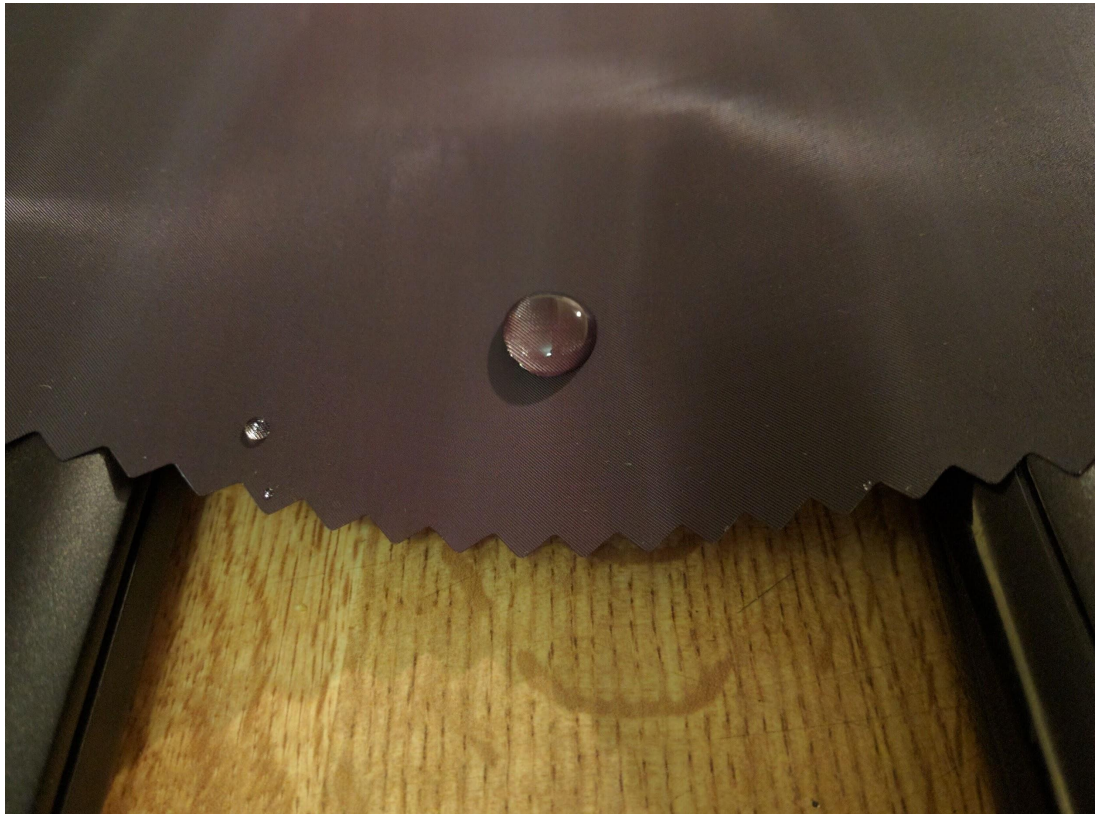
Backup Choice (See Appendix)

Sumitomo Electric Industries

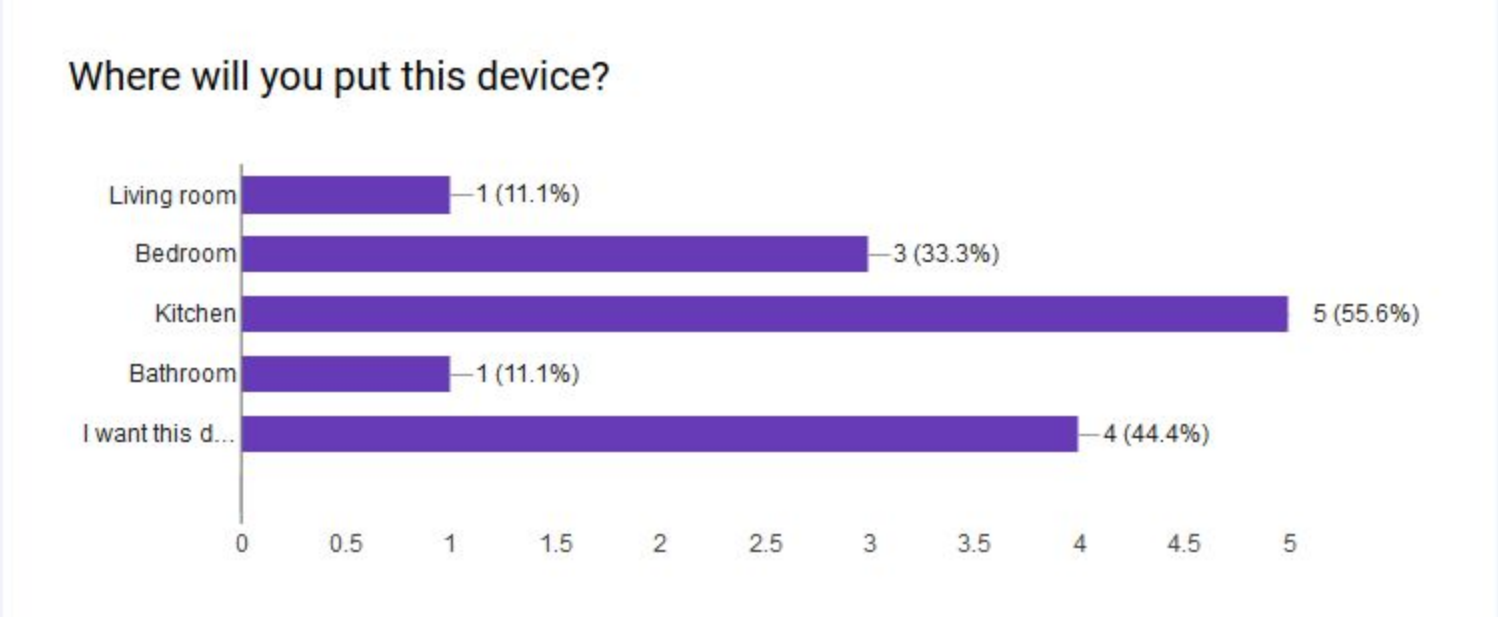
Poreflon™ Air Vent

Sterlitech Corporation
PTFE LAMINATED FILTER

Test of the membrane



Survey result of where people will use this product



Detail of dust protection

Level sized	Effective against	Description
0	—	No protection against contact and ingress of objects
1	>50 mm	Any large surface of the body, such as the back of a hand, but no protection against deliberate contact with a body part
2	>12.5 mm	Fingers or similar objects
3	>2.5 mm	Tools, thick wires, etc.
4	>1 mm	Most wires, slender screws, large ants etc.
5	Dust protected	Ingress of dust is not entirely prevented, but it must not enter in sufficient quantity to interfere with the satisfactory operation of the equipment.
6	Dust tight	No ingress of dust; complete protection against contact (dust tight). A vacuum must be applied. Test duration of up to 8 hours based on air flow.

Detail of water protection(1)

Level	Protection against	Effective against	Details
0	None	—	—
1	Dripping water	Dripping water (vertically falling drops) shall have no harmful effect on the specimen when mounted in an upright position onto a turntable and rotated at 1 RPM.	Test duration: 10 minutes Water equivalent to 1 mm rainfall per minute
2	Dripping water when tilted at 15°	Vertically dripping water shall have no harmful effect when the enclosure is tilted at an angle of 15° from its normal position. A total of four positions are tested within two axes.	Test duration: 2.5 minutes for every direction of tilt (10 minutes total) Water equivalent to 3 mm rainfall per minute
3	Spraying water	Water falling as a spray at any angle up to 60° from the vertical shall have no harmful effect, utilizing either: a) an oscillating fixture, or b) A spray nozzle with a counterbalanced shield. Test a) is conducted for 5 minutes, then repeated with the specimen tilted 90° for the second 5-minute test. Test b) is conducted (with shield in place) for 5 minutes minimum.	For a Spray Nozzle: Test duration: 1 minute per square meter for at least 5 minutes[2] Water volume: 10 litres per minute Pressure: 50–150 kPa For an oscillating tube: Test duration: 10 minutes Water Volume: 0.07 l/min per hole
4	Splashing of water	Water splashing against the enclosure from any direction shall have no harmful effect, utilizing either: a) an oscillating fixture, or b) A spray nozzle with no shield. Test a) is conducted for 10 minutes. Test b) is conducted (without shield) for 5 minutes minimum.	Oscillating tube: Test duration: 10 minutes, or spray nozzle (same as IPX3 spray nozzle with the shield removed)

Detail of water protection(2)

5	Water jets	Water projected by a nozzle (6.3 mm) against enclosure from any direction shall have no harmful effects.	Test duration: 1 minute per square meter for at least 3 minutes Water volume: 12.5 litres per minute Pressure: 30 kPa at distance of 3 m
6	Powerful water jets	Water projected in powerful jets (12.5 mm nozzle) against the enclosure from any direction shall have no harmful effects.	Test duration: 1 minute per square meter for at least 3 minutes Water volume: 100 litres per minute Pressure: 100 kPa at distance of 3 m
6K	Powerful water jets with increased pressure	Water projected in powerful jets (6.3 mm nozzle) against the enclosure from any direction, under elevated pressure, shall have no harmful effects. Found in DIN 40050, and not IEC 60529.	Test duration: at least 3 minutes[*citation needed*] Water volume: 75 litres per minute Pressure: 1000 kPa at distance of 3 m
7	Immersion, up to 1 m depth	Ingress of water in harmful quantity shall not be possible when the enclosure is immersed in water under defined conditions of pressure and time (up to 1 m of submersion).	Test duration: 30 minutes - ref IEC 60529, table 8. Tested with the lowest point of the enclosure 1000 mm below the surface of the water, or the highest point 150 mm below the surface, whichever is deeper.
8	Immersion, 1 m or more depth	The equipment is suitable for continuous immersion in water under conditions which shall be specified by the manufacturer. However, with certain types of equipment, it can mean that water can enter but only in such a manner that it produces no harmful effects. The test depth and/or duration is expected to be greater than the requirements for IPx7, and other environmental effects may be added, such as temperature cycling before immersion.	Test duration: Agreement with Manufacturer Depth specified by manufacturer, generally up to 3 m

Microphone Protection

Sumitomo Electric Industries

Poreflon™ Air Vent

Item No.	Pore Size (μm)	Thickness (μm)	IPA Bubble Point (kPa)	Waterproof Pressure (kPa)	Flow Rate	
					Liquid (ml/min,cm2)	Air (L/min,cm2)
FP-010-60	0.1	60	150	220	4	1
FP-022-60	0.22	60	120	180	8	2
FP-045-80	0.45	80	80	120	20	4
FP-100-100	1	100	40	60	60	8
FP-500-100	5	100	15	20	120	15

Sterlitech Corporation

PTFE LAMINATED FILTER

SKU	PTFE_Laminated_Sample_Pack	Pore Size (μm)	0.1-1.0 μm
Diameter (mm)	13 - 47	Pack Size	10

Performance by Pore Size

Pore Size	Thickness	Air Permeability[1]	Water Entry Pressure	IPA Buble Point
0.1 μm	6-10 mil (152-254 μm)	0.05	>65 psi	>25 psi
0.22 μm	4-6 mil (102-152 μm)	0.2-0.4	>14.5 psi	>20 psi
0.45 μm	3-5 mil (76-127 μm)	0.4-0.8	>11 psi	>10 psi
1 μm	3-5 mil (76-127 μm)	1.5-3.5	>4 psi	>8 psi

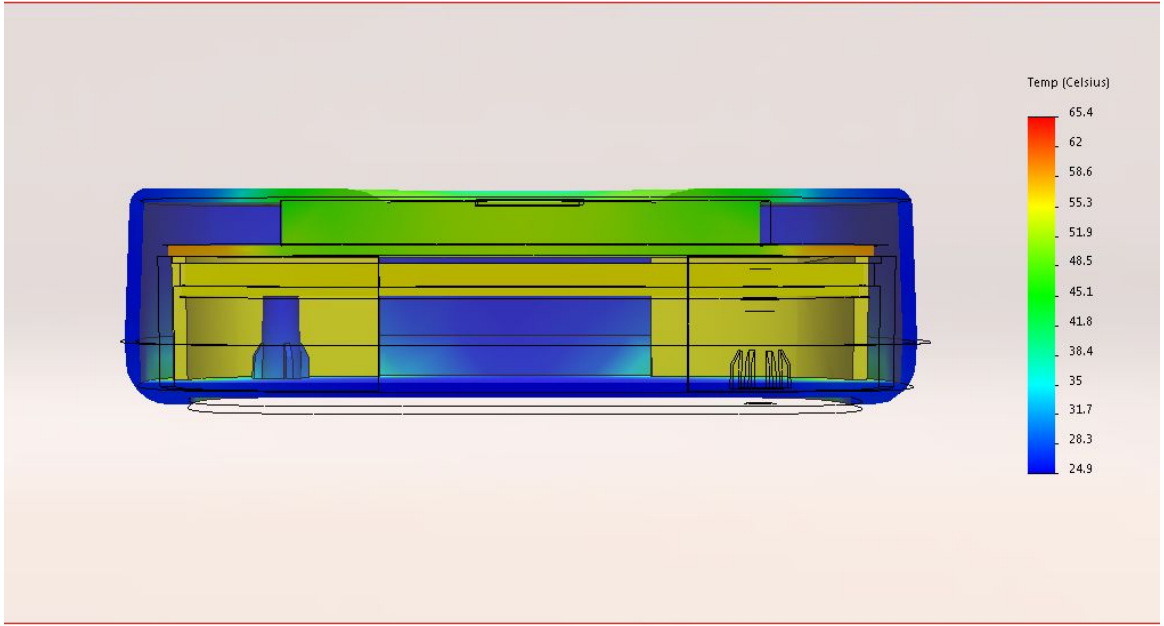
Thermal Analysis

Assumptions:

1. Average heat power on PCB
2. PCB efficiency is zero
3. 25°C Ambient Temperature
4. PCB Power is 10W

	Thermal conductivity (W/(m*K))	Temperature (°C)
PCB	>0.81	55
Heat Sink	108.89	55
Shell	>0.2256	24~45
LCD	0.74976	48

Natural Convection coefficient	~ 4.3 (W/m^2 K)



Needs and Engineering Characteristics

- Needs
  - Technical
  - Customer

- Engineering Characteristics
  - Power
  - Appearance
  - Material

List of technical needs / Engineering Characteristics	Power Supply(W)	noise cancellation (dB)	Volume(dB)	Gaskets, tight tolerances (mm)	Temperature, (F, C, J/S)	Toughness(J)	USB cable powered	Simple Button Layout	Appearance(mm, g, $$$)	antenna(Hz)	Material(1-10)
Communication		X	X					X	X	X	
Clarity of Microphone Input and Output	X	X								X	
Water Resistant				X		X					X
Not Hot to the touch	X				X						X
Drop Resistant				X		X			X		X
Get good WIFI reception									X	X	X
Fit Sonos Design Guidelines								X	X		X
Can be powered by a cell phone wall wart.	X						X				
List of customers' consideration											
Some Mobility	X						X			X	
Easy to Use							X	X			
Suitable Size	X					X		X	X		X
Good Weight	X					X					
Less Wires	X						X		X		
Affordable	X	X	X	X	X	X	X	X	X	X	X

Power Requirement

- The WIFI module power requirement is about 1.5W(max).
- Mic power requirement is about 25mW (max) each, hence the power for mic array should be about 100mW.
- LCD display takes about 0.5W.
- For CPU, the max supply current for each pin is 100 mA. With supply voltage 3.3 V, the max power would be about 5-6W, which is the worst case, depending on the number of driving pins.

The ideal power requirement is 6w at work. In case more are in need, we would take the worst case at first for testing to find out the more appropiated value. The power requirement at work would be taken as 10W.