Acoustic-Mechanical Design, Testing and Tuning Plan 1

Typical R&D

- COMSOL Simulation Time: ~8-10 weeks
- Speaker Component Measurements – Klippel Test System Time: ~2 weeks
- Speaker Component Measurements – SoundCheck Time: ~2 weeks
- Speaker System Measurements – SoundCheck Time: ~3 weeks
- Microphone Component Measurements – SoundCheck Time: ~2 weeks
- Microphone System Measurements – SoundCheck Time: ~2 weeks
- Amplifier Measurements – Audio Precision Time: ~2 weeks
- DSP Measurements – Audio Precision Time: ~2 weeks
- DSP-AMP Measurements – Audio Precision Time: ~2 weeks
- XBOX-DSP-AMP Measurements – Audio Precision Time: ~2 weeks
- Custom Python/Matlab scripts Time: ~3 weeks
- Voice Quality, Noise and Echo Suppression Measurements Time: ~8 weeks
- Speaker Playback Tuning, Gain, EQ, DRC
- Microphone Tuning, Gain, EQ, DRC Time: ~8-10 weeks
- DSP Echo and Noise Suppression Tuning
- Final quality system level objective and subjective acoustic tests Time: ~3 weeks

Low Risk

Time: ~50-54 weeks if performed sequentially

Time: ~27 weeks for a team (Simulation Engineer, Tuning Engineer, 2 Test Engineers, Test Technician, Prototype/Mechanical engineer, DSP Engineer, Python Developer)

Acoustic-Mechanical Design, Testing and Tuning Plan 2

9 weeks – 360 hours

- ~~COMSOL Simulation~~
- ~~Speaker Component Measurements – Klippel Test System~~ } High Risk
- Speaker Component Measurements – SoundCheck
- Speaker System Measurements – SoundCheck } Time: ~2 weeks or ~80 hours High Risk
- Microphone Component Measurements – SoundCheck
- Microphone System Measurements – SoundCheck } Time: ~1 week or ~40 hours High Risk
- Amplifier Measurements – Audio Precision
- DSP Measurements – Audio Precision
- DSP-AMP Measurements – Audio Precision
- XBOX-DSP-AMP Measurements – Audio Precision } Time: ~1 week or ~40 hours High Risk
- ~~Custom Python/Matlab scripts for Voice Quality Testing~~ } Acquire AP SW-POLQA module Low Risk
  but no Voice Intelligibility testing
- Voice Quality, Noise and Echo Suppression Measurements
- Speaker Playback Tuning, Gain, EQ, DRC
- Microphone Tuning, Gain, EQ, DRC
- DSP Echo and Noise Suppression Tuning } Time: ~9 weeks or ~360 hours High Risk
- Final quality system level objective and subjective acoustic tests } Time: ~1 week or ~40 hours High Risk

Time: ~640 hours or ~4 months High Risk

Acoustic-Mechanical Design, Testing and Tuning Plan 3

9 weeks – 360 hours

- ~~COMSOL Simulation~~
- ~~Speaker Component Measurements – Klippel Test System~~

High Risk

- Speaker Component Measurements – SoundCheck
- Speaker System Measurements – SoundCheck
- Microphone Component Measurements – SoundCheck
- Microphone System Measurements – SoundCheck
- Amplifier Measurements – Audio Precision
- DSP Measurements – Audio Precision
- DSP-AMP Measurements – Audio Precision
- XBOX-DSP-AMP Measurements – Audio Precision

Time: ~4 weeks or ~160 hours Very High Risk

- ~~Custom Python/Matlab scripts for Voice Quality Testing~~

Acquire AP SW-POLQA module Low Risk

but no Voice Intelligibility testing

- Voice Quality, Noise and Echo Suppression Measurements
- Speaker Playback Tuning, Gain, EQ, DRC
- Microphone Tuning, Gain, EQ, DRC
- DSP Echo and Noise Suppression Tuning
- Final quality system level objective and subjective acoustic tests

Time: ~4 weeks or ~160 hours

Very High Risk

Time: ~360 hours or ~2 months Very High Risk

Proposed System Tuning and Measurements

SoundCheck and AudioPrecision – ~~Free Field, ETSI compliant room~~, Reverberant room

- Tuning Environment setup (Actual Living room)
- Tuning-Test System setup
- Calibrations
- Python and/or Matlab Test tuning script development
- SC and AP Test sequence/script adaptation
- Test sequence/script measurement runs
- Reporting
- Analysis

Tuning-Test System setup

- TV
- Xbox
- Game controller
- Auditus interface prototypes
- PC with app controlling Nuvoton DSP parameters
- SoundCheck PC
- Audio Precision PC
- PC running Voice quality testing Python/Matlab scripts
- SoundCheck system
- Audio Precision Analyzer 515
- Measurement microphones + stands
- Reference speakers (one as mouth simulator, one as FB playback) + stands
- Noise Playback speakers (JBL 308 Pro) + stands
- HDMI/SPDIF to analog audio converters
- Far-end PC running Xbox Game or Party Chat with controller and Auditus interface and/or other headset or mic/speaker/headphone setup
- Custom connectors, cables, adaptors

Time: 8-10 weeks

Amplifier Comparison

V4 vs. V5 Speaker Amplifier Comparison

Engineering Insights

🔷 **V4 Advantages (TPA2012D2):**

- Higher dynamic range and audio fidelity (100 dB+ SNR)
- Lower THD
- Stereo support (or summed mono)
- Better PSRR → cleaner sound in noisy power conditions
- Excellent for **high-quality speech and music playback**

🔶 **V5 Advantages (PAM8302):**

- Simpler, smaller footprint
- Slightly higher output at same voltage in mono
- Filter-less architecture saves space and cost
- Good for **voice-centric applications** with low BOM cost

Amplifier Comparison

Battery-Powered Output Power Comparison (Into 8 Ω Load)

Summary of Audio Power Capabilities

Engineering Conclusion

- **V4** provides **more total power and better audio quality**, especially when stereo is active or when mono is derived from both channels.
- **V5** provides **sufficient power for voice playback** with lower cost, space, and part count, but at the expense of fidelity.

Comparative SPL (Sound Pressure Level) Output Estimate for the V4 and V5 designs

Assumptions

Summary

SPL Output Estimate vs. Voltage & Power

Full Charge (4.2 V)

Nominal (3.7 V)

Minimum (3.3 V)

SPL increases by ~3 dB for each doubling of power, so even small power differences translate into perceptible loudness changes.

Suggestions if You Want to Increase SPL although another critical metric is THD for AEC and NS:

1. **Choose a higher sensitivity speaker** (e.g., 88–90 dB SPL @ 1 W).
2. **Use a boost converter** to raise amplifier supply to 5 V+ (only if thermally and electrically safe).
3. **Use larger diaphragm transducer** for better efficiency.
4. **Tune enclosure geometry** (front/rear volume, porting) to improve acoustic output below 1 kHz.

Need to run component and system level measurements to verify performance before and after the speaker is integrated into the enclosure

- Port Size & Shape Effects - Port Diameter, Port Length / Tube Effects
- Enclosure Design Effects - Cavity Volume Behind the speaker, Speaker Placement
- Venting, Dust, and Waterproofing - Acoustic Mesh / Gasket

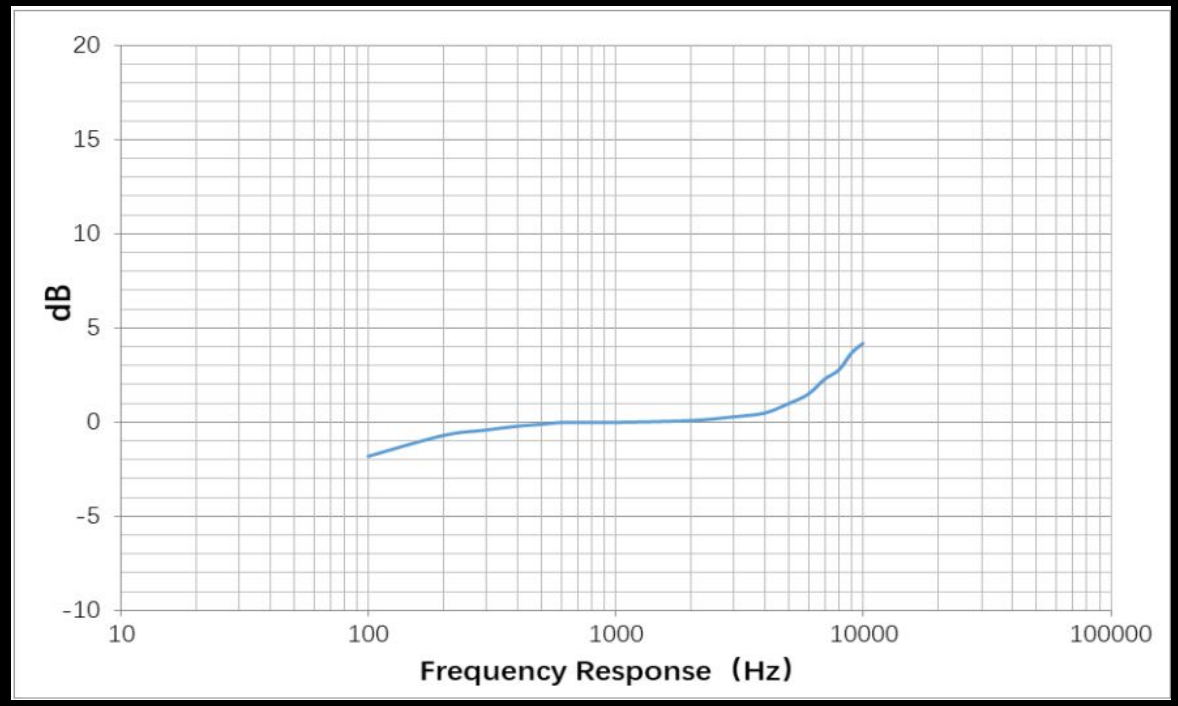
WILLSEMI WMM7027ATSN1-4-TR Analog MEMS Microphone

ACOUSTIC & ELECTRICAL SPECIFICATIONS

TEST CONDITIONS: 23 ±2 ℃, 55±20% R.H., V_{DD}(min) < V_{DD} < V_{DD}(max), no load, unless otherwise indicated

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Supply Voltage	VDD		1.5	-	3.6	V
Supply Current	IDD		-	92	100	uA
Sensitivity	S	94dB SPL @1KHz	-39	-38	-37	dBv
Signal to Noise Ratio	SNR	94dB SPL @1KHz, A-weighted	-	59	-	dB(A)
Total Harmonic Distortion	THD	94dB SPL @1KHz, S=Typ, VDD=2.2V	-	0.15	-	%
Acoustic Overload Point	AOP	3%THD @1KHz, S=Typ, VDD=2.2V	124	126	-	dBSPL
Power Supply Rejection	PSR	100mVpp 7/8 duty cycle rectangular wave @217Hz, A-weight, 20KHz BW	-	-101	-	dBv
DC Output		VDD=2.2V	-	-	1.1	V
Output impedance	ZOUT	@1KH	-	-	300	Ω
Directivity			Omnidirectional			

Typical specifications are measured at VDD = 2.2V.



Need to run component and system level measurements to verify performance before and after the mic is integrated into the enclosure

- Port Size & Shape Effects - Port Diameter, Port Length / Tube Effects
- Enclosure Design Effects - Cavity Volume Behind the Mic, Mic Placement
- Venting, Dust, and Waterproofing - Acoustic Mesh / Gasket, Wind and Plosive Protection