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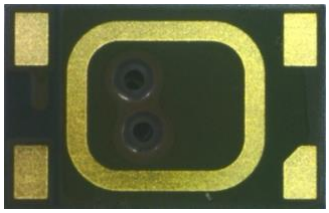
DATASHEET

XSC-2200-S

Muir Side-Firing MEMS Microspeaker



Document Revision: 1.0
Release Date: Aug. 12, 2024

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1.0 Introduction

Muir is xMEMS' smallest piezoMEMS microspeaker introduced in 2024. Muir is optimized for tweeter applications in 2-way designs (TWS and headphone) and can also be considered for hearing aid applications.

Key Features:

- Full Bandwidth speaker for fully-occluded system designs (20Hz – 20kHz).
- High-performance tweeter for non-occluded or multi-driver earphone implementations.
- Monolithic, uniform, and consistent MEMS Process eliminates calibration and driver matching.
- Exceptionally fast mechanical response, enabling wider-bandwidth ANC and improved spatial audio.
- IP58 Waterproof to 1M @ 60mins and Dust Resistant.
- High resonant frequency and linear response for superb fidelity at higher frequencies and improved gain before feedback.
- SMT-Ready, enabling simplified system integration and reduced assembly complexity.
- 10,000g Shock Resistance.
- World's thinnest (1.15mm) and smallest volume (20mm^3) speaker with greater than 110dB output at 1kHz.

Target Applications:

- True Wireless Stereo (TWS) earbuds
- Hearing Health
- Wireless/Wired In-Ear Monitors (IEM)
- Smart Glasses (tweeter only)

Ordering Information:

Part Number	Description	Dimensions	Weight
XSC-2200-S	Muir xMEMS Side-Firing Microspeaker	3.2_W x 5.0_L x 1.15_H (mm)	48mg
XAA-2000	Aptos2 audio amplifier (16x gain) companion chip	See XAA-2000 datasheet	
XAA-2000-12	Aptos2 audio amplifier (4x gain) companion chip	See XAA-2000-12 datasheet	

2.0 Specifications

2.1 Electroacoustic Parameters

PARAMETER	UNIT	TYP	+/-	NOTE
f_{res}	kHz	12.2		

2.2 Acoustic Parameters

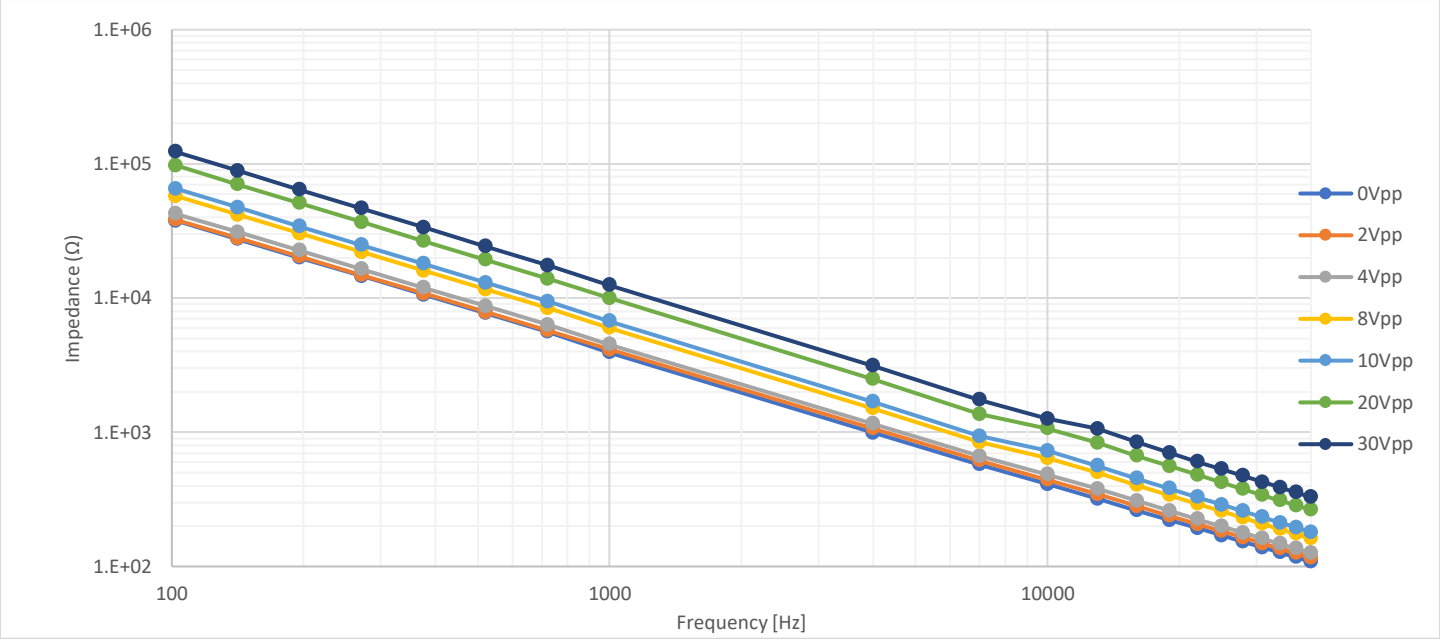
The following acoustic parameters were measured with:

- IEC 60318-4 Coupler
- Muir Test Socket & Coupler Adapter
- xMEMS Aptos2 Class-H amplifier with 10Vbias

PARAMETER	UNIT	TYP	+/-	NOTE
SPL @ 1 kHz / 30 V_{PP}	dB	111	1.5	
SPL @ 5 kHz / 30 V_{PP}	dB	122		
SPL @ 1 kHz / 4.0V_{pp}	dB	94	1.5	94dB @ 1kHz
SPL @ 5 kHz / 4.0V_{pp}	dB	109		94dB @ 1kHz
nTHD @ 1 kHz	%	0.5	0.5	94dB @ 1kHz
Lower bandwidth (-3dB)	Hz	<20		

2.3 Electrical Interface Parameters

PARAMETER	UNIT	MIN	TYP	MAX	NOTE
Load Capacitance	nF		24		At $1V_{pp}$, $10V_{bias}$, 1kHz
Loss Tangent of Load Capacitance	%		1.79		Between T and B terminal @ 1kHz, $10V_{bias}$, $1V_{pp}$
Wiring Series Resistance	Ω		1.72		
AC Voltage Drive	V_{ac}	0	2.0	15	Voltage difference between B to T terminal 4Vpp aligns to 94dB SPL @ 1kHz
DC Bias Voltage (V_{bias})	V_{dc}	0	10	15	Voltage difference between B to T terminal with XAA-2000
Maximum Applied Voltage	V	0		60	Voltage difference between B to T terminal applied in unipolar drive



Measured impedance with Agilent E4980A LCR meter

2.4 Power Consumption

PARAMETER	UNIT	MIN	TYP	MAX	NOTE
Single Tone 94dB SPL@ 1kHz	μW		21.4		PKG level

3.0 Acoustic Parameters

3.1 Bench Socket Setup for Extended Range (20Hz to 40kHz) Measurements

Bench Tester	
Ear Simulator	GRAS RA0404
Ear Simulator Volume	1.26cc
Connection volume (to Ref plane)	0.00635cc
Front volume (inside lid)	0.00435cc
Socket Back Volume (to atm)	0.01835cc
Back Volume (inside LGA)	0.00210cc
Total test volume	1.271cc
Applied back volume	Open (infinite)
Microphone	GRAS 40BD
Microphone Amplifier	GRAS 26CB
Speaker Amplifier	xMEMS Aptos XAA-1000 (BTL30 EVB-XAA-1000)
Measurement System	Audio Precision APx525
DAC	Audio Precision APx525
Test Fixture	Bench socket for Muir SF v1.0
Measurement Signal	Sine sweep, 1/24 oct stepped
Frequency Range	Swept from 40kHz to 20Hz

DAC of APx525 -> xMEMS Aptos XAA-1000 -> Muir -> GRAS RA0404 -> APx525

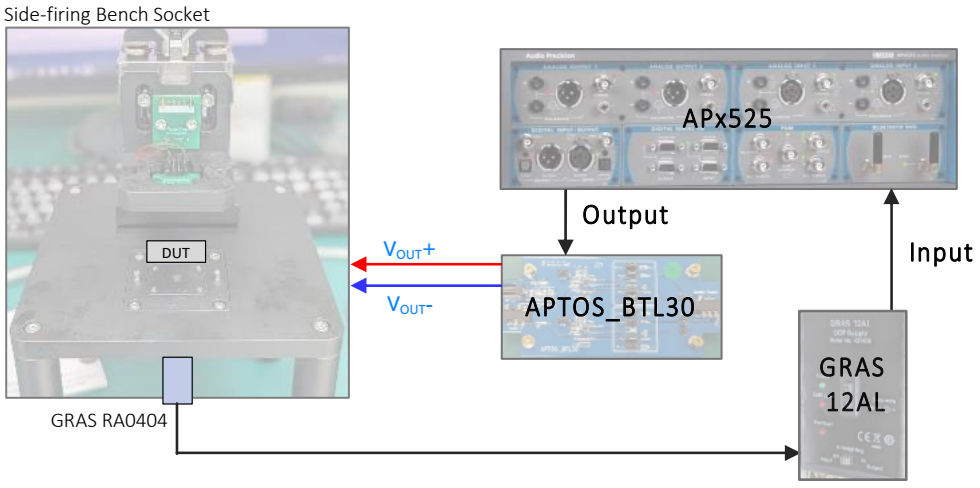
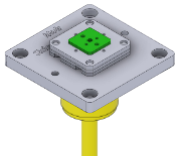


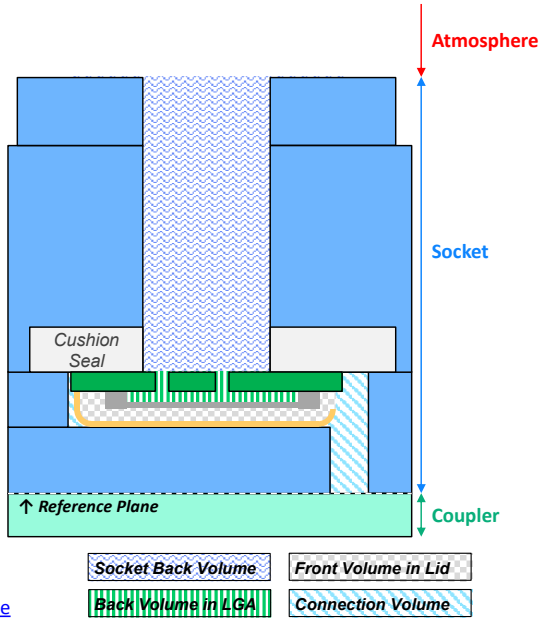
Figure 3.1.1: Test Measurement Apparatus

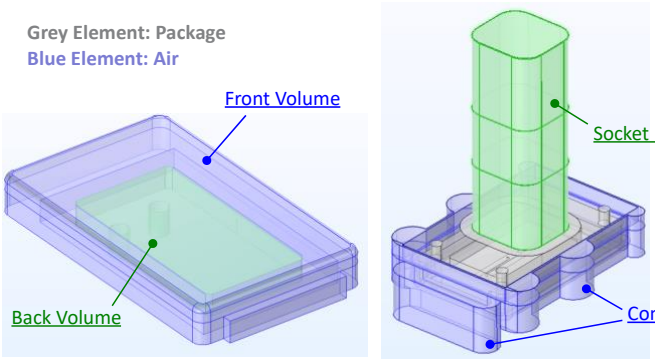
Side-firing Muir Package in Bench Socket

- Package Volume in Socket:

Region	Volume [cc]
Socket Back Volume (to atm)	0.01835
Back Volume (Inside LGA)	0.00210
Front Volume (Inside Lid)	0.00435
Connection Volume (to Ref plane)	0.00635







3.2 Frequency Response and THD for Full-Range (20Hz to 20kHz) Applications

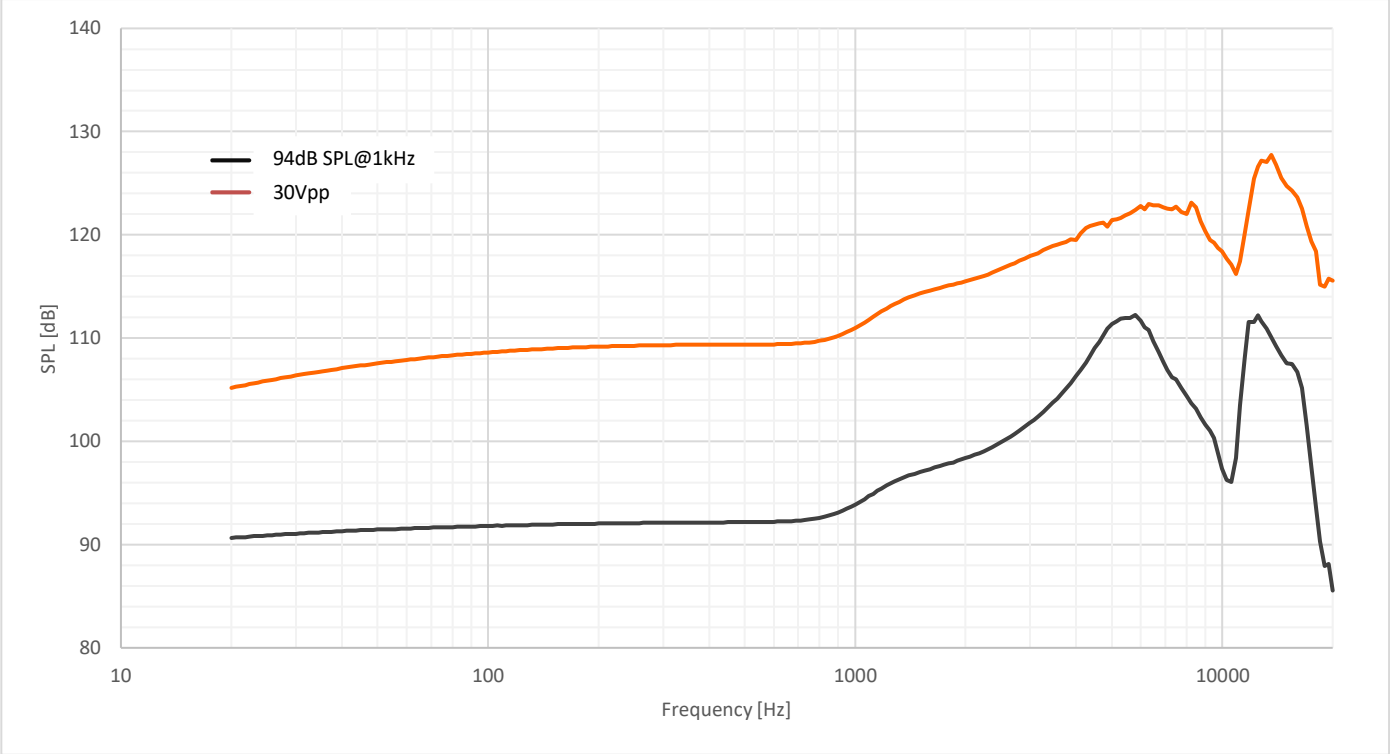


Figure 3.2.1: Full-Range Frequency Response

Technical Notes: The Muir driver generates near-ideal constant volume velocity due to its high resonant frequency. Therefore, the measured SPL of Muir with a RA0404 coupler is strongly affected by the acoustic impedance of the coupler.

The rise SPL above 800Hz and the SPL peak around 5.8kHz is the acoustic signature of Muir side-firing package.

The 11-12kHz peak is the acoustic signature of 7-11 coupler.

The roll-off starting at 15-16kHz towards 20kHz is the acoustic signature of Muir side-firing package.
The dip around 10kHz is a result of the acoustic behavior of extra air volume between socket & side-firing package.

It is recommended to use acoustic dampers, electronics low-pass-filters, and/or signal equalizers to reduce the input signals to achieve the desired frequency response.

Muir produces high sound pressure levels (>120dB SPL) at frequencies above 5kHz. By applying equalization or filtering at these frequencies to reduce SPL and to shape the frequency response into a more traditional consumer listening curve, Muir returns to linear behavior.

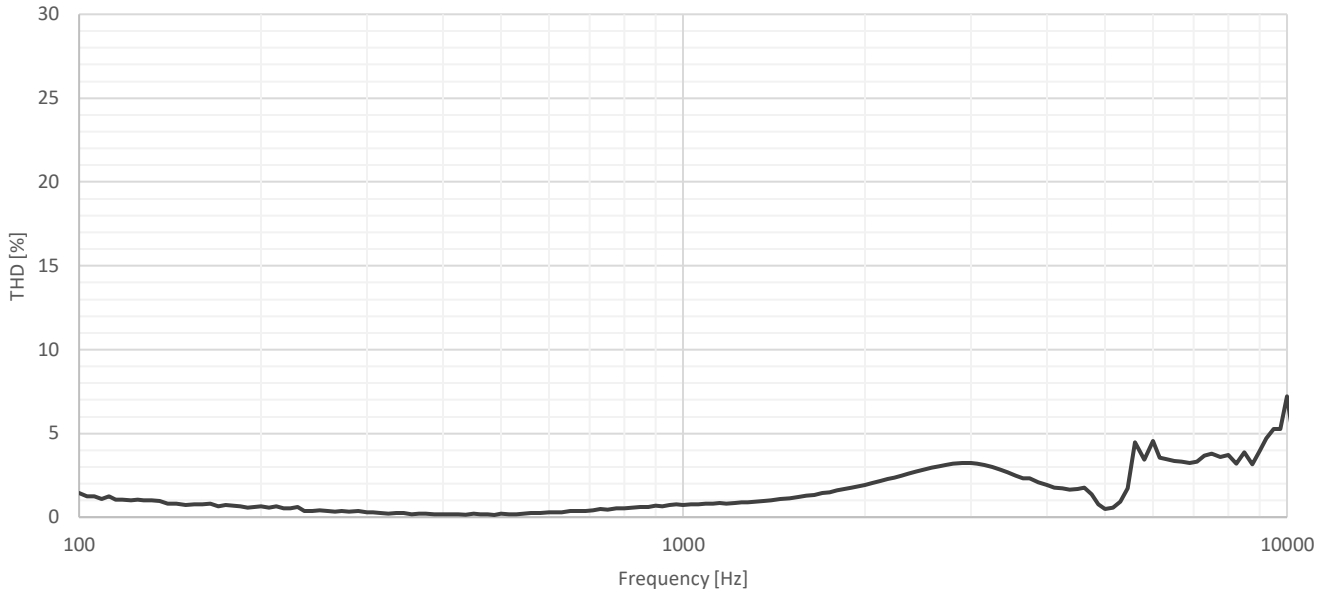


Figure 3.2.2: Full-Range THD, 94dB SPL@1kHz

Technical Note: The THD peaks around 3kHz and 6kHz are the harmonic distortion caused by the SPL peaks around 5.8kHz and 12.2kHz respectively, boosted by the acoustic resonance of Muir package connected with the ear coupler by the adapter.

3.3 Ultrasonic Frequency Response for Hi-Res Audio Applications

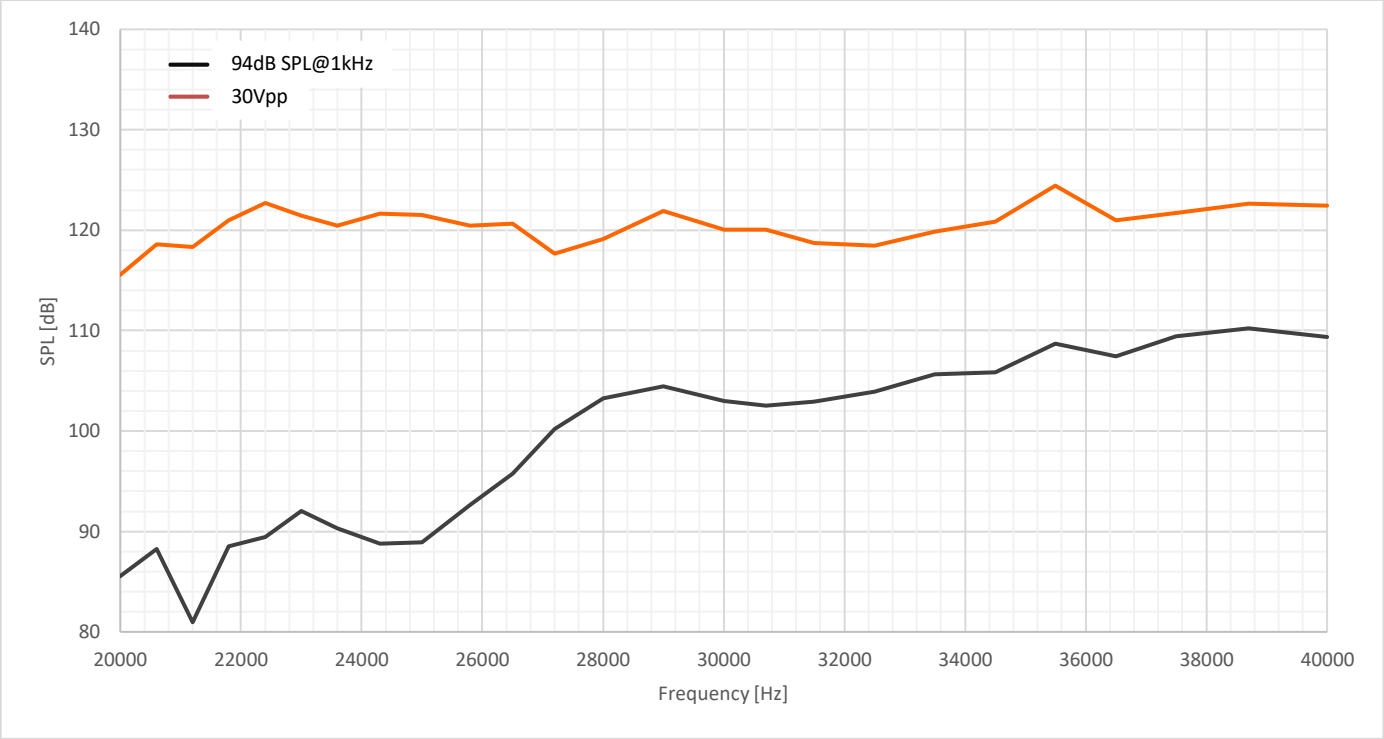


Figure 3.4.1: Ultrasonic Frequency Response

Technical Notes: With its flat frequency response from 20kHz to 40kHz, Muir meets the demanding standards of Japan Audio Society for Hi-Res Audio certification, delivering consistent loudness and unwavering sound quality even at extremely high frequencies.

Frequency response for 20Hz to 20kHz – see section 3.2.

4.0 Power Consumption and Reference Driving Circuit

4.1 Power Consumption

PARAMETER	UNIT	MIN	TYP	MAX	NOTE
Quiescent (3.6V)	mA		1.6		XSC-2200-S + XAA-2000 (Aptos2 amplifier)
94dB SPL playing IEC 60268-1 noise	mA mW		1.65 5.94		XSC-2200-S + XAA-2000 (Aptos2 amplifier)

Power consumption was measured with one XSC-2200-S speaker including the typical driving circuitry including the xMEMS XAA-2000 Aptos2 amplifier.

4.2 Reference Driving Circuit

For more information on the main blocks, reference driving circuit and BOM - see XAA-2000 Aptos2 datasheet.

5.0 Mechanical Dimensions

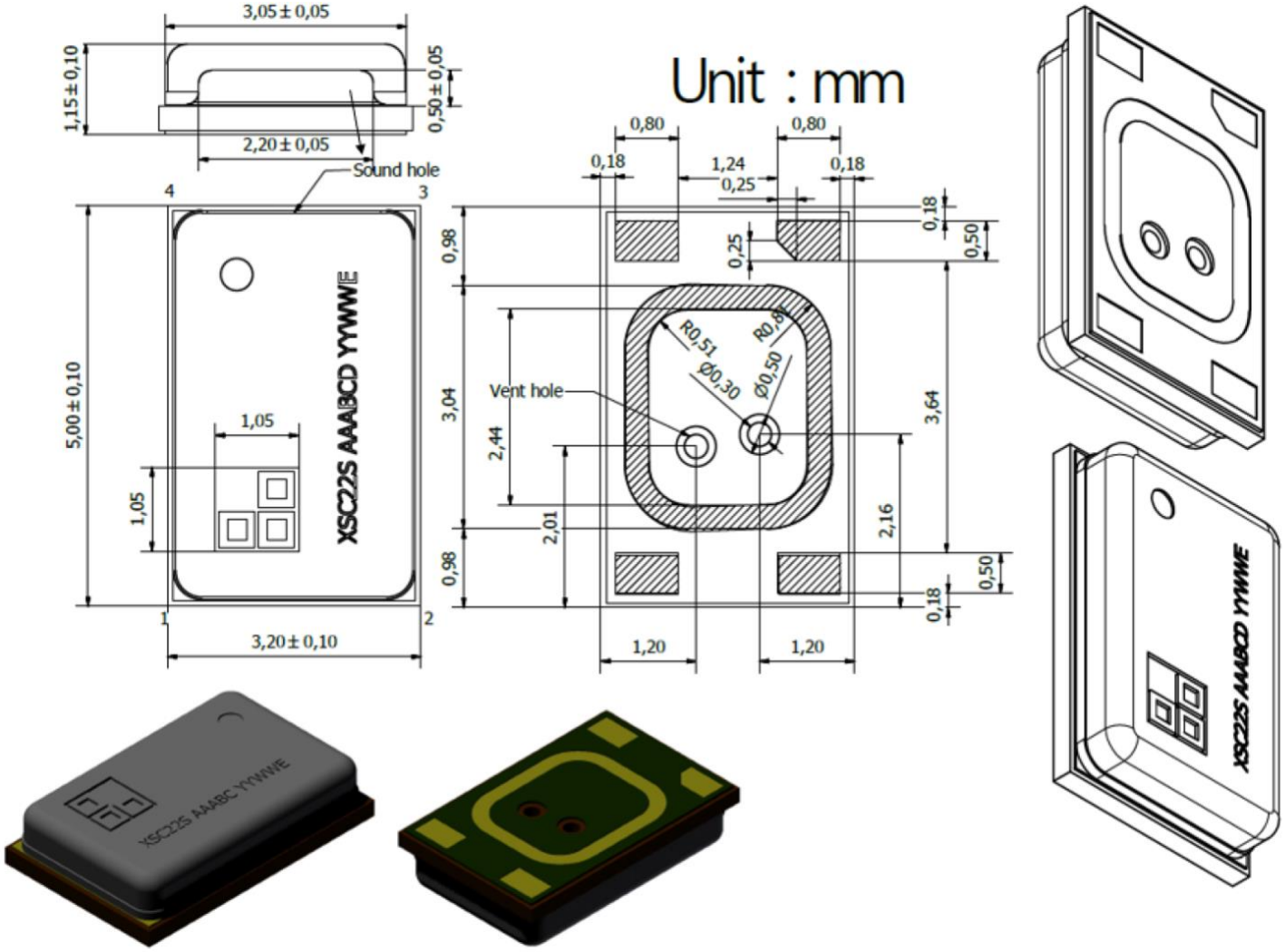
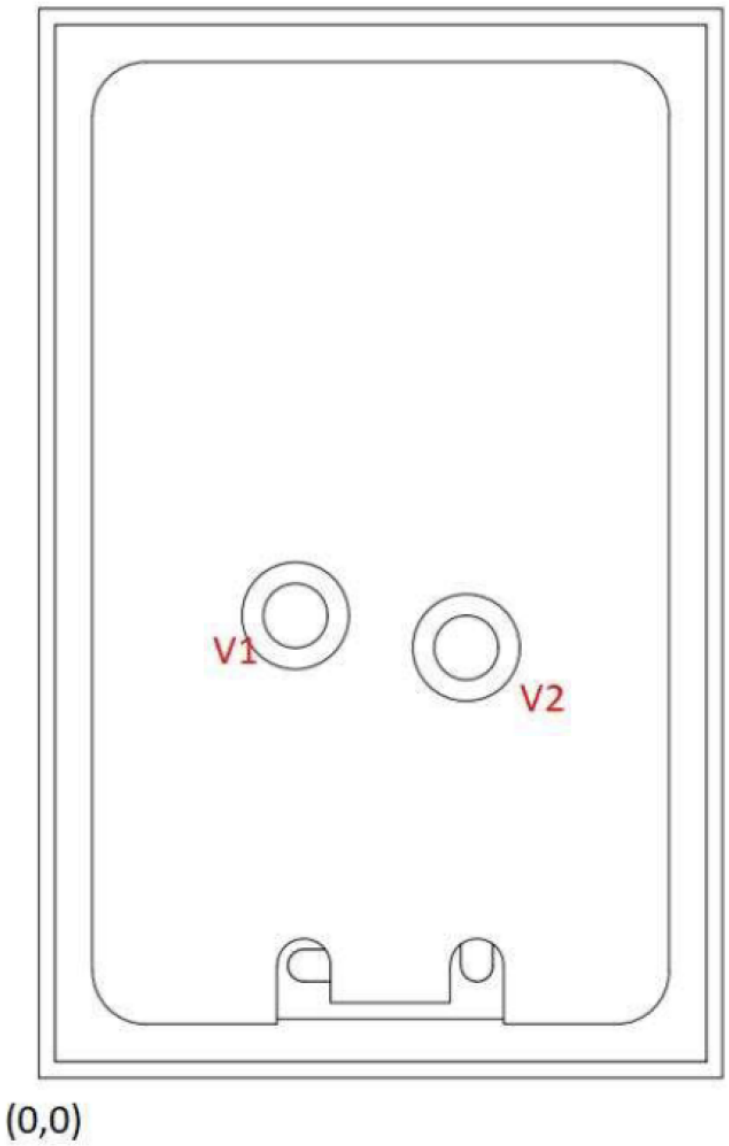


Figure 5.1: XSC-2200-S Package Dimensions

Figure 5.1 illustrates the PCB substrate and the 2 back vent holes.

Figure 5.2 describes their position information (XY location in µm unit) for Muir assembly.

Acoustic Port Location Information



Acoustic Port Location Information(um)

AP No.	X Coordinate	Y Coordinate	Size	AP No.	X Coordinate	Y Coordinate	
V1	1200	2160	Φ300				
V2	2000	2010	Φ300				

Figure 5.2: Back vent hole locations for PCB substrate

6.0 Pads Definition and Solder Footprint

6.1 Muir Pad Definitions

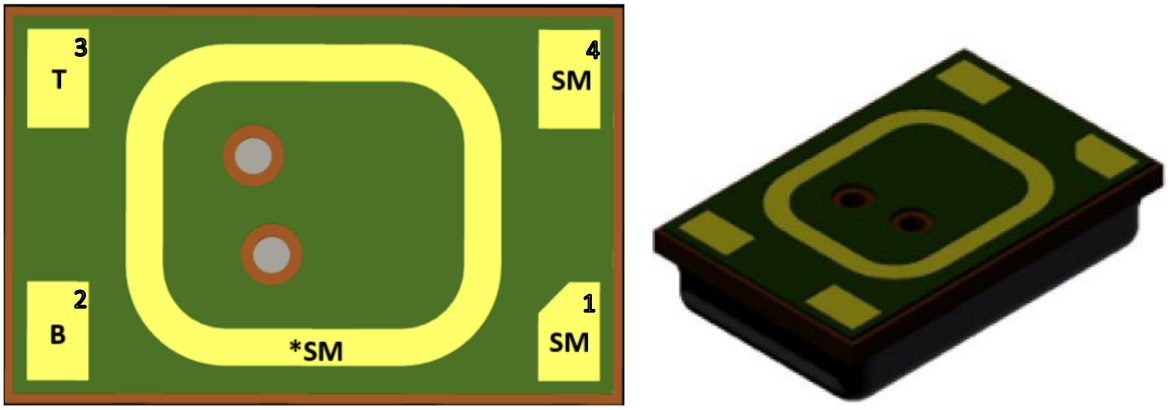


Figure 6.1.1: Bottom pads of XSC-2200-S package

The following descriptions define how the finished package should be interfaced electrically:

- SM: For use when employing SMT process. No electrical connection.
- **T** (TOP electrode of piezoMEMS): Connect to **POSITIVE** end of driving signal input.
- **B** (BOTTOM electrode of piezoMEMS): Should be connected to the **NEGATIVE** end of driving signal input.
- **Solder Enclosure Ring**: When employing SMT this ring can be used to solder the package to the host PCB, this can help isolate front chamber from back chamber. A vent hole in the host PCB is required and should be placed under the back vents.

6.2 Solder Footprint and Paste Masks

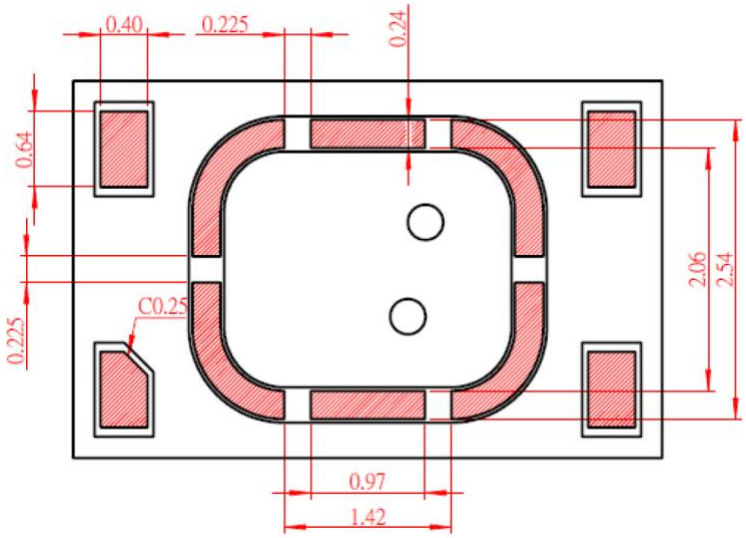


Figure 7.1.2: Suggested solder paste stencil pattern dimensions show in millimeters.

7.0 Handling and Assembly

7.1 Reflow Soldering and Board Assembly Guidelines

7.1.1 Printing Parameters

The recommended solder paste printing parameters are:

• Print pressure = 3 kg

• Print speed = 30 mm/sec

• Squeegee type = metal

• Squeegee angle = 60°

7.1.2 Stencil Parameters

The recommended stencil parameters are:

• Stencil type = laser cut

• Stencil thickness = 3 mils (~75um)

7.1.3 Suggested Solder Paste

The suggested solder paste is Indium8.9 (Type 4—alloy composition—96.5Sn/3.0Ag/0.5Cu (SAC305)). This paste is an air reflow, no-clean solder paste specifically formulated to accommodate the higher processing temperatures required by the Sn/Ag/Cu, Sn/Ag, and other alloy systems favored by the electronics industry to replace conventional Pb-bearing solders.

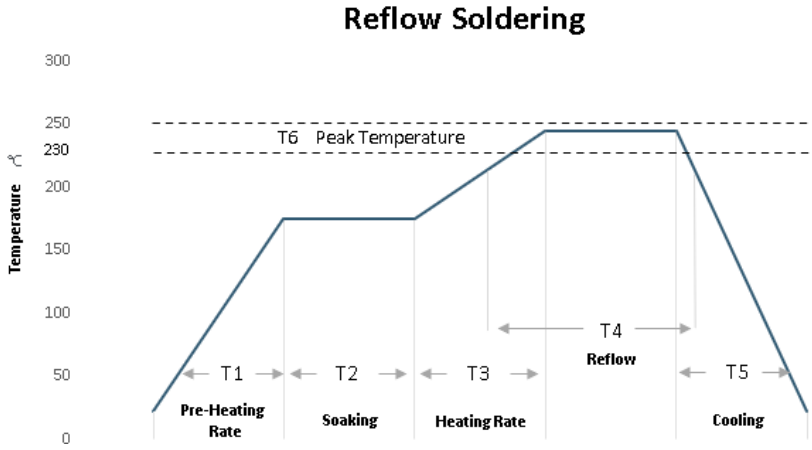
7.1.4 Placement Force

The MEMS speaker can be handled using standard pick-and-place and chip shooting equipment. Cautions should be taken to avoid damage the speaker structure as follows:

- Use a standard pickup tool to handle the speaker. For side-firing speaker where the sound port is on the side of the package, the pickup tool can make contact with any part of the lid surface; For top-firing speaker where the sound port is on the top of the package, the pickup tool can make contact on the lid surface but need to avoid touch the MEMS structure through the sound port.
- The size of the pickup tool should be no smaller than the size of the package. This will prevent denting of the lid during mounting.
- Do not pick up the speaker with a vacuum tool that makes contact with the sound port of speaker. Do not pull air out of or blow air into the sound port.
- Do not use excessive force (>1 kg) to place the speaker on the PCB.

7.1.5 Reflow Profile

xMEMS products are qualified in accordance with IPC/JEDEC J-STD-020D.1. This standard classifies proper packaging, storage and handling in order to avoid subsequent thermal and mechanical damage during the solder-reflow attachment phase of PCB assembly. The qualification preconditioning process specifies a sequence consisting of a bake cycle, a moisture soak cycle (in a temperature humidity oven), and three consecutive solder reflow cycles, followed by functional device testing. The peak solder reflow classification temperature requirement for package qualification is (260°C +0°C/-5°C) for lead-free soldering of components measuring less than 1.6 mm in thickness. The qualification profile and a table explaining the set points are shown below. The reflow profile in Figure 1 is recommended for board manufacturing with xMEMS MEMS speakers. These speakers are also compatible with the profile described in J-STD-020D.1:



No.	Item	Recommended
T1	Pre-Heating Rate	1.0~3.0 ℃/sec
T2	Soaking	60~120 sec
T3	Heating Rate	1.2~2.3 ℃/sec
T4	Reflow Time(>220℃)	30~100 sec
T5	Cooling	1.0~6.0 ℃/sec
T6	Peak temperature	230~250 ℃

Figure 7.1.1: Reflow Temperature Profile

*The most appropriate temperature profile condition differs depending on the solder paste.

Recommended Condition of Hand Soldering

- Temperature: 350°C
- Time: 2s Max
- Number of Hand Soldering: One time

Rework

The rework process of the MEMS speaker should be carried out with a rework station and steps as follows.

- Preheat the board between 100°C and 125°C.
- Place a nozzle over the part (need put high temperature tape on the sound port of top-firing package).
- Enable the hot airflow through this nozzle so that the solder becomes liquidus.
- Use the other nozzle to remove the speaker from the substrate.
- Apply additional solder paste to pad sites using a manually operated dispensing system, such as a syringe with a small gauge tip.
- Use a surface-mount placement machine to place the replacement component.
- Reflow the component on the rework station.

7.2 Handling Instructions

7.2.1 MEMS Handling

Unlike conventional IC products in similar packages, MEMS devices contain moving micromechanical structures. Therefore, MEMS devices require different handling precautions than conventional ICs prior to mounting onto PCBs. xMEMS products have been qualified to a shock tolerance of 10,000g. Furthermore, the products are shipped in cushioned packaging to protect them from potential damage induced by normal handling and shipping.

• Devices dropped during handling should not be used.

• Do not drop individually packaged speakers or trays of speakers.

• PCBs that incorporate mounted speakers should not be separated by manually snapping apart. This could also create g-forces in excess of 10,000g.

• Do not open and remove MEMS devices from the moisture barrier bag until you are ready to use them. The moisture barrier bag provides good protection to the MEMS speakers during storage and transfer.

7.2.2 ESD Considerations

Establish and use ESD-safe handling precautions when unpacking and handling ESD-sensitive devices.

• Store ESD sensitive devices in ESD safe containers until ready for use. The Tray moisture-sealed bag is an ESD approved barrier. The best practice is to keep the units in the original moisture sealed bags until ready for assembly.

• Ensure that all workstations and personnel are properly grounded to prevent ESD. Contact xMEMS for the ESD-MM (Machine Model) rating of each individual speaker product. Restrict all device handling to ESD protected work areas that measure less than the static charge for the specific speaker's rating.

7.2.3 Storage Specifications

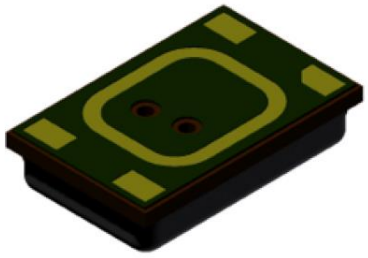
xMEMS products conform to the storage specifications of IPC/JEDEC J-STD-020D.1. The Moisture Sensitivity Level (MSL) of xMEMS speakers is 3 (168 hours storage conditions: ambient ≤30°C at 60%RH).

7.3 Device Handling

7.3.1 Force

The MEMS speaker passes 20N force test by uniform loading on the metal lid.

Direction of Stress	Maximum Applied Force
Top	20N
Long Side	20N
Short Side	20N
Bottom	20N



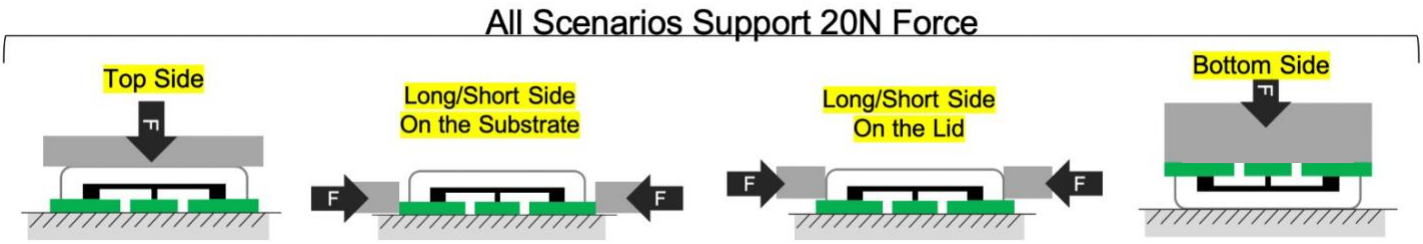


Figure 7.3.1: Applied package force parameters

8.0 Reliability Test Conditions

8.1 Device Qualification

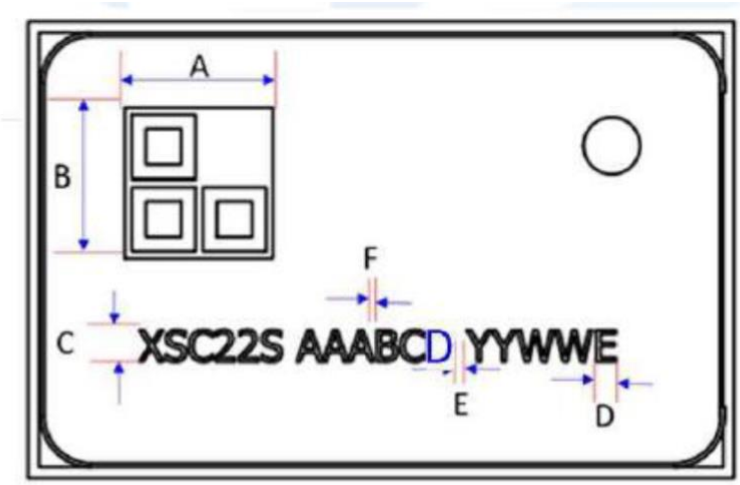
Rel. Stress Test	Method/Condition	Test Level
(DHO) **Dry Heat Operation**	IEC 60068-2-2; Biased bake, 70°C, V_{bias}=Vdd+Vpp with 94dB pink noise; Read points: 0, 120, 240, **480** hrs.	PCB
(CO) **Cold Operation**	IEC 60068-2-1; Biased bake, -20°C, V_{bias}=Vdd+Vpp with 94dB pink noise; Read points: 0, 120, 240, **480** hrs.	PCB
(TS) **Thermal Shock**	IEC 60068-2-14; -40°C~85°C, dwell time 30 mins; Read points: 0, 60, **100** cycles.	Component
(DHSS) **Damp Heat Steady State**	IEC 60068-2-78; 40 °C/85 % RH; Read points: 0, 120, 240, **480** hrs.	Component
(DHCT) **Damp Heat Cycle**	IEC 60068-2-30; +25/+55°C, 90-95% RH, dwell time 24 hrs; Read points: 0, **6** cycles.	Component
(VIB) **Vibration Test**	MIL-STD-883K-CHG3, Method 2007.3, Condition B; 20Hz-2kHz, ≥4min/cycle, 4 cycles, 50g peak accel.; Read points: T0, **POST**	Component
(MS) **Mechanical Shock Test**	IEC 60068-2-27, Condition E; 10,000g, 0.1ms pulse, ±X, ±Y, ±Z – 5 shock pulses, 6 directions. Read points: T0, **POST**	Component
(ESD-HBM) **ESD Human-Body Model**	ANSI/ESDA/JEDEC JS-001-2014; 7.5kV, **8.0kV**, All Pins, 1 per Polarity. Read points: T0, **POST**	Component
(ESD-CDM) **ESD Charged Device Model**	JESD22-C101; 750V, **1000V**, Std. Sample, 1 zap per Polarity. Read points: T0, **POST**	Component
(IP5x) **Particle Susceptibility Test**	IEC 60529; Vertical dust chamber; dust type: Talcum. Module port face-up for 8hrs. Read points: T0, **POST**	Component
(IPx8) **Waterproof Test**	IEC 60529; 1m under water for 60min. Read points: T0, **POST**	Component

8.2 Assembly Qualification

Rel. Stress Test	Method/Condition	Test Level
(PC) **Preconditioning**	JESD22-A113F/J-STD-020D. Bake 24hrs, 125˚C. Moisture Soak 192hrs at 30˚C/60%RH (MSL3), followed by 3 cycles 260˚C IR-Reflow (Pb-free).	Component
(SD) **Solderability**	JESD22-B102E, Precondition C, Method 1 or 2. 36 bonds/5 units.	Component
(BPS) **Wirebond Pull Strength**	MIL-STD-883J, M2011.9, 36 bonds/5 units. Ppk ≥ 1.66 or Cpk ≥ 1.33.	Component
(BS) **Bond Shear**	JESD22-B116A, 36 bonds/5 units. Ppk ≥ 1.66 or Cpk ≥ 1.33.	Component
(DS) **Die Shear**	MIL-STD-883J, M2019.9, 5 units. Ppk ≥ 1.66 or Cpk ≥ 1.33.	Component
(LS) **Lid Shear**	MIL-STD-883J, M2019.9, 5 units. Ppk ≥ 1.66 or Cpk ≥ 1.33.	Component
(PD) **Physical Dimensions**	All Dimensions.	Component

9.0 Part Labeling and Packaging

9.1 Part Labeling



Symbol / Package	A	B	C	D	E	F
5x3.2mm	1.05	1.05	0.26	0.22	0.1	0.05

TOLERANCE : ±0.1mm

UNIT : mm

Muir Side-Fire markings: **XSC22S AAABCD YYWWE**

- XSC22S – denotes Muir SF part (XSC-2200-S)
- AAA – Foundry Lot number
- B – Assembly house code
- C – Package substrate lot code
- D – Package revision code
- YY – Year
- WW – Work week
- E – “E” for engineering sample (ES). Blank for mass-production (MP) part

Figure 9.1.1 Part Labeling for Muir Side-Fire

Figure 9.1.2 Sample Label

9.2 Part Delivery Packing

The XSC-2200-S will ship in standardized 13” Tape & Reel with 3000 parts per reel. Each reel will be sealed with desiccant and temperature/humidity card inside of a foil ESD safe bag. Each bag will be packed into a box. 5 boxes will be packed into one carton, for a total of 15000 pieces per bulk shipment.

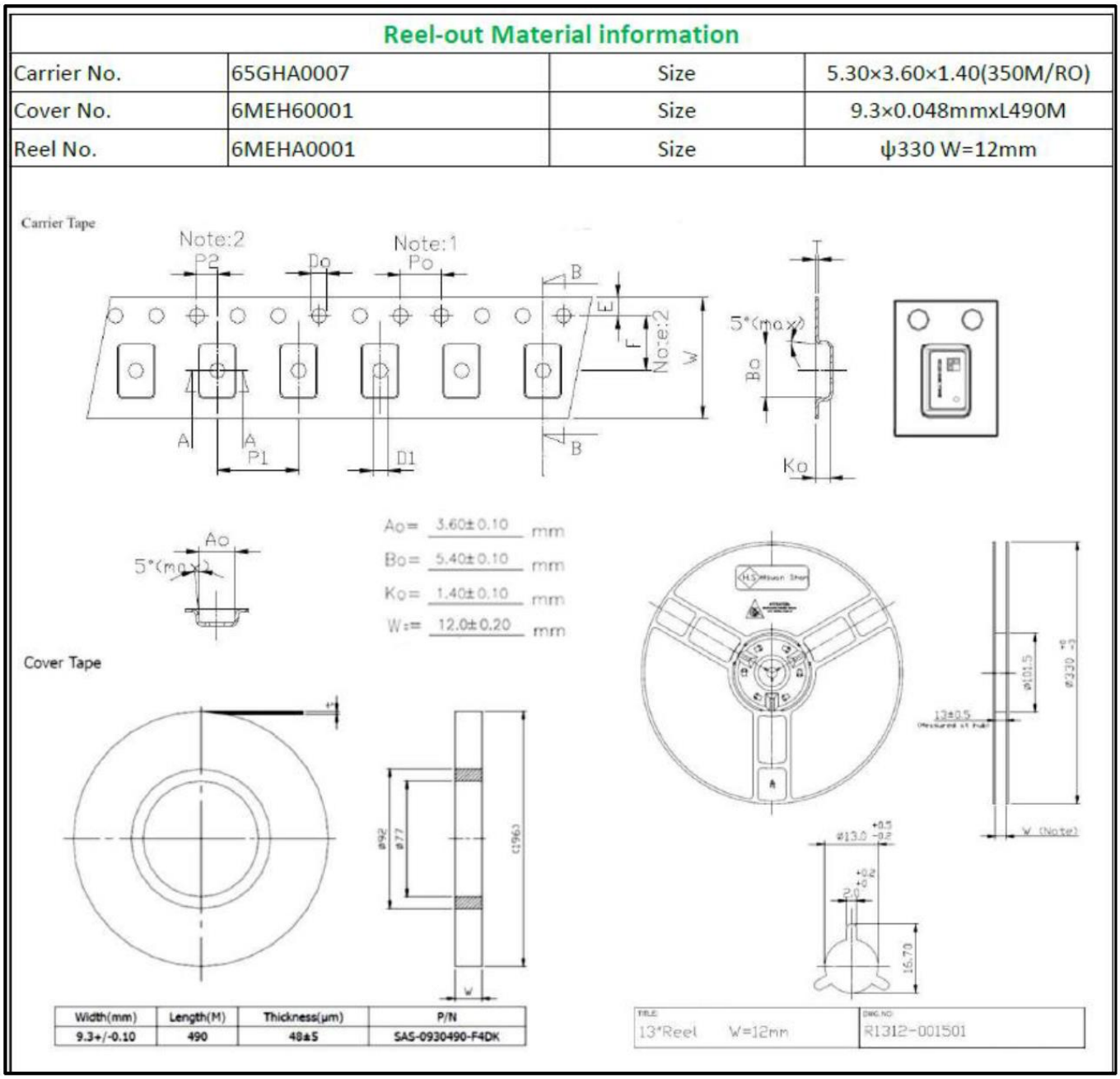


Figure 9.2.1: Tape & Reel Drawing

10.0 Disclosures

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