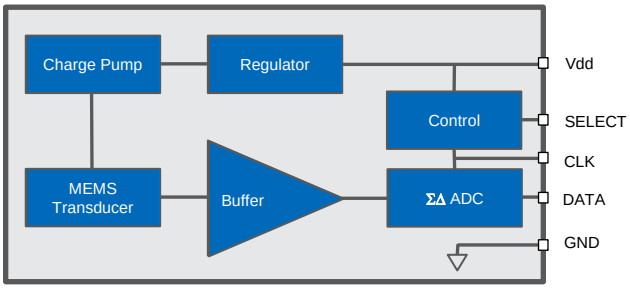
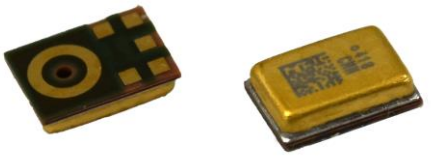
SYNTIANT®

SPS11R1LM4H
LOW-POWER MULTIMODE DIGITAL BOTTOM PORT SISONIC™ MICROPHONE

The SPS11R1LM4H is a miniature, high-performance, low power, bottom port silicon digital microphone with a single bit PDM output. Using Syntiant's proven high performance SiSonic™ MEMS technology, the SPS11R1LM4H consists of an acoustic sensor, a low noise input buffer, and a sigma-delta modulator. These devices are suitable for applications such as cellphones, smart phones, sensors, and other portable electronic devices where low power and excellent wideband audio performance and RF immunity are required. In addition, the SPS11R1LM4H offers multiple performance modes.





PRODUCT FEATURES

- Small Package Size
- Support for 1.2 V_{io}
- Low Current Consumption
- Low Latency
- High SNR
- Excellent Robustness and Reliability
- Flat Frequency Response
- High Drive Capability
- RF Shielded
- Bottom Port
- Sensitivity Matching
- Supports Dual Multiplexed Channels
- Multiple Performance Modes (Sleep, Low-Power, Normal)
- Ultra-Stable Performance
- Omnidirectional
- Standard SMD Reflow
- LGA Package

TYPICAL APPLICATIONS

- Smartphones
- TWS
- Wearables/IOT
- Far Field Recordings/Audio Zoom
- Always-On Applications

ABSOLUTE MAXIMUM RATINGS

Table 1: Absolute Maximum Ratings

Parameter	Absolute Maximum Rating	Units
AVdd to Ground	-0.5, +5.0	V
DVdd to Ground	-0.5, +5.0	V
DATA, CLOCK, SELECT to Ground	-0.3, +5.0	V
Input Current	±5	mA
Short Circuit to/from DATA	Indefinite to Ground or Vdd	sec
Storage Temperature	-40 to +125	ºC
Operating Temperature	-40 to +100	ºC

Stresses exceeding these “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only. Functional operation at these or any other conditions beyond those indicated under “Acoustic & Electrical Specifications” is not implied. Exposure beyond those indicated under “Acoustic & Electrical Specifications” for extended periods may affect device reliability.

ACOUSTIC & ELECTRICAL SPECIFICATIONS[1]

Table 2: General Microphone Specifications
Test Conditions: 23 ±2°C, 55±20% R.H., AVdd=1.8 V, DVdd=1.2 V, Tedge ≤ 6ns, unless otherwise indicated

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Analog Supply Voltage	AVdd		1.62	1.8	1.98	V
Digital Supply Voltage, 1.2V	DVdd		1.08	1.2	1.32	V
Digital Supply Voltage. 1.8V	Dvdd		1.62	1.8	1.98	V
Low Frequency Rolloff	LFRO	-3dB relative to 1 kHz	-	33	-	Hz
High Frequency Flatness		+3dB relative to 1 kHz	-	20	-	kHz
Resonant Frequency Peak	Fres	Free Field response	-	40	-	kHz
Latency		@ 4 kHz, Fclock=3.072 MHz	-	3	-	µs
DC Offset		SEL = 0 / SEL = 1: Fullscale = ±100%	-	0.0 / -0.39	-	%
Directivity			Omnidirectional			
Polarity		Increasing sound pressure	Increasing density of 1's			
Data Format			½ Cycle PDM			
Sensitivity Drop		Vdd(min) ≤ Vdd ≤ Vdd(max)	-	-	±0.25	dB
Clock Input Capacitance	Cin		-	8	-	pF
Data Output Capacitance	Cout		-	31	-	pF
Data Output Load	Cload		-	-	110	pF
SELECT (high)			DVdd-0.2	-	DVdd	V
SELECT (low)			-0.3	-	0.2	V
Short Circuit Current	Isc	Grounded DATA pin	1	-	20	mA
Fall-asleep Time[3,4]		Fclock < 1kHz	-	-	10	ms
Wake-up Time[3,5]		Fclock ≥ 380kHz	-	-	20	ms
Startup Time[3]		Powered Down → Active, S within 1 dB of final value	-	-	20	ms
Time to First Data Bit[6]		Time from valid Vdd and CLK until the first logical bit is driven on the DATA line. The output is tristate until First Data Bit. Initial output bits represent muted audio. Audio data will follow Startup Time.	-	2	-	ms
Mode-Change Time[3, 6]		Low Power Mode ⇔ Normal Mode	-	-	20	ms

Table 3: Normal Mode

Test Conditions: 23 ±2°C, 55±20% R.H., AVdd=1.8 V, DVdd=1.2 V, Fclock = 3.072 MHz (D.C. = 50%), Tedge ≤ 6ns, BW=20-20kHz, SELECT grounded, no load, unless otherwise indicated

Parameter	Symbol	Conditions		Min	Typ	Max	Units
Current consumption[2]		Fclock = 1.536 MHz	Avdd=1.8V Dvdd=1.2V Dvdd=1.8V	- - -	204 75 96	- - -	µA
		Fclock = 2.4 MHz	Avdd=1.8V Dvdd=1.2V Dvdd=1.8V	- - -	308 92 121	- - -	
		Fclock = 3.072 MHz	Avdd=1.8V Dvdd=1.2V Dvdd=1.8V	- - -	328 116 152	- - -	
Sensitivity	S	94 dB SPL @ 1 kHz		-38	-37	-36	dBFS
Signal to Noise Ratio	SNR	94 dB SPL @ 1 kHz, A-weighted, Fclock = 2.4 MHz 94 dB SPL @ 1 kHz, A-weighted, Fclock = 3.072 MHz		- -	64 64.8	- -	dB(A)
Speech Range SNR		94 dB SPL @ 1 kHz, BW = 300Hz - 3kHz		-	68.5	-	dB(A)
Near-Ultrasonic SNR		94 dB SPL @ 19 kHz, BW = 18.5 - 20.0 kHz		-	78	-	dB
Total Harmonic Distortion	THD	94 dB SPL @ 1 kHz 120 dB SPL @ 1 kHz		- -	0.2 0.5	0.5 -	%
		1% THD @ 1 kHz, S = typ		-	127	-	dB SPL
Acoustic Overload Point	AOP	10% THD @ 1 kHz, S = typ		-	132	-	dB SPL
Power Supply Rejection Ratio	PSRR	200 mVpp sinewave @ 1 kHz		-	90	-	dB V/FS

Table 4: Low-Power Mode

Test Conditions: 23 ±2°C, 55±20% R.H., AVdd=1.8 V, DVdd=1.2 V, Fclock = 768 kHz (D.C. = 50%), Tedge ≤ 6ns, BW=20-8kHz, SELECT grounded, no load, unless otherwise indicated

Parameter	Symbol	Conditions		Min	Typ	Max	Units
Current Consumption[2]		Fclock = 768KHz	Avdd=1.8V Dvdd=1.2V Dvdd=1.8V	- - -	143 40 50	- - -	µA
Sensitivity	S	94 dB SPL @ 1 kHz		-38	-37	-36	dBFS
Signal to Noise Ratio	SNR	94 dB SPL @ 1 kHz, A-weighted (BW = 8 kHz)		-	61	-	dB(A)
Speech Range SNR		94 dB SPL @ 1 kHz , BW = 300Hz - 3kHz		-	65.5	-	dB(A)
Total Harmonic Distortion	THD	94 dB SPL @ 1 kHz		-	0.5	0.7	%
		1% THD @ 1 kHz, S = typ		-	127	-	dB SPL
Acoustic Overload Point	AOP	10% THD @ 1 kHz, S = typ		-	132	-	dB SPL
Power Supply Rejection Ratio	PSRR	200 mVpp sinewave @ 1 kHz		-	86	-	dBV/FS

Table 5: Sleep Mode
Test Conditions: 23 ±2°C, 55±20% R.H., AVdd=1.8 V, DVdd=1.2 V, Fclock = 0 Hz, SELECT grounded, no load, unless otherwise indicated

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Sleep Current	Isleep		-	-	1	µA

[1] Sensitivity and Supply Current are 100% tested.

[2] Power consumption varies with Cload according to: ΔP = 1/3*DVdd*DVdd*ΔCload*Fclock.

[3] Valid microphones states are: Powered Down Mode (mic off), Sleep Mode (low current, DATA = high-Z, fast startup), Low-Power Mode (low clock speed) and Normal Mode.

[4] Time from Fclock < 250 kHz to Isleep specification is met when transitioning from Active Mode to Sleep Mode.

[5] Time from Fclock ≥ 380 kHz to all applicable specifications are met when transitioning from Sleep Mode to Active Mode.

[6] Audio is temporarily muted during the transition between any microphone state.

Table 6: Digital Interface
Test Conditions: 23 ±2°C, 55±20% R.H., AVdd=1.8 V, DVdd=1.2 V, Tedge ≤ 6ns, unless otherwise indicated

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Logic Input High[7]	Vih		0.65xDVdd	-	DVdd+0.3	V
Logic Input Low[7]	Vil		-0.3	-	0.35xDVdd	V
Logic Output High[7]	Voh	I_{OUT} = 2 mA	0.75xDVdd	-	DVdd	V
Logic Output Low[7]	Vol	I_{OUT} = 2 mA	0	-	0.25xDVdd	V
Low→High Threshold[8]	Vl-h		-	-	0.65xDVdd	V
High→Low Threshold[8]	Vh-l		0.35xDVdd	-	-	V
Hysteresis Width[8]	Vhyst		0.1xDVdd	-	0.5xDVdd	V
Clock Frequency[7]	Fclock	Sleep Mode	0	-	250	kHz
		Low-Power Mode	380 730	- -	645 800	kHz
		Normal Mode	1.15 1.92 2.35 2.83	- - - -	1.73 2.1 2.56 3.3	MHz
Clock Duty Cycle	D.C.		40	50	60	%
Delay Time to Data Line Driven[7]	Tdd		40	-	80	ns
Delay Time to Valid Data[7]	Tdv	Max Cload	-	-	150	ns
Delay Time to High Z[7]	Tdz		5	-	30	ns
Hold Time[7]	Thold	Thold, as observed by the input device, will be dependent on Cload	5	-	-	ns

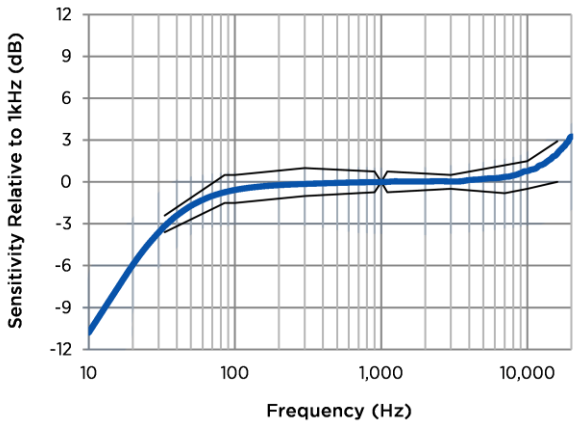
[7] See Figure 10: Timing Diagram.

[8] See Figure 11: Hysteresis Diagram.

PERFORMANCE CURVES

Test Conditions: 23 ±2°C, 55±20% R.H., Vdd=1.8 V, Fclock = 3.072MHz, SELECT grounded, no load, unless otherwise indicated

Figure 1: Typical Free Field Magnitude and Masks



	33	85	100	300	900	1000	1100	3000	7000	10000	16000
USL	-2.4	0.5	0.5	1	0.75	0	0.75	0.5	1.2	1.5	2.9
LSL	-3.6	-1.5	-1.5	-1	-0.75	0	-0.75	-0.5	-0.8	-0.5	0

Figure 2: Typical THD vs SPL

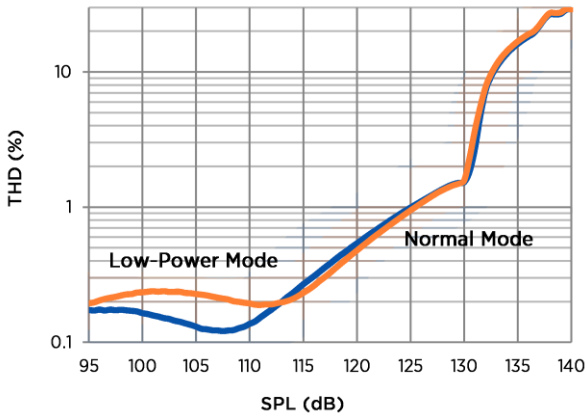
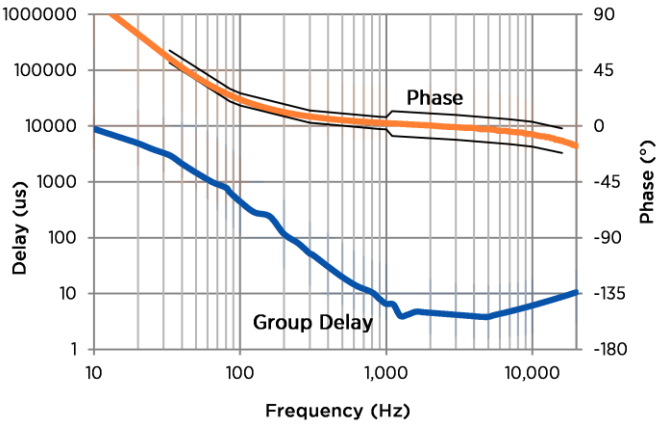


Figure 3: Typical Phase and Group Delay



	33	85	100	300	900	1000	1100	3000	7000	10000	16000
USL	61	30	26.5	12.6	7.6	7.3	12	9	5.5	3.4	-1.8
LSL	51	20	16.5	2.6	-2.4	-2.7	-8	-11	-14.5	-16.6	-21.8

Figure 4: Typical THD vs Frequency

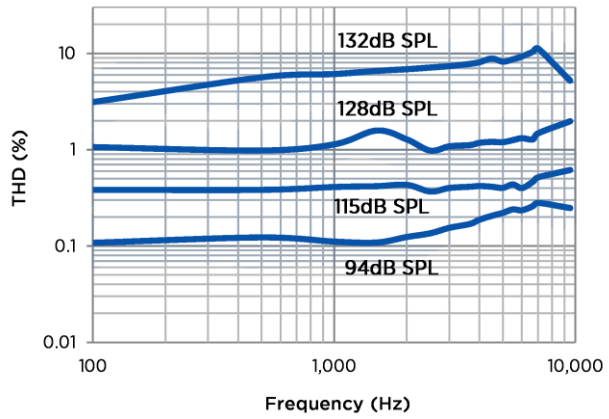


Figure 5: Typical Free Field Ultrasonic Response

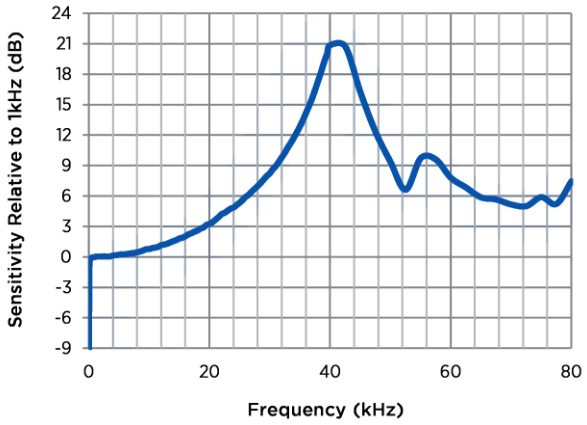


Figure 6: Typical Power Consumption vs DVdd (1.2V I/O)

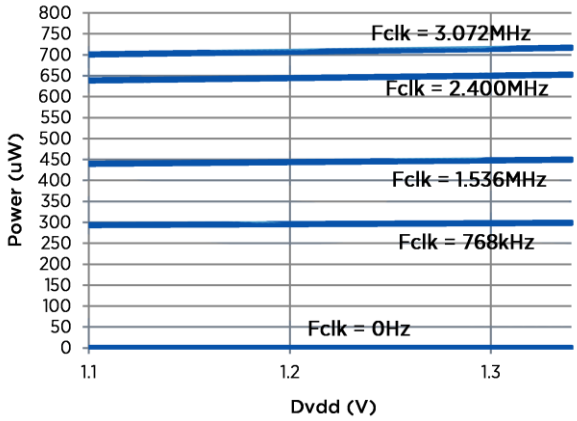


Figure 7: Noise Floor Power Spectral Density

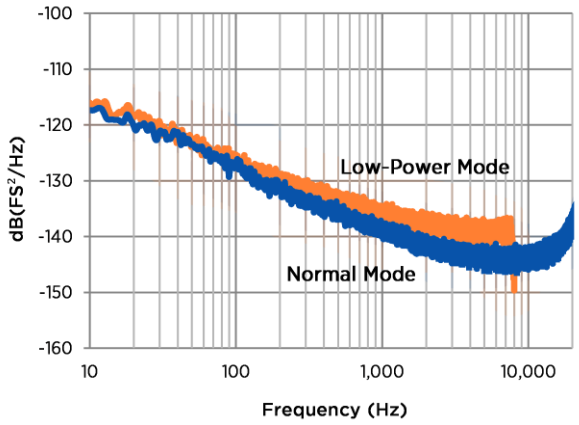


Figure 8: Typical PSRR

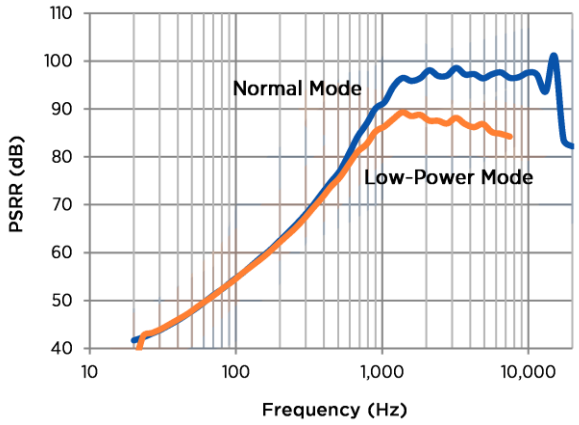


Figure 9: Typical Input-Referred 1/3 Octave Integrated Noise

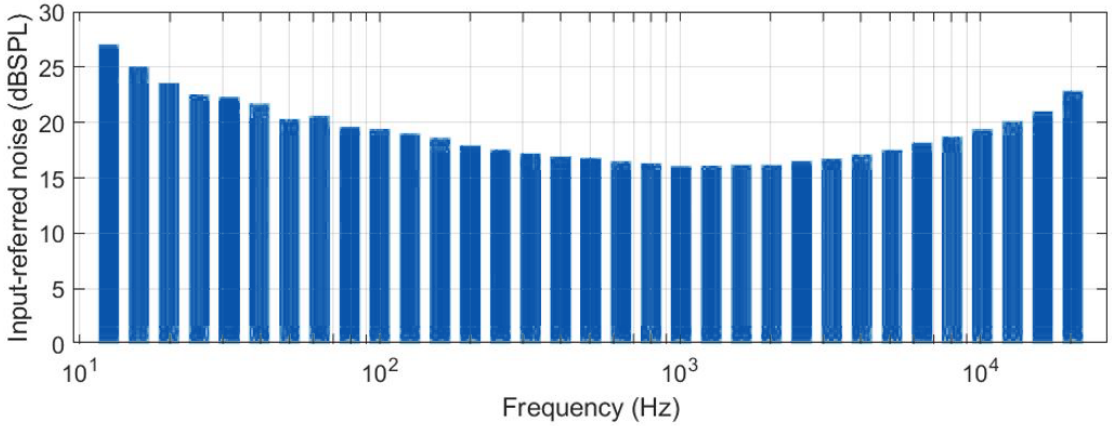


Figure 10: Timing Diagram

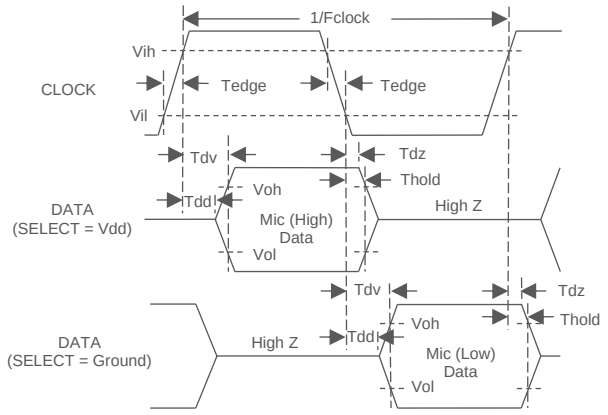


Figure 11: Hysteresis Diagram

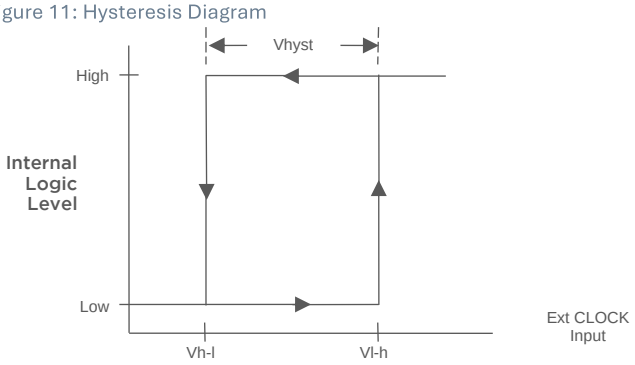


Figure 12: State Diagram

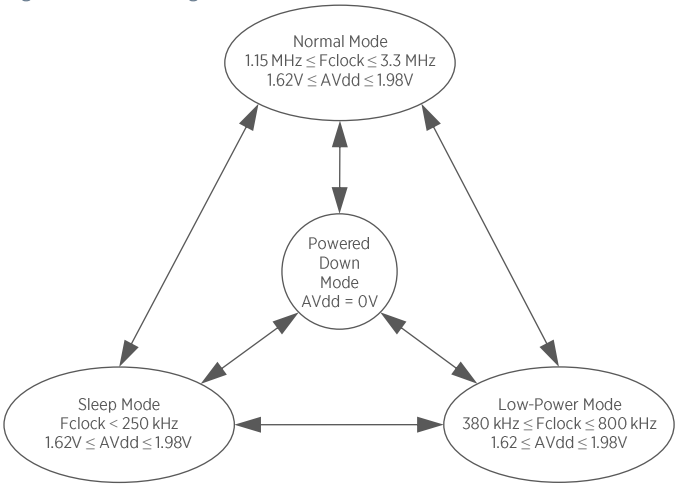


Figure 13: Typical Stereo Application Circuit

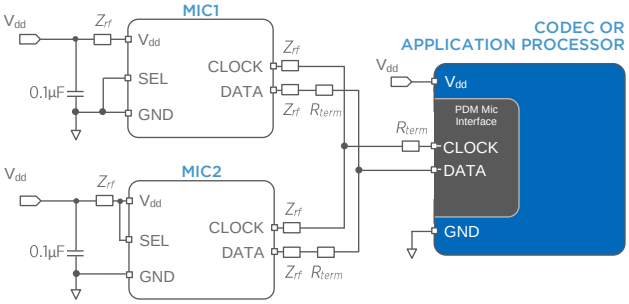
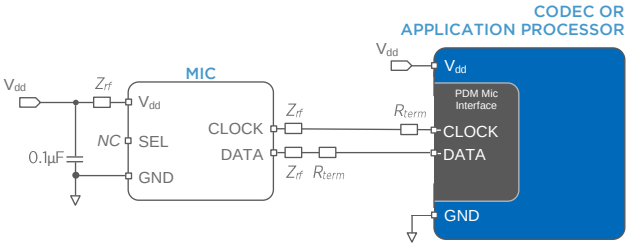


Figure 14: Typical Single-Microphone Application Circuit



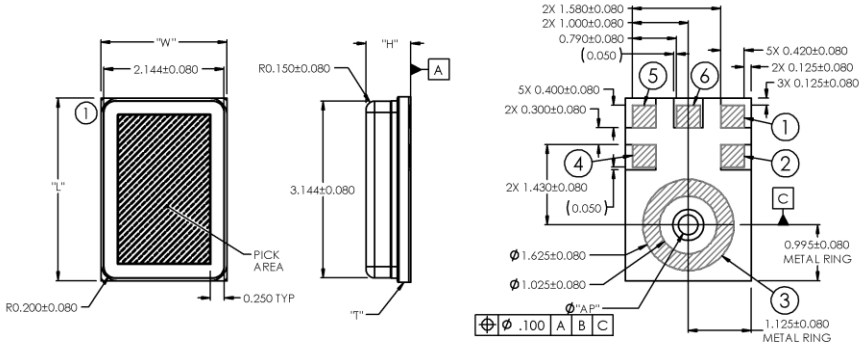
NOTES:

All Ground pins must be connected to ground.
If necessary to improve RF performance, optional series components (resistors, ferrites, etc.) should be placed closest to the microphone pads.
Bypass capacitors should be placed near each Vdd pin for best performance.
Capacitors near the microphone should not contain Class 2 dielectrics due to their piezoelectric effect.

Table 7: SELECT Functionality

Microphone	SELECT	Asserts DATA on	Latch DATA on
Mic (High)	DVdd	CLK rising edge	CLK falling edge
Mic (Low)	Ground	CLK falling edge	CLK rising edge

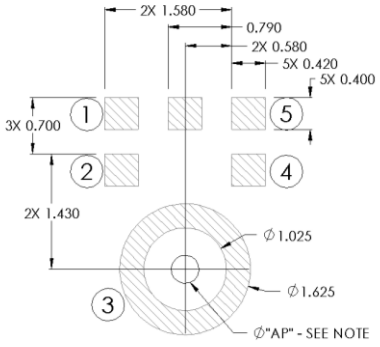
MECHANICAL SPECIFICATIONS



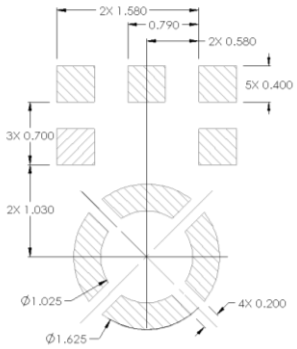
Item	Dimension	Tolerance
Length (L)	3.25	±0.10
Width (W)	2.25	±0.10
Height (H)	0.8	±0.10
Acoustic Port (AP)	Ø0.350	±0.05
PCB Thickness (T)	0.250	±0.05

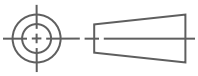
Pin #	Pin Name	Type	Description
1	DATA	Digital O	PDM Output
2	SELECT	Digital I	Lo/Hi (L/R) Select Connect to Vdd or GND
3	GROUND	Power	Ground
4	CLOCK	Digital I	Clock Input
5	DVdd	Power	Power Supply: Do not connect to GND while CLOCK is applied.
6	AVdd	Power	Power Supply: Do not connect to GND while CLOCK is applied.

Example Land Pattern



Example Solder Stencil Pattern





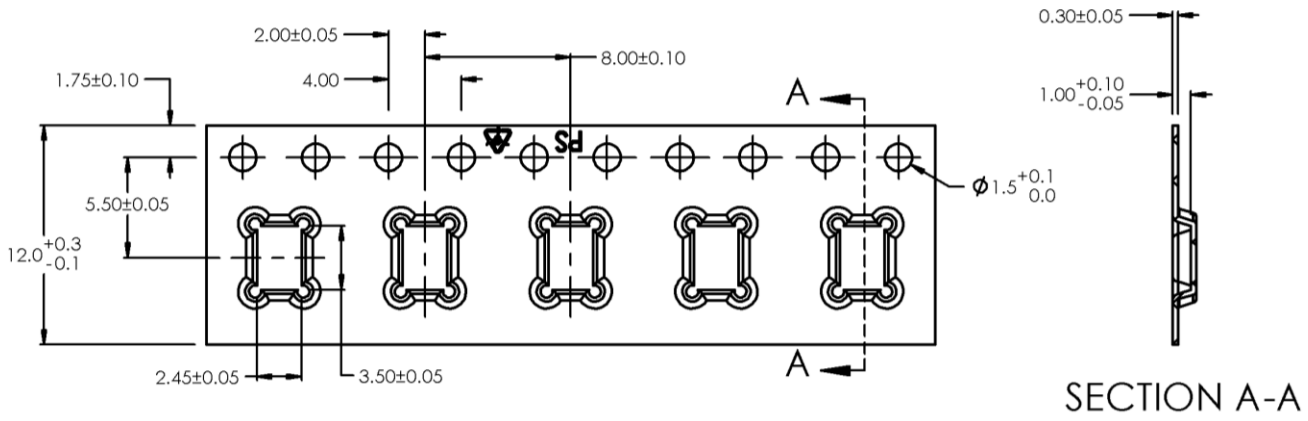
NOTES:

Pick Area only extends to 0.25 mm of any edge or hole unless otherwise specified.
Dimensions are in millimeters unless otherwise specified.
Tolerance is ±0.15mm unless otherwise specified.
Maximum force applied to microphone package:

- Transient 50N max applied to entire metal can top area. 10N max point force (spherical push pin 1mm radius).
- Static 10N max on entire can top area.

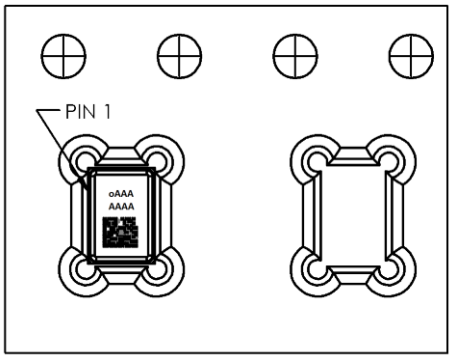
In the acoustic path, the recommended PCB Hole Diameter is 0.5 ≤ D ≤ 0.65mm, the recommended Gasket Cavity Diameter is D ≥1.2mm and the recommended Case Hole Diameter is 1.0 ≤ D ≤ 1.5mm. Further optimizations based on application should be performed.

PACKAGING & MARKING DETAIL



Model Number	Suffix	Reel Diameter	Quantity Per Reel
SPS11R1LM4H-1	-8	13”	5900

Component	Surface Resistance (ohms)
Reel	10^5 - 10^9
Carrier Tape	10^5 - 10^9
Cover Tape	10^4 - 10^{10}

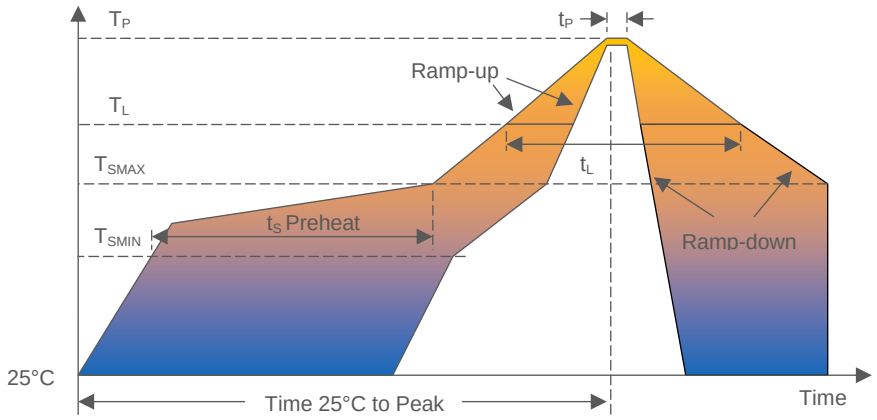


Letter: “o”, orientation mark (pin 1)
AAAAAA = Internal Code
2D barcode "ABCDEFGHJKLMNPQRSTUVWXYZ0123456789":
Unique Job Identification Number for product traceability

NOTES:

Dimensions are in millimeters unless otherwise specified.
Vacuum pickup only in the pick area indicated in Mechanical Specifications.
Tape & reel per EIA-481.
Labels applied directly to reel and external package.
Shelf life: Twelve (12) months when devices are stored in the factory-supplied, unopened ESD moisture sensitive bag under the maximum environmental conditions of 30°C, 70% R.H.

RECOMMENDED REFLOW PROFILE



Profile Feature	Pb-Free
Average Ramp-up rate (T_{SMAX} to T_P)	3°C/second max.
Preheat • Temperature Min (T_{SMIN}) • Temperature Max (T_{SMAX}) • Time (T_{SMIN} to T_{SMAX}) (t_S)	 150°C 200°C 60-180 seconds
Time maintained above: • Temperature (T_L) • Time (t_L)	 217°C 60-150 seconds
Peak Temperature (T_P)	260°C
Time within 5°C of actual Peak Temperature (t_P)	20-40 seconds
Ramp-down rate (T_P to T_{SMAX})	6°C/second max
Time 25°C to Peak Temperature	8 minutes max

NOTES:

Based on IPC/JDEC J-STD-020 Revision C.

All temperatures refer to topside of the package, measured on the package body surface.

The actual reflow profile used should be optimized based on the reflow requirements of all components, board design, solder paste formulation and reflow equipment used. Details of recommended handling and manufacturing processes can be found in AN25 SMT Manufacturing Guidelines for SiSonic™ Microphones.

ADDITIONAL NOTES

(A) MSL (moisture sensitivity level) Class 1.
(B) Maximum of 3 reflow cycles is recommended.
(C) In order to minimize device damage:
- Do not board wash or clean after the reflow process.
- Do not brush board with or without solvents after the reflow process.
- Do not directly expose to ultrasonic processing, welding, or cleaning.
- Do not insert any object in port hole of device at any time.
- Do not apply over 30 psi of air pressure into the port hole.
- Do not pull a vacuum over port hole of the microphone.
- Do not apply a vacuum when repacking into sealed bags at a rate faster than 0.5 atm/sec.
- Do not directly expose to vapor phase soldering.

MATERIALS STATEMENT

Meets the requirements of the European RoHS directive 2011/65/EC as amended.

Meets the requirements of the industry standard IEC 61249-2-21:2003 for halogenated substances and Syntiant Green Materials Standards Policy section on Halogen-Free.

Product is Beryllium Free according to limits specified on the Syntiant Hazardous Material List (HSL for Products).

Ozone depleting substances are not used in the product or the processes used to make the product, including compounds listed in Annex A, B, and C of the "Montreal Protocol on Substances That Deplete the Ozone Layer.

RELIABILITY SPECIFICATIONS

Test	Description
Thermal Shock	100 cycles of air-air thermal shock from -40°C to +125°C with 15 minute soaks (IEC 68-2-14)
High Temperature Storage	+105°C environment for 1,000 hours (JESD22-A103)
Low Temperature Storage	-40°C environment for 1,000 hours (JESD22-A119)
High Temperature Bias	+105°C environment while under bias for 1,000 hours (JESD22-A108)
Low Temperature Bias	-40°C environment while under bias for 1,000 hours (JESD22-A108)
Temperature/Humidity Bias	+85°C/85% R.H. environment while under bias for 1,000 hours (JESD22-A101A-B)
Vibration	16 minutes in each X, Y, Z axis from 20 to 2,000 Hz with peak acceleration of 20g (MIL STD-883e, Method 2007.2, Condition A)
ESD-HBM	3 discharges at ±2kV direct contact to I/O pins (ANSI/ESDA/JEDEC JS-001-2014)
ESD-HMM	10 discharges at ±8kV direct contact to lid when unit is grounded (ANSI/ESD SP5.6-2009)
ESD-CDM	3 discharges at ±500V (ANSI/ESDA/JEDEC JS-002-2014)
Reflow	5 reflow cycles with peak temperature of +260°C (JEDEC 22-A113F)
Mechanical Shock	3 pulses of 12,000g in each of the X, Y, and Z directions (IEC 68-2-27 Test Ea)

NOTES:

Microphones meet all acoustic and electrical specifications before and after reliability testing, except sensitivity which can deviate up to 3dB.

After 3 reflow cycles, the sensitivity of the microphones shall not deviate more than 1 dB from its initial value.

Temperature Storage testing is covered by Temperature Bias testing as Ta = Tj for Syntiant Microphones.

SPECIFICATION REVISIONS

Revision	Specification Changes	Date
A	Initial Release ECR#24-6053	9/4/2024
A-1	Updated datasheet format	11/25/2024

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