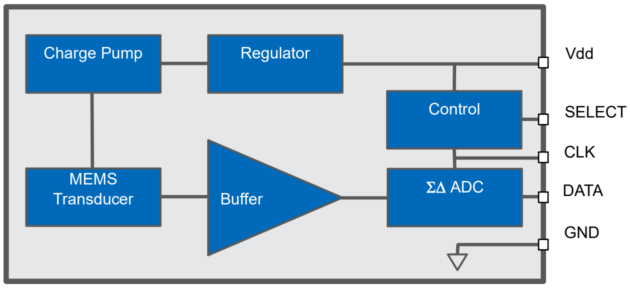
SPH8690LM4H-1
MULTIMODE DIGITAL BOTTOM PORT SISONIC™ MICROPHONE

The SPH8690LM4H-1 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 SPH8690LM4H-1 consists of an acoustic sensor, a low noise input buffer, and a sigma-delta modulator. These devices are suitable for far-field voice up and 360 degree conference call mode , such as laptop computers, cellphones, smart phones, sensors, digital still cameras, portable music recorders and other portable electronic devices where excellent wideband audio performance and RF immunity are required. In addition, the SPH8690LM4H-1 offers multiple performance modes

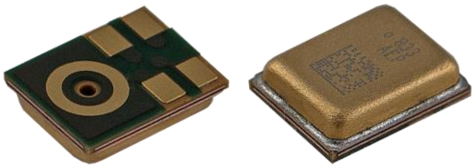


ABSOLUTE MAXIMUM RATINGS

Table 1: Absolute Maximum Ratings

Parameter	Absolute Maximum Rating	Units
Vdd 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 +100	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.



PRODUCT FEATURES

- Notebook Application-required sensitivity (-26dBFS/Pa)
- High SNR (68dB,start with a 1.536MHz clock)
- Low Distortion / High AOP
- Low Current Consumption in Low-Power Mode
- 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(360 degree)
- Far-Field sound pickup
- Standard SMD Reflow
- LGA Package

TYPICAL APPLICATIONS

- Laptop Computers
- Cellphones
- Portable Electronics
- Tablets
- Digital Still Cameras
- Portable Music Recorders

ACOUSTIC & ELECTRICAL SPECIFICATIONS[1]

Table 2: General Microphone Specifications

Test Conditions: 23 ±2°C, 55±20% R.H., Vdd=1.8 V, Tedge ≤ 3ns, unless otherwise indicated

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Supply Voltage	Vdd		1.65	1.8	3.6	V
Low Frequency Rolloff	LFRO	-3dB relative to 1 kHz	-	30	-	Hz
High Frequency Flatness		+3dB relative to 1 kHz	-	14.5	-	kHz
Resonant Frequency Peak	Fres	Free Field response	-	24	-	kHz
DC Offset		Fullscale=±100	-3.25	-	0.1	% FS
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		-	5	-	pF
Data Output Capacitance	Cout		-	54	-	pF
Data Output Load	Cload		-	-	100	pF
SELECT (high)			Vdd-0.2	-	3.6	V
SELECT (low)			-0.3	-	0.2	V
Short Circuit Current	Isc	Grounded DATA pin	1	-	20	mA
Fall-asleep Time[3,4]		Fclock < 250kHz	-	-	10	ms
Wake-up Time[3,5]		Fclock ≥ 500kHz	-	-	35	ms
Startup Time[3]		Powered Down → Active, S within 1 dB of final value	-	-	35	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.	-	4	-	ms
Mode-Change Time[3, 6]		Low Power Mode ⇔ Normal Mode	-	-	17	ms

Table 3: Normal Mode

Test Conditions: 23 ±2°C, 55±20% R.H., Vdd=1.8 V, Fclock = 2.4 MHz (D.C. = 50%), Tedge ≤ 3ns, SELECT grounded, no load, unless otherwise indicated

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Supply Current[2]	Idd	Fclock = 1.2 MHz Fclock = 1.536 MHz Fclock = 2.4 MHz Fclock = 3.072 MHz Fclock = 4.8 MHz	- - 800 - -	650 750 1000 1225 1850	690 820 1200 1350 2000	µA
Sensitivity	S	94 dB SPL @ 1 kHz	-27	-26	-25	dBFS
Signal to Noise Ratio	SNR	94 dB SPL @ 1kHz, A-weighted, Fclock = 1.2 MHz 94 dB SPL @ 1kHz, A-weighted, Fclock = 1.536 MHz 94 dB SPL @ 1kHz, A-weighted, Fclock = 2.4 MHz 94 dB SPL @ 1kHz, A-weighted, Fclock = 3.072 MHz 94 dB SPL @ 1kHz, A-weighted, Fclock = 4.8 MHz	- - - - -	68 68 68 68 68	- - - - -	dB(A)
Near-Ultrasonic SNR		94 dB SPL, @ 19 kHz , BW = 18.5 - 20.0 kHz	-	82	-	dB
Total Harmonic Distortion	THD	94 dB SPL @ 1 kHz 115 dB SPL @ 1kHz	-	0.2 0.8	0.3 -	%
Acoustic Overload Point	AOP	1% THD @ 1 kHz, S = typ 10% THD @ 1 kHz, S = typ	- -	117 121	- -	dB SPL
Power Supply Rejection Ratio	PSRR	200 mVpp sinewave @ 1 kHz	-	84	-	dB V/FS
Power Supply Rejection	PSR+N	200 mVpp 7/8 duty cycle rectangular waveform @ 217 Hz, A-weighted	-	-98	-	dBFS(A)

Table 4: Low-Power Mode

Test Conditions: 23 ±2°C, 55±20% R.H., Vdd=1.8 V, Fclock = 768 kHz (D.C. = 50%), OSR=48, Tedge ≤ 3ns, SELECT grounded, no load, unless otherwise indicated

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Supply Current[2]	Idd		240	260	310	µA
Sensitivity	S	94 dB SPL @ 1 kHz	-22	-21	-20	dBFS
Signal to Noise Ratio	SNR	94 dB SPL @ 1 kHz, A-weighted (BW = 8 kHz)	-	66	-	dB(A)
Total Harmonic Distortion	THD	94 dB SPL @ 1 kHz	-	0.2	0.3	%
Acoustic Overload Point	AOP	1% THD @ 1 kHz, S = typ 10% THD @ 1 kHz, S = typ	- -	111 113	- -	dB SPL
Power Supply Rejection Ratio	PSRR	200 mVpp sinewave @ 1 kHz		77	-	dBV/FS
Power Supply Rejection	PSR+N	200 mVpp 7/8 duty cycle rectangular waveform @ 217 Hz, A-weighted	-	-86	-	

Table 5: Sleep Mode

Test Conditions: 23 ±2°C, 55±20% R.H., Vdd=1.8 V, Fclock = 0 Hz, SELECT grounded, no load, unless otherwise indicated

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Sleep Current	Isleep		-	40	55	µA

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

[2] Power consumption varies with Cload according to: ΔP = 0.5*Vio*Vio*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 ≥ 500 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., Vdd=1.8 V, Tedge ≤ 3ns, unless otherwise indicated

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Logic Input High[7, 8]	Vih		0.65xVdd	-	3.6	V
Logic Input Low[7, 8]	Vil		-0.3	-	0.35xVdd	V
Logic Output High[7, 8]	Voh	I_{OUT} = 2 mA, 1.2Vio configuration	Vdd-0.45	-	Vdd	V
Logic Output Low[7, 8]	Vol	I_{OUT} = 2 mA	0	-	0.45	V
Low→High Threshold	Vl-h		-	-	0.65xVdd	V
High→Low Threshold	Vh-l		0.35xVdd	-	-	V
Hysteresis Width[8]	Vhyst		0.05xVdd	-	0.20xVdd	V
Clock Frequency[7]	Fclock	Sleep Mode	0	-	250	kHz
		Low-Power Mode	500	-	900	
		Normal Mode	1.1	-	4.8	MHz
Clock Duty Cycle	D.C.		40	50	60	%
Delay Time to Data Line Driven[7]	Tdd		18	-	35	ns
Delay Time to Valid Data[7]	Tdv	Max Cload	-	-	100	ns
Delay Time to High Z[7]	Tdz		5	-	16	ns
Hold Time[7]	Thold	Thold, as observed by the input device, will be dependent on Cload	5	-	-	ns

[7] See Figure 1: Timing Diagram.

[8] See Figure 2: Hysteresis Diagram.

Figure 1: Timing Diagram

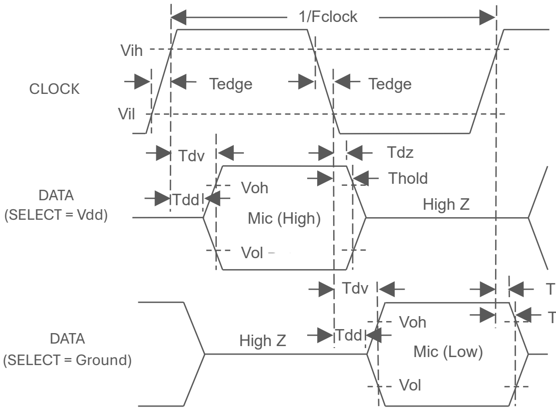


Figure 2: Hysteresis Diagram

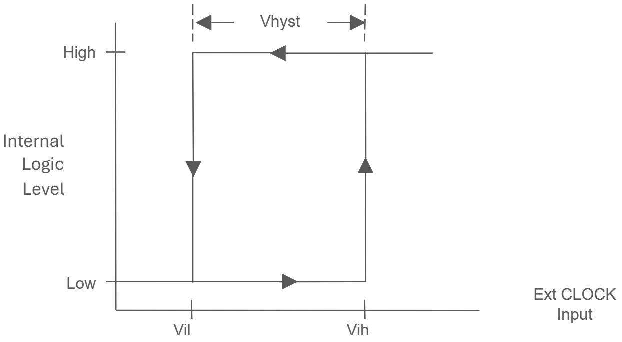


Figure 3: State Diagram

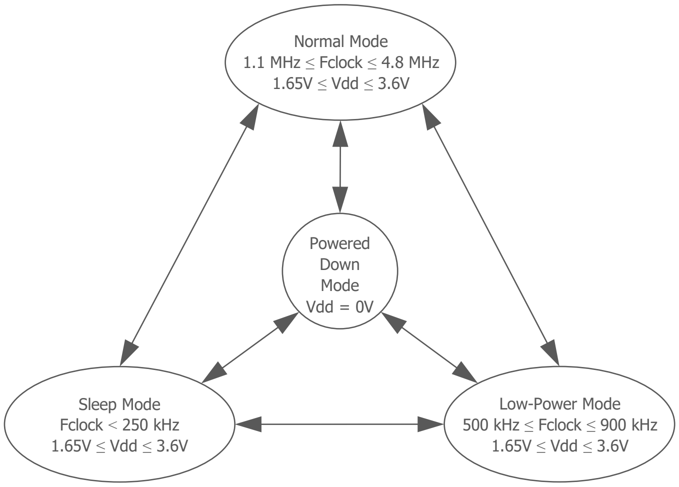


Figure 4: Typical Stereo Application Circuit

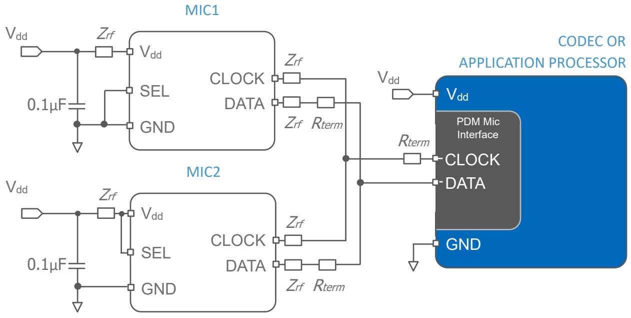
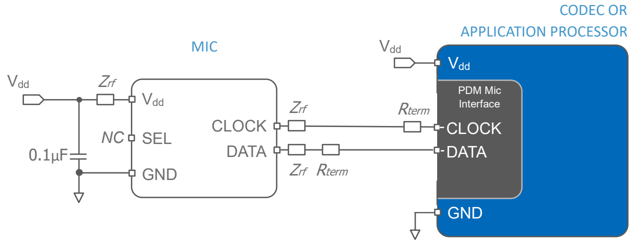


Figure 5: Typical Single-Microphone Application Circuit



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)	Vdd	CLK rising edge	CLK falling edge
Mic (Low)	Ground	CLK falling edge	CLK rising edge

PERFORMANCE CURVES

Test Conditions: 23 ±2°C, 55±20% R.H., Vdd=1.8 V, Fclock = 2.4 MHz, SELECT grounded, no load, unless otherwise indicated

Figure 6: Typical Free Field Magnitude and Masks

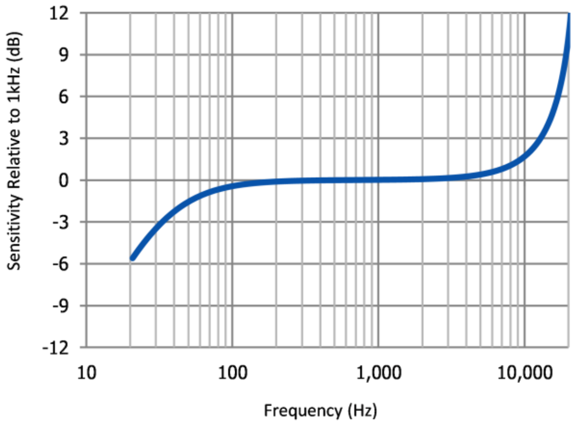


Figure 8: Typical Phase and Group Delay

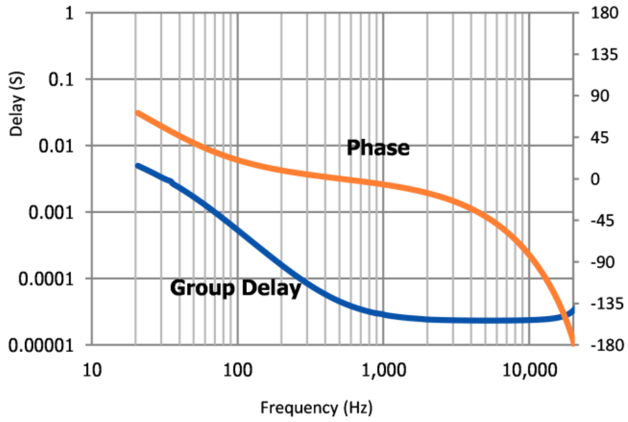


Figure 7: Typical THD vs SPL

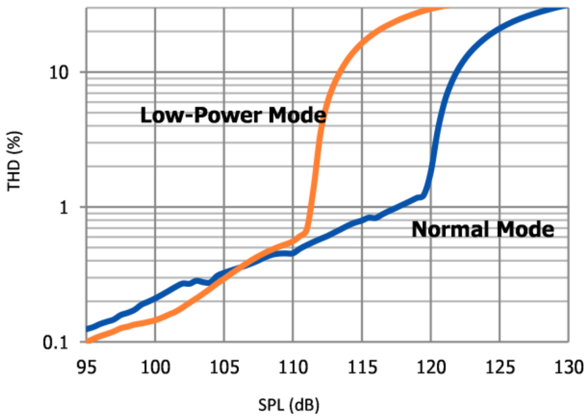


Figure 9: Typical THD vs Frequency

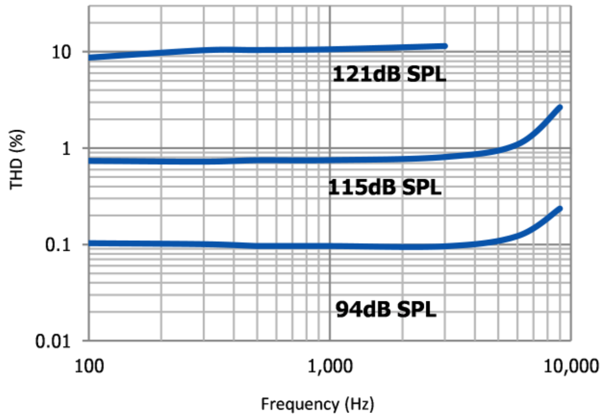


Figure 10: Typical Free Field Ultrasonic Response

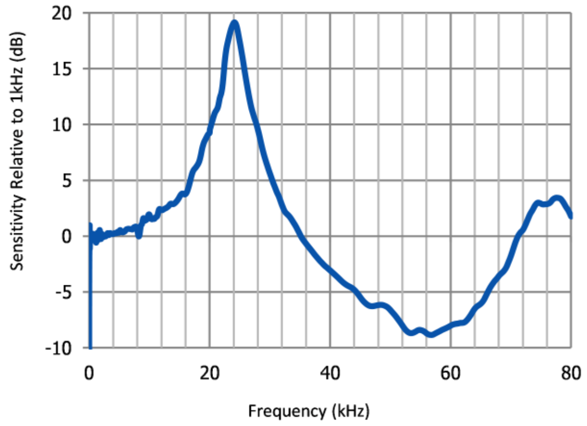


Figure 12: Noise Floor Power Spectral Density

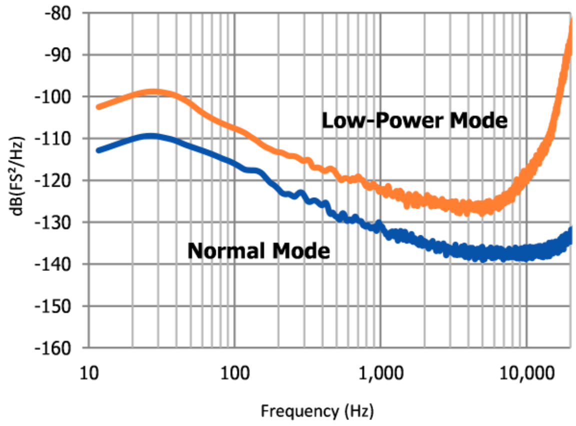


Figure 11: Typical Idd vs Vdd

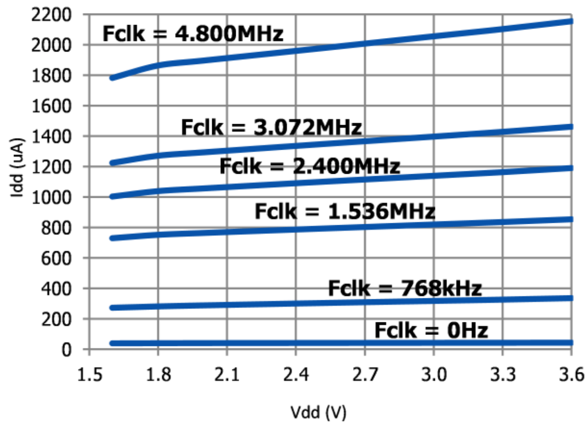
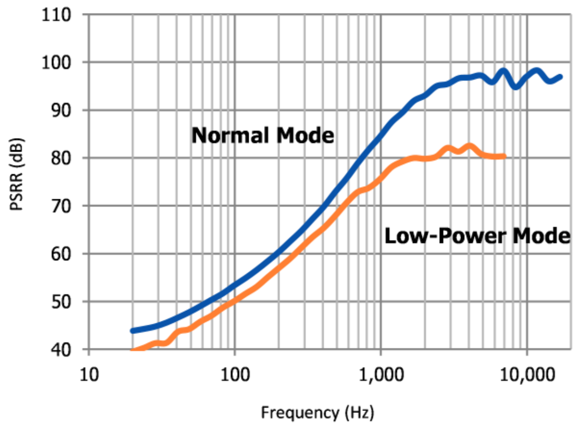
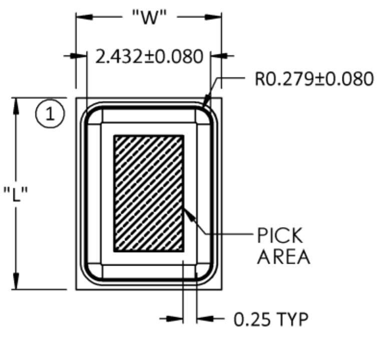
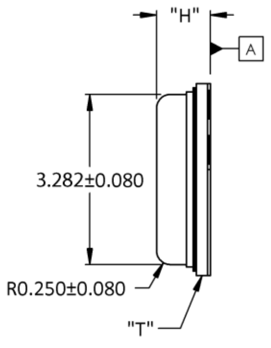


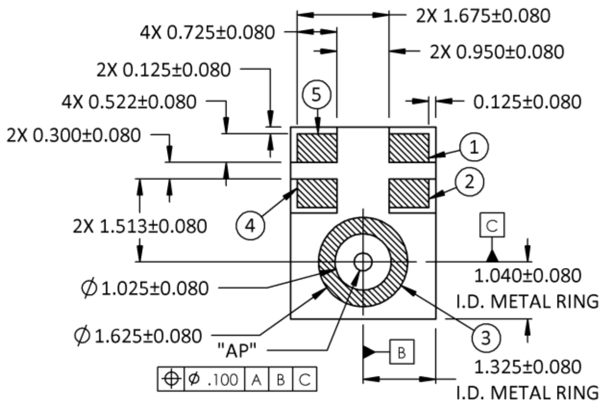
Figure 13: Typical PSRR



MECHANICAL SPECIFICATIONS



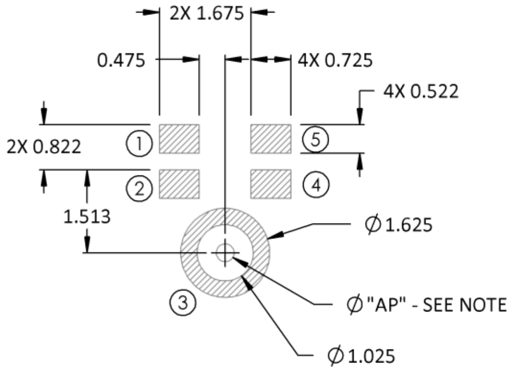




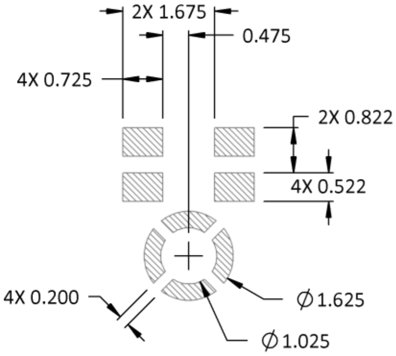
Item	Dimension	Tolerance
Length (L)	3.5	±0.10
Width (W)	2.65	±0.10
Height (H)	0.98	±0.10
Acoustic Port (AP)	Ø0.325	±0.05
PCB Thickness (T)	0.307	±0.05

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	Vdd	Power	Power Supply

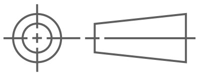
Example Land Pattern



Example Solder Stencil Pattern

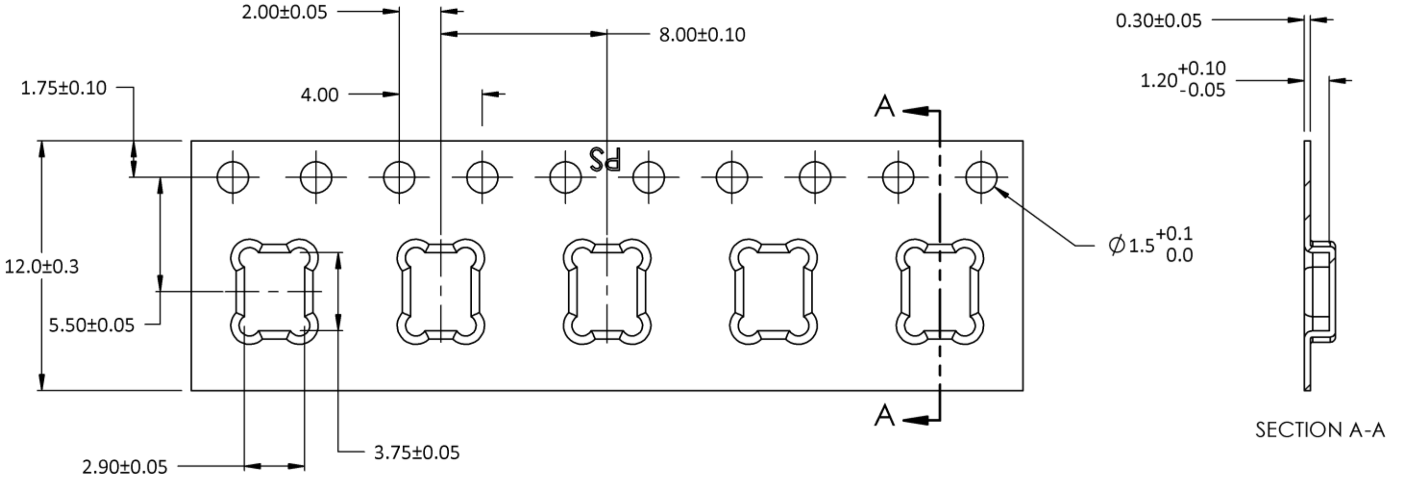


NOTES:



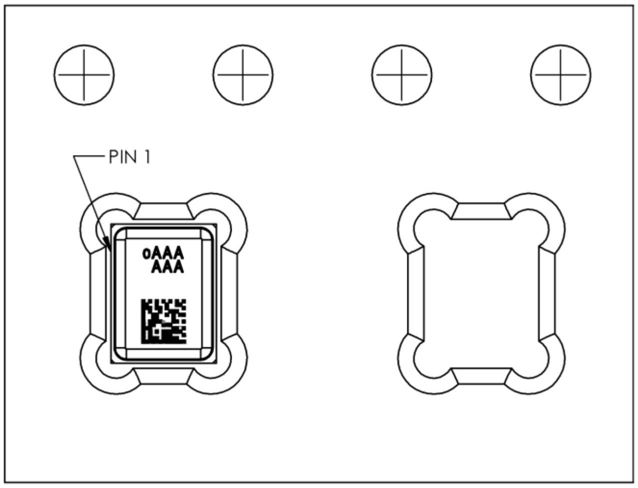
Pick Area only extends to 0.25 mm of any edge or hole unless otherwise specified.
Dimensions are in millimeters unless otherwise specified.
Tolerance is ±0.15mm unless otherwise specified
Maximum force applied to microphone package: Transient 50N max applied to entire metal can top area. 10N max point force (spherical push pin 1mm radius). Static 10N max on entire can top area.
In the acoustic path, the recommended PCB Hole Diameter is 0.6 ≤ D ≤ 1.0mm, the recommended Gasket Cavity Diameter is D ≥ 1.0mm 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
SPH8690LM4H-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}

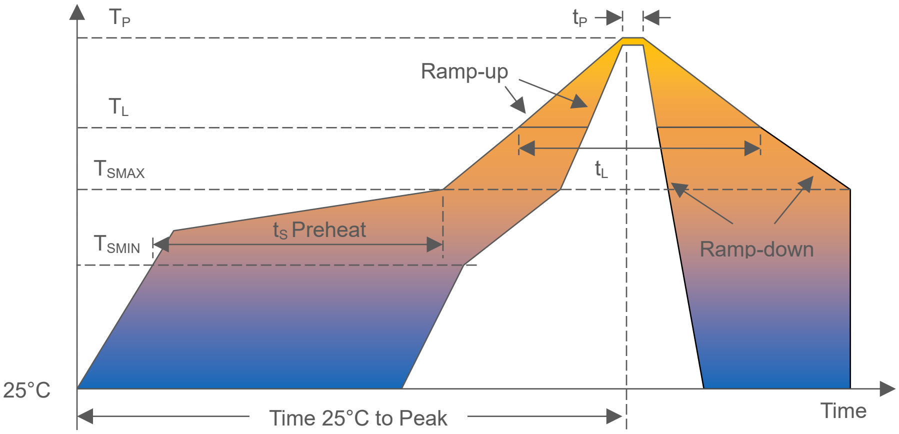


Letter: “o”, orientation mark (pin 1)
AAAAAA = Internal Code
2D barcode "ABCDEFGHJKLMNPQRSTUVWXYZ0123456789":
Unique Job Identification Number for product traceability

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/JEDEC 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, 1,000 hours per JESD22-A103 (See Notes)
Low Temperature Storage	-40°C, 1,000 hours per JESD22-A119 (See Notes)
High Temperature Bias	+140°C, 168 hours (equivalent to +105°C, 1,000 hours per JESD22-A108)
Low Temperature Bias	-55°C, 168 hours (equivalent to -40°C, 1,000 hours per JESD22-A108)
Temperature/Humidity Bias	+85°C/85% R.H., 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-21-4500)	8/16/2021
B	Updated the Mic in tape picture and description(ECR-22-4830)	1/26/2022
C	Updated PSD Curve(ECR-23-5489)	2/21/2023
D	Updated THD vs. frequency curve(ECR-23-5624)	6/15/2023
D-1	Format update	12/01/2024