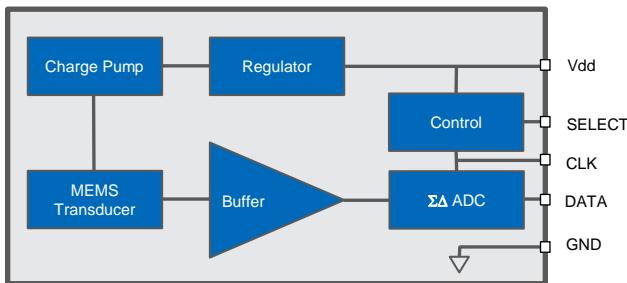


SPH18R1LM4H-1

LOW-POWER MULTIMODE DIGITAL BOTTOM PORT SISONIC™
MICROPHONE

The SPH18R1LM4H-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 SPH18R1LM4H-1 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 SPH18R1LM4H-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 | °C |
| Operating Temperature | -40 to +100 | °C |

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

- 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

ACOUSTIC & ELECTRICAL SPECIFICATIONS¹

Table 2: General Microphone Specifications

Test Conditions: 23 ±2°C, 55±20% R.H., Vdd=1.8 V, Tedge ≤ 6ns, unless otherwise indicated

| Parameter | Symbol | Conditions | Min | Typ | Max | Units |
|-------------------------------------|--------|--|---------------------------|-------------|-------|-------|
| Supply Voltage | Vdd | | 1.62 | 1.8 | 1.98 | V |
| Low Frequency Rolloff | LFRO | -3dB relative to 1 kHz | - | 30 | - | Hz |
| High Frequency Flatness | | +3dB relative to 1 kHz | - | 13 | - | kHz |
| Resonant Frequency Peak | Fres | Free Field response | - | 24.5 | - | kHz |
| Latency | | @ 4kHz, Fclock = 2.4 MHz | - | 3 | - | μs |
| DC Offset | | SEL = 0 / SEL = 1: max/min code = ±100% | - | 0.0 / -0.39 | - | % 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 | | - | 15 | - | pF |
| Data Output Capacitance | Cout | | - | 55 | - | pF |
| Data Output Load | Cload | | - | - | 110 | pF |
| SELECT (high) | | | Vdd-0.2 | - | Vdd | 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 | 3 | ms |
| Mode-Change Time ^{3,6} | | Low Power Mode ⇔ Normal Mode | - | - | 20 | ms |

SPH18R1LM4H-1**LOW-POWER MULTIMODE DIGITAL BOTTOM PORT SISONIC™ MICROPHONE****SYNTIANT®**

Table 3: Normal Mode

Test Conditions: $23 \pm 2^\circ\text{C}$, $55 \pm 20\%$ R.H., $V_{dd}=1.8$ V, $F_{clock} = 2.4$ MHz (D.C. = 50%), $T_{edge} \leq 6$ ns, $BW=20-20$ kHz, $SELECT$ grounded, no load, unless otherwise indicated

| Parameter | Symbol | Conditions | Min | Typ | Max | Units |
|------------------------------|-----------------|--|-------------|-------------------|-------------|---------|
| Supply Current ² | I _{dd} | $F_{clock} = 1.536$ MHz $F_{clock} = 2.4$ MHz $F_{clock} = 3.072$ MHz | - - - | 300 430 480 | - - - | μA |
| Sensitivity | S | 94 dB SPL @ 1 kHz | -38 | -37 | -36 | dBFS |
| Signal to Noise Ratio | SNR | $F_{clock}=1.536$ MHz, 94 dB SPL @ 1 kHz, A-weighted $F_{clock}=2.4$ MHz, 94 dB SPL @ 1 kHz, A-weighted $F_{clock}=3.072$ MHz, 94 dB SPL @ 1 kHz, A-weighted | - - - | 65 68 68.5 | - - - | dB(A) |
| Near-Ultrasonic SNR | | 94 dB SPL, @ 19 kHz, BW = 18.5 - 20.0 kHz | - | 70 | - | dB |
| Total Harmonic Distortion | THD | 94 dB SPL @ 1 kHz | - | 0.2 | - | % |
| | | 120 dB SPL @ 1 kHz | - | 0.7 | - | |
| Acoustic Overload Point | AOP | 10% THD @ 1 kHz, S = typ | - | 123 | - | dB SPL |
| Power Supply Rejection Ratio | PSRR | 200 mVpp sinewave @ 1 kHz | - | 103 | - | dB V/FS |

Table 4: Low-Power Mode

Test Conditions: $23 \pm 2^\circ\text{C}$, $55 \pm 20\%$ R.H., $V_{dd}=1.8$ V, $F_{clock} = 768$ kHz (D.C. = 50%), $T_{edge} \leq 6$ ns, $BW=20-8$ kHz, $SELECT$ grounded, no load, unless otherwise indicated

| Parameter | Symbol | Conditions | Min | Typ | Max | Units |
|------------------------------|-----------------|--|-----|-----|-----|--------|
| Supply Current ² | I _{dd} | | - | 190 | - | μA |
| Sensitivity | S | 94 dB SPL @ 1 kHz | -28 | -27 | -26 | 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 | - | 0.3 | - | % |
| | | 1% THD @ 1 kHz, S = typ | - | 118 | - | dB SPL |
| Acoustic Overload Point | AOP | 10% THD @ 1 kHz, S = typ | - | 121 | - | dB SPL |
| Power Supply Rejection Ratio | PSRR | 200 mVpp sinewave @ 1 kHz | - | 87 | - | dBV/FS |

Table 5: Sleep Mode

Test Conditions: $23 \pm 2^\circ\text{C}$, $55 \pm 20\%$ R.H., $V_{dd}=1.8$ V, $F_{clock} = 0$ Hz, SELECT grounded, no load, unless otherwise indicated

| Parameter | Symbol | Conditions | Min | Typ | Max | Units |
|---------------|-------------|------------|-----|-----|-----|---------------|
| Sleep Current | I_{sleep} | | - | - | 1 | μA |

¹ Sensitivity and Supply Current are 100% tested.² Power consumption varies with Cload according to: $\Delta P = 1/3 \cdot V_{io} \cdot V_{io} \cdot \Delta C_{load} \cdot F_{clock}$.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 $F_{clock} < 250$ kHz to I_{sleep} specification is met when transitioning from Active Mode to Sleep Mode.⁵ Time from $F_{clock} \geq 380$ 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: $23 \pm 2^\circ\text{C}$, $55 \pm 20\%$ R.H., $V_{dd}=1.8$ V, $T_{edge} \leq 6$ ns, unless otherwise indicated

| Parameter | Symbol | Conditions | Min | Typ | Max | Units |
|---|-------------|--|----------------------|-----|----------------------|-------|
| Logic Input High ⁷ | V_{ih} | | $0.65 \times V_{dd}$ | - | $V_{dd} + 0.3$ | V |
| Logic Input Low ⁷ | V_{il} | | -0.3 | - | $0.35 \times V_{dd}$ | V |
| Logic Output High ⁷ | V_{oh} | $I_{out} = 2$ mA | $0.75 \times V_{dd}$ | - | V_{dd} | V |
| Logic Output Low ⁷ | V_{ol} | $I_{out} = 2$ mA | 0 | - | $0.25 \times V_{dd}$ | V |
| Low→High Threshold ⁸ | V_{l-h} | | - | - | $0.65 \times V_{dd}$ | V |
| High→Low Threshold ⁸ | V_{h-l} | | $0.35 \times V_{dd}$ | - | - | V |
| Hysteresis Width ⁸ | V_{hyst} | | $0.1 \times V_{DD}$ | - | $0.5 \times V_{DD}$ | V |
| Clock Frequency ⁷ | F_{clock} | Sleep Mode | 0 | - | 250 | kHz |
| | | Low-Power Mode | 380 | - | 645 | |
| | | | 730 | - | 1024 | |
| | | Normal Mode | 1.15 | - | 1.73 | MHz |
| | | | 1.92 | - | 2.1 | |
| | | | 2.35 | - | 2.56 | |
| | | | 2.83 | - | 3.3 | |
| Clock Duty Cycle | D.C. | | 40 | 50 | 60 | % |
| Delay Time to Data Line Driven ⁷ | T_{dd} | | 43 | - | 113 | ns |
| Delay Time to Valid Data ⁷ | T_{dv} | Max Cload | - | - | 150 | ns |
| Delay Time to High Z ⁷ | T_{dz} | | 5 | - | 30 | ns |
| Hold Time ⁷ | T_{hold} | dependent on Cload as observed by the input device | 5 | - | - | ns |

⁷ See Figure 1: Timing Diagram.⁸ See Figure 2: Hysteresis Diagram.

Figure 1: Timing Diagram

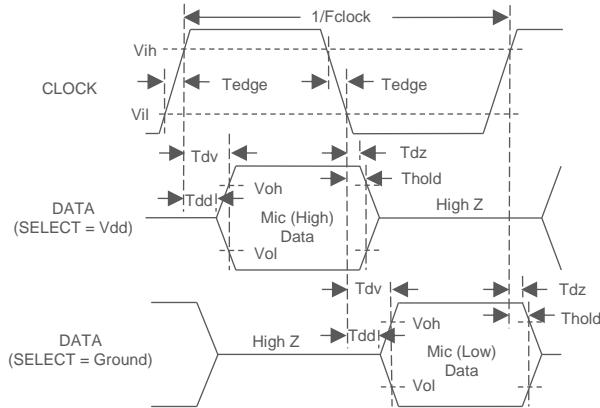


Figure 2: Hysteresis Diagram

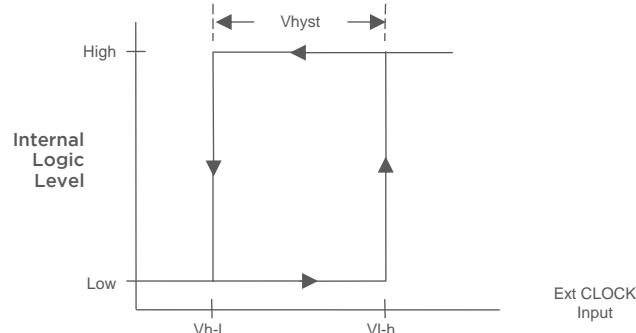


Figure 3: State Diagram

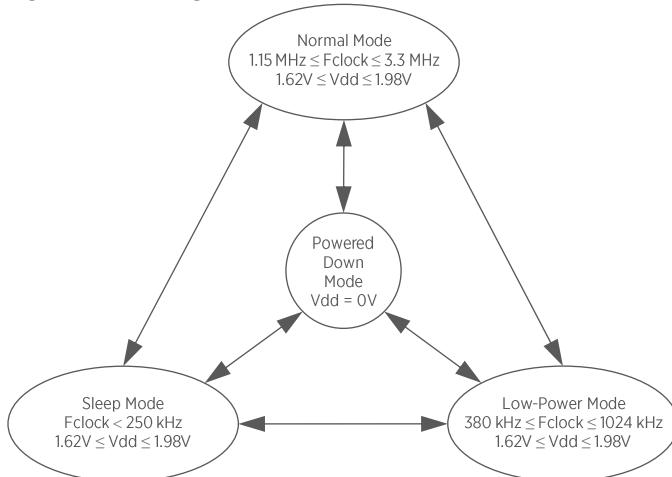


Figure 4: Typical Stereo Application Circuit

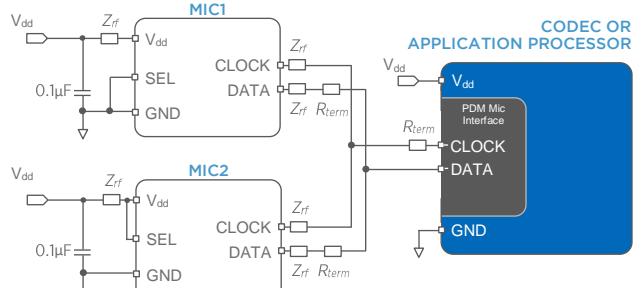
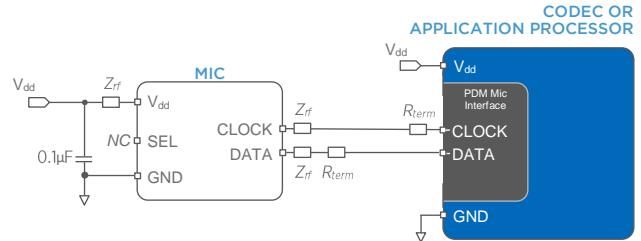


Figure 5: Typical Single-Microphone Application Circuit



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 \pm 2°C, 55 \pm 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

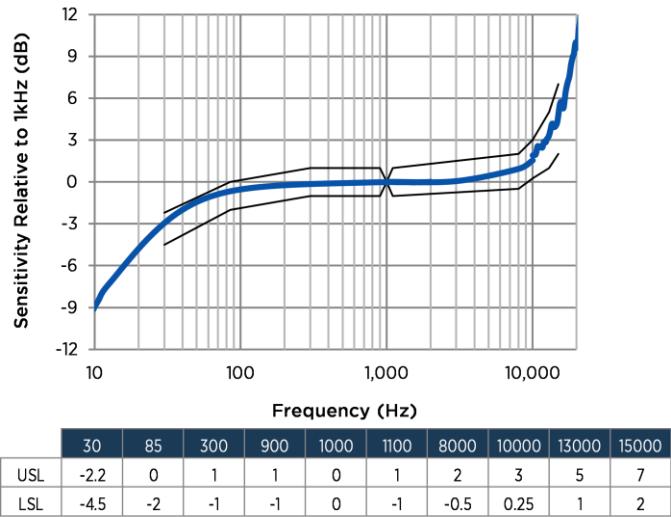


Figure 7: Typical THD vs SPL

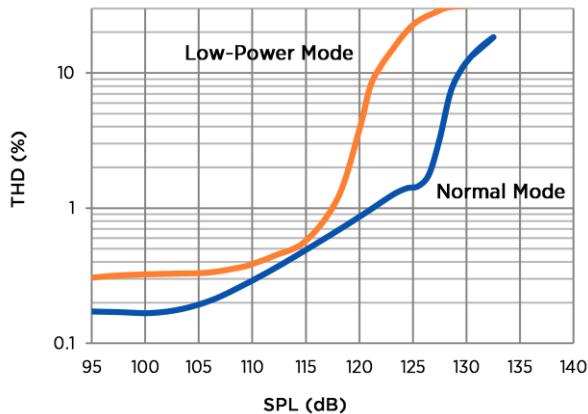


Figure 8: Typical Phase and Group Delay

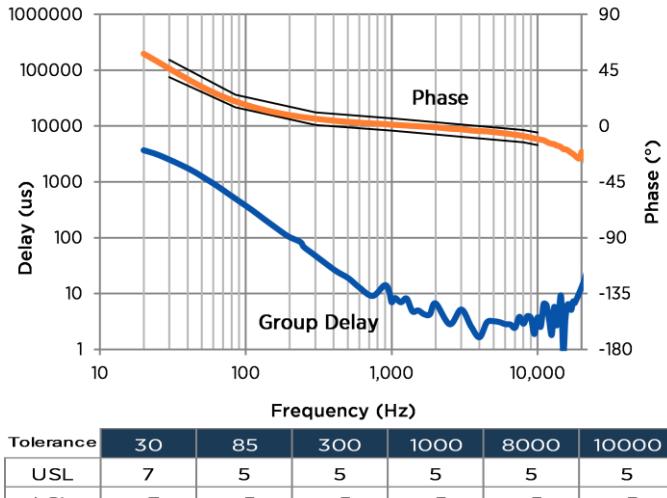


Figure 9: Typical THD vs Frequency

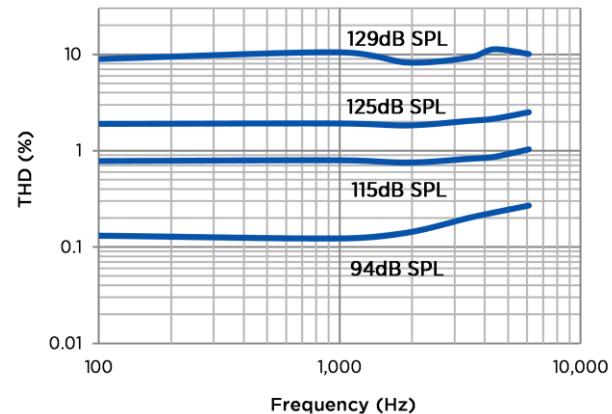


Figure 10: Typical Free Field Ultrasonic Response

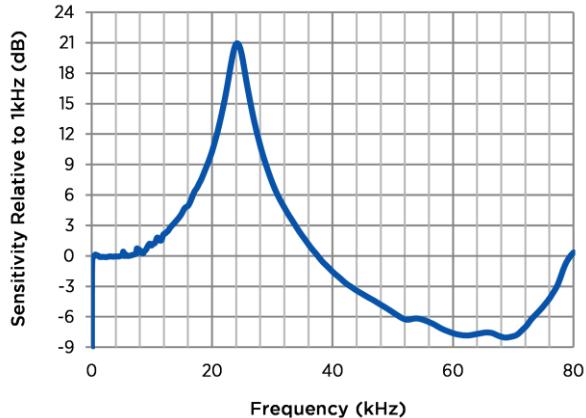


Figure 12: Noise Floor Power Spectral Density

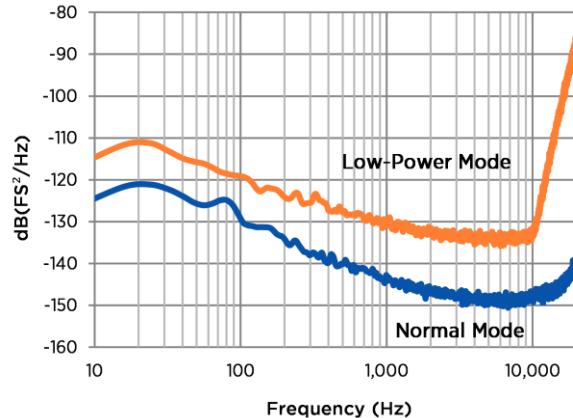


Figure 11: Typical Idd vs Vdd

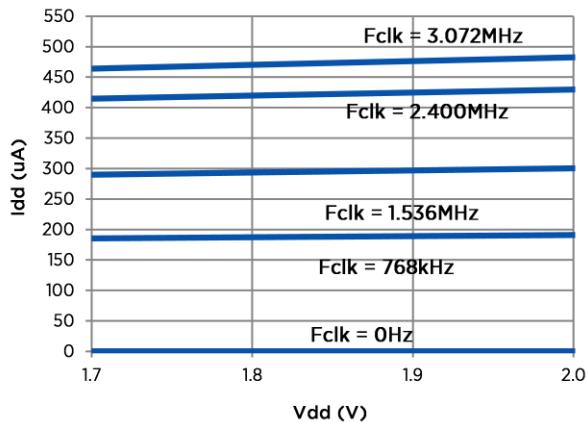
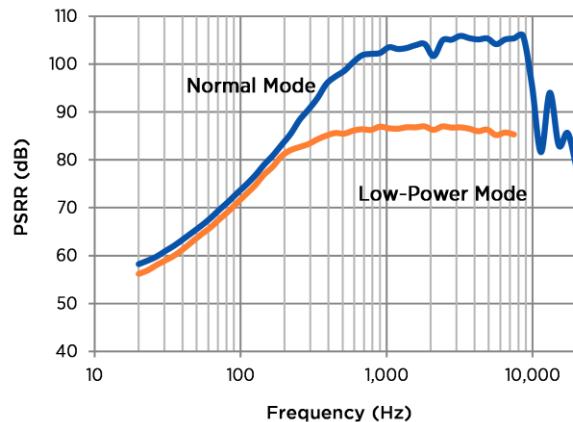
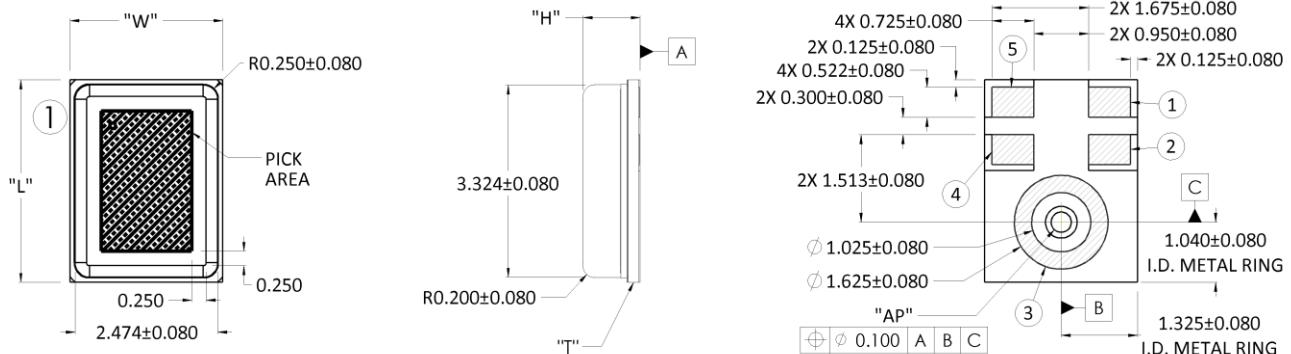


Figure 13: Typical PSRR



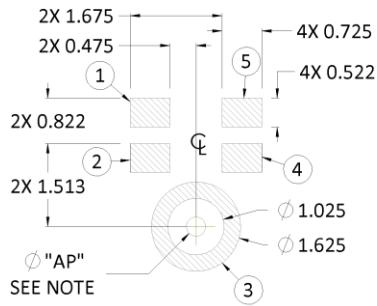
MECHANICAL SPECIFICATIONS



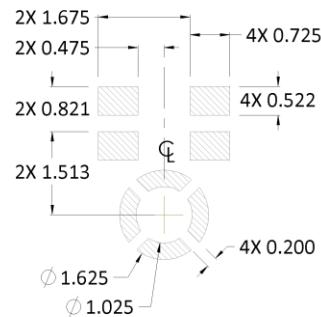
| Item | Dimension | Tolerance |
|--------------------|-------------------|------------|
| Length (L) | 3.5 | ± 0.10 |
| Width (W) | 2.65 | ± 0.10 |
| Height (H) | 1.00 | ± 0.10 |
| Acoustic Port (AP) | $\emptyset 0.325$ | ± 0.05 |
| PCB Thickness (T) | 0.285 | ± 0.05 |

| 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: Do not connect to GND while CLOCK is applied. |

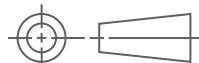
Example Land Pattern



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 ± 0.15 mm unless otherwise specified.

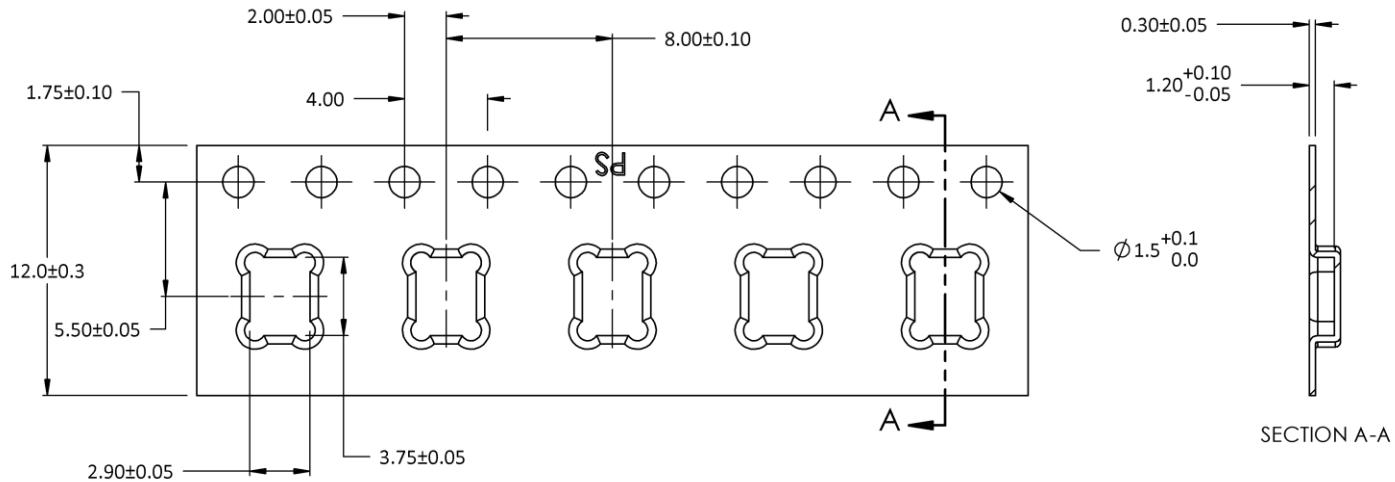
In the acoustic path, the recommended PCB Hole Diameter is $0.6 \leq D \leq 1.0$ mm, the recommended Gasket Cavity Diameter is $D \geq 1.0$ mm and the recommended Case Hole Diameter is $1.0 \leq D \leq 1.5$ mm. Further optimizations based on application should be performed.

SPH18R1LM4H-1

LOW-POWER MULTIMODE DIGITAL BOTTOM PORT SISONIC™ MICROPHONE

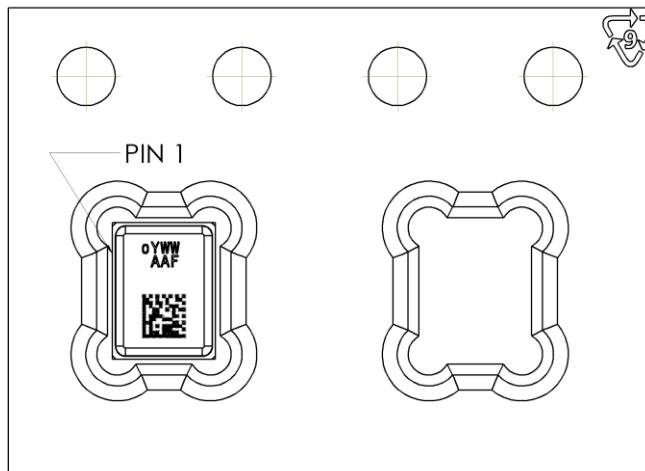
SYNTIANT®

PACKAGING & MARKING DETAIL



| Model Number | Suffix | Reel Diameter | Quantity Per Reel |
|---------------|--------|---------------|-------------------|
| SPH18R1LM4H-1 | -8 | 13" | 5900 |

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



NOTES:

Dimensions are in millimeters unless otherwise specified.

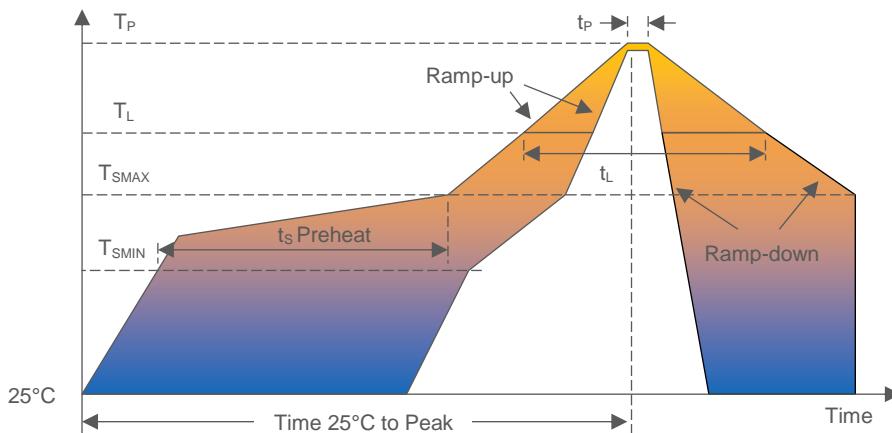
Vacuum pickup only in the pick area indicated in Mechanical Specifications.

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 | <ul style="list-style-type: none"> Temperature Min (T_{SMIN}) Temperature Max (T_{SMAX}) Time (T_{SMIN} to T_{SMAX}) (t_S) |
| Time maintained above: | <ul style="list-style-type: none"> Temperature (T_L) Time (t_L) |
| 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, 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 $\pm 2\text{kV}$ direct contact to I/O pins (ANSI/ESDA/JEDEC JS-001-2014) |
| ESD-HMM | 10 discharges at $\pm 8\text{kV}$ direct contact to lid when unit is grounded (ANSI/ESD SP5.6-2009) |
| ESD-CDM | 3 discharges at $\pm 500\text{V}$ (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 $T_a = T_j$ for Syntiant Microphones.

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