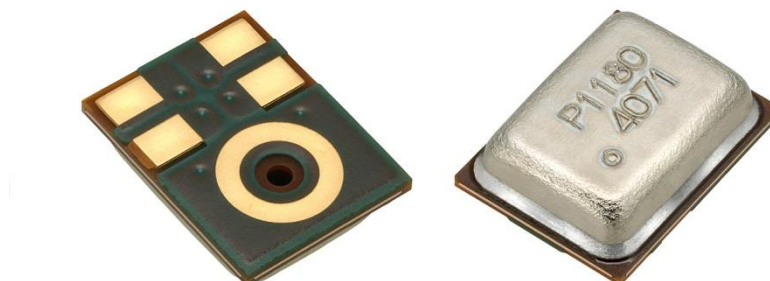


## Digital Zero-Height SiSonic™ Microphone With Multi-Mode And Ultrasonic Support



The SPH0641LU4H-1 is a miniature, high-performance, low power, bottom port silicon digital microphone with a single bit PDM output. Using Knowles' proven high performance SiSonic™ MEMS technology, the SPH0641LU4H-1 consists of an acoustic sensor, a low noise input buffer, and a sigma-delta modulator. This microphone is suitable for applications such as cellphones, smart phones, laptop computers, 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 SPH0641LU4H-1 offers multiple performance modes and supports ultrasonic applications.

### Features:

- High SNR of 64.3dB
- Low Current Consumption of 235uA in Low-Power Mode
- Multiple performance modes (Sleep, Low-Power, Standard Performance and Ultrasonic Modes)
- Flat Frequency Response
- RF Shielded
- Zero-Height Mic™
- Supports Dual Multiplexed Channels
- Omnidirectional
- Ultrasonic Support
- Sensitivity Matching
- Small Size
- Standard SMD Reflow
- LGA Package

## 1. ABSOLUTE MAXIMUM RATINGS

| Parameter                          | Absolute Maximum Rating          | Units |
|------------------------------------|----------------------------------|-------|
| $V_{DD}$ , DATA to Ground          | -0.3, +5.0                       | V     |
| CLOCK to Ground                    | -0.3, +5.0                       | V     |
| SELECT to Ground                   | -0.3, +5.0                       | V     |
| Input Current                      | ±5                               | mA    |
| Short Circuit Current to/from DATA | Indefinite to Ground or $V_{DD}$ | sec   |
| Temperature Range                  | -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.

## 2. ACOUSTIC & ELECTRICAL SPECIFICATIONS

TEST CONDITIONS: 23 ±2°C, 55±20% R.H.,  $V_{DD}$ =1.8 V,  $f_{CLOCK}$ =2.4 MHz, SELECT pin grounded, no load, unless otherwise indicated

### General Microphone Specifications

| Parameter                       | Symbol                    | Conditions               | Min                       | Typ | Max   | Units |
|---------------------------------|---------------------------|--------------------------|---------------------------|-----|-------|-------|
| Supply Voltage                  | $V_{DD}$                  |                          | 1.62                      | -   | 3.6   | V     |
| Clock Frequency Range           | Sleep Mode                |                          | 0                         |     | 250   | KHz   |
|                                 | Low-Power Mode            |                          | 351                       |     | 815   | KHz   |
|                                 | Standard Performance Mode |                          | 1.024                     |     | 2.475 | MHz   |
|                                 | Ultrasonic Mode           |                          | 3.072                     |     | 4.8   | MHz   |
| Sleep Current <sup>1,3</sup>    | $I_{SLEEP}$               | $f_{CLOCK} \leq 250$ kHz | -                         | 80  |       | µA    |
| DC Output                       |                           | Fullscale = ±100         | -                         | 0   | -     | % FS  |
| Directivity                     |                           |                          | Omnidirectional           |     |       |       |
| Polarity                        |                           | Increasing sound         | Increasing density of 1's |     |       |       |
| Data Format                     |                           |                          | ½ Cycle PDM               |     |       |       |
| Short Circuit Current           | $I_{SC}$                  | Grounded DATA pin        | 1                         | -   | 20    | mA    |
| Output Load                     | $C_{LOAD}$                |                          | -                         | -   | 140   | pF    |
| Fall-asleep Time <sup>4,5</sup> |                           | $f_{CLOCK} \leq 250$ kHz | -                         | -   | 10    | ms    |
| Wake-up Time <sup>4,6</sup>     |                           | $f_{CLOCK} \geq 351$ kHz | -                         | -   | 15    | ms    |

# SPH0641LU4H-1

| Parameter                     | Symbol | Conditions                  | Min | Typ | Max | Units |
|-------------------------------|--------|-----------------------------|-----|-----|-----|-------|
| Power-up Time <sup>4,6</sup>  |        | $V_{DD} \geq V(\text{min})$ | -   | -   | 50  | ms    |
| Mode-Change Time <sup>4</sup> |        |                             | -   | -   | 10  | ms    |

## Ultrasonic Mode

TEST CONDITIONS:  $f_{\text{CLOCK}} = 3.072 \text{ MHz}$ ,  $V_{DD} = 1.8 \text{ V}$ , unless otherwise indicated

| Parameter                     | Symbol   | Conditions                                   | Min | Typ  | Max  | Units         |
|-------------------------------|----------|--|-----|------|------|---------------|
| Supply Current <sup>2,3</sup> | $I_{DD}$ |  | -   | 845  | 1000 | $\mu\text{A}$ |
| Sensitivity                   | S        | 94 dB SPL @ 1 kHz                            | -27 | -26  | -25  | dBFS          |
| Signal to Noise Ratio         | SNR      | 94 dB SPL @ 1 kHz,<br>A-weighted             | -   | 64.3 | -    | dB(A)         |
| Total Harmonic Distortion     | THD      | 94 dB SPL @ 1 kHz, S = Typ                   | -   | 0.2  | -    | %             |
| Acoustic Overload Point       | AOP      | 10% THD @ 1 kHz, S = Typ                     | -   | 120  | -    | dB SPL        |
| Power Supply Rejection Ratio  | PSRR     | 200 mVpp sinewave @ 1 kHz                    | -   | 55   | -    | dBV/FS        |
| Power Supply Rejection        | PSR+N    | 100 mVpp square wave<br>@ 217 Hz, A-weighted | -   | -84  | -    | dBFS<br>(A)   |

## Standard Performance Mode

TEST CONDITIONS:  $f_{\text{CLOCK}} = 2.4 \text{ MHz}$ ,  $V_{DD} = 1.8 \text{ V}$ , unless otherwise indicated

| Parameter                       | Symbol   | Conditions   | Min | Typ  | Max | Units         |
|---------------------------------|----------|--|-----|------|-----|---------------|
| Supply Current <sup>1,2,3</sup> | $I_{DD}$ | $f_{\text{CLOCK}} = 2.4 \text{ MHz}$                                   | -   | 620  | 700 | $\mu\text{A}$ |
| Sensitivity <sup>1</sup>        | S        | 94 dB SPL @ 1 kHz  | -27 | -26  | -25 | dBFS          |
| Signal to Noise Ratio           | SNR      | 94 dB SPL @ 1 kHz,<br>A-weighted, $f_{\text{CLOCK}} = 2.4 \text{ MHz}$ | -   | 64.3 | -   | dB(A)         |
| Total Harmonic Distortion       | THD      | 94 dB SPL @ 1 kHz, S = Typ   | -   | 0.2  | -   | %             |
| Acoustic Overload Point         | AOP      | 10% THD @ 1 kHz, S = Typ   | -   | 120  | -   | dB SPL        |
| Power Supply Rejection Ratio    | PSRR     | 200 mVpp sinewave @ 1 kHz  | -   | 55   | -   | dBV/FS        |
| Power Supply Rejection          | PSR+N    | 100 mVpp square wave<br>@ 217 Hz, A-weighted                           | -   | -84  | -   | dBFS<br>(A)   |

## Low-Power Mode

TEST CONDITIONS:  $f_{\text{CLOCK}} = 768 \text{ kHz}$ ,  $V_{\text{DD}} = 1.8 \text{ V}$ , unless otherwise indicated

| Parameter                     | Symbol          | Conditions   | Min | Typ | Max | Units         |
|-------------------------------|-----------------|--|-----|-----|-----|---------------|
| Supply Current <sup>2,3</sup> | $I_{\text{DD}}$ | $f_{\text{CLOCK}} = 768 \text{ kHz}$                       | -   | 235 | 270 | $\mu\text{A}$ |
| Sensitivity                   | S               | 94 dB SPL @ 1 kHz  | -27 | -26 | -25 | dBFS          |
| Signal to Noise Ratio         | SNR             | 94 dB SPL @ 1 kHz,<br>A-weighted (20 Hz - 8 kHz)           | -   | 64  | -   | dB(A)         |
| Total Harmonic Distortion     | THD             | 94 dB SPL @ 1 kHz, S = Typ                                 | -   | 0.2 | -   | %             |
| Acoustic Overload Point       | AOP             | 10% THD @ 1 kHz, S = Typ                                   | -   | 120 | -   | dB SPL        |
| Power Supply Rejection Ratio  | PSRR            | 200 mVpp sinewave @ 1 kHz                                  | -   | 59  | -   | dBV/FS        |
| Power Supply Rejection        | PSR+N           | 100 mVpp square wave @ 217 Hz,<br>A-weighted (20Hz - 8kHz) | -   | -86 | -   | dBFS<br>(A)   |

## Microphone Interface Specifications

| Parameter                          | Symbol            | Conditions  | Min                        | Typ | Max                        | Units |
|------------------------------------|-------------------|---|----------------------------|-----|----------------------------|-------|
| Logic Input High                   | $V_{\text{IH}}$   |   | $0.7 \times V_{\text{DD}}$ | -   | 3.6                        | V     |
| Logic Input Low                    | $V_{\text{IL}}$   |   | -0.3                       | -   | $0.3 \times V_{\text{DD}}$ | V     |
| Logic Output High                  | $V_{\text{OH}}$   | $I_{\text{OUT}} = 2 \text{ mA}$                           | $V_{\text{DD}} - 0.45$     | -   | $V_{\text{DD}}$            | V     |
| Logic Output Low                   | $V_{\text{OL}}$   | $I_{\text{OUT}} = 2 \text{ mA}$                           | 0                          | -   | 0.45                       | V     |
| Clock Duty Cycle                   |                   | $f_{\text{CLOCK}} \leq 2.4 \text{ MHz}$                   | 40                         | -   | 60                         | %     |
|                                    |                   | $2.4 \text{ MHz} < f_{\text{CLOCK}} \leq 4.8 \text{ MHz}$ | 48                         | 50  | 52                         | %     |
| Clock Rise/Fall Time               | $t_{\text{EDGE}}$ |   | -                          | -   | 3                          | ns    |
| Delay Time for Data Assertion      | $t_{\text{DD}}$   |   | 18                         | 28  | 40                         | ns    |
| Delay Time for High Z <sup>7</sup> | $t_{\text{DZ}}$   |   | 3                          | -   | 16                         | ns    |

<sup>1</sup> 100% tested.

<sup>2</sup>  $I_{\text{DD}}$  varies with  $C_{\text{LOAD}}$  according to:  $\Delta I_{\text{DD}} = 0.5 \times V_{\text{DD}} \times \Delta C_{\text{LOAD}} \times f_{\text{CLOCK}}$ .

<sup>3</sup> Typical and Maximum specifications are measured at standard test conditions.

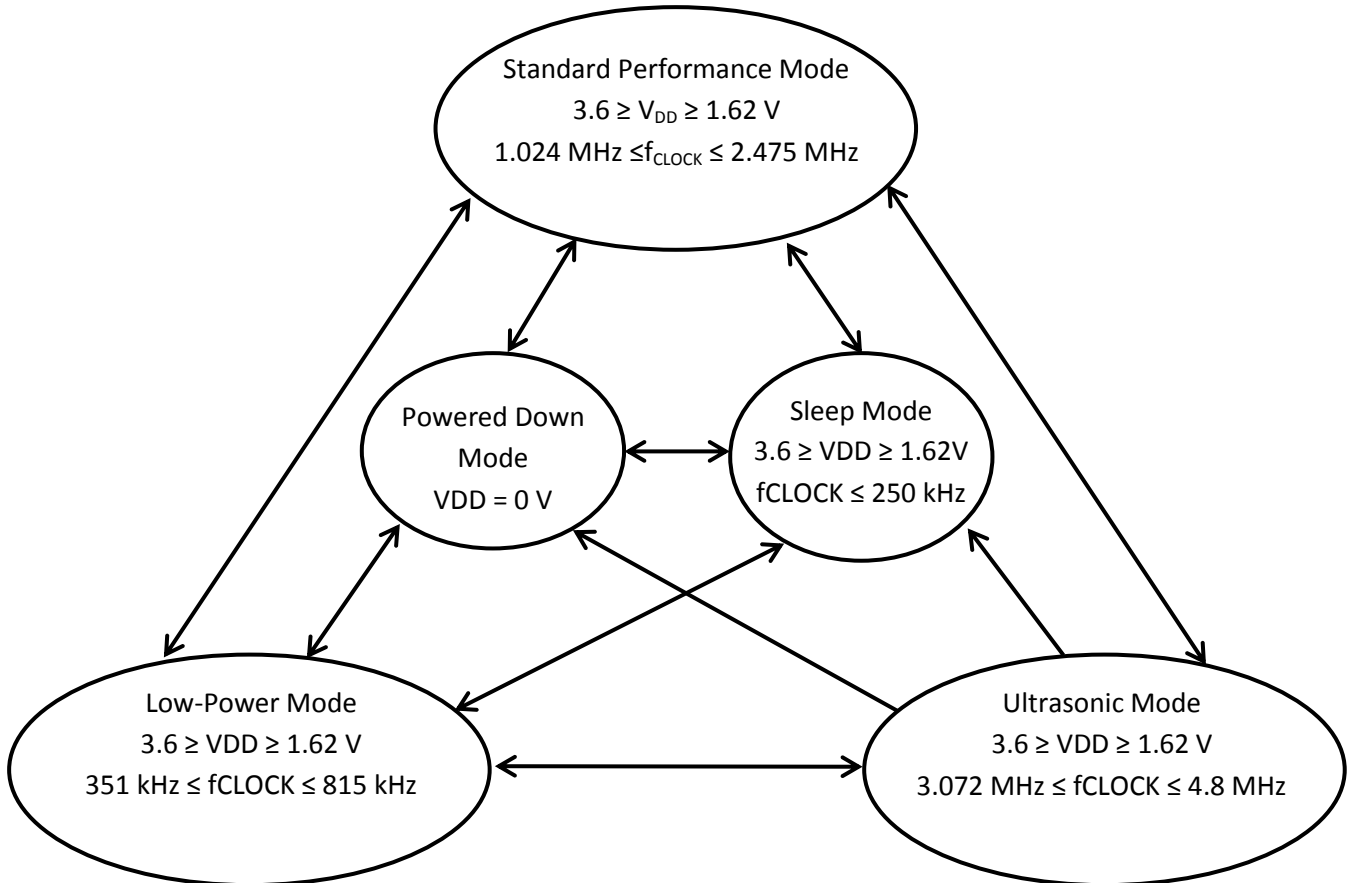
<sup>4</sup> Valid microphone states are: Powered Down Mode (mic off), Sleep Mode (low current, DATA = high-Z, fast startup), Low-Power Mode (low clock speed), Standard Performance Mode (normal operation), and Ultrasonic Mode (high clock speed).

<sup>5</sup> Time from  $f_{\text{CLOCK}} < 250 \text{ kHz}$  to  $I_{\text{SLEEP}}$  specification is met when transitioning from Active Mode to Sleep Mode.

<sup>6</sup> Time from  $f_{\text{CLOCK}} \geq 351 \text{ kHz}$  to all applicable specifications are met when transitioning from Sleep Mode to Active Mode.

<sup>7</sup>  $t_{\text{HOLD}}$  is dependent on  $C_{\text{LOAD}}$ .

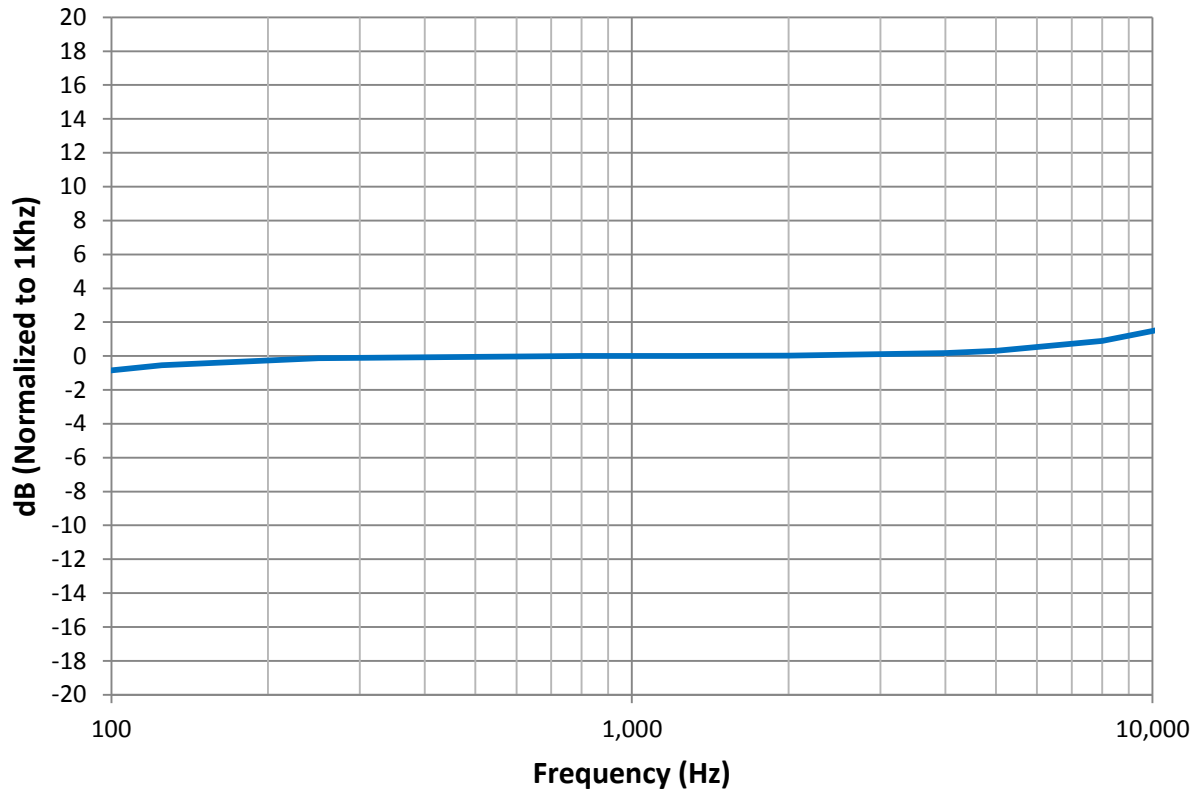
### 3. MICROPHONE STATE DIAGRAM



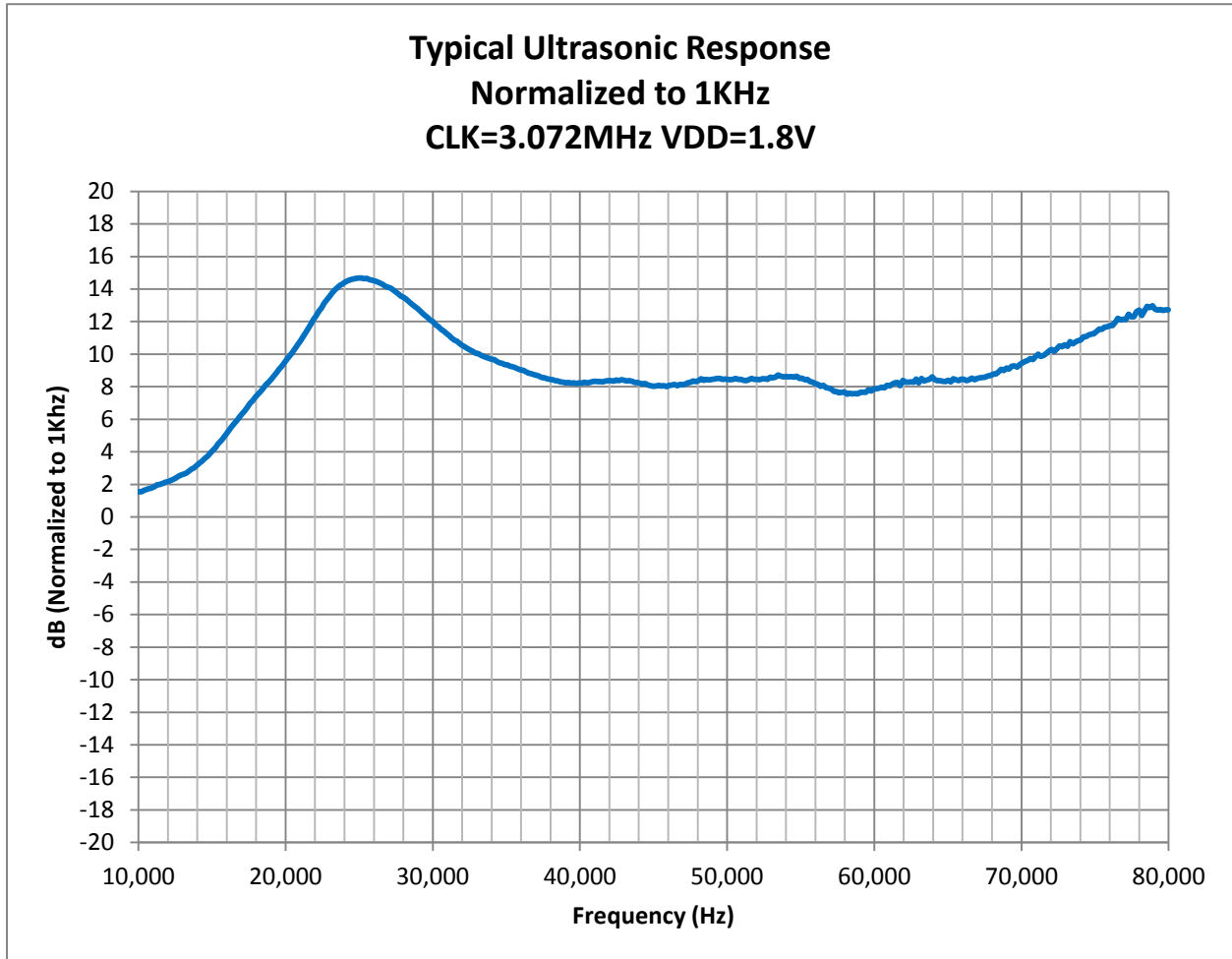
Note: Do not power up into ultrasonic mode.  
Do not wake-up from sleep mode into ultrasonic mode.

## 4. FREQUENCY RESPONSE CURVE

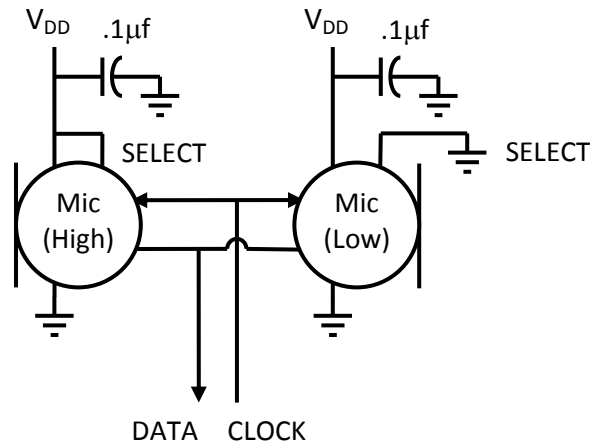
**Typical Free Field Response**  
**Normalized to 1 kHz**  
**CLK=2.4MHz VDD=1.8V**



## 5. ULTRASONIC RESPONSE CURVE



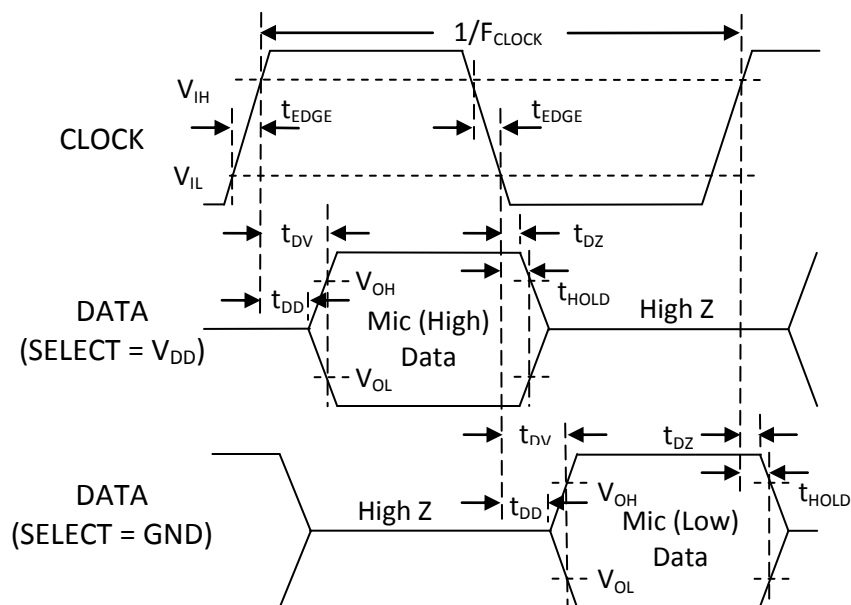
## 6. INTERFACE CIRCUIT



| Microphone | SELECT          | Asserts DATA On    | Latch DATA On      |
|------------|-----------------|--------------------|--------------------|
| Mic (High) | V <sub>DD</sub> | Rising Clock Edge  | Falling Clock Edge |
| Mic (Low)  | GND             | Falling Clock Edge | Rising Clock Edge  |

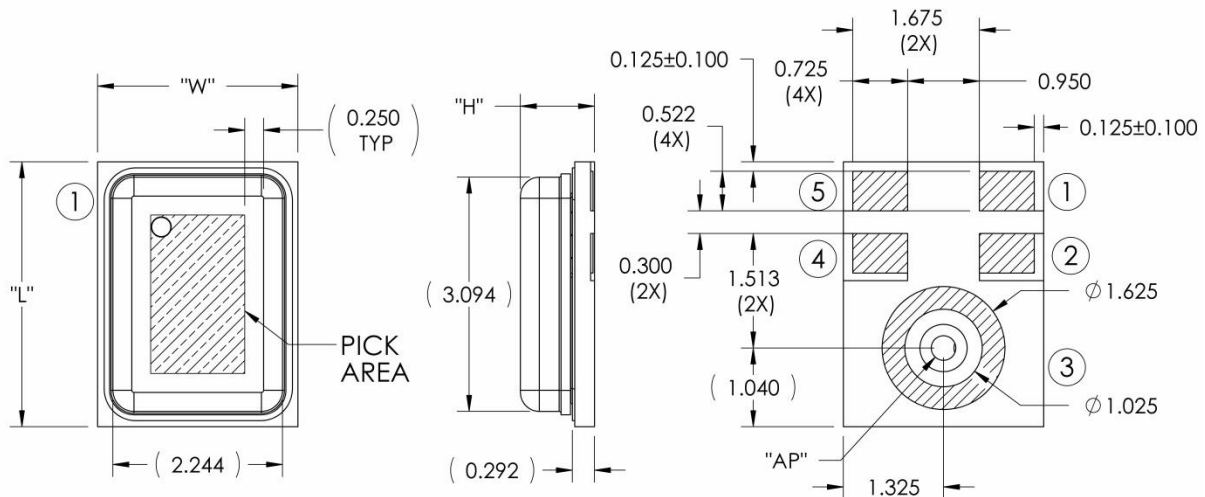
Note: Bypass capacitors near each Mic V<sub>DD</sub> PIN are recommended to provide maximum SNR performance. Capacitors near the microphone should not contain Class 2 dielectrics. Detailed information on acoustic, mechanical, and system integration can be found in the latest *SiSonic™ Design Guide* application note.

## 7. TIMING DIAGRAM





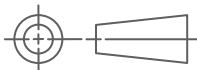
## 8. MECHANICAL SPECIFICATIONS



| Item               | Dimension | Tolerance |
|--------------------|-----------|-----------|
| Length (L)         | 3.50      | ±0.10     |
| Width (W)          | 2.65      | ±0.10     |
| Height (H)         | 0.98      | ±0.10     |
| Acoustic Port (AP) | ∅0.325    | ±0.05     |

| Pin # | Pin Name        | Type      | Description  |
|-------|-----------------|-----------|--|
| 1     | DATA            | Digital O | PDM Output   |
| 2     | SELECT          | Digital I | Lo/Hi (L/R) Select<br>This pin is internally pulled low but should not be left floating. |
| 3     | GROUND          | Power     | Ground   |
| 4     | CLOCK           | Digital I | Clock Input  |
| 5     | V <sub>DD</sub> | Power     | Power Supply   |

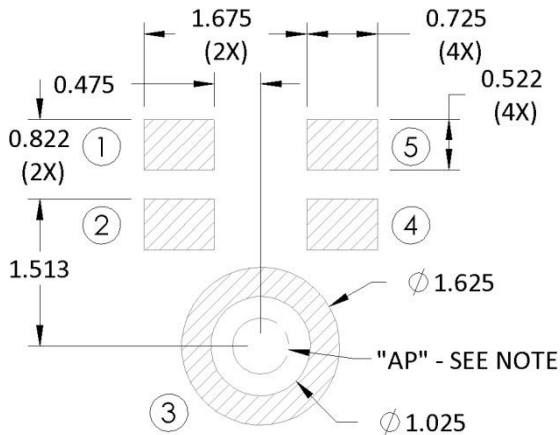
Notes: Pick Area only extends to 0.25 mm of any edge or hole unless otherwise specified.



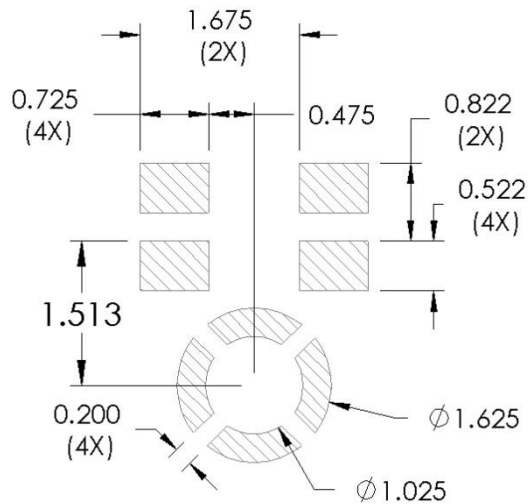
Dimensions are in millimeters unless otherwise specified.

Tolerance is ±0.15mm unless otherwise specified

## 9. EXAMPLE LAND PATTERN



## 10. EXAMPLE SOLDER STENCIL PATTERN

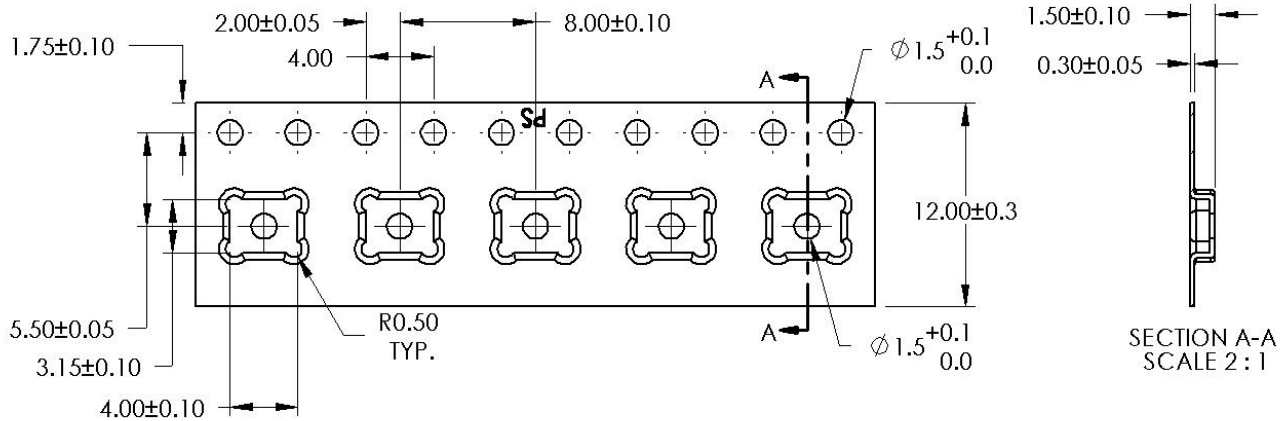


Notes: Dimensions are in millimeters unless otherwise specified.

Detailed information on AP size considerations can be found in the latest *SiSonic™ Design Guide* application note.

Further optimizations based on application should be performed.

## 11. PACKAGING & MARKING DETAIL



| Model Number  | Suffix | Reel Diameter | Quantity Per Reel |
|---------------|--------|---------------|-------------------|
| SPH0641LU4H-1 | -8     | 13"           | 5,900             |

Alpha Character A:

"S": Knowles SiSonic™ Production

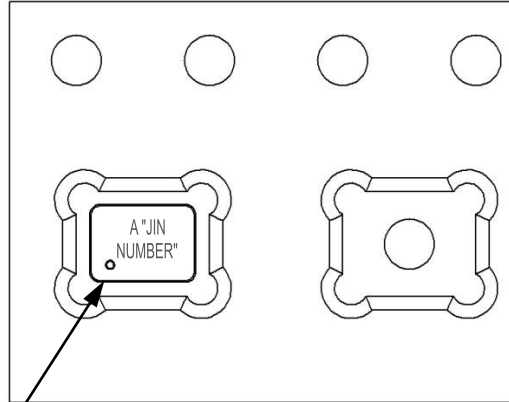
"E": Knowles Engineering Samples

"P": Knowles Prototype Samples

"JIN NUMBER":

Unique Job Identification Number for product traceability

Pin 1



Notes: Dimensions are in millimeters unless otherwise specified.

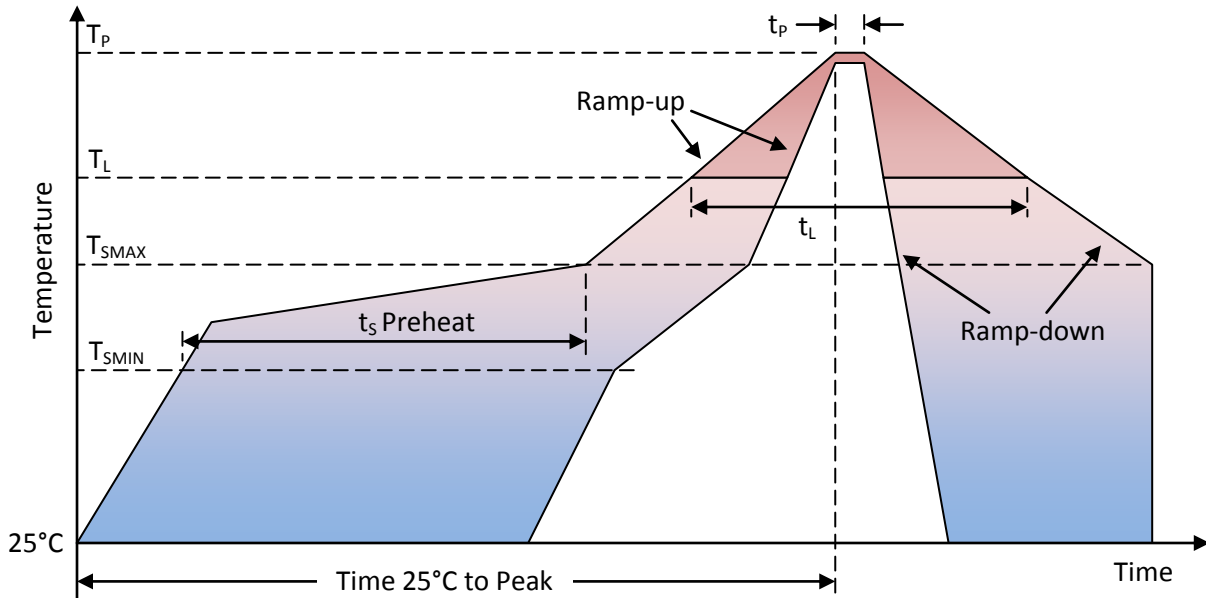
Vacuum pickup only in the pick area indicated in Mechanical Specifications.

Tape & reel per EIA-481.

Labels applied directly to reel and external package.

Shelf life: Twelve (12) months when devices are to be stored in factory supplied, unopened ESD moisture sensitive bag under maximum environmental conditions of 30°C, 70% R.H.

## 12. 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"> <li>• Temperature Min (<math>T_{SMIN}</math>)</li> <li>• Temperature Max (<math>T_{SMAX}</math>)</li> <li>• Time (<math>T_{SMIN}</math> to <math>T_{SMAX}</math>) (<math>t_s</math>)</li> </ul> | 150°C<br>200°C<br>60-180 seconds |
| Time maintained above: <ul style="list-style-type: none"> <li>• Temperature (<math>T_L</math>)</li> <li>• Time (<math>t_L</math>)</li> </ul>   | 217°C<br>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.



### 13. 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.

### 14. 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 Knowles Green Materials Standards Policy section on Halogen-Free.

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.”

## 15. RELIABILITY SPECIFICATIONS

| Test                        | Description   |
|-----------------------------|---|
| Thermal Shock               | 100 cycles air-to-air thermal shock from -40°C to +125°C with 15 minute soaks. (IEC 68-2-4)   |
| High Temperature Storage    | 1,000 hours at +105°C environment (IEC 68-2-2 Test Ba)  |
| Low Temperature Storage     | 1,000 hours at -40°C environment (IEC 68-2-2 Test Aa)   |
| High Temperature Bias       | 1,000 hours at +105°C under bias (IEC 68-2-2 Test Ba)   |
| Low Temperature Bias        | 1,000 hours at -40°C under bias (IEC 68-2-2 Test Aa)  |
| Temperature / Humidity Bias | 1,000 hours at +85°C/85% R.H. under bias. (JESD22-A101A-B)  |
| Vibration                   | 4 cycles of 20 to 2,000 Hz sinusoidal sweep with 20 G peak acceleration lasting 12 minutes in X, Y, and Z directions. (Mil-Std-883E, method 2007.2 A) |
| ESD-LID/GND                 | 3 discharges of ±8 kV direct contact to lid while unit is grounded. (IEC 61000-4-2)   |
| ESD-MM                      | 3 discharges of ±200V direct contact to I/O pins. (ESD STM5.2)  |
| Reflow                      | 5 reflow cycles with peak temperature of +260°C   |
| Mechanical Shock            | 3 pulses of 10,000 G in the X, Y, and Z direction (IEC 68-2-27, Test Ea)  |

Note: After reliability tests are performed, the sensitivity of the microphones shall not deviate more than 3 dB from its initial value.

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



# SPH0641LU4H-1

## 16. SPECIFICATION REVISIONS

| Revision | Specification Changes             | Date    |
|----------|-----------------------------------|---------|
| A        | Initial Release(C10115945)        | 5/16/14 |
| B        | Updated State Diagram(DCN 15-180) | 4/06/15 |
|          |                                   |         |
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