The SPH0655LM4H-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 SPH0655LM4H-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, 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 SPH0655LM4H-1 offers multiple performance modes.

**ABSOLUTE MAXIMUM RATINGS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Absolute Maximum Rating</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vdd to Ground</td>
<td>-0.5, +5.0</td>
<td>V</td>
</tr>
<tr>
<td>DATA, CLOCK, SELECT to Ground</td>
<td>-0.3, +5.0</td>
<td>V</td>
</tr>
<tr>
<td>Input Current</td>
<td>±5</td>
<td>mA</td>
</tr>
<tr>
<td>Short Circuit to/from DATA</td>
<td>Indefinite to Ground or Vdd</td>
<td>sec</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-40 to +100</td>
<td>°C</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40 to +100</td>
<td>°C</td>
</tr>
</tbody>
</table>

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 Distortion /High AOP
- High SNR
- 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
- Standard SMD Reflow
- LGA Package

**TYPICAL APPLICATIONS**

- Portable Electronics
- Cellphones
- Laptop Computers
- Tablets
- Digital Still Cameras
- Portable Music Recorders
ACOUSTIC & ELECTRICAL SPECIFICATIONS

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>Vdd</td>
<td></td>
<td>1.65</td>
<td>1.8</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>Low Frequency Rolloff</td>
<td>LFRO</td>
<td>-3dB relative to 1 kHz</td>
<td>-</td>
<td>25</td>
<td>-</td>
<td>Hz</td>
</tr>
<tr>
<td>High Frequency Flatness</td>
<td></td>
<td>+3dB relative to 1 kHz</td>
<td>-</td>
<td>22</td>
<td>-</td>
<td>kHz</td>
</tr>
<tr>
<td>Resonant Frequency Peak</td>
<td>Fres</td>
<td>Free Field response</td>
<td>-</td>
<td>36</td>
<td>-</td>
<td>kHz</td>
</tr>
<tr>
<td>DC Offset</td>
<td></td>
<td>Fullscale = ±100</td>
<td>-3.25</td>
<td>-</td>
<td>0.1</td>
<td>% FS</td>
</tr>
<tr>
<td>Directivity</td>
<td></td>
<td>Omnidirectional</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polarity</td>
<td></td>
<td>Increasing sound pressure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Format</td>
<td></td>
<td>Increasing density of 1’s</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity Drop</td>
<td>Vdd(min) ≤ Vdd ≤ Vdd(max)</td>
<td>-</td>
<td></td>
<td></td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>Clock Input Capacitance</td>
<td>Cin</td>
<td></td>
<td>-</td>
<td>15</td>
<td>-</td>
<td>pF</td>
</tr>
<tr>
<td>Data Output Capacitance</td>
<td>Cout</td>
<td></td>
<td>-</td>
<td>55</td>
<td>-</td>
<td>pF</td>
</tr>
<tr>
<td>Data Output Load</td>
<td>Cload</td>
<td></td>
<td>-</td>
<td>-</td>
<td>110</td>
<td>pF</td>
</tr>
<tr>
<td>SELECT (high)</td>
<td></td>
<td>Vdd-0.2</td>
<td></td>
<td></td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>SELECT (low)</td>
<td></td>
<td></td>
<td>-0.3</td>
<td>-</td>
<td>0.2</td>
<td>V</td>
</tr>
<tr>
<td>Short Circuit Current</td>
<td>Isc</td>
<td>Grounded DATA pin</td>
<td>1</td>
<td></td>
<td>20</td>
<td>mA</td>
</tr>
<tr>
<td>Fall-asleep Time(^{3,4})</td>
<td></td>
<td>F&lt;sub&gt;clock&lt;/sub&gt; &lt; 250kHz</td>
<td>-</td>
<td></td>
<td>10</td>
<td>ms</td>
</tr>
<tr>
<td>Wake-up Time(^{3,5})</td>
<td></td>
<td>F&lt;sub&gt;clock&lt;/sub&gt; ≥ 500kHz</td>
<td>-</td>
<td></td>
<td>35</td>
<td>ms</td>
</tr>
<tr>
<td>Startup Time(^{3})</td>
<td></td>
<td>Powered Down → Active, S within 1 dB of final value</td>
<td>-</td>
<td></td>
<td>35</td>
<td>ms</td>
</tr>
<tr>
<td>Time to First Data Bit(^{8})</td>
<td></td>
<td>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.</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>ms</td>
</tr>
<tr>
<td>Mode-Change Time(^{3,6})</td>
<td></td>
<td>Low Power Mode ⇔ Normal Mode</td>
<td>-</td>
<td></td>
<td>17</td>
<td>ms</td>
</tr>
</tbody>
</table>
### 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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Current²</td>
<td>Idd</td>
<td>Fclock = 1.2 MHz</td>
<td>-</td>
<td>650</td>
<td>690</td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fclock = 1.536 MHz</td>
<td>-</td>
<td>750</td>
<td>820</td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fclock = 2.4 MHz</td>
<td>800</td>
<td>1000</td>
<td>1200</td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fclock = 3.072 MHz</td>
<td>-</td>
<td>1225</td>
<td>1350</td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fclock = 4.8 MHz</td>
<td>-</td>
<td>1850</td>
<td>2000</td>
<td>µA</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>S</td>
<td>94 dB SPL @ 1 kHz</td>
<td>-38</td>
<td>-37</td>
<td>-36</td>
<td>dBFS</td>
</tr>
<tr>
<td></td>
<td>SNR</td>
<td>94 dB SPL @ 1 kHz, A-weighted, Fclock = 1.2 MHz</td>
<td>64.5</td>
<td>-</td>
<td>-</td>
<td>dB(A)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>94 dB SPL @ 1 kHz, A-weighted, Fclock = 1.536 MHz</td>
<td>66</td>
<td>-</td>
<td>-</td>
<td>dB(A)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>94 dB SPL @ 1 kHz, A-weighted, Fclock = 2.4 MHz</td>
<td>66</td>
<td>-</td>
<td>-</td>
<td>dB(A)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>94 dB SPL @ 1 kHz, A-weighted, Fclock = 3.072 MHz</td>
<td>66</td>
<td>-</td>
<td>-</td>
<td>dB(A)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>94 dB SPL @ 1 kHz, A-weighted, Fclock = 4.8 MHz</td>
<td>66</td>
<td>-</td>
<td>-</td>
<td>dB(A)</td>
</tr>
<tr>
<td>Near-Ultrasonic SNR</td>
<td></td>
<td>94 dB SPL, @ 19 kHz , BW = 18.5 - 20.0 kHz</td>
<td>-</td>
<td>78</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>Total Harmonic Distortion</td>
<td>THD</td>
<td>94 dB SPL @ 1 kHz</td>
<td>-</td>
<td>0.05</td>
<td>-</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>115 dB SPL @ 1 kHz</td>
<td>-</td>
<td>0.2</td>
<td>-</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1% THD @ 1 kHz, S = typ</td>
<td>-</td>
<td>130.5</td>
<td>-</td>
<td>dB SPL</td>
</tr>
<tr>
<td>Acoustic Overload Point</td>
<td>AOP</td>
<td>10% THD @ 1 kHz, S = typ</td>
<td>-</td>
<td>132.5</td>
<td>-</td>
<td>dB SPL</td>
</tr>
<tr>
<td>Power Supply Rejection Ratio</td>
<td>PSRR</td>
<td>200 mVpp sinewave @ 1 kHz</td>
<td>-</td>
<td>86</td>
<td>-</td>
<td>dB VFS</td>
</tr>
<tr>
<td>Power Supply Rejection</td>
<td>PSR+N</td>
<td>200 mVpp 7/8 duty cycle rectangular waveform @ 217 Hz, A-weighted</td>
<td>-</td>
<td>-98</td>
<td>-</td>
<td>dBFS(A)</td>
</tr>
</tbody>
</table>

### Table 4: Low-Power Mode
Test Conditions: 23 ±2°C, 55±20% R.H., Vdd=1.8 V, Fclock = 768 kHz (D.C. = 50%), Tedge ≤ 3ns, SELECT grounded, no load, unless otherwise indicated

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Current²</td>
<td>Idd</td>
<td>94 dB SPL @ 1 kHz</td>
<td>240</td>
<td>260</td>
<td>330</td>
<td>µA</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>S</td>
<td>94 dB SPL @ 1 kHz</td>
<td>-22</td>
<td>-21</td>
<td>-20</td>
<td>dBFS</td>
</tr>
<tr>
<td>Signal to Noise Ratio</td>
<td>SNR</td>
<td>94 dB SPL @ 1 kHz, A-weighted (BW = 8 kHz)</td>
<td>-</td>
<td>65.5</td>
<td>-</td>
<td>dB(A)</td>
</tr>
<tr>
<td>Total Harmonic Distortion</td>
<td>THD</td>
<td>94 dB SPL @ 1 kHz</td>
<td>-</td>
<td>0.05</td>
<td>-</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1% THD @ 1 kHz, S = typ</td>
<td>-</td>
<td>113</td>
<td>-</td>
<td>dB SPL</td>
</tr>
<tr>
<td>Acoustic Overload Point</td>
<td>AOP</td>
<td>10% THD @ 1 kHz, S = typ</td>
<td>-</td>
<td>116</td>
<td>-</td>
<td>dB SPL</td>
</tr>
<tr>
<td>Power Supply Rejection Ratio</td>
<td>PSRR</td>
<td>200 mVpp sinewave @ 1 kHz</td>
<td>-</td>
<td>75</td>
<td>-</td>
<td>dB VFS</td>
</tr>
<tr>
<td>Power Supply Rejection</td>
<td>PSR+N</td>
<td>200 mVpp 7/8 duty cycle rectangular waveform @ 217 Hz, A-weighted</td>
<td>-</td>
<td>-85</td>
<td>-</td>
<td>dBFS(A)</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleep Current</td>
<td>Isleep</td>
<td></td>
<td>-</td>
<td>40</td>
<td>55</td>
<td>μA</td>
</tr>
</tbody>
</table>

1 Sensitivity and Supply Current are 100% tested.
2 Idd varies with Cload according to ΔIdd = 0.5*Vdd*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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logic Input High7</td>
<td>Vih</td>
<td></td>
<td>0.65xVdd</td>
<td>-</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>Logic Input Low7</td>
<td>Vll</td>
<td></td>
<td>-0.3</td>
<td>-</td>
<td>0.35xVdd</td>
<td>V</td>
</tr>
<tr>
<td>Logic Output High7</td>
<td>Voh</td>
<td>Iout = 2 mA</td>
<td>Vdd-0.45</td>
<td>-</td>
<td>Vdd</td>
<td>V</td>
</tr>
<tr>
<td>Logic Output Low7</td>
<td>Vol</td>
<td>Iout = 2 mA</td>
<td>0</td>
<td>-</td>
<td>0.45</td>
<td>V</td>
</tr>
<tr>
<td>Low—&gt;High Threshold9</td>
<td>Vl-h</td>
<td></td>
<td>-</td>
<td>-</td>
<td>0.65xVdd</td>
<td>V</td>
</tr>
<tr>
<td>High—&gt;Low Threshold9</td>
<td>Vh-l</td>
<td></td>
<td>0.35xVdd</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>Hysteresis Width8</td>
<td>Vhyst</td>
<td></td>
<td>0.05xVdd</td>
<td>-</td>
<td>0.20xVdd</td>
<td>V</td>
</tr>
<tr>
<td>Clock Frequency7</td>
<td>Fclock</td>
<td>Sleep Mode</td>
<td>0</td>
<td>-</td>
<td>250</td>
<td>kHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low-Power Mode</td>
<td>500</td>
<td>-</td>
<td>900</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Normal Mode</td>
<td>1.1</td>
<td>-</td>
<td>4.8</td>
<td>MHz</td>
</tr>
<tr>
<td>Clock Duty Cycle</td>
<td>D.C.</td>
<td></td>
<td>40</td>
<td>50</td>
<td>60</td>
<td>%</td>
</tr>
<tr>
<td>Delay Time to Data Line Driver7</td>
<td>Tdd</td>
<td></td>
<td>18</td>
<td>-</td>
<td>35</td>
<td>ns</td>
</tr>
<tr>
<td>Delay Time to Valid Data7</td>
<td>Tdv</td>
<td>Max Clod</td>
<td>-</td>
<td>-</td>
<td>100</td>
<td>ns</td>
</tr>
<tr>
<td>Delay Time to High Z7</td>
<td>Tdz</td>
<td></td>
<td>5</td>
<td>-</td>
<td>16</td>
<td>ns</td>
</tr>
<tr>
<td>Hold Time7</td>
<td>Thold</td>
<td>Thold, as observed by the input device, will be</td>
<td>5</td>
<td>-</td>
<td>-</td>
<td>ns</td>
</tr>
</tbody>
</table>

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

- **CLOCK**
  - DATA (SELECT = Vdd)
  - DATA (SELECT = Ground)

- **DATA (SELECT = Vdd)**
  - Tdd → Tedge → Tdv → Voh → Mic (High) Data → Voh → Mic (Low) Data → Tdz → Thold

- **DATA (SELECT = Ground)**
  - Tdd → Tedge → Tdv → Vol → High Z → Data

**Figure 2: Hysteresis Diagram**

- **Internal Logic Level**
  - High
  - Low

**Figure 3: State Diagram**

- **Normal Mode**
  - 1.1 MHz ≤ Fclock ≤ 4.8 MHz
  - 1.65V ≤ Vdd ≤ 3.6V

- **Powered Down Mode**
  - Vdd ≤ 0V

- **Sleep Mode**
  - Fclock < 250 kHz
  - 1.65V ≤ Vdd ≤ 3.6V

- **Low-Power Mode**
  - 500 kHz ≤ Fclock ≤ 900 kHz
  - 1.65V ≤ Vdd ≤ 3.6V

**Figure 4: Typical Stereo Application Circuit**

- CODEC OR APPLICATION PROCESSOR
  - CLOCK DATA
  - Vdd
  - 0.1 µF
  - Rterm
  - Zrf

**Figure 5: Typical Single-Microphone Application Circuit**

- CODEC OR APPLICATION PROCESSOR
  - CLOCK DATA
  - Vdd
  - 0.1 µF
  - Rterm
  - Zrf

**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**

<table>
<thead>
<tr>
<th>Microphone</th>
<th>SELECT</th>
<th>Asserts DATA on</th>
<th>Latch DATA on</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mic (High)</td>
<td>Vdd</td>
<td>CLK rising edge</td>
<td>CLK falling edge</td>
</tr>
<tr>
<td>Mic (Low)</td>
<td>Ground</td>
<td>CLK falling edge</td>
<td>CLK rising edge</td>
</tr>
</tbody>
</table>
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 Phase Response

Figure 8: Typical THD vs SPL

Figure 7: Typical Group Delay

Figure 9: Typical THD vs Frequency
MECHANICAL SPECIFICATIONS

<table>
<thead>
<tr>
<th>Item</th>
<th>Dimension</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (L)</td>
<td>3.5</td>
<td>±0.10</td>
</tr>
<tr>
<td>Width (W)</td>
<td>2.65</td>
<td>±0.10</td>
</tr>
<tr>
<td>Height (H)</td>
<td>0.98</td>
<td>±0.10</td>
</tr>
<tr>
<td>Acoustic Port (AP)</td>
<td>Ø0.325</td>
<td>±0.05</td>
</tr>
<tr>
<td>PCB Thickness (T)</td>
<td>0.307</td>
<td>±0.05</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Pin Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DATA</td>
<td>Digital O</td>
<td>PDM Output</td>
</tr>
<tr>
<td>2</td>
<td>SELECT</td>
<td>Digital I</td>
<td>Lo/Hi (L/R) Select Connect to Vdd or GND</td>
</tr>
<tr>
<td>3</td>
<td>GROUND</td>
<td>Power</td>
<td>Ground</td>
</tr>
<tr>
<td>4</td>
<td>CLOCK</td>
<td>Digital I</td>
<td>Clock Input</td>
</tr>
<tr>
<td>5</td>
<td>Vdd</td>
<td>Power</td>
<td>Power Supply</td>
</tr>
</tbody>
</table>

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.
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

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Suffix</th>
<th>Reel Diameter</th>
<th>Quantity Per Reel</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPH0655LM4H-1</td>
<td>-8</td>
<td>13&quot;</td>
<td>5900</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Component</th>
<th>Surface Resistance (ohms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reel</td>
<td>$10^5 - 10^9$</td>
</tr>
<tr>
<td>Carrier Tape</td>
<td>$10^5 - 10^9$</td>
</tr>
<tr>
<td>Cover Tape</td>
<td>$10^4 - 10^10$</td>
</tr>
</tbody>
</table>

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

![Reflow Profile Diagram]

<table>
<thead>
<tr>
<th>Profile Feature</th>
<th>Pb-Free</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Ramp-up rate ($T_{\text{SMAX}}$ to $T_p$)</td>
<td>3°C/second max.</td>
</tr>
<tr>
<td>Preheat</td>
<td></td>
</tr>
<tr>
<td>• Temperature Min ($T_{\text{SMIN}}$)</td>
<td>150°C</td>
</tr>
<tr>
<td>• Temperature Max ($T_{\text{SMAX}}$)</td>
<td>200°C</td>
</tr>
<tr>
<td>• Time ($T_{\text{SMIN}}$ to $T_{\text{SMAX}}$) ($t_0$)</td>
<td>60-180 seconds</td>
</tr>
<tr>
<td>Time maintained above:</td>
<td></td>
</tr>
<tr>
<td>• Temperature ($T_L$)</td>
<td>217°C</td>
</tr>
<tr>
<td>• Time ($t_L$)</td>
<td>60-150 seconds</td>
</tr>
<tr>
<td>Peak Temperature ($T_p$)</td>
<td>260°C</td>
</tr>
<tr>
<td>Time within 5°C of actual Peak Temperature ($t_p$)</td>
<td>20-40 seconds</td>
</tr>
<tr>
<td>Ramp-down rate ($T_p$ to $T_{\text{SMAX}}$)</td>
<td>6°C/second max</td>
</tr>
<tr>
<td>Time 25°C to Peak Temperature</td>
<td>8 minutes max</td>
</tr>
</tbody>
</table>

**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 atmos/sec.
  - Do not directly expose to vapor phase soldering.
MATERIALS STATEMENT

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


Product is Beryllium Free according to limits specified on the Knowles 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

<table>
<thead>
<tr>
<th>Test</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Shock</td>
<td>100 cycles of air-air thermal shock from -40°C to +125°C with 15 minute soaks (IEC 68-2-4)</td>
</tr>
<tr>
<td>High Temperature Storage</td>
<td>+105°C environment for 1,000 hours (IEC 68-2-2 Test Ba)</td>
</tr>
<tr>
<td>Low Temperature Storage</td>
<td>-40°C environment for 1,000 hours (IEC 68-2-1 Test Aa)</td>
</tr>
<tr>
<td>High Temperature Bias</td>
<td>+105°C environment while under bias for 1,000 hours (IEC 68-2-2 Test Ba)</td>
</tr>
<tr>
<td>Low Temperature Bias</td>
<td>-40°C environment while under bias for 1,000 hours (IEC 68-2-1 Test Aa)</td>
</tr>
<tr>
<td>Temperature/Humidity Bias</td>
<td>+85°C/85% R.H. environment while under bias for 1,000 hours (JESD22-A101A-B)</td>
</tr>
<tr>
<td>Vibration</td>
<td>12 minutes in each X, Y, Z axis from 20 to 2,000 Hz with peak acceleration of 20 G (MIL 883E, Method 2007.2.A)</td>
</tr>
<tr>
<td>ESD-HBM</td>
<td>3 discharges at ±2kV direct contact to I/O pins (ESD STMS.2)</td>
</tr>
<tr>
<td>ESD-LID/GND</td>
<td>3 discharges at ±8kV direct contact to lid when unit is grounded (IEC 61000-4-2)</td>
</tr>
<tr>
<td>Reflow</td>
<td>5 reflow cycles with peak temperature of +260°C</td>
</tr>
<tr>
<td>Mechanical Shock</td>
<td>3 pulses of 10,000 G in each of the X, Y, and Z directions (IEC 68-2-27 Test Ea)</td>
</tr>
</tbody>
</table>

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.
## SPECIFICATION REVISIONS

<table>
<thead>
<tr>
<th>Revision</th>
<th>Specification Changes</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Initial Release (ECR 19-3368)</td>
<td>10/16/19</td>
</tr>
<tr>
<td>B</td>
<td>Updated Mechanical Drawing and Picture (ECR 19-3436)</td>
<td>11/11/19</td>
</tr>
</tbody>
</table>

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