# IM69D127V11

## IP57 dust and water resistant PDM digital XENSIV™ MEMS microphone

## Description

The IM69D127V11 is an ultra-high performance digital PDM MEMS microphone designed for applications which require a very high SNR (low self-noise) and low distortion (high AOP) and which is also IP57 robust to dust and water.

Best-in-class signal-to-noise ratio (SNR) of 69dB(A) enables far field and low volume audio pick-up. The flat frequency response (40Hz low-frequency roll-off) and tight manufacturing tolerance improve performance of multi-microphone (array) applications.

The digital microphone ASIC contains an extremely low-noise preamplifier and a high-performance sigma-delta ADC. Different power modes can be selected in order to suit specific clock frequency and current consumption requirements.

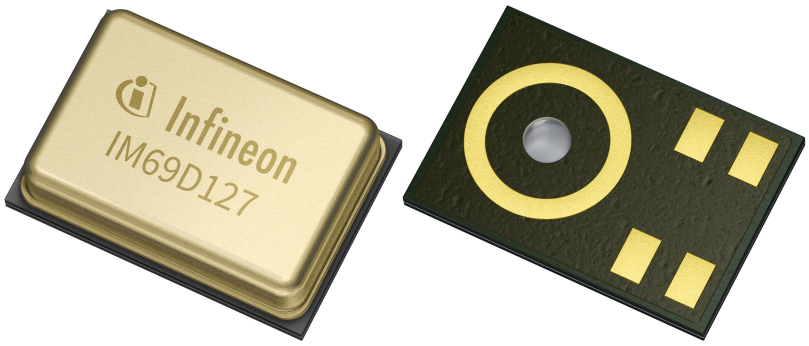
Each IM69D127V11 microphone is calibrated with an advanced Infineon calibration algorithm, resulting in low sensitivity tolerances (± 1dB).

## Features

- Component level IP57 dust and water resistant
- Dynamic range of 102dB
  - Signal to noise ratio of 69dB(A) SNR
  - <1% total harmonic distortions up to 123dBSPL
  - Acoustic overload point at 127dBSPL
- Accurate sensitivity matching (± 1dB) for beam forming applications
- Flat frequency response with low frequency roll-off at 40Hz
- Power optimized modes determined by PDM clock frequency
- Package dimensions: 3.60mm x 2.50mm x 1.00mm
- PDM Output
- Omnidirectional pickup pattern

## Typical applications

- Active Noise Cancellation (ANC) headphones and wireless earbuds
- Devices with Voice User Interface (VUI)
  - Smart speakers
  - Home automation
  - IoT devices
- High quality audio capturing
  - Cameras
  - Laptops and tablets
  - Conference systems



# Block diagram

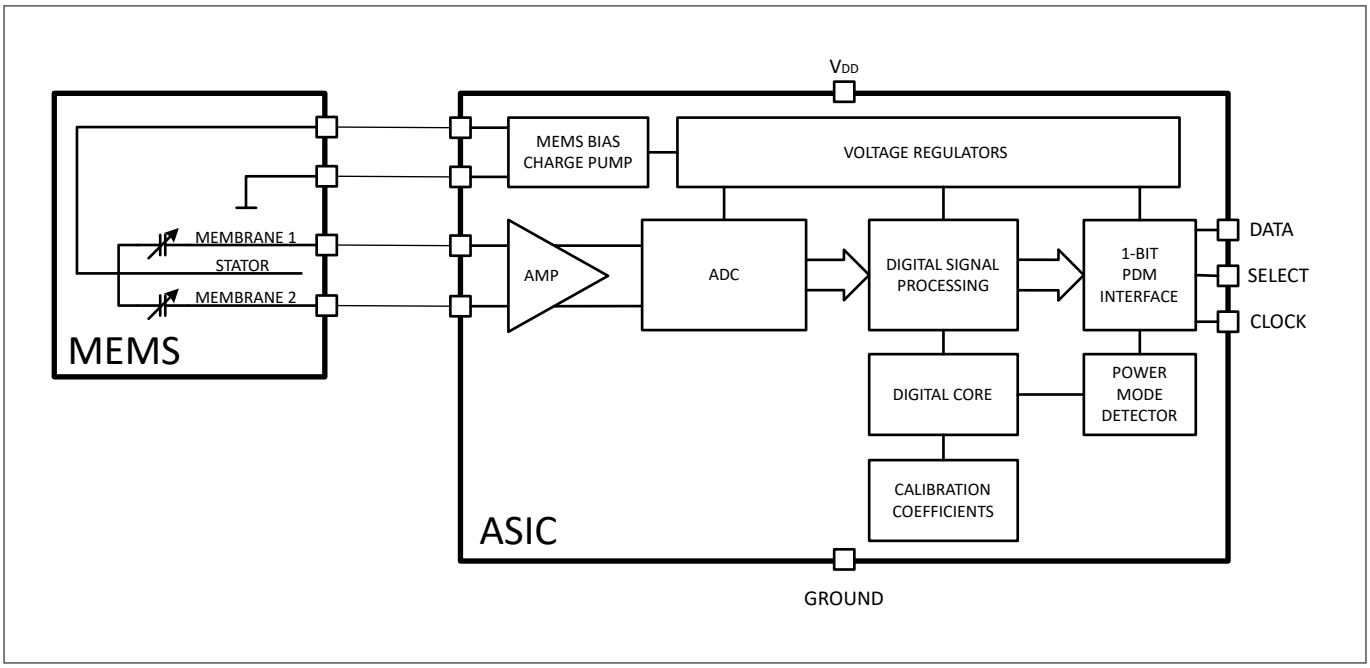



**Figure 1 IM69D127V11 block diagram.**

# Product validation

Technology qualified for industrial applications.

Ready for validation in industrial applications according to the relevant tests of IEC 60747 and 60749 or alternatively JEDEC47/20/22.

# Environmental robustness

Infineon's latest Sealed Dual Membrane MEMS technology delivers high ingress protection (IP57) at a microphone level. The sealed MEMS design prevents water or dust from entering between membrane and backplate, preventing mechanical blockage or electric leakage issues commonly observed in MEMS microphones. Microphones built with the Sealed Dual Membrane technology can be used to create IP68 devices, requiring only minimal mesh protection.

**Table 1 Environmental robustness**

| Test Standard | Test Condition |
|---|---|
| IP5x dust resistance[1)] | Arizona dust A4 coarse, vertical orientation , sound hole upwards, 10 cycles (15 minutes sedimentation, 6 sec blowing) |
| IPx7 water immersion[2)] | Temporary immersion of 1 meters for 30 minutes. Microphone tested 2 hours after removal |

1 The number "5" stands for the dust ingress rating or the capacity to withstand the effects of fine, abrasive dust particles.
2 The "7" specifies the higher water immersion rating.

# Table of contents

# 1 Typical performance characteristics

Test conditions: $V_{DD}$ = 1.8V, $f_{CLK}$ = 3.072MHz, no load on DATA

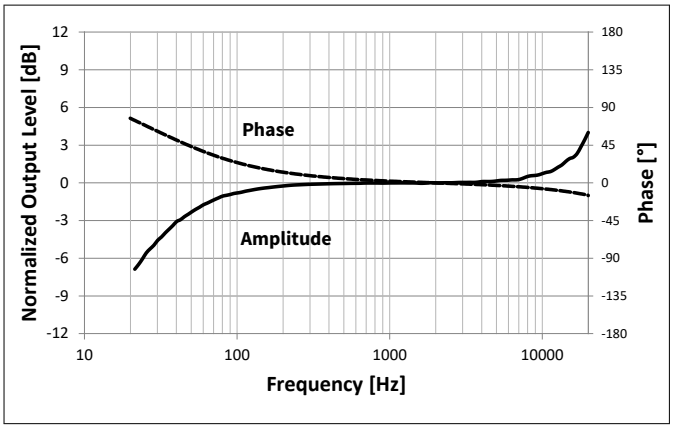



**Figure 2** **Typical amplitude and phase response**

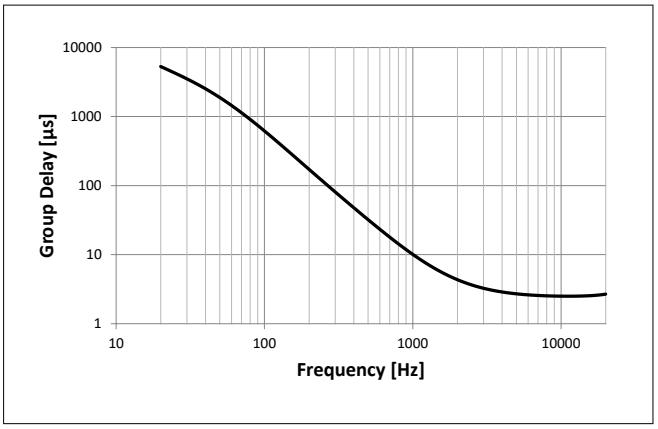



**Figure 3** **Typical group delay vs frequency**

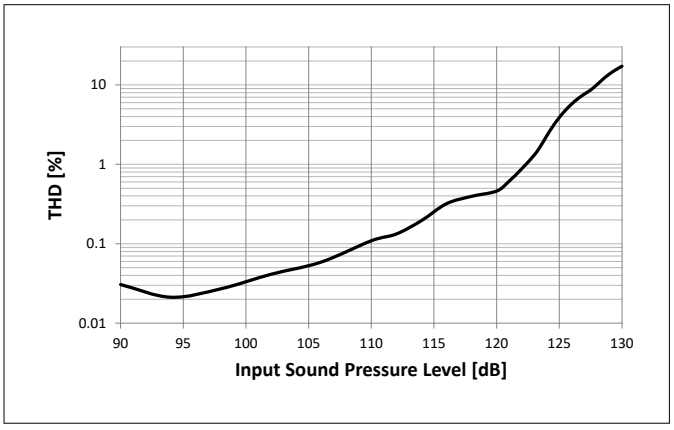



**Figure 4** **Typical THD vs SPL**

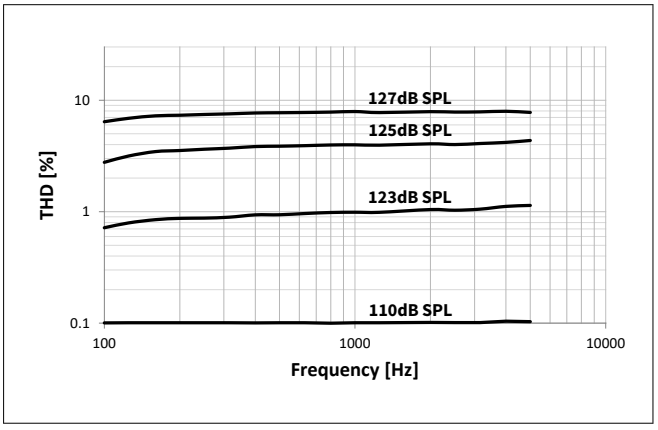



**Figure 5** **Typical THD vs frequency**

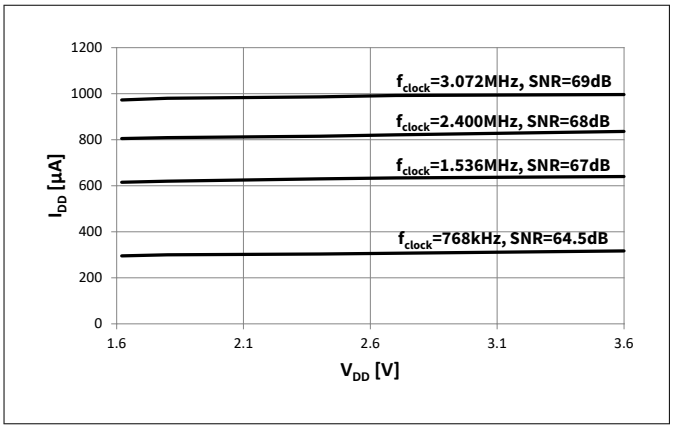



**Figure 6** **Typical $I_{DD}$ vs $V_{DD}$**

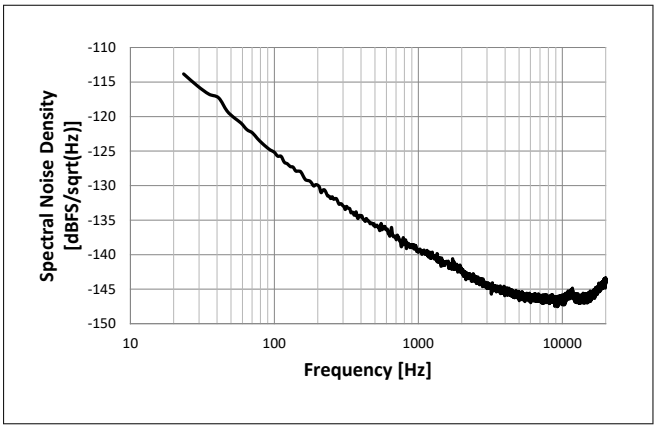



**Figure 7** **Typical noise floor (unweighted)**

# 2 Acoustic characteristics

Test conditions ( unless otherwise specified in the table): $V_{DD}$ = 1.8V, $f_{CLK}$ = 3.072MHz, $T_A$ = 25°C, 55% R.H., Audio bandwidth 20Hz to 20kHz, Select pin grounded, no load, $T_{edge}$ = 9ns.

**Table 2 IM69D127V11 acoustic specifications**

| Parameter | | Symbol | Values | | | Unit | Note or Test Condition |
|---|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | | |
| Sensitivity | | | -35 | -34 | -33 | dBFS | 1kHz, 94dB SPL, all operating modes |
| Acoustic overload point | | AOP | | 127 | | dBSPL | THD = 10%, all operating modes |
| Signal to Noise ratio | $f_{clock}$=3.072MHz | SNR | | 69 | | dB (A) | A-Weighted |
| | $f_{clock}$=2.4MHz | | | 68 | | | |
| | $f_{clock}$=1.536MHz | | | 67 | | | |
| | $f_{clock}$=768kHz | | | 65 | | | 20Hz to 8kHz bandwidth, A-Weighted; |
| Total harmonic distortion | 94dBSPL | THD | | 0.5 | | % | Measuring 2nd to 5th harmonics; 1kHz. All power modes |
| | 123dBSPL | | | 1 | | | |
| | 127dBSPL | | | 10 | | | |
| Low frequency cutoff point | | $f_{C\ LP}$ | | 40 | | Hz | -3dB point relative to 1kHz |
| Group delay | 250Hz | | | 113 | | µs | |
| | 600Hz | | | 23 | | | |
| | 1kHz | | | 9 | | | |
| | 4kHz | | | 3 | | | |
| Phase response | 75Hz | | | 30 | | ° | |
| | 1kHz | | | 2 | | | |
| | 3kHz | | | -2 | | | |
| Directivity | | | Omnidirectional | | | | Pickup pattern |
| Polarity | | | Positive pressure increases density of 1's, negative pressure decreases density of 1's in data output. | | | | |

## 2.1 Free field frequency response

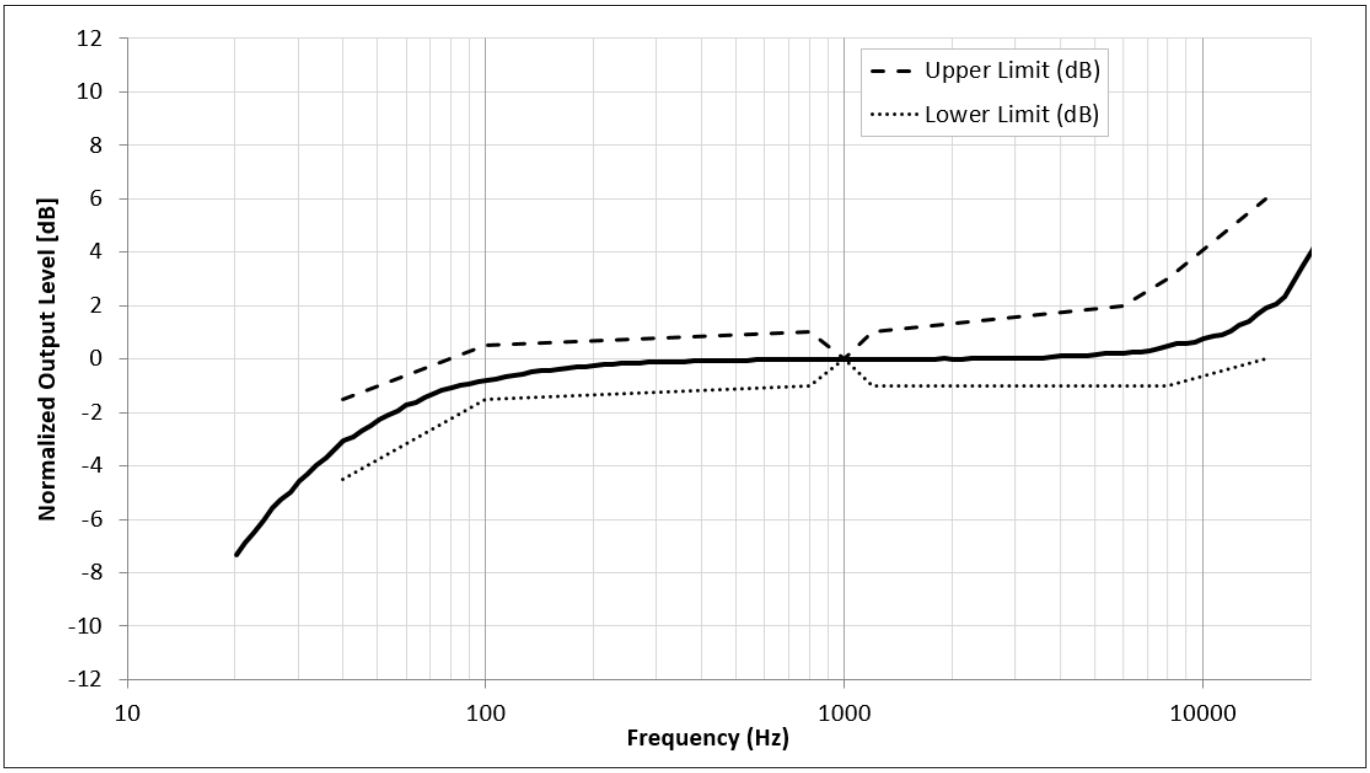



**Figure 8 IM69D127V11 free field frequency response**

**Table 3 IM69D127V11 free field frequency response, normalised to 1kHz sensitivity value.**

| Frequency (Hz) | Upper Limit (dB) | Lower Limit (dB) |
|---|---|---|
| 40 | -1.5 | -4.5 |
| 100 | +0.5 | -1.5 |
| 800 | +1 | -1 |
| 1000 | 0 | 0 |
| 1200 | +1 | -1 |
| 6000 | +2 | -1 |
| 8000 | +3 | -1 |
| 15000 | +6 | 0 |

# 3 Electrical parameters and characteristics

## 3.1 Absolute maximum ratings

Stresses at or above the listed maximum ratings may affect device reliability or cause permanent device damage. Functional device operation at these conditions is not guaranteed.

**Table 4 Absolute maximum ratings**

| Parameter | Symbol | Values | | Unit | Note / Test Condition |
|---|---|---|---|---|---|
| | | Min. | Max. | | |
| Voltage on any pin | $V_{max}$ | | 4 | V | |
| Storage temperature | $T_S$ | -40 | 100 | °C | |
| Operating temperature | $T_A$ | -40 | 85 | °C | |

## 3.2 Electrical parameters

**Table 5 Electrical parameters and digital interface input**

| Parameter | | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | | |
| Supply voltage | | $V_{DD}$ | 1.65 | 1.8 | 3.6 | V | A 100nF bypass capacitor should be placed close to the microphone's VDD pin to ensure best SNR performance |
| Clock frequency range | Operating modes | $f_{clock}$ | 2.9 | 3.072 | 3.3 | MHz | Intermediate frequencies between those listed cannot be used |
| | | | 2.2 | 2.4 | 2.6 | | |
| | | | 1.38 | 1.536 | 1.7 | | |
| | | | 450 | 768 | 850 | kHz | |
| | Standby mode | | | | 250 | | DATA = high-Z |
| $V_{DD}$ ramp-up time | | | | | 50 | ms | Time until $V_{DD} \geq V_{DD\_min}$ |
| Clock duty cycle | | | 40 | | 60 | % | At PDM clock frequency range from minimum to typical value |
| | | | 45 | | 55 | | At PDM clock frequency range from typical to maximum value |
| Clock rise/fall time | | $t_{CR}$, $t_{CF}$ | | | 13 | ns | |
| Input logic low level | | $V_{IL}$ | -0.3 | | $0.35xV_{DD}$ | V | |
| Input logic high level | | $V_{IH}$ | $0.65xV_{DD}$ | | $V_{DD}+0.3$ | V | |
| Output load capacitance on DATA | | $C_{load}$ | | | 200 | pF | |

## 3.3 Electrical characteristics

Test conditions (unless otherwise specified in the table): $V_{DD}$= 1.8V, $T_A$=25°C, 55% R.H.

**Table 6 General electrical characteristics**

| Parameter | | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | | |
| Current consumption | $f_{clock}$=3.072MHz | $I_{DD}$ | | 980 | 1200 | µA | Output load <5pF |
| | $f_{clock}$=2.4MHz | | | 800 | 950 | | |
| | $f_{clock}$=1.536MHz | | | 620 | 740 | | |
| | $f_{clock}$=768kHz | | | 300 | 350 | | |
| | Standby mode | $I_{standby}$ | | | 50 | | |
| | Clock Off mode | $I_{clock\_off}$ | | | 10 | | CLOCK pulled low |
| Short circuit current | | | 1 | | 20 | mA | Grounded DATA pin |
| Power supply rejection | | PSR | | | -75 | dBFS | $V_{DD}$=1.8V+100m$V_{pp}$ sine wave, f=40Hz to 100Hz |
| | | | | | -80 | | $V_{DD}$=1.8V+100m$V_{pp}$ sine wave, f=100Hz to 20kHz |
| Startup time | ±0.5dB sensitivity accuracy | | | | 20 | ms | Time to start up in all operating modes after $V_{DD\_min}$ and CLOCK have been applied |
| | ±0.2dB sensitivity accuracy | | | | 50 | | |
| Mode switch time | ±0.5dB sensitivity accuracy | | | | 20 | ms | Time to switch between operating modes. $V_{DD}$ remains on during the mode switch |
| | ±0.2dB sensitivity accuracy | | | | 50 | | |
| Hysteresis width | | $V_{hys}$ | 0.1x$V_{DD}$ | | | V | |
| Output logic low level | | $V_{OL}$ | | | 0.3x$V_{DD}$ | V | $I_{out}$= 2mA |
| Output logic high level | | $V_{OH}$ | 0.7x$V_{DD}$ | | | | $I_{out}$= 2mA |
| Delay time for DATA driven | | $t_{DD}$ | 40 | | 80 | ns | Delay time from CLOCK edge (0.5x$V_{DD}$) to DATA driven |
| Delay time for DATA high-Z [3] | | $t_{HZ}$ | 5 | | 30 | ns | Delay time from CLOCK edge (0.5x$V_{DD}$) to DATA high impedance state |
| Delay time for DATA valid [4] | | $t_{DV}$ | | | 100 | ns | Delay time from CLOCK edge (0.5x$V_{DD}$) to DATA valid (<0.3x$V_{DD}$ or >0.7x$V_{DD}$). Load on data: $C_{load}$=100pF, $R_{load}$=100kΩ |
| Power-on behavior | | Idle tone is output over PDM within 3ms of applying VDD and CLK, remains until a valid microphone signal is available. Idle tones consists of alternating 1s and 0s, representing a zero input signal. | | | | | |

3 $t_{hold}$ is depended on $C_{load}$
4 Load on data: $C_{load}$=100pF, $R_{load}$=100kΩ

## 3.4 Digital interface timing specifications

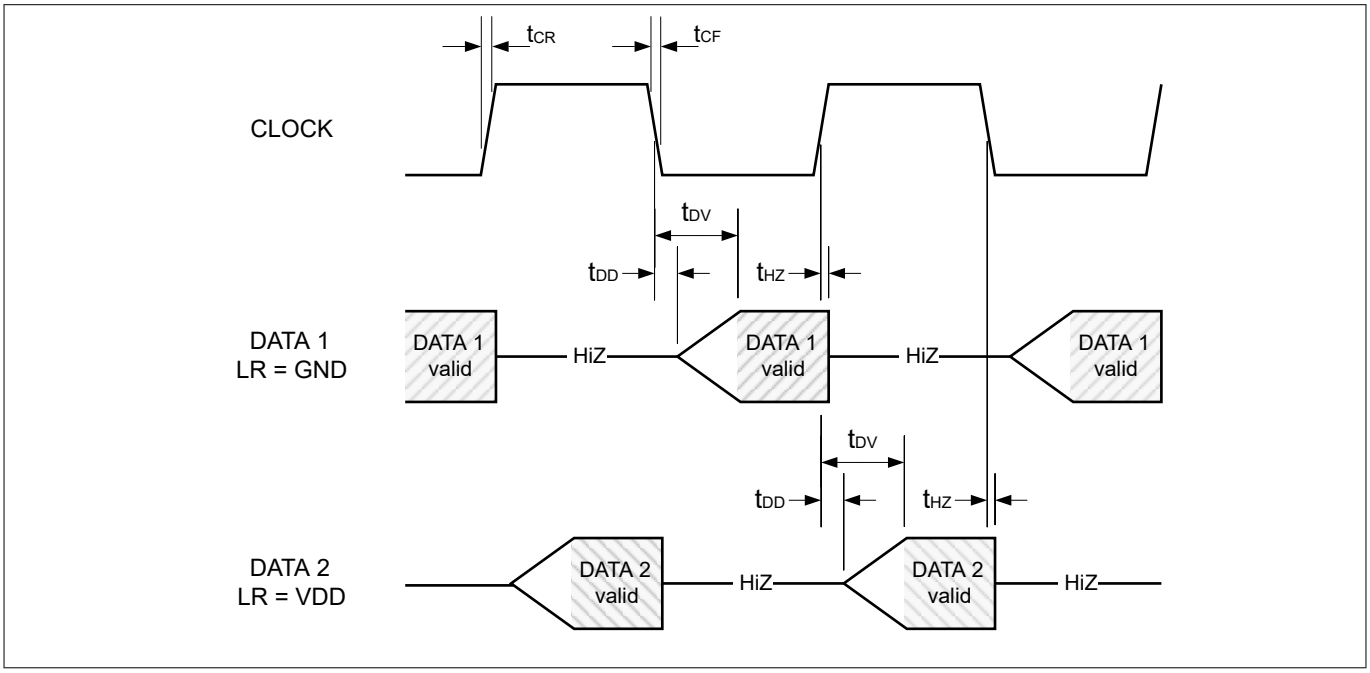



**Figure 9 IM69D127V11 timing diagram**

## 3.5 PDM channel configurations

**Table 7 PDM channel configuration using L/R pin.**

| Channel | Data driven | Data high-Z | L/R connection |
|---|---|---|---|
| DATA1 | Falling clock edge | Rising clock edge | GND |
| DATA2 | Rising clock edge | Falling clock edge | $V_{DD}$ |

## 3.6 Audio DC offset

The DC output level encoded in the DC bit stream is determined by the L/R state on startup. In each case the DC output level is stable over time and does not vary with input signal level.

**Table 8 DC output level using L/R pin**

| LR state | DC output level (typical) | Unit |
|---|---|---|
| LR = GND | -80 | dBFS |
| LR = VDD | -40 | dBFS |

## 3.7 Stereo PDM operation

The IM69D127V11 is designed to function in circuits with one or two microphones on the PDM bus. When two microphones are connected, data is transmitted alternately according to the L/R pin status of each microphone. When two microphones are connected to a shared PDM bus, the power modes of both microphones will be the same as both are controlled by the same PDM clock. The performance is unchanged relative to a single microphone per bus configuration.

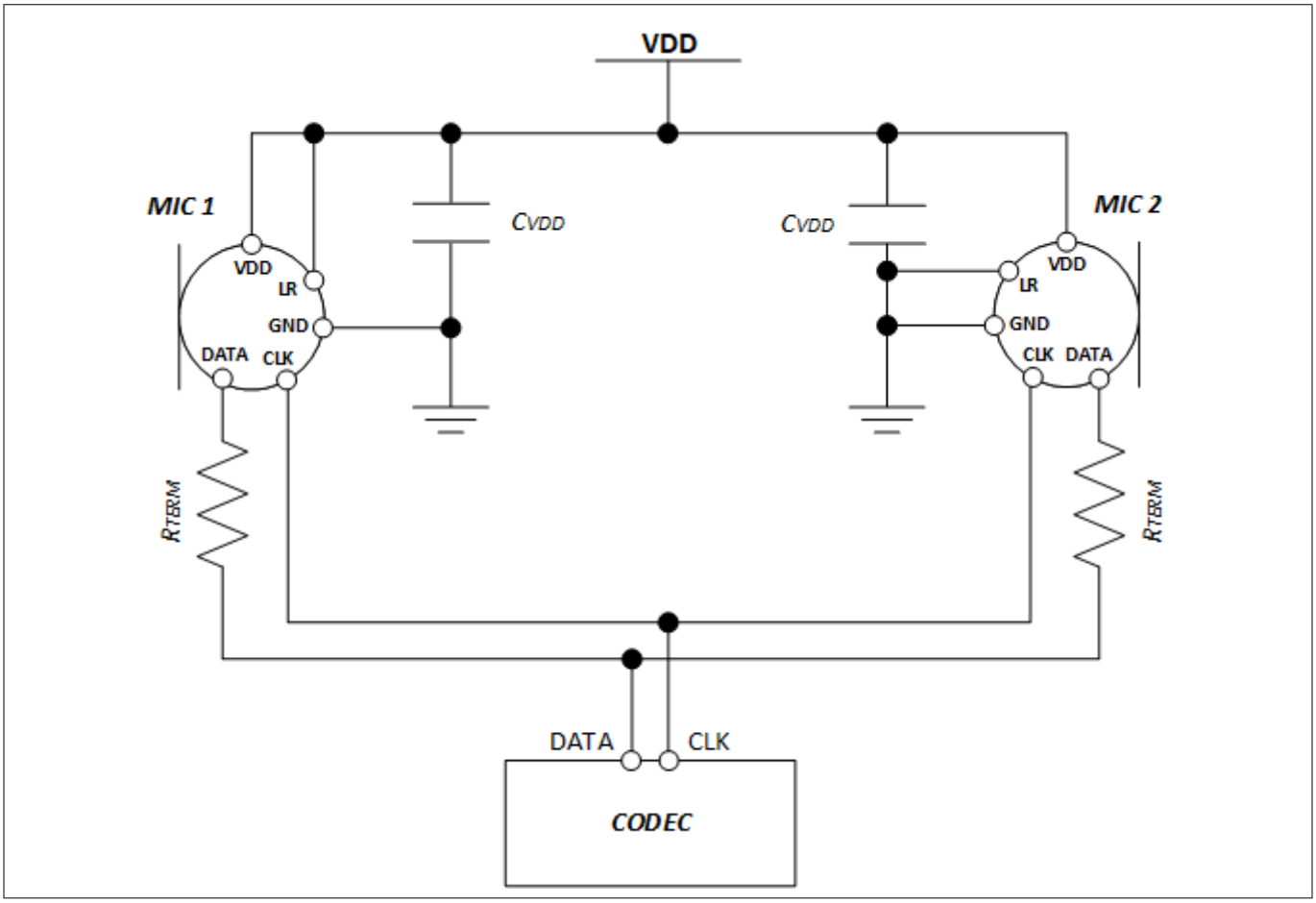



**Figure 10 IM69D127V11 stereo mode configuration**

*Note: For best performance it is strongly recommended to place a 100nF ($C_{VDD\_typical}$) capacitor between $V_{DD}$ and ground. The capacitor should be placed as close to $V_{DD}$ as possible. A termination resistor ($R_{TERM}$) of about 100Ω may be added to reduce the ringing and overshoot on the output signal.*

# 4 Package information

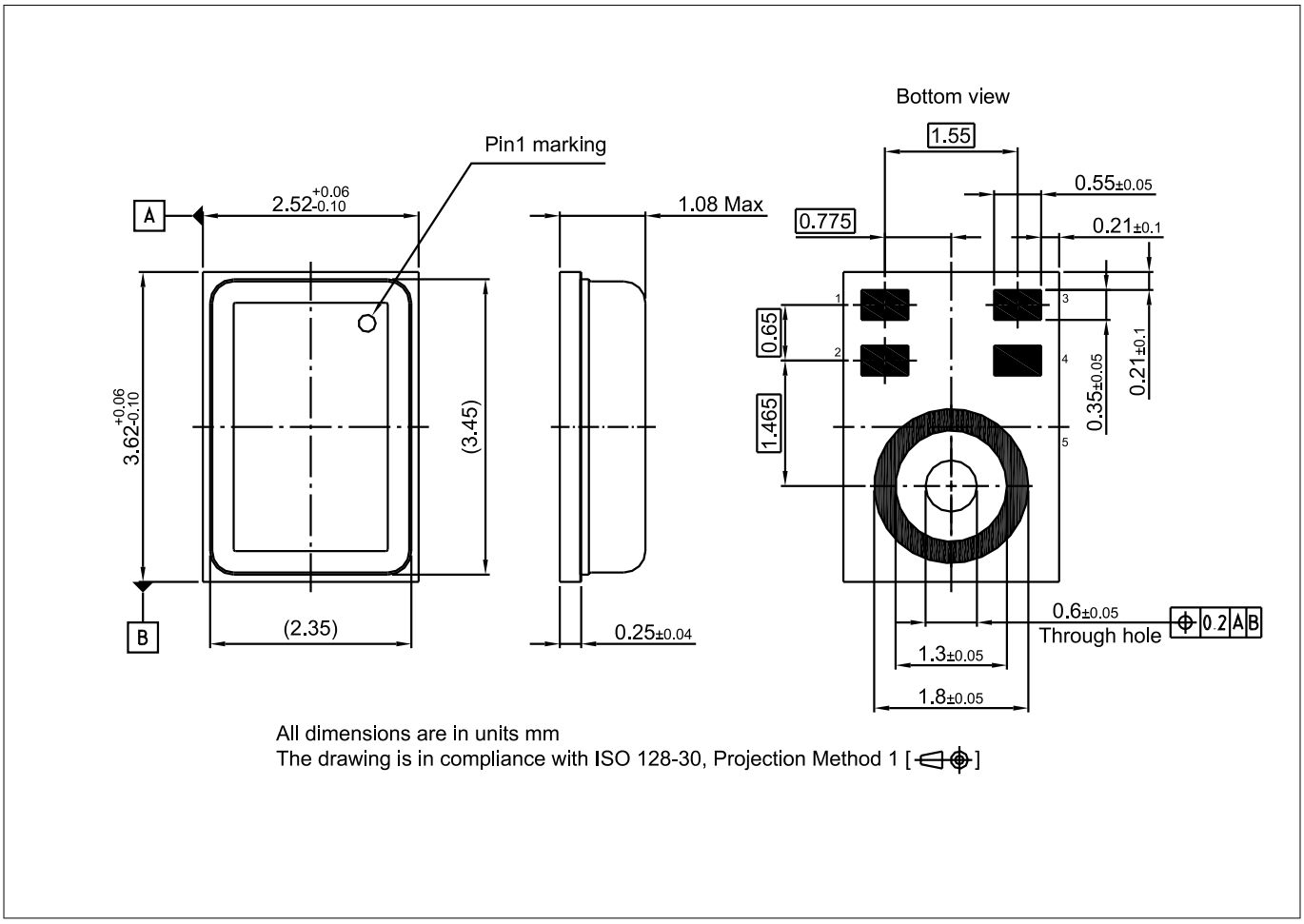



**Figure 11 IM69D127V11 package drawing.**

**Table 9 IM69D127V11 pin configuration**

| Pin Number | Name | Description |
|---|---|---|
| 1 | DATA | PDM data output |
| 2 | $V_{DD}$ | Power supply |
| 3 | CLOCK | PDM clock input |
| 4 | SELECT | PDM left/right select |
| 5 | Ground | Ground |

# 5 Footprint and stencil recommendation

The acoustic port hole diameter in the PCB should be larger than the acoustic port hole diameter of the MEMS Microphone to ensure optimal performance. A PCB sound port size of radius 0.4 mm (diameter 0.8mm) is recommended.

The board pad and stencil aperture recommendations shown in Figure 12 are based on Solder Mask Defined (SMD) pads. The specific design rules of the board manufacturer should be considered for individual design optimizations or adaptations.

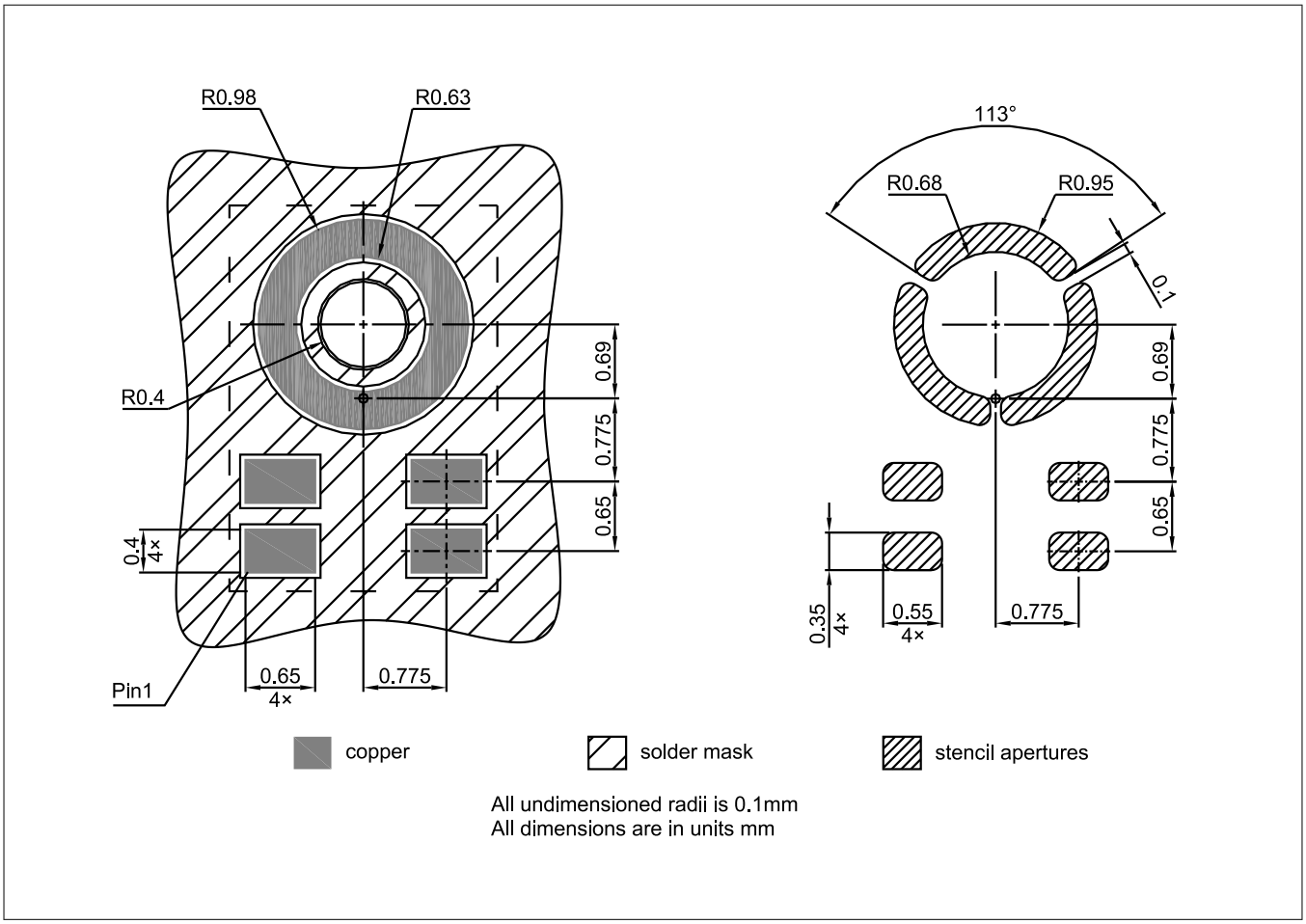



**Figure 12 IM69D127V11 footprint and stencil recommendation**

*Note: Dimensions are in millimeters unless otherwise specified*

# 6 Packing information

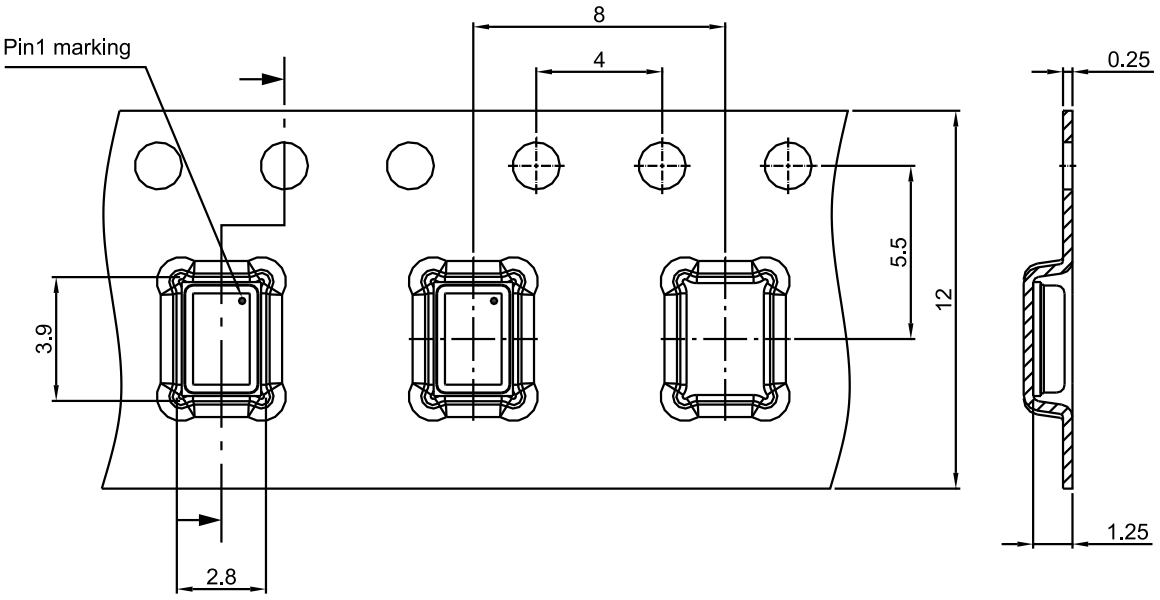



**Figure 13 IM69D127V11 packing information**

**Table 10 IM69D127V11 packing information**

| Product | Type code | Reel diameter | Quantity per reel |
|---|---|---|---|
| IM69D127V11 | I69D10 | 330 mm | 5000 |

# 7 Reflow soldering and board assembly

Infineon MEMS microphones are qualified in accordance with the IPC/JEDEC J-STD-020D-01. The moisture sensitivity level of MEMS microphones is rated as MSL1. For PCB assembly of the MEMS microphone the widely used reflow soldering using a forced convection oven is recommended.

The soldering profile should be in accordance with the recommendations of the solder paste manufacturer to reach an optimal solder joint quality. The reflow profile shown in Figure 14 is recommended for board manufacturing with Infineon MEMS microphones.

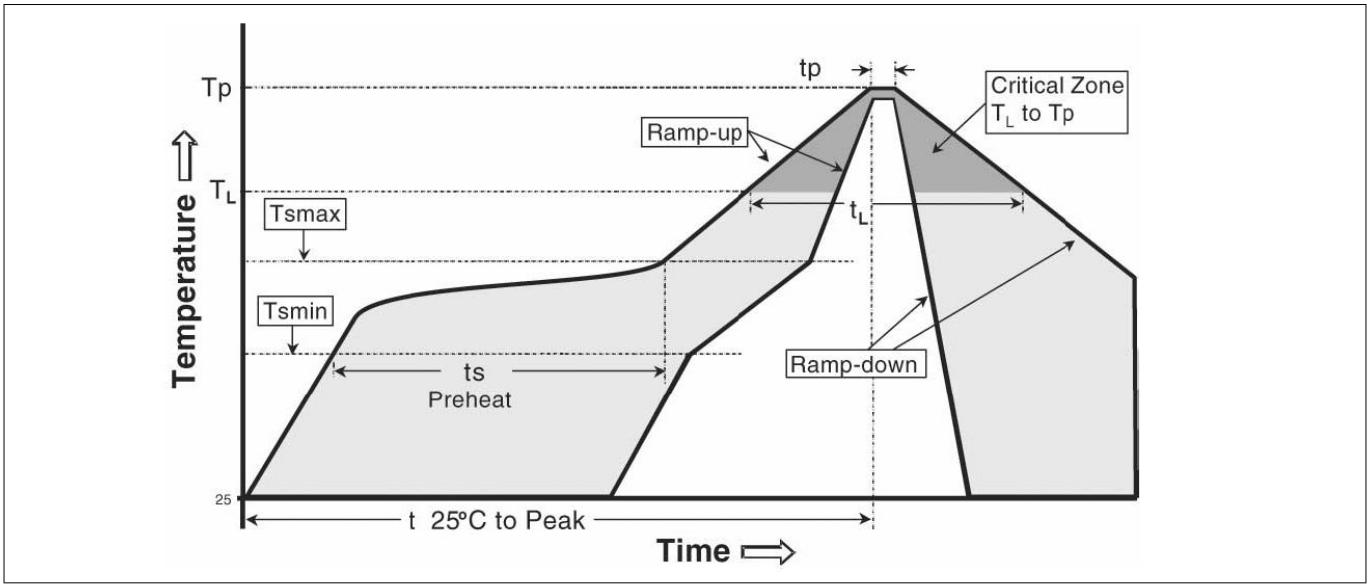



**Figure 14 Recommended reflow profile**

**Table 11 Reflow profile limits**

| Profile feature | Pb-Free assembly | Sn-Pb Eutectic assembly |
|---|---|---|
| Temperature Min ($T_{smin}$) | 150 °C | 100 °C |
| Temperature Max ($T_{smax}$) | 200 °C | 150 °C |
| Time ($T_{smin}$ to $T_{smax}$) ($t_s$) | 60-120 seconds | 60-120 seconds |
| Ramp-up rate ($T_L$ to $T_P$) | 3 °C/second max. | 3 °C/second max. |
| Liquidous temperature ($T_L$) | 217 °C | 183 °C |
| Time ($t_L$) maintained above $T_L$ | 60-150 seconds | 60-150 seconds |
| Peak Temperature ($T_p$) | 260°C +0°C/-5°C | 235°C +0°C/-5°C |
| Time within 5°C of actual peak temperature (tp) [5)] | 20-40 seconds | 10-30 seconds |
| Ramp-down rate | 6 °C/second max. | 6 °C/second max. |
| Time 25°C to peak temperature | 8 minutes max. | 6 minutes max. |

*Note: For further information please consult the 'General recommendation for assembly of Infineon packages' document which is available on the Infineon Technologies web page*

5 Tolerance for peak profile temperature ($T_p$) is defined as a supplier minimum and a user maximum

## Reflow soldering and board assembly

The MEMS microphones can be handled using industry standard pick and place equipment. Care should be taken to avoid damage to the microphone structure as follows:

- Do not pick the microphone with vacuum tools which make contact with the microphone acoustic port hole.
- The microphone acoustic port hole should not be exposed to vacuum, this can destroy or damage the MEMS.
- Do not blow air into the microphone acoustic port hole. If an air blow cleaning process is used, the port hole must be sealed to prevent particle contamination.
- It is recommended to perform the PCB assembly in a clean room environment in order to avoid microphone contamination.
- Air blow and ultrasonic cleaning procedures shall not be applied to MEMS Microphones. A no-clean paste is recommended for the assembly to avoid subsequent cleaning steps. The microphone MEMS can be severely damaged by cleaning substances.
- To prevent the blocking or partial blocking of the sound port during PCB assembly, it is recommended to cover the sound port with protective tape during PCB sawing or system assembly.
- Do not use excessive force to place the microphone on the PCB. The use of industry standard pick and place tools is recommended in order to limit the mechanical force exerted on the package.

# 8 Reliability specifications

The microphone sensitivity and SNR after stress must deviate by no more than 3dB from the initial value. All samples are submitted to 3x reflow (260°C peak temperature) before stress

**Table 12 Reliability Tests**

| Test | Test Condition | Standard |
|---|---|---|
| Low temperature operation | $T_a$=-40°C, VDD=2.5V, 1000 hours. | JESD22-A108 |
| Low temperature storage | $T_a$=-40°C, 1000 hours. | JESD22-A119 |
| High temperature operation | $T_a$=+125°C, VDD=2.5V, 1000 hours. | JESD22-A108 |
| High temperature storage | $T_a$=+125°C, 1000 hours. | JESD22-A103 |
| Temperature cycling | 1000 cycles, -40°C to +125°C, 30 minutes per cycle. | JESD22-A104 |
| Temperature Humidity bias | $T_a$=+85°C, R.H = 85%, VDD=2.5V, 1000 hours. | JESD22-A101 |
| Vibration | 20Hz to 2000Hz with a peak acceleration of 20g in X, Y, and Z for 4 minutes each, total 4 cycles. | IEC 60068-2-6 / MIL-STD 883K 2007.3 |
| Mechanical shock | 10000g/0.1 msec in X, Y, Z direction. 5 shocks in each direction, 30 shocks in total. VDD=2.0V | IEC 60068-2-27 |
| Reflow solder[6)] | 3 reflow cycles, peak temperature = +260°C | IPC-JEDEC J-STD-020D-01 |
| ESD-SLT | 25 discharges of +/-8kV direct contact to lid while unit is grounded. | IEC-61000-4-2 |
| ESD-CDM | 3 discharges of +/-500V direct contact to I/O pins. | JEDEC JS-002-2014 |
| ESD-HBM | 3 discharges of ±2kV pin to pin. | JEDEC JS-001-2011 |

6 The microphone sensitivity must deviate by no more than 1dB from the initial value after 3 reflow cycles.

# Revision history

| Document version | Date of release | Description of changes |
|---|---|---|
| v01_00 | 2020-10-27 | • Initial datasheet release |
| v01_10 | 2022-03-15 | • updated Tape and Reel Information |

# Glossary

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**Edition 2022-03-15**

**Published by**

**Infineon Technologies AG**

**81726 Munich, Germany**



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**Document reference**
**IFX-nnz1570625061557**

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