

## **3SM221KMT1GA MEMS Microphone IC**

### **Product Description**

The *3SM221KMT1GA* microphone IC are integrated with specialized pre-amplification & analog-to-digital converter ASIC to provide high SNR output from a capacitive audio sensor. It's packaged for surface mounting and high temperature reflow assembly. *3SM221KMT1GA* is ideal in many compact portable consumer electronic devices such as Notebook, TV.

### **Features**

- Top port
- High stability - no risk of membrane aging
- Suitable for automatic pick-and-place handler and SMT process
- Pulse density modulator (PDM) output interface supports two microphones on a single data line
- Miniature dimension 4.00mm x 2.00mm x 1.10mm
- RoHS/Green compliant
- Sensitivity deviation within  $\pm 1$ dB
- Package type : LGA 6-pin
- Omnidirectional

### **Applications**

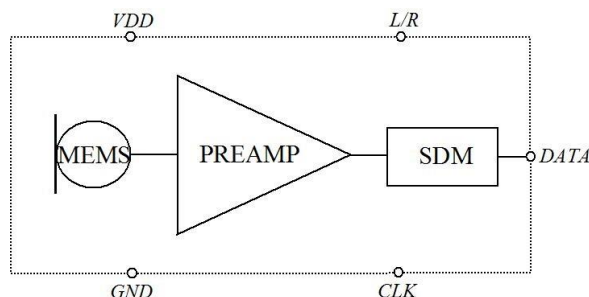
- Notebooks
- TVs
- IoT Devices

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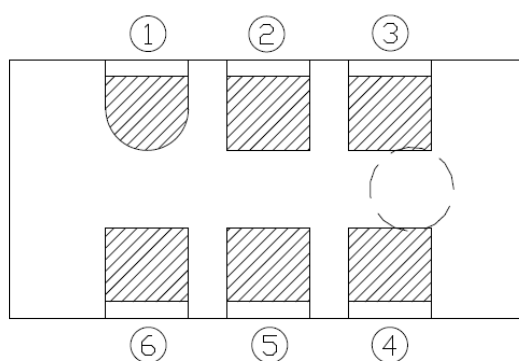
## Table of Contents

|  |      |
|--|------|
| Product Description .....                      | P.1  |
| Features .....                                 | P.1  |
| Applications .....                             | P.1  |
| Table of Contents.....                         | P.2  |
| Functional Block Diagram.....                  | P.3  |
| Pin Definition and Function .....              | P.3  |
| Temperature Range.....                         | P.3  |
| Acoustical and Electrical Characteristics..... | P.4  |
| Timing Characteristics.....                    | P.6  |
| Frequency Response.....                        | P.7  |
| State Diagram.....                             | P.8  |
| Reliability Qualifications .....               | P.9  |
| Reflow Profile .....                           | P.10 |
| PCB Land Pattern Layout .....                  | P.11 |
| Application Circuit .....                      | P.12 |
| Handling Instructions .....                    | P.13 |
| Dimensions .....                               | P.14 |
| Package Information.....                       | P.15 |
| Revision History.....                          | P.17 |

## Functional Block Diagram



## Pin Definition and Function



Bottom View

Table 1.

| Pin # | Symbol | Type          | Function                           |
|-------|--------|---------------|------------------------------------|
| 1     | VDD    | Power         | Power Supply                       |
| 2     | GND    | Power         | Ground                             |
| 3     | DATA   | Digital O     | Digital Output Signal              |
| 4     | CLK    | Digital I     | Clock Input to Microphone          |
| 5     | GND    | Power         | Ground                             |
| 6     | L/R    | Non-Digital I | Left(Low) / Right(High) Select Pin |

## Temperature Range

Table 2.

|                             |                  |               |
|-----------------------------|------------------|---------------|
| Storage Temperature         | T <sub>STG</sub> | -40°C ~ 125°C |
| Operating Temperature Range | T <sub>A</sub>   | -40°C ~ 105°C |

## Acoustical and Electrical Characteristics

*Table 3. General Microphone Specifications*

*Typical test conditions are TA = 23 °C, VDD = 1.8V and R.H. = 50 % measured in a pressure chamber test setup. All voltages refer to GND node*

| Parameters                  | Symbol                    | Min. | Typ. | Max. | Unit | Test Conditions           |
|-----------------------------|---------------------------|------|------|------|------|---------------------------|
| Low Frequency Roll-off      | LFRO                      |      | 100  |      | Hz   | -3dB relative to 1KHz     |
| Supply Voltage              | Vdd                       | 1.6  |      | 3.6  | V    |                           |
| Output Load                 | C <sub>Load</sub>         |      |      | 100  | pF   |                           |
| Wake-up Time <sup>(1)</sup> |                           |      | 100  |      | ms   | Fclk ≥ 1MHz               |
| Startup Time                |                           |      | 100  |      | ms   |                           |
| Sleep Time                  |                           |      | 1    |      | ms   | Fclk ≤ 1KHz               |
| DC Offset                   |                           | -0.5 |      | 3.0  | %FS  | Fullscale = ±100          |
| Data Format                 | 1/2 Cycle PDM             |      |      |      |      |                           |
| Directivity                 | Omnidirectional           |      |      |      |      |                           |
| Polarity                    | Decreasing density of 1's |      |      |      |      | Increasing sound pressure |

*Table 4. Performance Mode Microphone Specifications*

*Typical test conditions are TA = 23 °C, VDD = 1.8V, Clock=2.4MHz and R.H. = 50 % measured in a pressure chamber test setup. All voltages refer to GND node*

| Parameters                   | Symbol | Min. | Typ. | Max. | Unit     | Test Conditions  |
|------------------------------|--------|------|------|------|----------|--|
| <b>Acoustic</b>              |        |      |      |      |          |  |
| Sensitivity                  | S      | -27  | -26  | -25  | dBFS     | 1KHz, 94dB SPL   |
| Signal to Noise Ratio        | S/N    |      | 64   |      | dBA      | A-weighted   |
| Equivalent Noise Level       | ENL    |      | 30   |      | dBA      | A-weighted   |
| Total Harmonic Distortion    | THD    |      | <0.2 |      | %        | 94dB SPL   |
|                              |        |      | 1    |      | %        | 110dB SPL  |
| Acoustic Overload Point      | AOP    |      | 120  |      | dB SPL   | 10% THD@1KHz,<br>S = Typ.  |
| <b>Electrical</b>            |        |      |      |      |          |  |
| Clock Frequency              | Fclk   | 1.0  |      | 3.25 | MHz      |  |
| Current Consumption          | Isb    |      | 550  |      | μA       | Vdd=1.8V   |
|                              |        |      | 850  |      | μA       | Vdd=3.6V   |
| Power Supply Rejection Ratio | PSRR   |      | 60   |      | dBV/FS   | 1KHz, 200mV peak to peak sine wave on Vcc 2.1V                               |
| Power Supply Rejection       | PSR+N  |      | -80  |      | dBFS (A) | 217Hz, 100mV 1/8 duty cycle peak to peak square wave on Vcc 2.1V, A-weighted |

**Table 5. Low-Power Mode Microphone Specifications**

Typical test conditions are  $T_A = 23\text{ }^\circ\text{C}$ ,  $V_{DD} = 1.8\text{V}$ ,  $\text{Clock} = 768\text{KHz}$  and  $R.H. = 50\%$  measured in a pressure chamber test setup. All voltages refer to GND node

| Parameters                   | Symbol          | Min. | Typ. | Max. | Unit     | Test Conditions  |
|------------------------------|-----------------|------|------|------|----------|--|
| <b>Acoustic</b>              |                 |      |      |      |          |  |
| Sensitivity                  | S               | -27  | -26  | -25  | dBFS     | 1KHz, 94dB SPL   |
| Signal to Noise Ratio        | S/N             |      | 64   |      | dB       | A-weighted   |
| Equivalent Noise Level       | ENL             |      | 30   |      | dB       | A-weighted   |
| Total Harmonic Distortion    | THD             |      | <0.2 |      | %        | 94dB SPL   |
|                              |                 |      | 1    |      | %        | 110dB SPL  |
| Acoustic Overload Point      | AOP             |      | 120  |      | dB SPL   | 10% THD@1KHz,<br>S = Typ.  |
| <b>Electrical</b>            |                 |      |      |      |          |  |
| Clock Frequency              | Fclk            | 350  |      | 800  | KHz      |  |
| Current Consumption          | I <sub>sb</sub> |      | 300  |      | μA       | V <sub>dd</sub> =1.8V  |
|                              |                 |      | 400  |      | μA       | V <sub>dd</sub> =3.6V  |
| Power Supply Rejection Ratio | PSRR            |      | 60   |      | dBV/FS   | 1KHz, 200mV peak to peak sine wave on V <sub>cc</sub> 2.1V                               |
| Power Supply Rejection       | PSR+N           |      | -80  |      | dBFS (A) | 217Hz, 100mV 1/8 duty cycle peak to peak square wave on V <sub>cc</sub> 2.1V, A-weighted |

**Table 6. Sleep Mode Microphone Specifications**

Typical test conditions are  $T_A = 23\text{ }^\circ\text{C}$ ,  $V_{DD} = 1.8\text{V}$ ,  $\text{Clock} = 0\text{Hz}$  and  $R.H. = 50\%$  measured in a pressure chamber test setup. All voltages refer to GND node

| Parameters                     | Symbol             | Min. | Typ. | Max. | Unit | Test Conditions    |
|--------------------------------|--------------------|------|------|------|------|--------------------|
| Clock Frequency                | Fclk               | 0    |      | 250  | KHz  |                    |
| Current Consumption Sleep Mode | I <sub>sleep</sub> |      | 10   |      | μA   | Clock = VDD or GND |

(1). Time from the first clock edge to valid output data

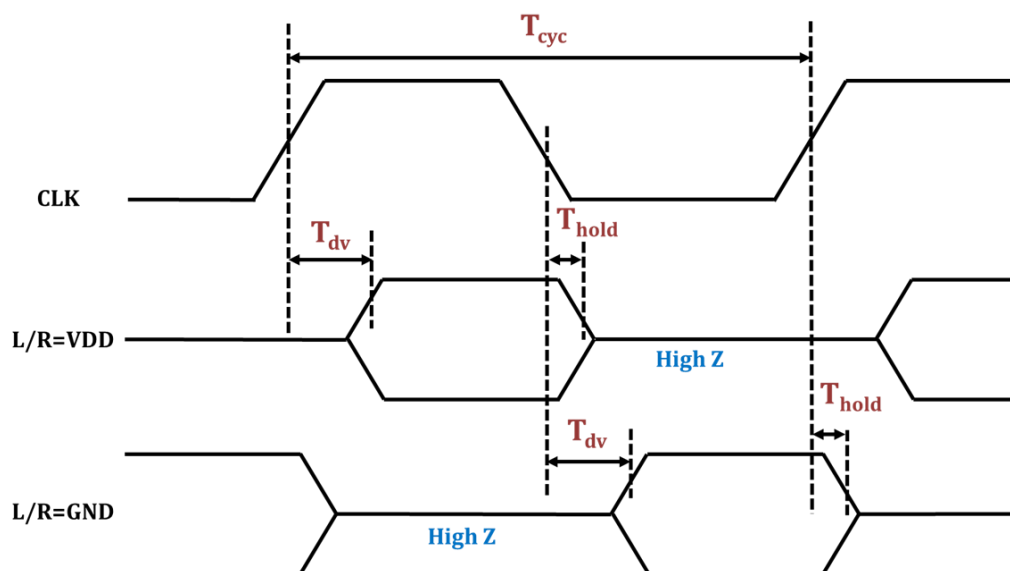
## Timing Characteristics

Table 7. Microphone Interface Specifications

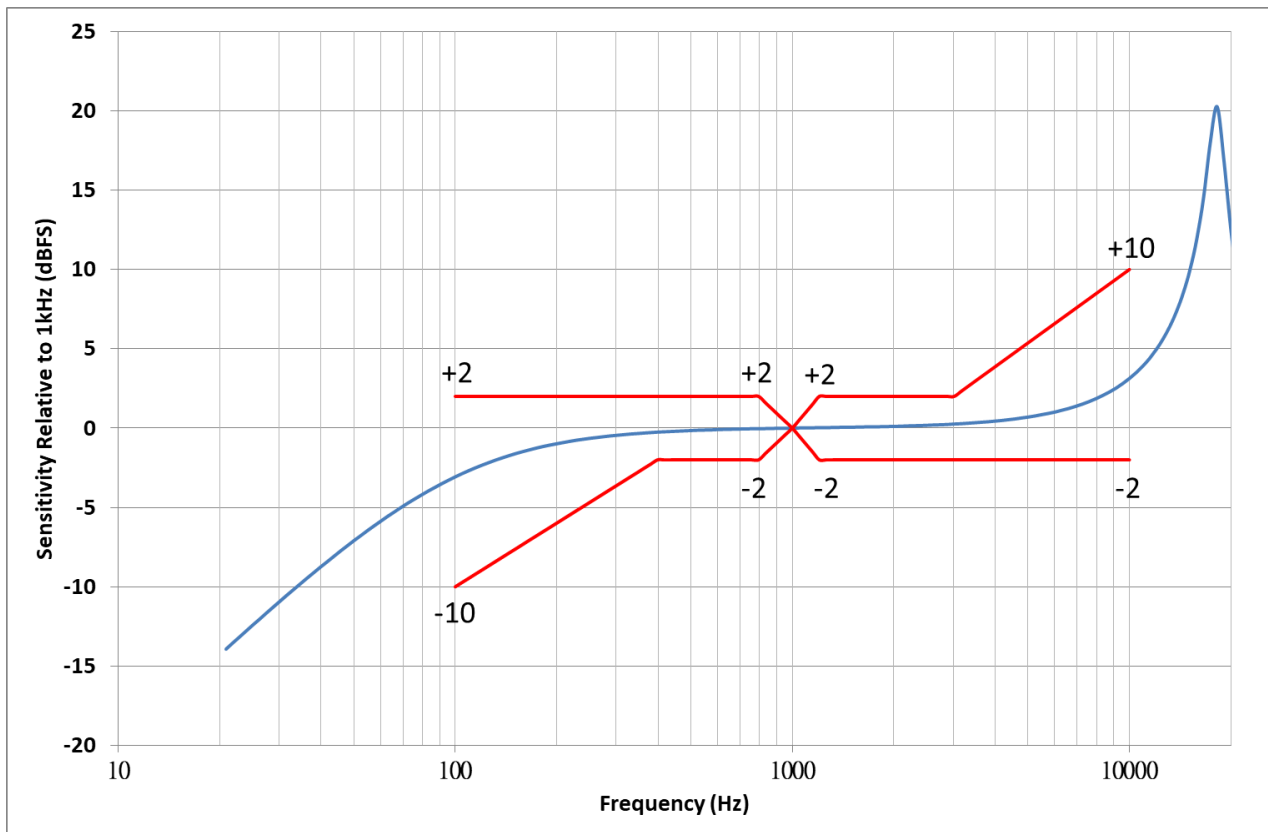
| Parameters                   | Symbol      | Min.             | Typ. | Max.               | Unit | Test Conditions        |
|------------------------------|-------------|------------------|------|--------------------|------|------------------------|
| Logic Input High             | $V_{IH}$    | 0.70x<br>VDD     |      | 3.6                | V    |                        |
| Logic Input Low              | $V_{IL}$    | -0.3             |      | 0.30x<br>VDD       | V    |                        |
| Logic Output High            | $V_{OH}$    | VDD<br>-0.45     |      | VDD                | V    | $I_{out} = 1\text{mA}$ |
| Logic Output Low             | $V_{OL}$    | 0                |      | 0.45               | V    | $I_{out} = 1\text{mA}$ |
| Clock Frequency              | $F_{clock}$ |                  |      | 250                | KHz  | Sleep Mode             |
|                              |             | 350              |      | 800                |      | Low-Power Mode         |
|                              |             | 1.0              |      | 3.25               | MHz  | Performance Mode       |
| Clock Duty Cycle             |             | 40               |      | 60                 | %    |                        |
| Clock Period for Normal Mode | $T_{cyc}$   | 208              |      | 1000               | ns   |                        |
| Data Setup Time              | $T_{dv}$    |                  |      | 100 <sup>(1)</sup> | ns   |                        |
| Data Hold Time               | $T_{hold}$  | 3 <sup>(1)</sup> |      |                    | ns   |                        |

(1). Guaranteed by design

## Timing Waveforms



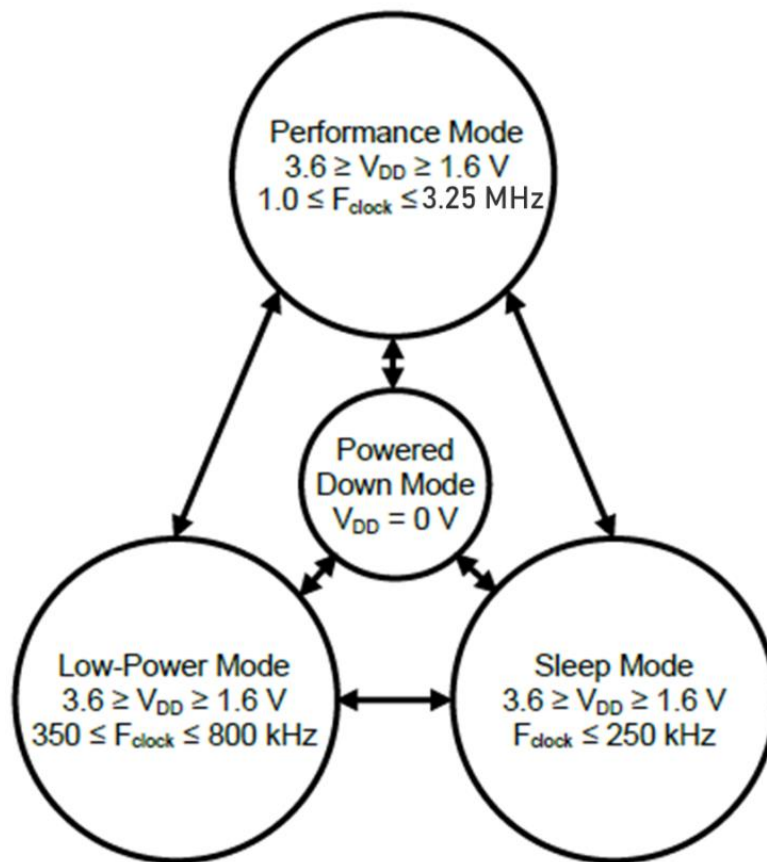
## Frequency Response



\* Measured frequency of 1 KHz

| Upper Limit  |     |     |      |      |      |      |       |
|--------------|-----|-----|------|------|------|------|-------|
| Hz           | 100 | 800 | 1000 | 1200 | 2000 | 3000 | 10000 |
| dB ref. 1KHz | +2  | +2  | 0    | +2   | +2   | +2   | +10   |
| Lower Limit  |     |     |      |      |      |      |       |
| Hz           | 100 | 400 | 800  | 1000 | 1200 | 3000 | 10000 |
| dB ref. 1KHz | -10 | -2  | -2   | 0    | -2   | -2   | -2    |

## State Diagram





## Reliability Qualifications

Table 8.

| Test Item                       | Description  |
|---------------------------------|--|
| High Temperature Storage        | Storage at 125°C for 1,000 hours<br>JESD22-A103  |
| Low Temperature Storage         | Storage at -40°C for 1,000 hours<br>JESD22-A119  |
| High Temperature Operation Bias | Under Bias at 105°C for 1,000 hours<br>JESD22-A108   |
| Low Temperature Operation Bias  | Under Bias at -40°C for 1,000 hours<br>JESD22-A108   |
| Temperature Humidity Bias       | Under Bias at 85°C/85%RH for 1,000 hours<br>JESD22-A101  |
| Thermal Cycling Test            | Thermal Cycle from -40°C~125°C, 100 cycles<br>JESD22-A104  |
| Reflow                          | 5 reflow cycles with peak 260°C<br>J-STD-020   |
| Vibration                       | 4 cycles lasting 12 minutes from 20 to 2KHz in X, Y and Z with peak acceleration of 20G<br>JESD22-B103   |
| Mechanical Shock                | Total 18 pulses 10,000G in X,Y and Z<br>JESD22-B104  |
| ESD                             | HBM:3KV, MM:300V, CDM:500V<br>Air Discharge:15KV,<br>Contact Discharg:8KV<br>JESD22-A114(HBM)<br>JESD22-A115(MM)<br>JESD22-C101(CDM)<br>IEC 61000-4-2(Air Discharge)<br>IEC 61000-4-2(Contact Discharge) |

Notes: Microphones meet all acoustic and electrical specifications before and after reliability testing, except sensitivity which can deviate up to 3dB from its initial value.

After 5 reflow cycles, the sensitivity of the microphone shall not deviate more than 1 dB from its initial value.

## Reflow Profile

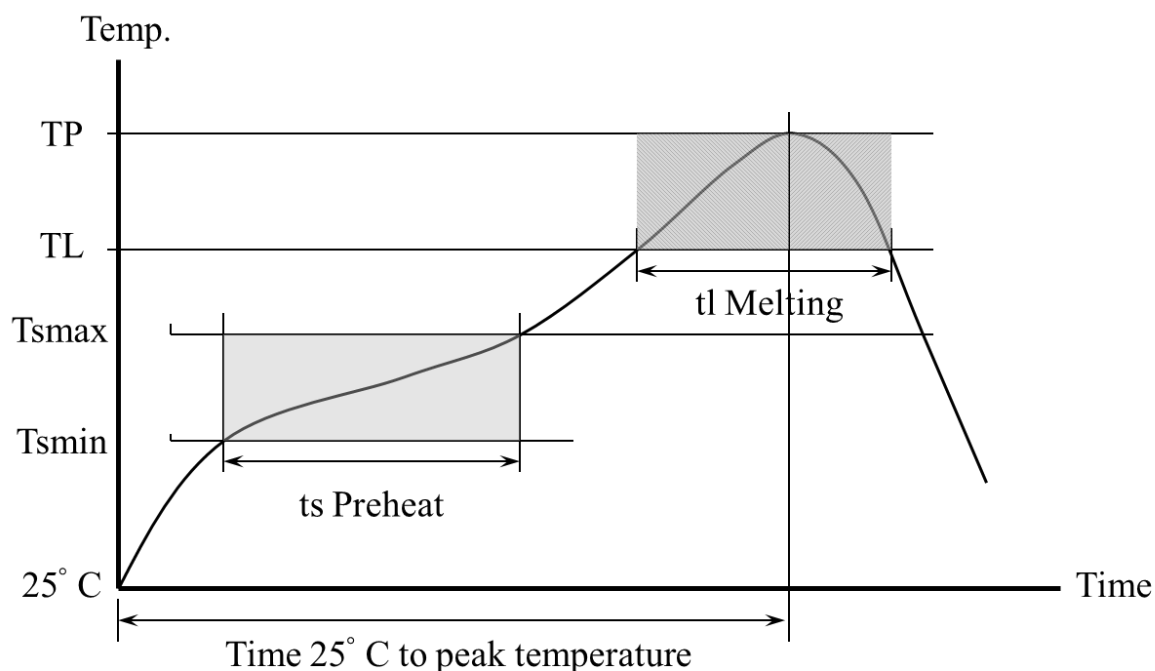


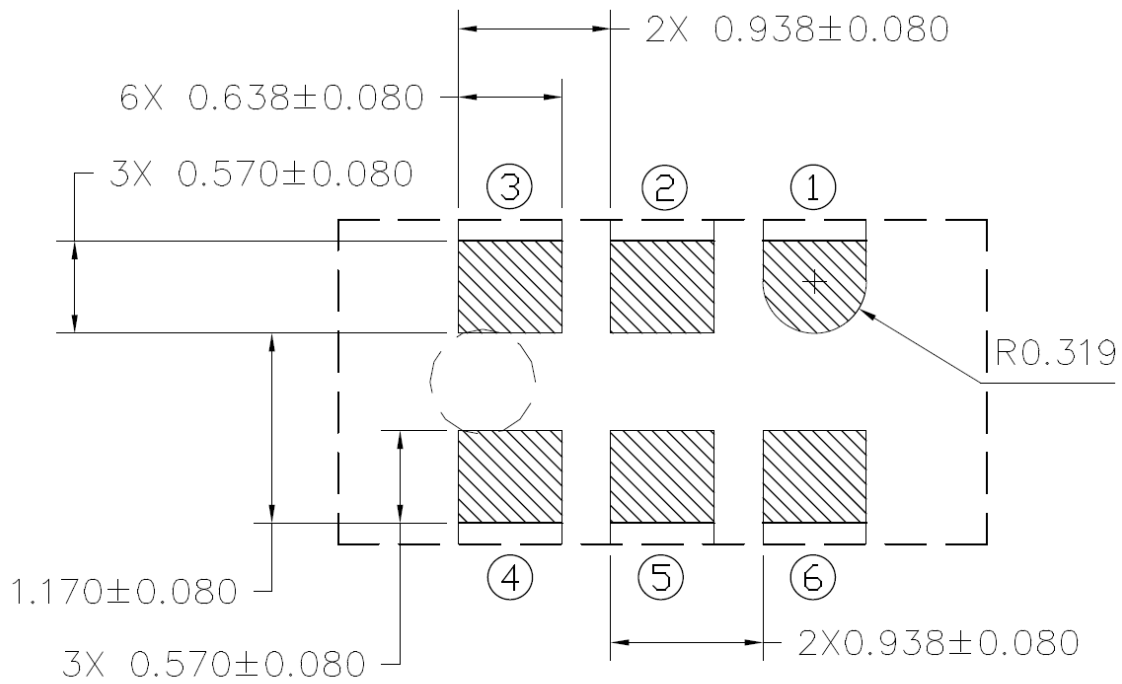
Table 9. Recommended Reflow Profile Limits

| Profile Feature                            | Pb-free          |
|--|------------------|
| Preheat                                    |                  |
| Minimum temperature (Tsmmin)               | 150 °C           |
| Maximum temperature (Tsmmax)               | 200 °C           |
| Time (ts)                                  | 60~180 sec       |
| Average Ramp up rate (Tsmmax to Tp)        | 3 °C/sec         |
| Melting area                               |                  |
| Melting temperature (TL)                   | 217 °C           |
| Time maintained above melting (tl)         | 60~150 sec       |
| Peak Temperature (TP)                      | 260 °C           |
| Time within 5°C of actual peak temperature | 20~40 sec        |
| Ramp down rate                             | 6 °C/sec maximum |
| Time 25°C to peak temperature              | 8 minute maximum |

Notes: Based on IPC/JDEC J-STD-020 Revision F.

All temperatures refer to topside of the package, measured on the package body surface.

### PCB Land Pattern Layout



## Application Circuit

The L/R pad lets the user to select the DATA signal pattern as explained in Table 7. The L/R pin must be connected to either VDD or GND.

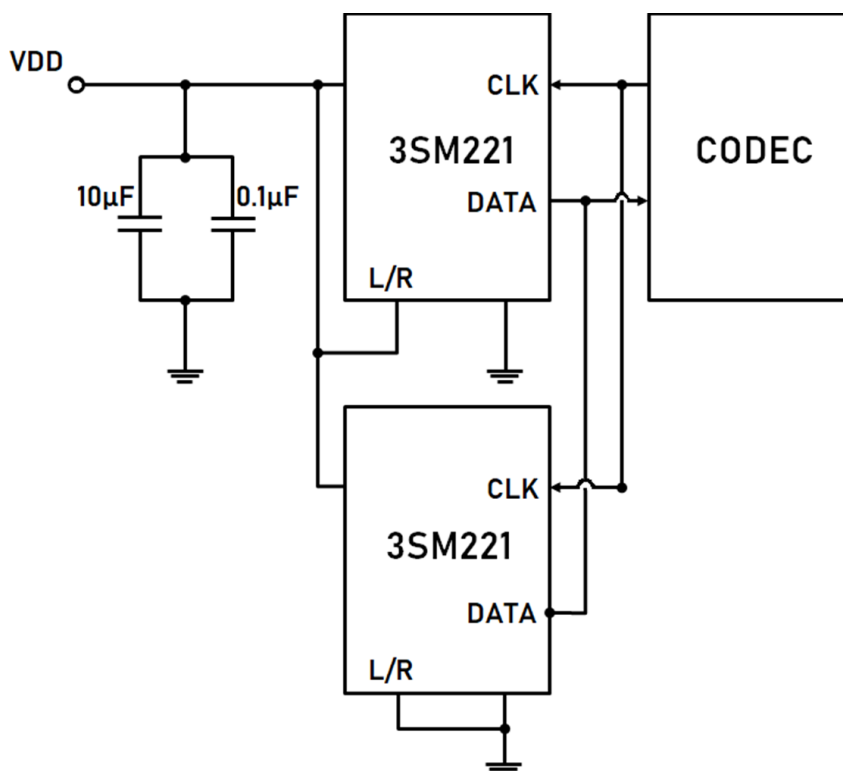
*Table 10. L/R channel selection*

| L/R | CLK low        | CLK high       |
|-----|----------------|----------------|
| GND | DATA valid     | High impedance |
| VDD | High impedance | DATA valid     |

### Single microphone application:

0.1 $\mu$ F ceramic, and 10 $\mu$ F ceramic power supply decoupling capacitors should be placed as near as possible to VDD of the device. **The L/R pin must be connected to VDD or GND** (refer to Table 7).

### Two microphones application:

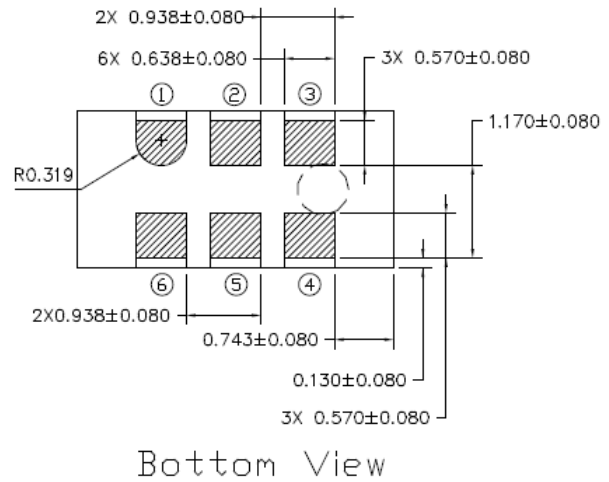
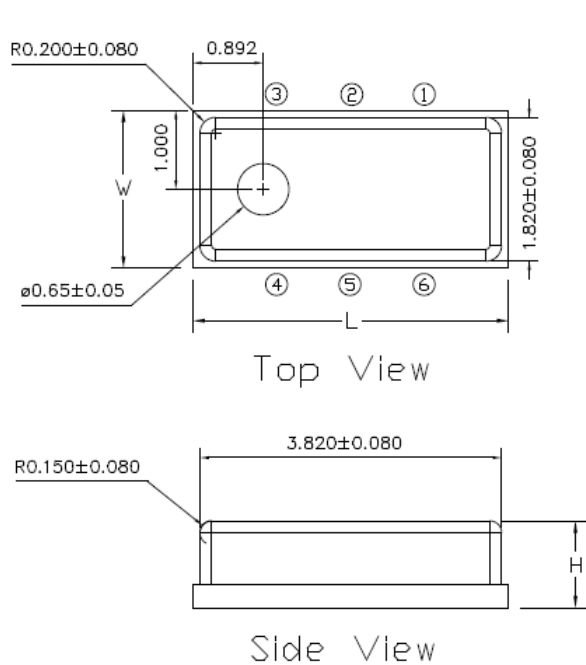


## **Handling Instructions**

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

- Do not apply vacuum nozzle over the acoustic port (AP) of the microphone to avoid damage to the device.
- Do not blow air directly into acoustic port.
- Brushing the board with/without solvents may damage the device.
- Do not use excessive force to place the microphone on the PCB.
- In case of manual handling, it should be handled with plastic tweezers to avoid damage the device.

## Dimensions



Unit: mm

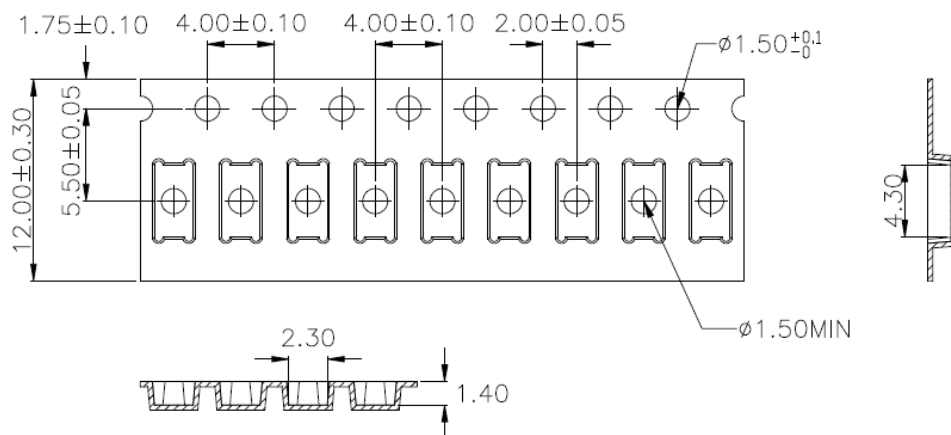
Dimension tolerance is  $\pm 0.15$ mm unless otherwise specified

Table 11. (Top View)

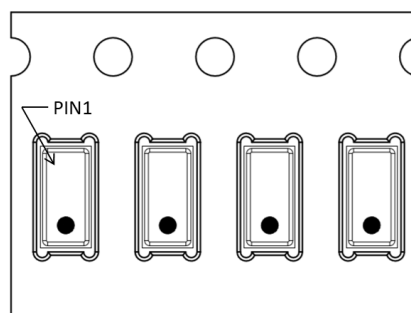
| Item          | Dimension      | Tolerance     |
|---------------|----------------|---------------|
| Length (L)    | 4.00 mm        | $\pm 0.10$ mm |
| Width (W)     | 2.00 mm        | $\pm 0.10$ mm |
| Height (H)    | 1.10 mm        | $\pm 0.10$ mm |
| Acoustic Port | $\Phi 0.65$ mm | $\pm 0.05$ mm |

## Package Information

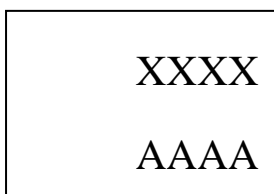
### Carrier Tape:



1. 10 sprocket hole pitch cumulative tolerance  $\pm 0.20$ .
2. Carrier camber is within 1 mm in 250 mm.
3. Material : Black Conductive Polystyrene Alloy.
4. All dimensions meet EIA-481 requirements.
5. Thickness :  $0.30 \pm 0.05$  mm.
6. MSL(Moisture sensitivity level) Class1.

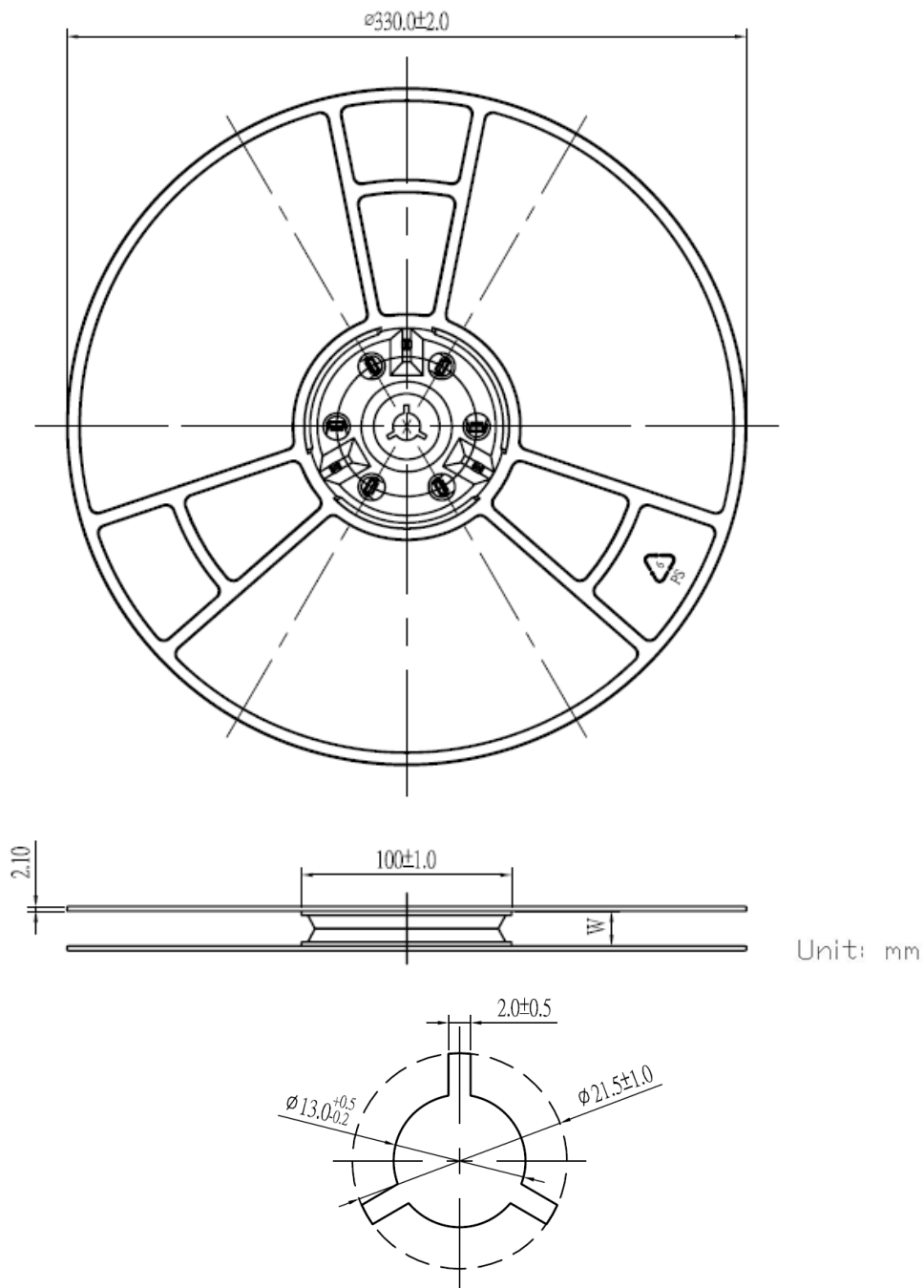


### Laser Marking:



### Laser marking on the top side

|             |                               |
|-------------|-------------------------------|
| <b>XXXX</b> | <b>Internal Tracking Code</b> |
| <b>AAAA</b> | <b>Lot Tracking Code</b>      |

**13" Tape Reel :**


| Model Number | Reel Diameter | Quantity Per Reel |
|--------------|---------------|-------------------|
| 3SM221KMT1GA | 13"           | 5,000             |



## Revision History

| <b>Revision</b> | <b>Date</b> | <b>Description</b>   |
|-----------------|-------------|--|
| 1.0             | 2019/11/22  | Formal release   |
| 1.1             | 2020/01/15  | Modify “Applications”  |
| 1.2             | 2020/07/23  | Modify “Features”<br>Modify “Acoustical and Electrical Characteristics”<br>Modify “Frequency Response”<br>Modify “Reliability Qualifications”<br>Modify “Reflow Profile” |
| 1.3             | 2020/08/20  | Modify “Acoustical and Electrical Characteristics”   |
| 1.4             | 2020/09/07  | Modify “Acoustical and Electrical Characteristics”   |
| 1.5             | 2020/12/29  | Modify “Timing Characteristics”<br>Add “Laser Marking”   |
| 1.6             | 2021/02/09  | Modify “Reliability Qualifications”  |
| 1.7             | 2021/03/10  | Modify “Package Information”   |
| 1.8             | 2021/07/29  | Modify “Acoustical and Electrical Characteristics”<br>Modify “Frequency Response”  |
| 1.9             | 2022/04/12  | Modify “Timing Characteristics”  |
| 2.0             | 2023/04/20  | Modify “Timing Characteristics”<br>Modify “Reliability Qualifications”<br>Modify “Package Information”   |