CHALLENGE ELECTRONICS

APPROVAL SHEET

Model No.	:	CM03M-01S38-MD-2X
Only No.	:	
Date	:	
Description	:	Digital MEMS Microphone

APPROVER	CHECKER	DESIGN

Please kindly make approval of our samples, And return this form by fax or airmail, Thanks for your kind attention and co-operation.

Customer Name	:	
Customer Model No.	:	
Customer Project No.	:	

CUSTOMER APPROVAL

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RoHS Compliant

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Contents

1. General Description

CM03M-01S38-MD-2X is a rear type MEMS (micro-electro mechanical systems) microphone with digital signal output. It provides high sensitivity, low power consumption and high SNR. Output impedance of this microphone is very low, so it is minorly affected by RF noise. CM03M-01S38-MD-2X introduces new add-on modes to sleep mode which use on chip processing in the microphone to determine if acoustic activity has occurred or not. The new mode is Acoustic Wake-Up (AWU); AWU Analog mode.

As a MEMS type transducer and an optimized ASIC are used inside this microphone, it has no thermal deterioration and superior thermal shock resistance. So, users can make full-automated assembly processes with this microphone. This microphone has also very small size in mechanical dimension, so it is very suitable for portable devices with audio input function.

2. Features

✓   CMOS MEMS microphone with digital output

✓   High sensitivity

✓   High SNR

✓   Low power consumption

✓   Low output impedance

✓   High thermal shock resistance

✓   Small sized mechanical dimension

✓   Free from Hazardous Substances

✓   Bottom Type Package

✓   Multiple Mode (Low Power Mode, Operation Mode, Sleep Mode)

✓   Acoustic Wake-Up (AWU)

✓   Waterproof Grade: IP67

3. Application

✓   Mobile phones and smart phones

✓   Notebooks and Tablets

✓   Ear microphones and Bluetooth head sets

✓   Digital still cameras and video cameras

✓   Car navigation and black boxes

✓   Gaming devices and other voice input devices

4. Absolute Maximum Ratings

Parameter	Absolute Maximum Rating	Units
VDD to Ground	TBD	V
Storage temperature in package (tape and Reel)	-10 to 50	℃
Operating Temperature	-40 to 105	℃
Storage Temperature	-55 to 155	℃

Absolute maximum continuous ratings are the values beyond which damage the device may occur. Exposure to those conditions or conditions beyond those indicated may adversely affect device reliability. Functional operation under these conditions is not implied.

5. Electrical Characteristics

TEST CONDITIONS: 23±2℃, 65±20% R.H., Typical specifications are measured at VDD = 1.8V, F_{CLK}=2.4MHz,

Parameter	Symbol	Condition	Limits			Unit
			Min	Typ.	Max	
Operating Voltage	VDD		1.65	1.8	1.98	V
Clock Frequency	C_{OP}	Operation Mode	2.0	2.4	4.8	MHz
	C_{LP}	Low Power Mode	400	768	800	kHz
	C_{SM}	Sleep Mode			200	kHz
	C_{AWU}	AWU Write Operation	50			kHz
Current Consumption	I_{DSS}	F_{CLK}= 2.4MHz	-	330		µA
		F_{CLK}= 768kHz	-	150		µA
		Sleep mode (F_{CLK}<200kHz)	-	9		µA
Sensitivity[1]	S	94dBSPL@1kHz , F_{CLK}= 2.4MHz	-38	-37	-36	dBFS
		94dBSPL@1kHz , F_{CLK}= 768kHz	-22	-21	-20	
Data Format		Single chip	1 Cycle of PDM			
Signal Noise Ratio	S/N	94dBSPL@1kHz, A-weighted, F_{CLK}= 2.4MHz		68		dB(A)
		94dBSPL@1kHz, A-weighted, F_{CLK}= 768kHz		65		
Total Harmonic Distortion	THD	94dBSPL@1kHz, S = Typ. F_{CLK}= 2.4MHz	-	0.15		%
		94dBSPL@1kHz, S = Typ. F_{CLK}= 768kHz				
Acoustic Overload Point	AOP	10% THD @ 1 kHz, S = Typ., F_{CLK}= 2.4MHz		133		dBSPL

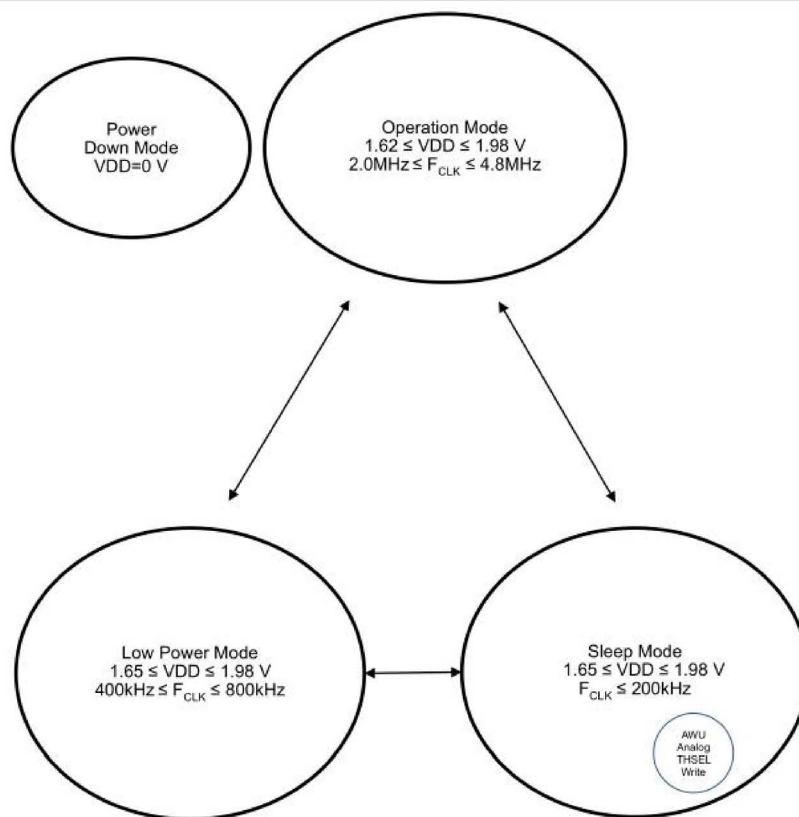| Parameter	Symbol	Condition	Limits			Unit
			Min	Typ.	Max	
Acoustic Overload Point	AOP	10% THD @ 1 kHz, S = Typ. F_{CLK}= 768kHz		118		dBSPL
Power Supply Rejection	PSR	200mV$_{PP}$ 7/8 duty cycle rectangular wave @ 217Hz, A-weighted BW= 20kHz	-	-105	-	dBFS (A)
		200mV$_{PP}$ 7/8 duty cycle rectangular wave @ 217Hz, A-weighted BW= 8kHz	-	-90	-	
Input Logic High	V_{IH}		0.65 xVDD			V
Input Logic Low	V_{IL}				0.35 xVDD	V
Output Logic High	V_{OH}	I_{OUT} = 0.5mA	0.7 xVDD			V
Output Logic Low	V_{OL}	I_{OUT} = 0.5mA			0.3 xVDD	V
Clock Duty Cycle	D_{CLK}	F_{CLK} <3.3 MHz	45		55	%
Wake-up Time	T_{WAKE}			7		ms
Sleep Time	T_{SLEEP}	F_{CLK} = 0Hz		1		ms
Mode Switch Time	T_{CHANGE}			7		ms

Note 1. ₁100% Tested

Note 2. Typical and Maximums specifications are measured at standard test condition.

6. *Electrical Characteristics – SLEEP + AWU MODE*

TEST CONDITIONS: 23±2℃, 65±20% R.H., Typical specifications are measured at VDD = 1.8V, F_{CLK}≤200kHz

Parameter	Condition	MIN	TYP	MAX	UNITS
AWU ANALOG PARAMETERS					
AWU Analog Absolute Threshold	Level for AWU Analog trigger @1Hz	60		97	dBSPL
AWU Analog HPF Cut Off	-3dB re 1 kHz	50		200	Hz
AWU A Supply Current (Is)	CLK OFF		20		μA

7. Microphone State Diagram

Power Down Mode
VDD=0 V

Operation Mode
$1.62 \leq VDD \leq 1.98$ V
$2.0\text{MHz} \leq F_{CLK} \leq 4.8\text{MHz}$

Low Power Mode
$1.65 \leq VDD \leq 1.98$ V
$400\text{kHz} \leq F_{CLK} \leq 800\text{kHz}$

Sleep Mode
$1.65 \leq VDD \leq 1.98$ V
$F_{CLK} \leq 200\text{kHz}$

AWU Analog THSEL Write

AWU MODE NAME	DESCRIPTION	CONFIGURABLE OPTIONS
AWU Analog	Analog activity detect, lowest power	Absolute Threshold(60-97.5dBSPL), HPF(50-200Hz)

8. *Acoustic Wake-Up Analog*

AWU Analog takes the buffered signal from the MEMS and compares it to the preselected conditions, Absolute Threshold and High pass Filter Frequency. If the signal is above the Absolute Threshold and is above the HPF cutoff the WAKE Pin will be set high. The WAKE pin will remain high while these conditions are met. It will return low when the signal level returns below this level. The microphone consumes only 20uA when in AWU Analog.
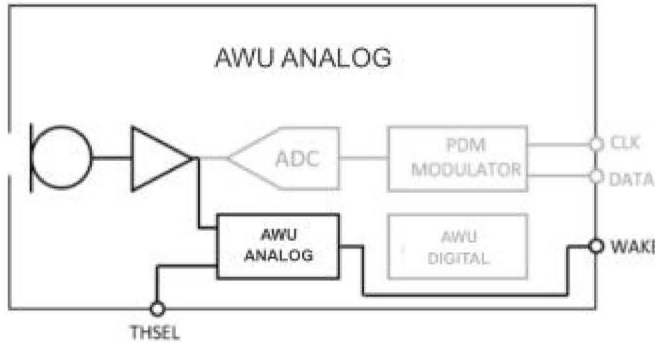

Block Diagram for AWU Analog Operation

9. *Acoustic Wake-Up Configuration Protocol*

A serial one wire interface on the THSEL pin controls Acoustic Wake-Up modes, AWU A. The protocol requires the standard PDM CLK to be running at a speed >50 kHz and the THSEL pin is modulated proportional to the CLK cycles to create the following symbols for logic zeros or one which turn form the device address, register address and data of the command. There are also unique symbols for start/pilot and stop to terminate each write. The start/pilot pulse width is important as it defines the pulse width of the zeros and one. See below for details.

SYMBOL NAME	DESCRIPTION	THSEL CONDITION	SYMBOL PULSE WIDTH		
			MIN	TYPICAL	MAX
Start/Pilot	Start symbol which also defines the PILOT width T_P	HIGH	10 CLK cycles	15 CLK cycles	20 CLK cycles
Zero	Single bit Zero	HIGH		$1 \times T_P$	$1.5 \times T_P$
One	Single bit One	HIGH	$2 \times T_P$	$3 \times T_P$	$3.5 \times T_P$
Stop	Stop Signal (High Method)	HIGH	$128 \times CLK$		
	Stop Signal (Low Method)	LOW	$8 \times T_P$		
Space	Separate individual symbols above	LOW	$1 \times T_P$		$2 \times T_P$
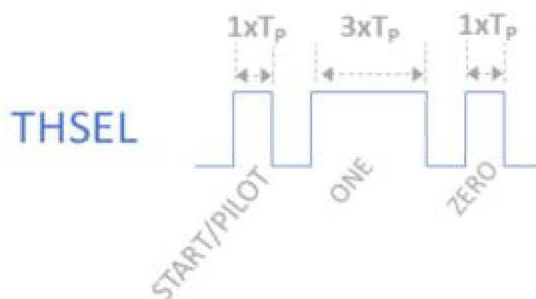
Example write on THSEL followed by a single bit Zero and One relative to the PILOT
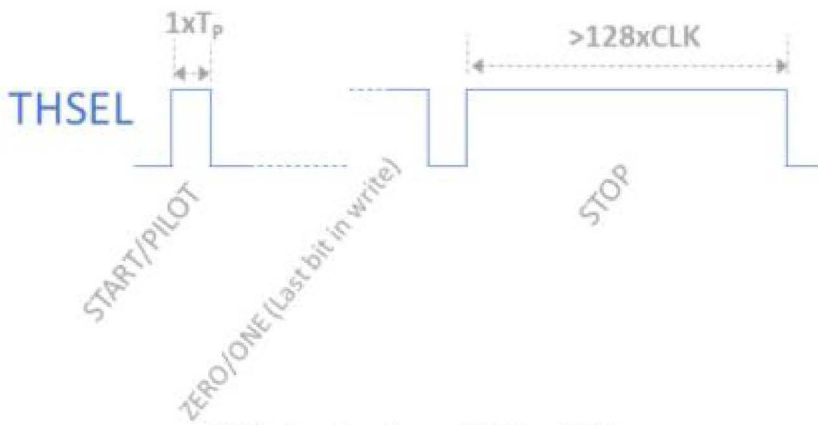
Write termination with Stop High
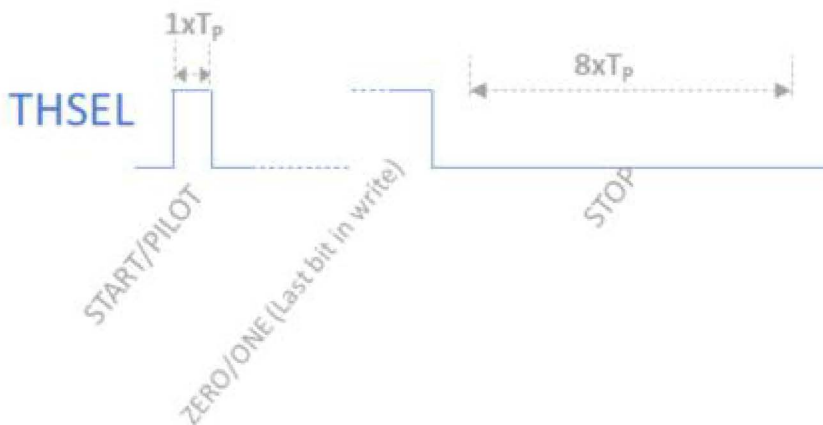
Write termination with Stop Low

The total write sequence consists of START/PILOT + 24 bits of payload + STOP. The payload consists of three 8 bit fields:

- Device Address +RW =7'b1010110(Constant for this device) +1'b0(write, constant for this device)

- Register Address = 8-bit value, determined by AWU function lookup table

- Data = 8-bit value, determined by AWU function lookup table

Example of AWU total write sequence:
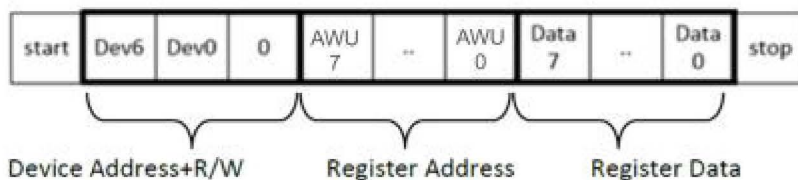
Example Write:
Device Addr+R/W = 10100110 (Constant for this device)
Register Address = 00000001 (Example Reg Addr only, not an option)
Register Data = 00000010 (Example data)
CLK = 150kHz

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The write calculations based on 150kHz CLK, 15 CLK cycle PILOT are shown below:

PIN	DESCRIPTION	CLK CONDITION	RATE	PERIOD
CLK	PDM CLK	Normal CLK HIGH/LOW	150kHz	6.66uS
SYMBOL NAME	DESCRIPTION	THSEL CONDITION	RATIO	WIDTH
Start/Pilot	Start/Pilot which indicates start of write and defines logic pulse widths	HIGH	15 X CLK cycles	100us = T_P
Zero	Single bit Zero	HIGH	1 x T_P	100us
One	Single bit One	HIGH	3 x T_P	300us
Stop	Stop Signal (High Method)	HIGH	>128 x CLK cycle	>853us
	Stop Signal (Low Method)	LOW	>8 x T_P	>800us
Space	Separate individual symbols above	LOW	1 x T_P	100us
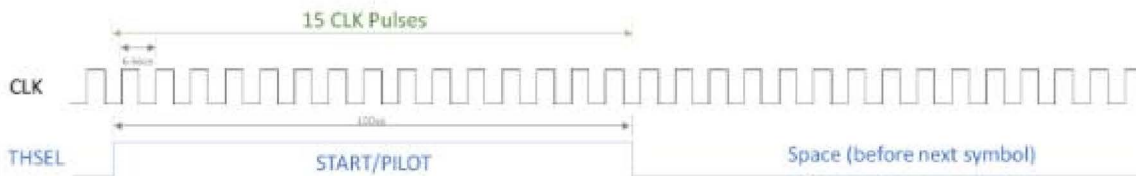
Timing diagram for example above showing relationship between THSEL pilot and CLK

START + 10100110 + 00000001 + 00000010 + STOP
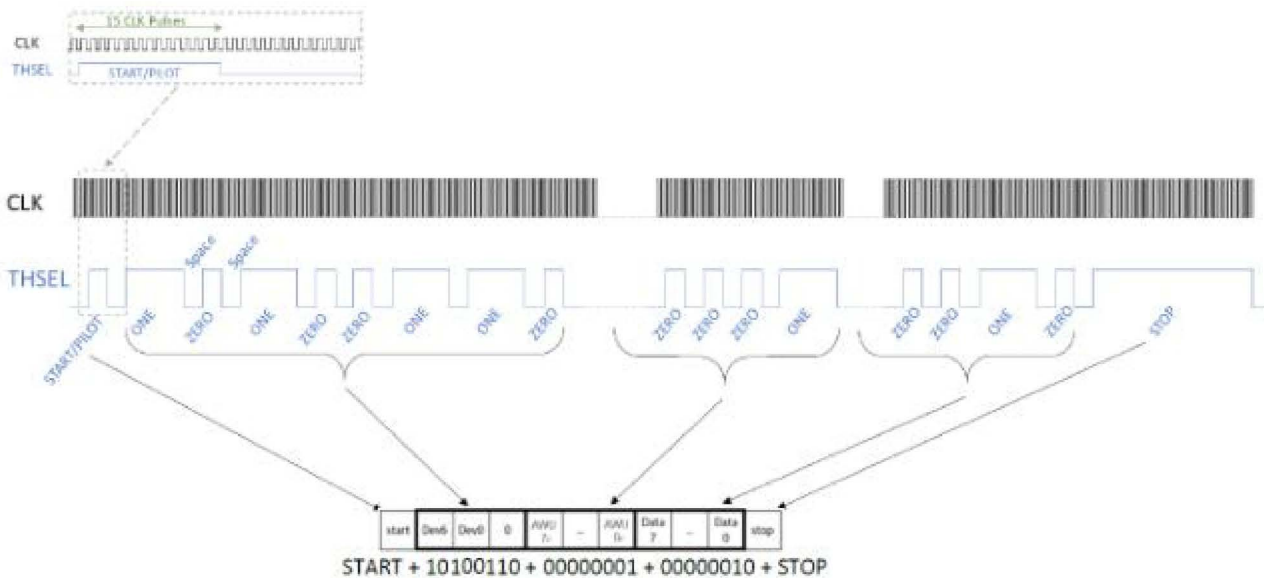
Expanded Timing diagram for example showing 3 x 8 bit values being written to the device, with the low level translation of each bit to their respective symbols.

10. AWU Initiation Sequence

Using the write sequence above, AWU (for all 3 modes) is enable using the following five writes in the sequence:

WRITE #	REGISTER ADDRESS (HEX)	REGISTER DATA (HEX)
1	0x5C	0x00
2	0x3E	0x00
3	0x6F	0x00
4	0x3B	0x00
5	0x4C	0x00

For example, write #1 with Address 0x5C (B01011100) and Data 0x00 (B00000000) would be:
START+10100110 + 01011100 + 00000000 + STOP

After this sequence has been completed any of the settings in AWU Analog or AWU Digital can start to be adjusted. The microphone will retain the completion of this enable sequence while power is maintained to the microphone. If the mic goes through a power cycle, then the sequence will have to be repeated.

11. AWU Analog Settings

AWU Analog has the following configurable options, an Absolute Threshold from 60dB SPL to 97.5dB SPL and a HPF configurable from 50Hz to 200Hz:

NAME	REGISTER ADDRESS	REGISTER DATA	APPLICABLE BITS IN DATA FIELD	DESCRIPTION
awua_en	0x29	0x08	[3]	Enables AWU- Analog
awu_th_d2a	0x36	0xXX	[3:0]	Adjusts the Threshold from 60dB SPL to 97.5dB SPL
awua_filter	0x35	0x0X	[2:0]	Adjusts HPF corner from 50Hz to 200Hz

The following table identifies the corresponding SPL for each Data value in register 0x36:

REGISTER ADDRESS	REGISTEP DATA	ACOUSTIC THRESHOLD (dB SPL)
0x35	0x01	60
	0x02	65
	0x03	67.5
	0x04	70
	0x05	72.5
	0x06	75
	0x07	77.5
	0x08	80
	0x09	82.5
	0x0A	85
	0x0B	87.5
	0x0C	90
	0x0D	92.5
	0x0E	95
	0x0F	97.5

An example of AWU-A enable and configuration from start to finish is shown below:

WRITE #	REGISTER ADDRESS (HEX)	REGISTER DATA (HEX)	COMMENT/DESCRIPTION
1	0x5C	0x00	Enable AWU Modes
2	0x3E	0x00	
3	0x6F	0x00	
4	0x3B	0x00	
5	0x4C	0x00	
6	0x36	0x08	Set AWU-A Threshold to 80 dB SPL
7	0x29	0x08	Enable AWU-A

Note to achieve the 20uA Idd the clock must be stopped after the configuration has been completed. A slow CLK <200kHz can be used to facilitate changing settings over THSEL while keeping the mic in AWU-A.

During AWU-A the WAKE pin will go HIGH when the acoustic stimulus exceeds the threshold and will go LOW when that acoustic stimulus drops back below the threshold:
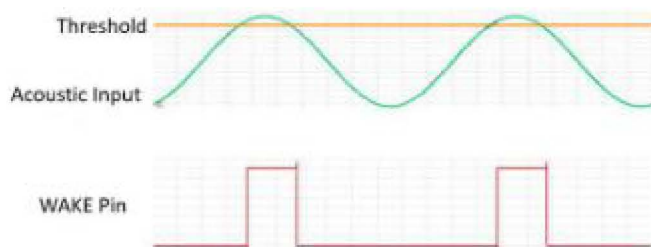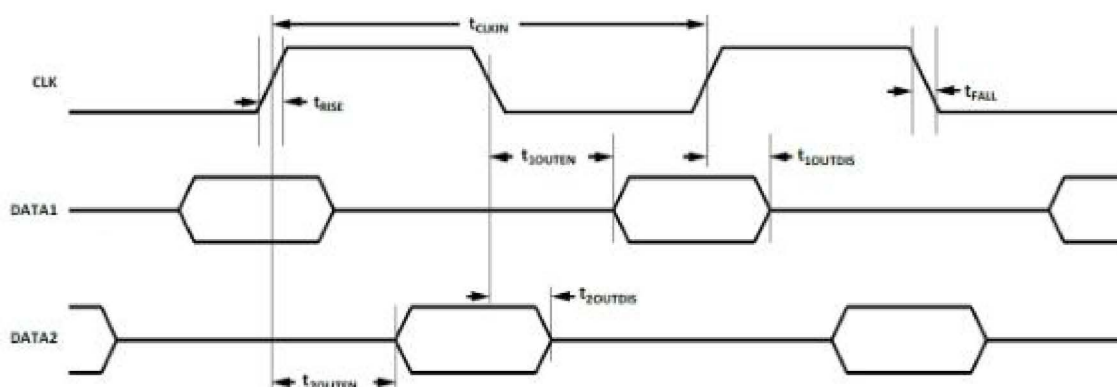

Example of response of WAKE pin to acoustic conditions exceeding the configured threshold

12. Typical Frequency Response Curve

Typical Field Frequency Response
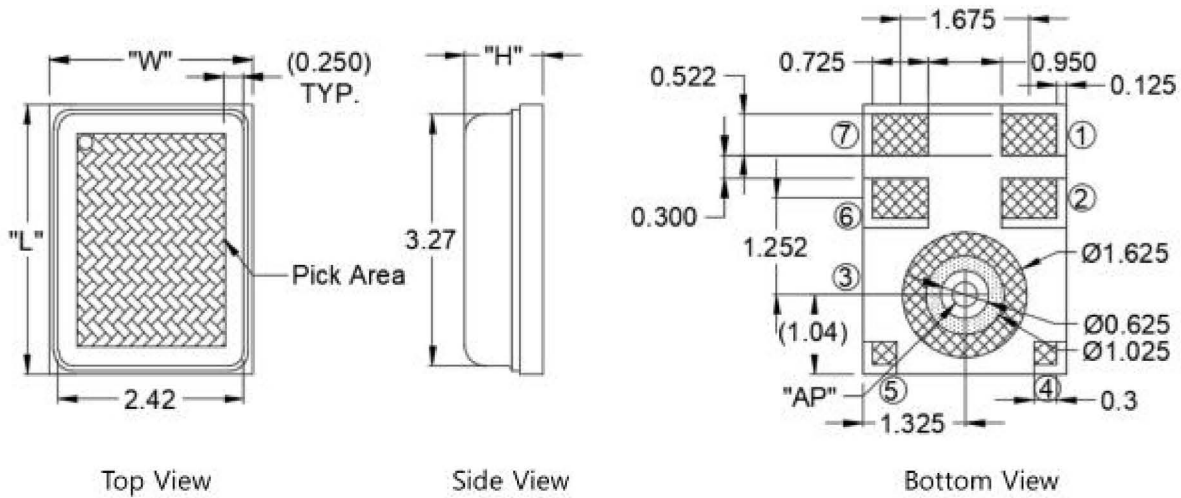**Normalized to 1kHz**
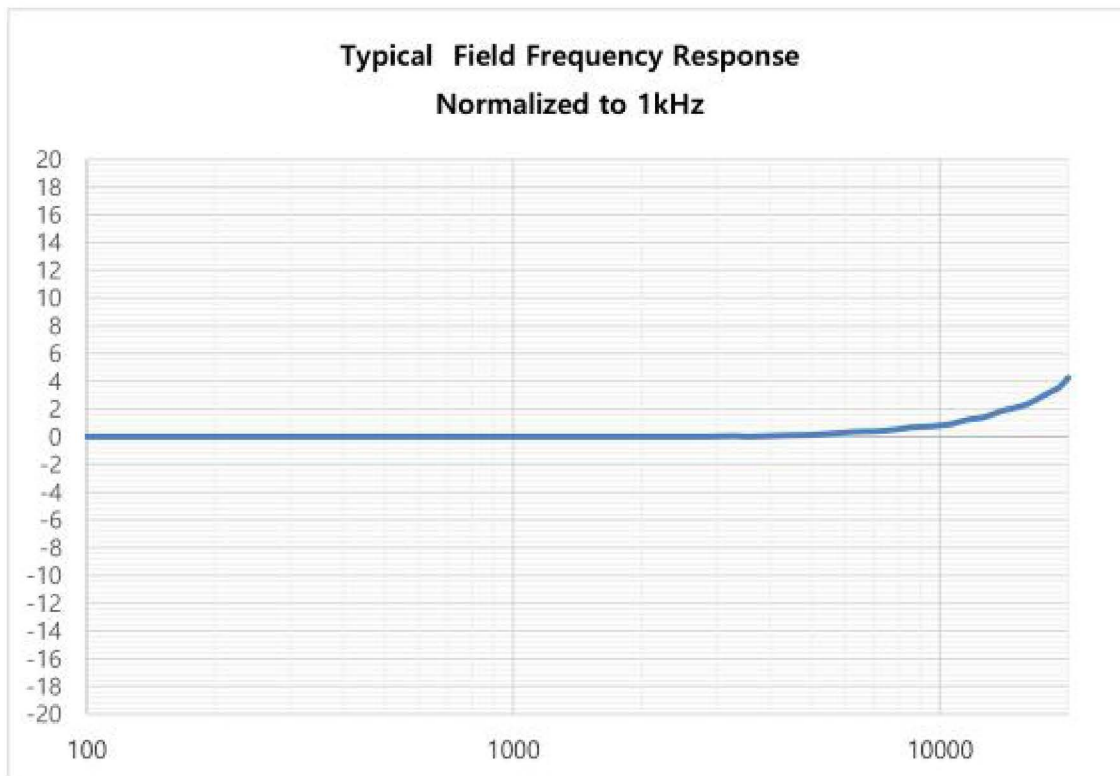
TEST CONDITION : 23±2℃, 65±20% R.H., Typical specifications are measured at VDD = 1.8V, F_{clk}=2.4MHz
Speaker : 1Pa (94dBSPL@1kHz) at 50cm distance from a loud-speaker
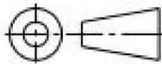
13. TIMING DIAGRAM

Note : t_{1OUTEN}, t_{2OUTEN} : 30~70ns $t_{1OUTDIS}$, $t_{1OUTDIS}$: 5~18ns t_{Rise}, t_{FALL} : Max 25ns

14. Mechanical Dimensions & Pin out

Top View   Side View   Bottom View

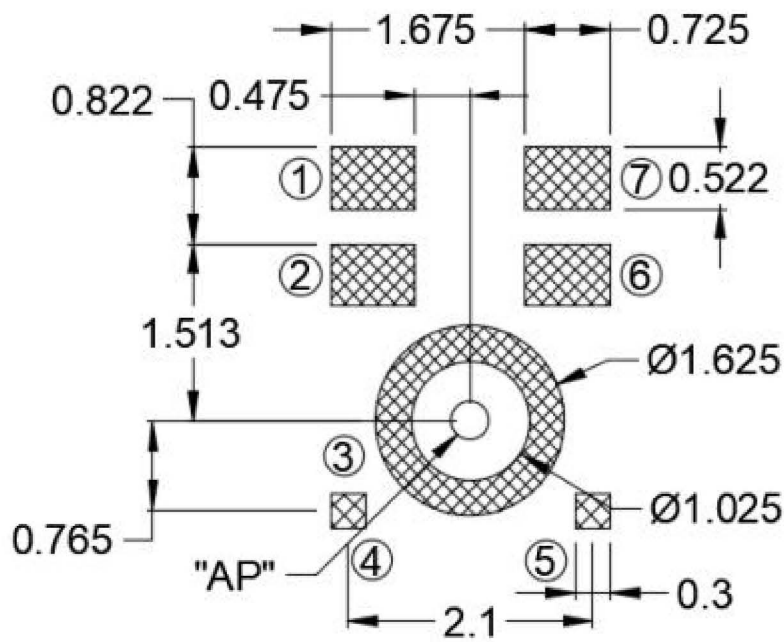| Item	Dimension	Tolerance
Length(L)	3.50	±0.10mm
Width(W)	2.65	±0.10mm
Height(H)	1.00	±0.10mm
Acoustic Port(AP)	Ø0.325	±0.05mm

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

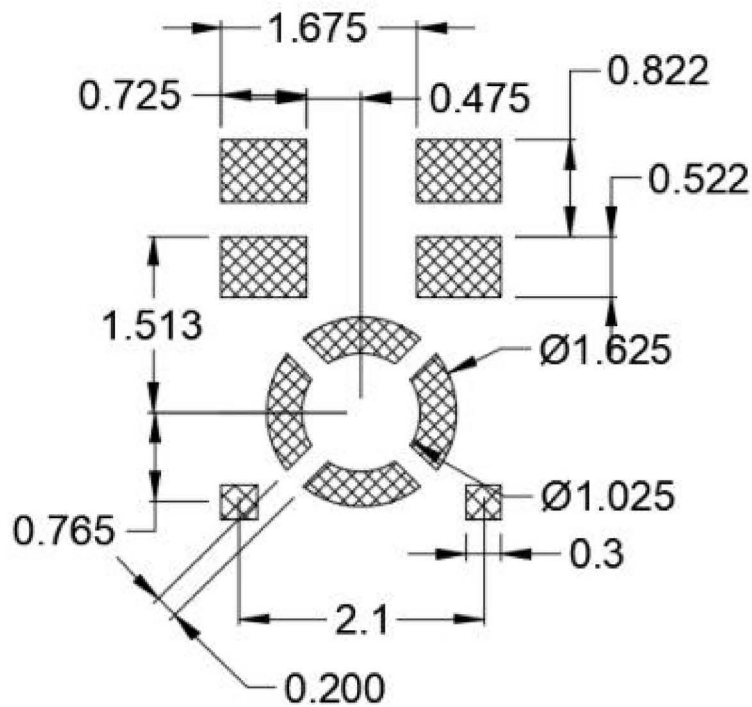Dimension are in millimeters unless otherwise specified. Tolerance : ±0.15mm

PIN	NAME	FUNCTION
1	Output	Digital Output
2	L/R	Left or Right Channel Selection DATA1(Right) : SELECT tied to GND DATA2(Left) : SELECT tied to VDD
3	Ground	Ground
4	WAKE	Wake Output pin. Interrupt pin for Acoustic Wake-Up (AWU) Modes. Outputs HIGH state to indicate the acoustic stimulus exceeds AWU conditions, returns LOW when the stimulus no longer exceeds them. No connection for operation without AWU Mode.
5	THSEL	Threshold Select Input Pin. Used to both enable and configure AWU Modes. No connection for operation without AWU Modes.
6	Clock	Clock input to Microphone
7	VDD	VDD

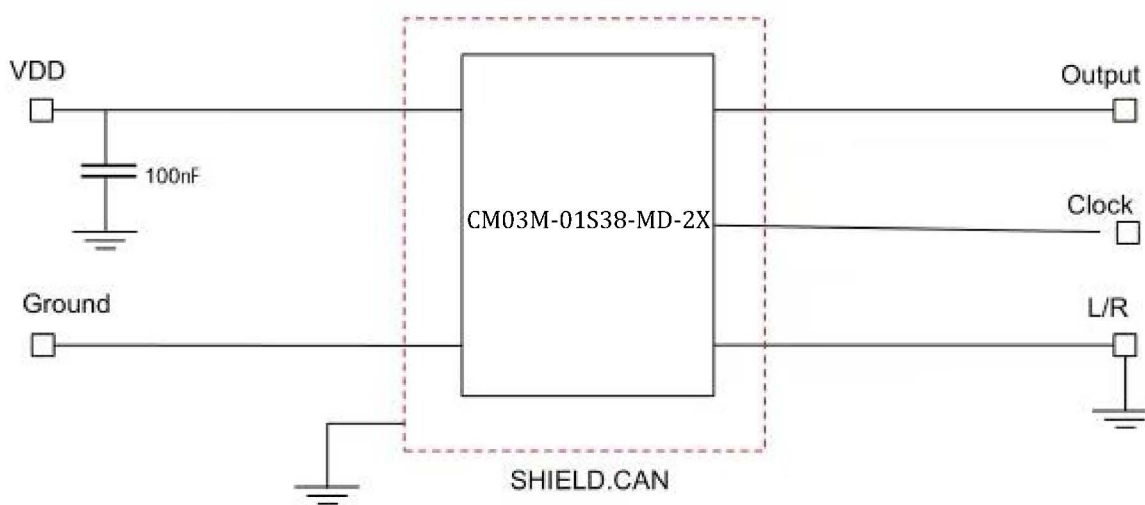## 15. Recommended Customer PCB Pattern

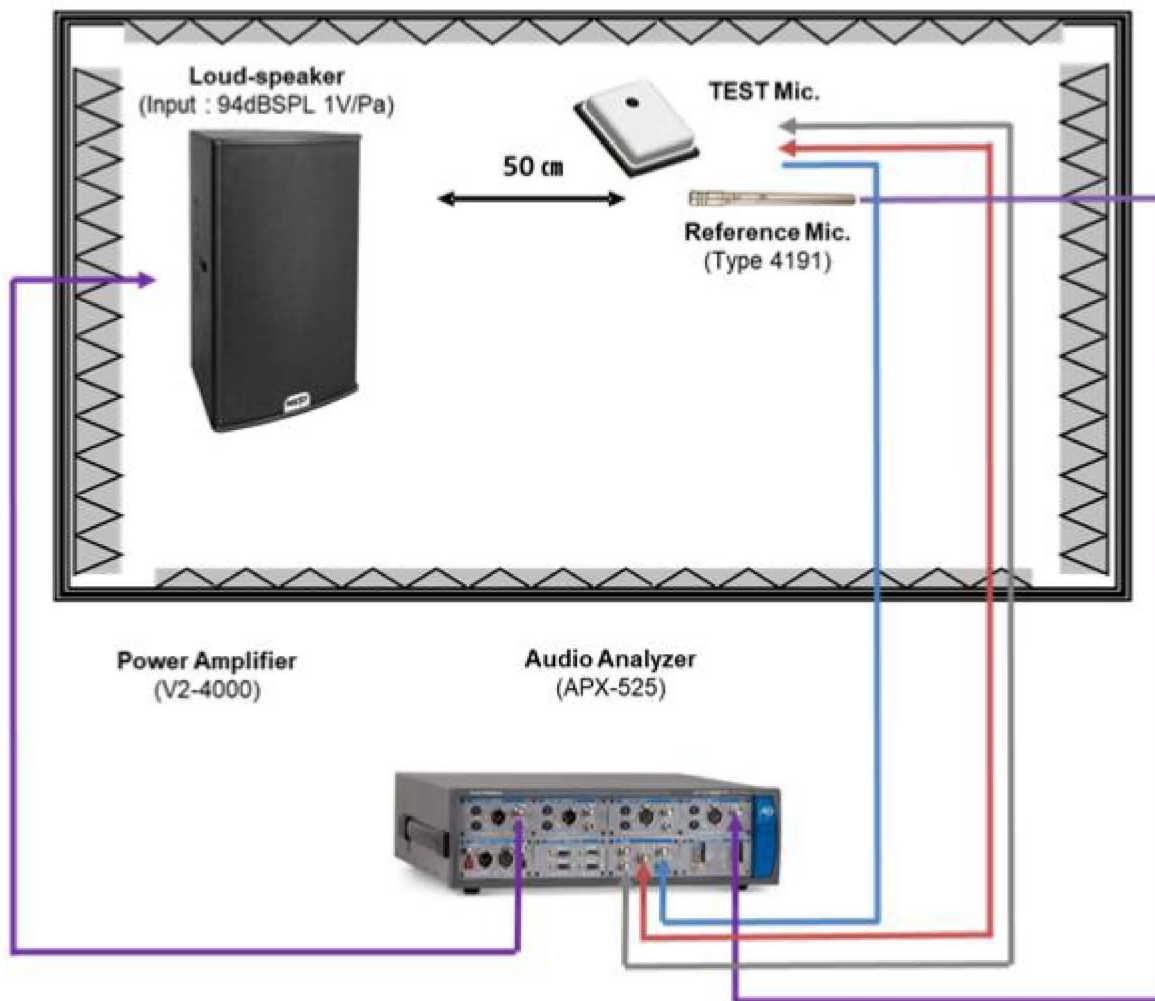AP Tolerance : 0.425 ~ 0.5mm

16. Recommended Customer Stencil Pattern

Note : Dimension are in millimeters unless otherwise specified
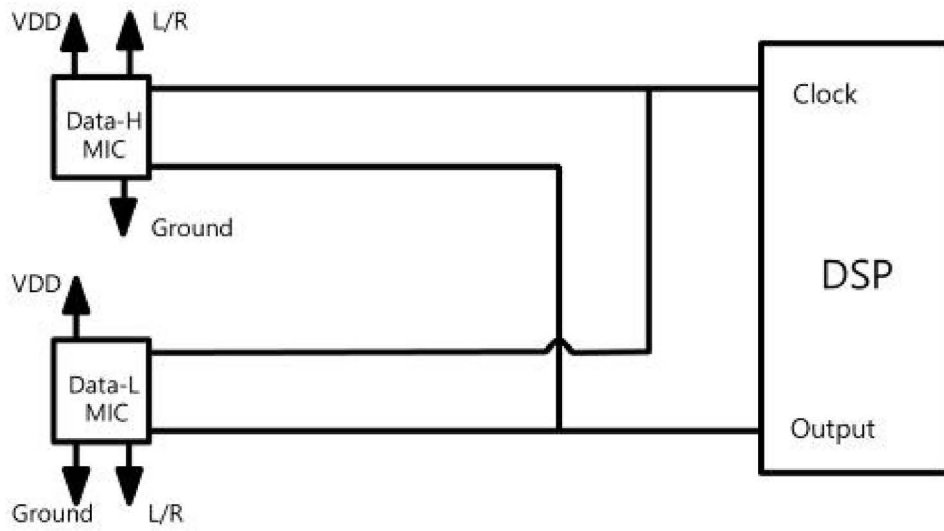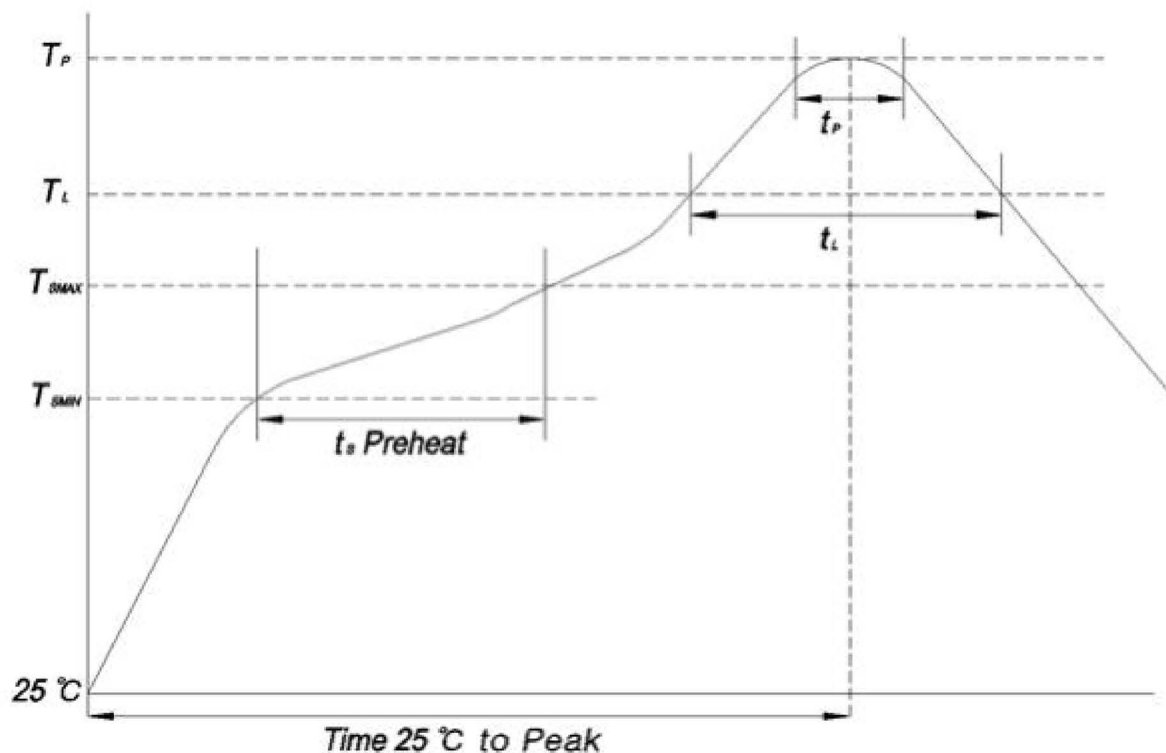
17. Standard Test Circuit


```
VDD                                              Output
 □                    ┌──────────────┐            □
    ─┬─               │              │
  100nF               │              │           Clock
    ═══               │CM03M-01S38-MD-2X│          □
    ───               │              │
                      │              │
Ground                │              │           L/R
 □                    └──────────────┘            □
   ───                                            ───
              SHIELD.CAN
```

Note : L/R pin must be grounded when using single Mic.

18. Typical Measurement System

Loud-speaker (Input : 94dBSPL 1V/Pa)

TEST Mic.

50 cm

Reference Mic. (Type 4191)

Power Amplifier (V2-4000)

Audio Analyzer (APX-525)

19. Recommended application circuit for stereo input

20. Reflow Profile

Profile Feature		Lead(Pb) Free Solder
Preheat	Temperature min.(T_{SMIN})	150°C
	Temperature max.(T_{SMAX})	200°C
	Time (t_S)	60-120 Seconds
Liquidous	Temperature (T_L)	217°C
	Time (t_L)	60-150 Seconds
Peak	Temperature (T_P)	260°C
	Time within 5°C of actual peak temperature (t_P)	30 Seconds Max.
Ramp up	Average ramp up rate T_{SMAX} to T_P	3°C / Second Max.
Ramp down	Average ramp down rate T_P to T_{SMAX}	6°C / Second Max.
Time 25°C to Peak temperature		8 Minutes Max.

21. *Typical Reliability Test Items*

NO	Tested Item	Condition	standard
1	Humidity	+85±2℃, 85±2%RH 120Hr	JESD 22-A 101A-B
2	Low Temperature	-40±2℃, 200Hr	IEC 68-2-2 Test Aa
3	High Temperature	+105±2℃, 200Hr	IEC 68-2-2 Test Ba
4	Thermal Shock	(-40±2℃ → +85℃±2℃)×96Cycle 30m	IEC 60068-2-4
5	Drop	Drop 12 times onto thick steel plate from height 1.52m (installed in JIG)	IEC 60068-2-32
6	Vibration	Frequency: 10~55Hz/min → 2Hr Direction: amplitude 1.52mm(X, Y, Z)	MIL 883E, Method 2007.2.A
7	ESD(Contact)	5 discharges at ±8kV direct contact to lid when unit is grounded. 5 discharges at ±2kV direct contact to I/O pins.	IEC 61000-4-2
8	Tumbling	Steel chamber length = 1m, 6.5rpm, 300 times.	Specification
9	Reflow	Pre heat: +170~180℃/120sec, Solder reflow-Above: +230℃/100sec, Peak: +260℃/30sec, Repeat 3 times	IPC-JEDEC J-STD-020D.1

Note: After reliability test, the samples shall be stored under climatic conditions such as leaving in the air with room temperature. Unless otherwise noted, the recovery period shall be 2 hours at least before performance testing. After test condition is performed, the sensitivity of the microphone shall not be varied more than 1dB V/Pa from its initial value

22. Cautions for using MEMS microphone

✓ 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.

+ If user has multiple reflow process, the microphone must be placed on PCB at final reflow process.

(If there are two times reflow-processes, microphone should be placed in second reflow process

on PCB not in first reflow process)

+MSL(moisture sensitivity level) Class 1.

Re-work Method

+250~270℃, Max 30sec

+Wind Speed: 15L/m

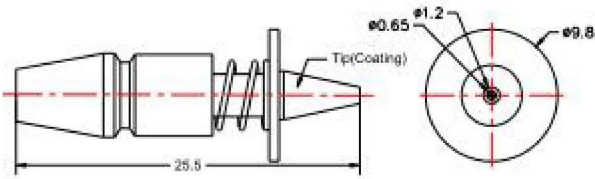+Do not put a heat-gun over the acoustic hole of MEMS Microphone.

+There must be no other parts on back side

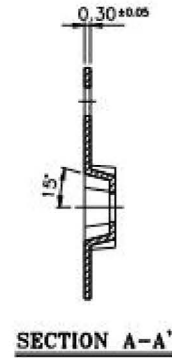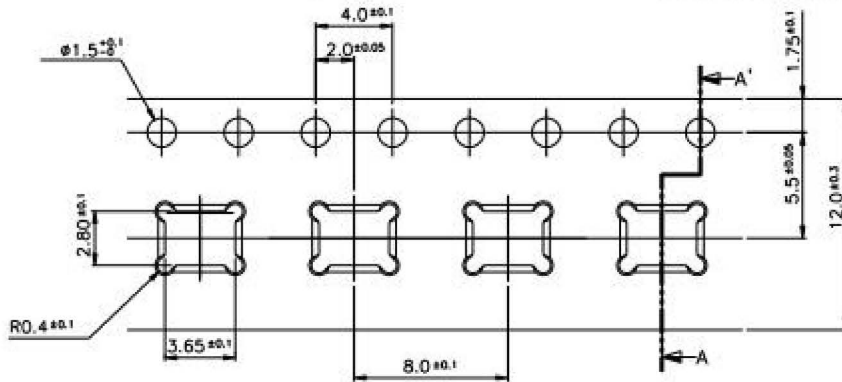+MEMS Mic. should be detached in 3 seconds. (Peak Temperature 330℃)

+After detach MEMS Mic. from PCB, solder ball and residue must be removed
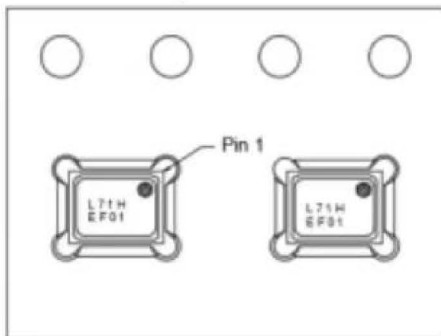
+Don't recommend re-work

23. Packing Information

Recommended Nozzle Model : CN065
Interner Diameter : Φ 0.65mm
Externer Diameter : Φ1.2mm

SECTION A-A'

Model	Reel Diameter	Quantity Per Reel
CM03M-01S38-MD-2X	13"	5,700

Marking : L 7 1 H
E F 0 1

YEAR	MONTH	Day	Halogen Free	Model		Serial No.	
2021	7	1	H	E	F	0	1

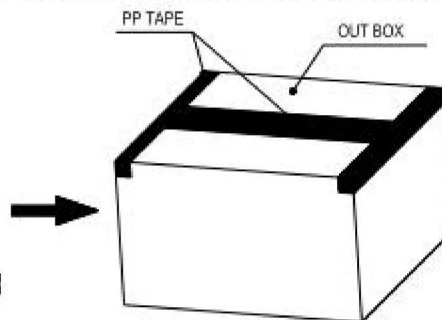Note : Dimension are in millimeters unless otherwise specified.
Vacuum pickup only in the pick area indicated in Mechanical Specifications.
Label applied directly to reel and external package.
Shelf life : Twelve(12)months when devices are to be stored in factory supplied unopened

INNER BOX
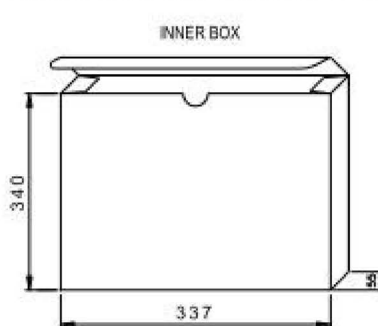
5,700PCS X 2BAG = 11,400PCS

PP TAPE   OUT BOX

CARTON SIZE : 330(W) X 350(L) X 355(H)
QUANTITY : 68,400 PCS

24. Specification Revision History

Revision	Remarks	Date
0-2023	Specification release.	Dec. 7, 2023