SKM2610-HC

PDM Hypercardioid Microphone Module

1. Characteristics

- Hypercardioid polar pattern
- 66 dBA SNR
- 5.3 dB DI
- Integrated meshes for IP58
- Pre-tested for >20 dB sealing
- Two acoustic ports on same surface
- 780 µA supply current
- 25.60 x 5.20 x 4.85 mm^3

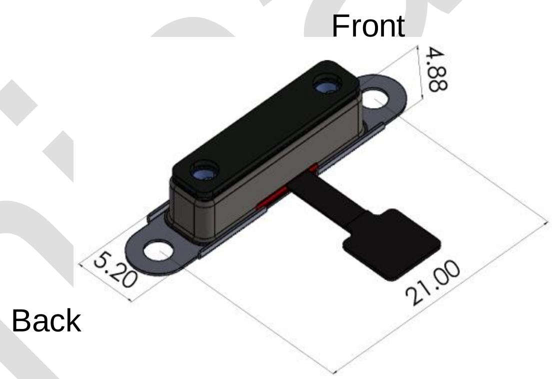
2. Applications

- AR & VR Devices
- Conferencing Devices
- Webcams & Security Cameras
- Headsets
- Intercoms & Video Doorbells
- Voice Badges
- Smart Home Devices

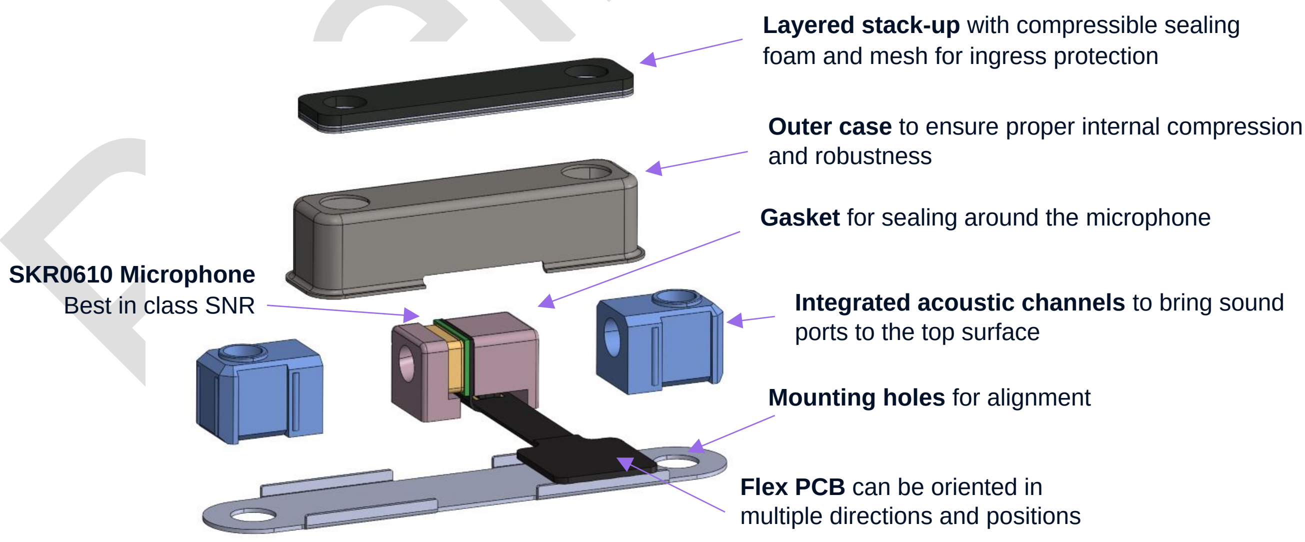
3. Description

The SKM2610-HC is a plug-and-play digital microphone module for consumer electronics with a PDM output. The module incorporates an SKR0610 dipole microphone. This module streamlines acoustic design by rerouting both sound ports on a single surface with a pre-installed acoustic mesh for ingress protection. With its optimized design, the module delivers exceptional directional audio capture with minimal integration effort, enabling fast and reliable product development.

The SKM2610-HC outputs a hypercardioid polar pattern.



4. Design Features



5. Table of Contents

6. Typical Application Circuit

The recommended operating conditions are CLK=3.072 MHz and V_{dd}=1.8 V. Using CLK<3.072 MHz will increase high-frequency noise and decrease SNR due to insufficient oversampling of the PDM signal. CLK>3.072 MHz will increase the current consumption without any improvement in SNR, AOP, or any other specification. Using V_{dd}>1.8 V will increase current consumption without any improvement in SNR, AOP, or any other specification.

The PDM interface (PDM to PCM converter) of the application processor should have a resolution ≥24 bit to achieve maximum SNR. A 16-bit resolution can also be used but will add high-frequency noise to both microphones and reduce SNR by 1dB.

0.1 µF capacitors should be placed between V_{dd} and GND as close to the microphone as possible to reduce supply noise. According to the PCB trace impedance, damping resistors R_{term} of 33 Ω to 100 Ω may be placed near the microphone DATA pins and near the application processor's CLOCK to reduce overshoots and ringing.

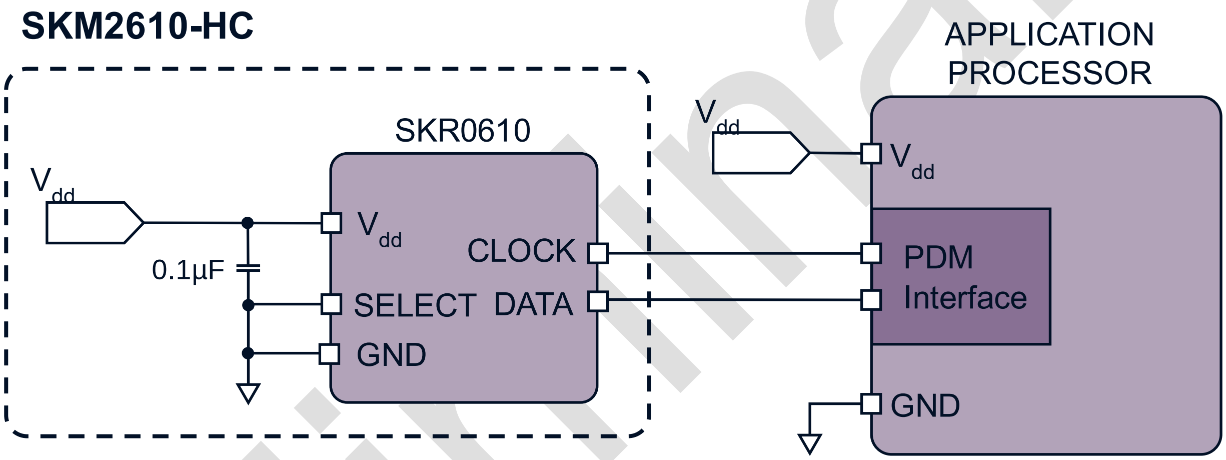


Figure 6.1: Typical stereo application circuit

7. Specifications

Test conditions throughout full datasheet unless otherwise indicated: 25 ºC, 55 ± 20% R.H., V_{dd} = 1.8 V, f_{clock} = 3.072 MHz, T_{edge}<3 ns, 1 m away, no load, connector facing toward loudspeaker and defined as 0º (front). SELECT is tied to GND.

7.1 Electrical Specifications

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Supply Voltage	V_{dd}		1.6	1.8	3.6	V
Supply Current	I_{dd}	fclock = 3.072 MHz		780		µA
	$I_{standby}$	fclock < 0.100 MHz		10		
Output Load Capacitance	C_{load}	On DATA pin		200		pF
Clock Duty Cycle		f_{clock} < 2.7 MHz	45		55	%
		f_{clock} ≥ 2.7 MHz	48	50	52	
Logic Input/Output Low	V_{IL} / V_{OL}		-0.3		0.35V_{dd}	V
Logic Input/Output High	V_{IH} / V_{OH}		0.65V_{dd}		0.3+V_{dd}	V
Delay Time for Valid Data	t_{DV}	Delay time from CLOCK edge (0.5V_{DD}) to DATA valid (<0.3V_{DD} or >0.7V_{DD})	30		180	ns
Delay Time for High Z	t_{HZ}	Delay time for CLOCK edge (0.5V_{DD}) to DATA high impedance state	1		26	ns
Startup Time		Sensitivity within 1 dB of final value, outputs AC coupled		60		ms

7.2 Acoustic Specifications

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Pickup Pattern				Hypercardioid		
Polarity		Increasing sound pressure at back (180°)		Decreasing density of 1's		
		Increasing sound pressure at front (0°)		Increasing density of 1's		
Average Directivity Index		Integrated from 20 Hz to 20 kHz		5.3		dB
Average Unidirectional Index		Integrated from 20 Hz to 20 kHz		6.2		dB
Null Angle				110, 250		º
Sensitivity	S	f_{clock} ≥ 1.536 MHz, 94 dB SPL, 1 kHz	-30.5	-29	-27.5	dBFS/Pa
Noise Floor				-90		dBFS(A)
Signal to Noise Ratio[1]	SNR	20 Hz to 20 kHz, 94 dB SPL		66		dB(A)
Total Harmonic Distortion[2]	THD	94dB SPL, 1kHz		<0.2		%
		1% THD, 1 kHz		109		dB SPL
Acoustic Overload Point	AOP	10% THD, 1 kHz		127.5		
Resonant Frequency	Fres			4		kHz
Power Supply Rejection Ratio	PSRR	200 mV_{pp} sine wave on V_{dd} at 1 kHz		75		dB
Power Supply Rejection	PSR+N	200 mV_{pp} 7/8 duty cycle rectangular waveform @ 217 Hz, A-weighted, BW = 22.4 kHz		-89		dBFS(A)

[1] A directional microphone has a non-flat frequency response, as such the SNR must be calculated for the entire frequency range. See SNR Calculation for details.

[2] To calculate the THD of a microphone with a non-flat frequency response, the frequency response must first be equalized. See THD Calculation for details.

7.3 Specification Calculation Details

Directivity Index and Average Directivity Index Calculation

The directivity index measures the ratio of the microphone output for a sound positioned directly in front of the microphone (θ = 0º) versus sound with the same amount of total acoustic power coming from all directions equally. The directivity index at each frequency is calculated with the equation below.

$$DI = 10log_{10}\left(4\frac{amplitude(\theta = 0)^2\left[\frac{V^2}{Pa^2}, \frac{FS^2}{Pa^2}\right]}{\int_0^{2\pi} amplitude(\theta)^2\left[\frac{V^2}{Pa^2}, \frac{FS^2}{Pa^2}\right]|sin\,\theta|d\theta}\right)$$

Equation 7.1: Directivity Index

The average directivity index is calculated by logarithmically weighing the directionality index at each frequency and then taking the average of these weighted values from 20 Hz to 20 kHz. For more information, refer to the app note: AN-110: Attributes of Soundskrit Directional Microphones.

SNR Calculation

The SNR of a directional microphone with a non-flat frequency response must be calculated differently than the typical method used for omnidirectional microphones that have a flat frequency response. Instead of only using the 1 kHz sensitivity, the electrical noise of the microphone at each frequency (units of V^2/Hz or FS^2/Hz) must be divided by the corresponding sensitivity squared at each frequency (units of V^2/Pa^2 or FS^2/Hz^2) to obtain the input referred acoustic noise at each frequency (units of Pa^2/Hz). Then, the acoustic noise is A-weighted by multiplying it by the A-weighting factor (A_w) squared and this A-weighted acoustic noise is integrated over the full audio bandwidth and converted to an equivalent sound pressure level (dBA SPL) by dividing by the reference pressure (P_{ref}=20 µPa). Finally, the SNR is calculated by subtracting the integrated input referred noise from 94 dB SPL. The equation for the calculation is shown below. For more information, refer to the app note: AN-110: Attributes of Soundskrit Directional Microphones.

$$SNR = 94 - 20\,log_{10}\left(\frac{1}{P_{ref}^2\,[Pa^2]}\int_{20Hz}^{20kHz}\frac{noise\left[\frac{V^2}{Hz},\frac{FS^2}{Hz}\right]}{sensitivity\left[\frac{V^2}{Pa^2},\frac{FS^2}{Pa^2}\right]}A_w df\,[Hz]\right)$$

Equation 7.2: Full-spectrum SNR calculation

THD Calculation

THD is calculated by playing an acoustic sine wave at a specific sound pressure level and frequency and dividing the sum of the powers of the harmonic components of the captured signal by the power of the fundamental frequency. To calculate the THD of a microphone with a non-flat frequency response, the response must first be equalized to equally weigh the fundamental frequency and its respective harmonic frequencies. For more information on equalization and THD calculation, refer to the app note: AN-110: Attributes of Soundskrit Directional Microphones.

7.4 Absolute Maximum Ratings

Meeting or exceeding the conditions listed as Absolute Maximum Ratings could permanently damage the devices. Operating the devices at these ratings could impact device reliability.

Parameter	Absolute Maximum Rating	Unit
V_{dd} to GND	5.0	V
Input Current	±5	mA
Storage Temperature	-40 to 85	°C
Operating Temperature	-40 to 85	°C

7.5 Performance Curves

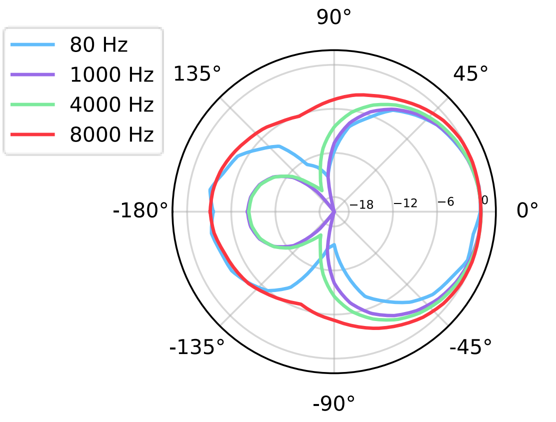


Figure 7.1: Polar pattern

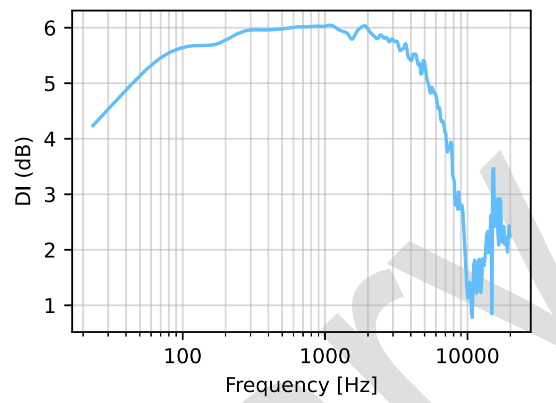


Figure 7.2: Directionality index vs frequency

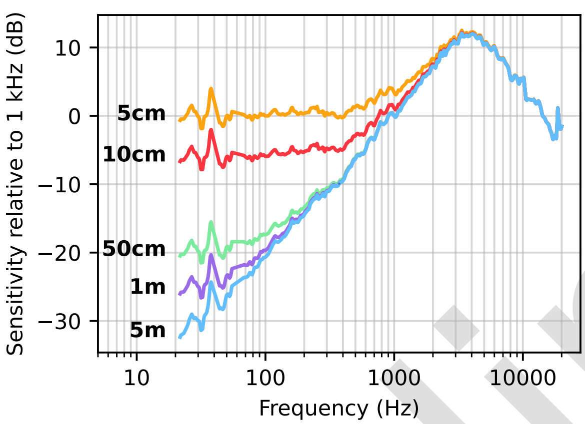


Figure 7.3: Magnitude response[3]

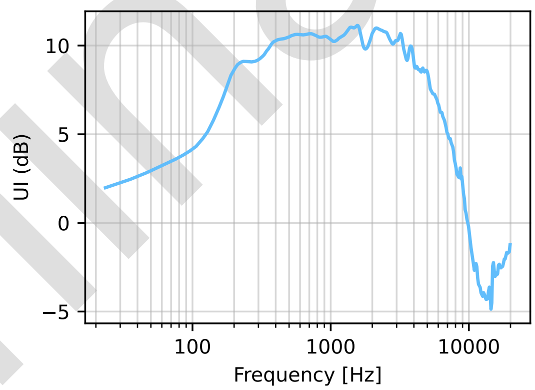


Figure 7.4: Unidirectionality index vs frequency

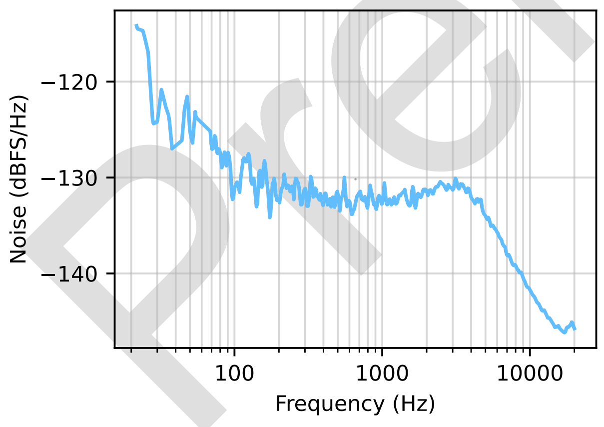


Figure 7.5: Noise floor

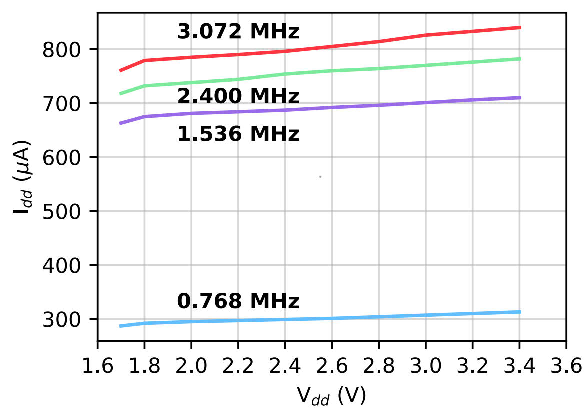


Figure 7.6: Supply current vs input voltage

[3] The increased bass response at close distances is known as the 'Proximity Effect.' See AN-110 for details.

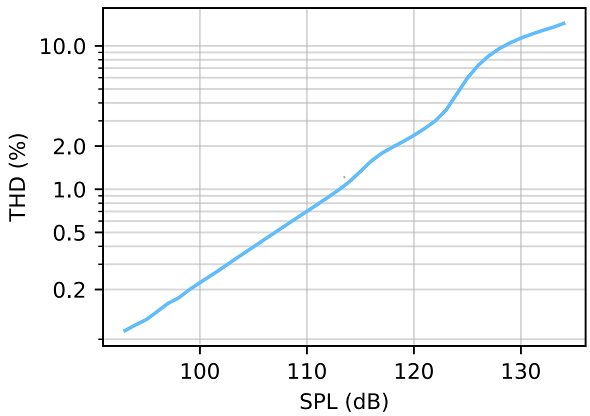


Figure 7.7: 1 kHz THD vs SPL

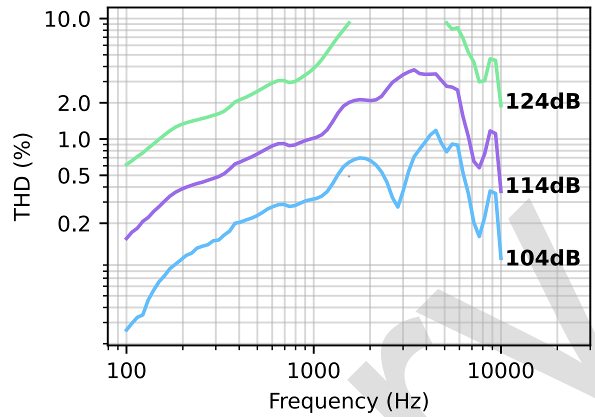


Figure 7.8: THD vs frequency

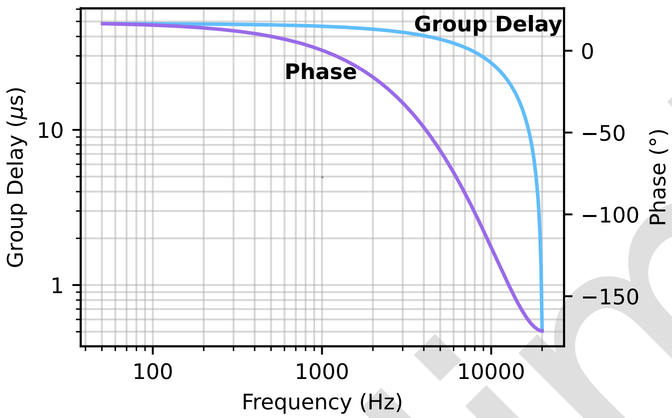


Figure 7.9: Phase and group delay

8. Mechanical Drawings and Integration Design

8.1 Mechanical Drawings and Pinout

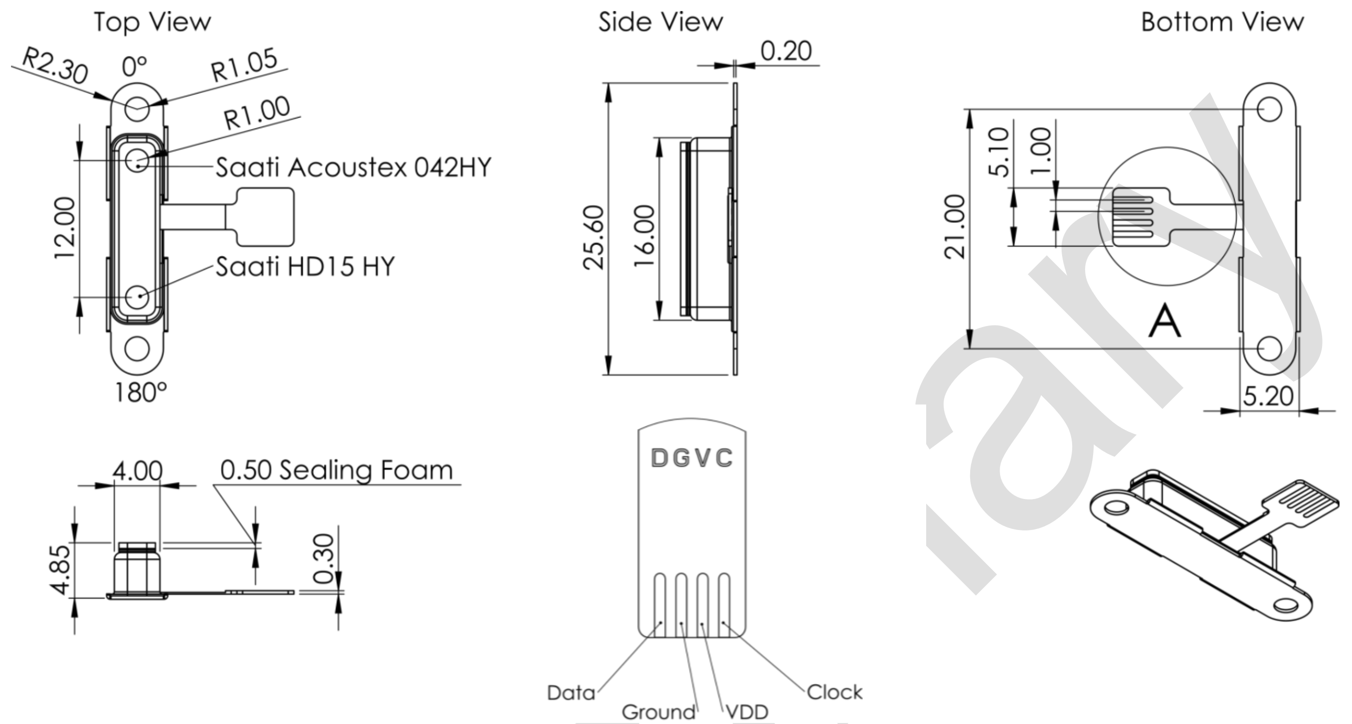


Figure 8.1: Mechanical drawings (mm)

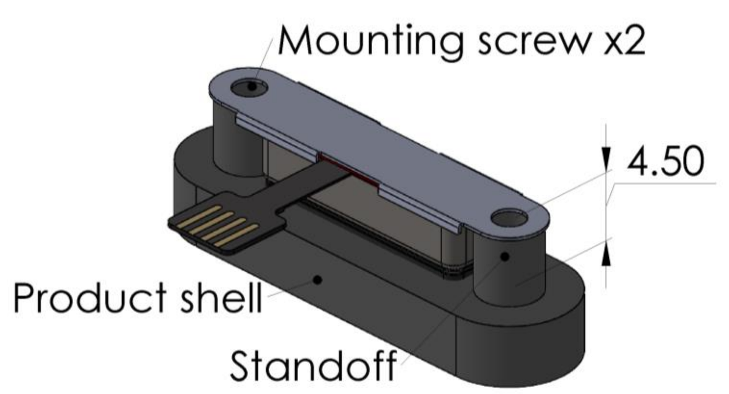
The SKM2610-HC incorporates a SAATI Acoustex 042HY mesh above the front port and a Saati HD15 HY mesh placed on the rear port for IP57 (ingress and water immersion protection) and a hypercardioid output.

8.2 CAD Models

The CAD model for the module is available here: SKM2610-HC STEP File

8.3 Installation

The SKM2610-HC module includes a layer of sealing foam which makes for easy installation into a product. To assure proper sealing with this foam, use 4.5-4.7mm standoffs to screw the module into. This ensures proper compression and acoustic sealing.



9.4 Packaging and Ordering Information

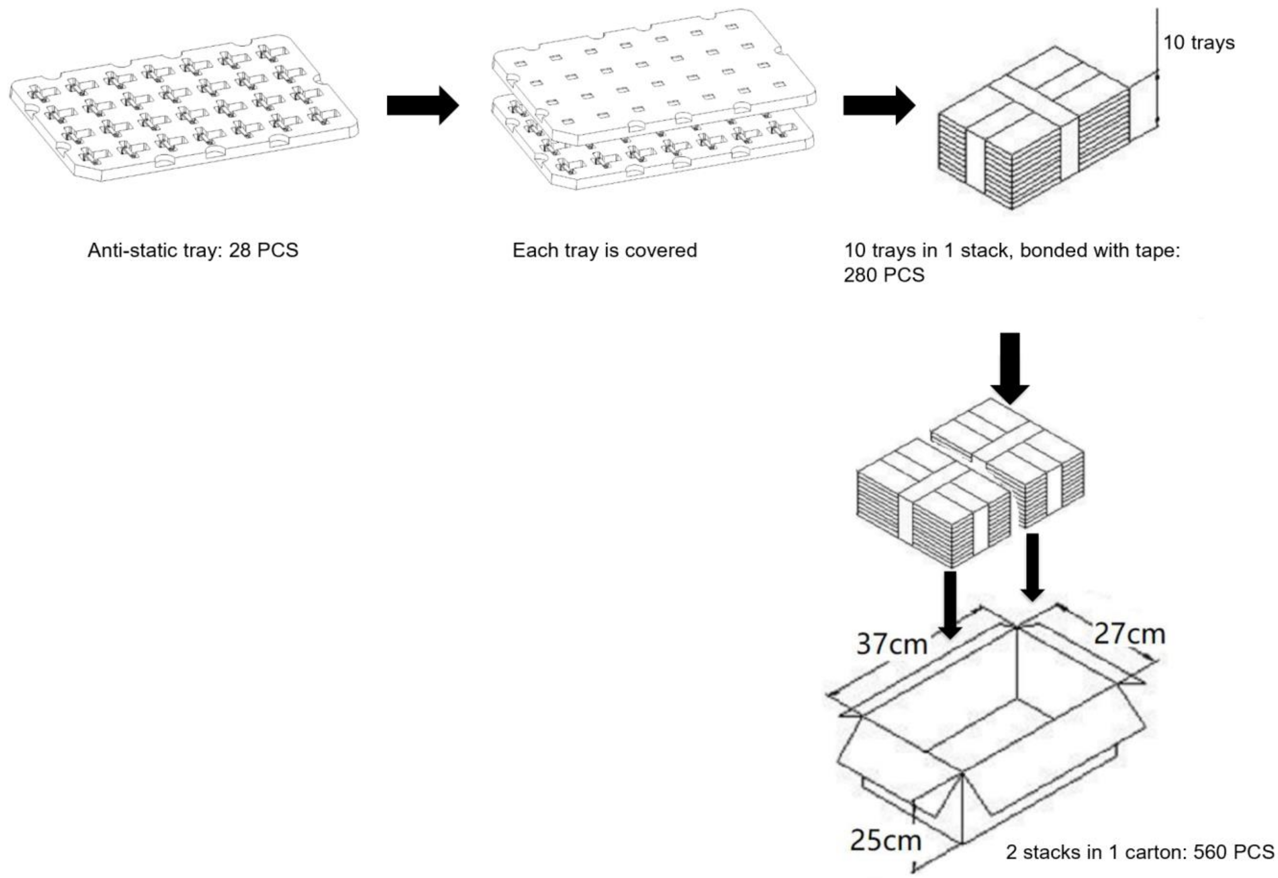


Table 9.1: Ordering Information

Model Number	Quantity per Carton
SKM2610-HC	560

9. Reliability Specifications

The sensitivity of each microphone in the module assembly must deviate by no more than 3 dB after each test. The microphone component itself has passed the standard microphone reliability tests listed in its respective datasheets (SKR0610).

Test	Test Condition	Standard
Humidity Soak	+85 °C / 93 % R.H., 240 hours	IEC 60068-2-78
Thermal Shock	100 cycles, air-to-air, -40 °C to +85 °C, 30 minutes soak	JESD22.A104-F
High Temperature Storage	+85 °C for 96 hours	JESD22 A-103-B
Low Temperature Storage	-40 °C for 96 hours	JESD22-A119A
Drop (Package)	Modules packaged in standard shipping box, drop from 1 m, 10 drops in total.	ASTM D4169-22
Vibration (Package)	Modules packaged in standard shipping box, apply truck spectrum for 13 minutes and 20 seconds along each axis, then apply air spectrum for 2 hours.	ASTM D4169-22

10. Additional Support

For additional design and applications support, please reach out to applications@soundskrit.ca.

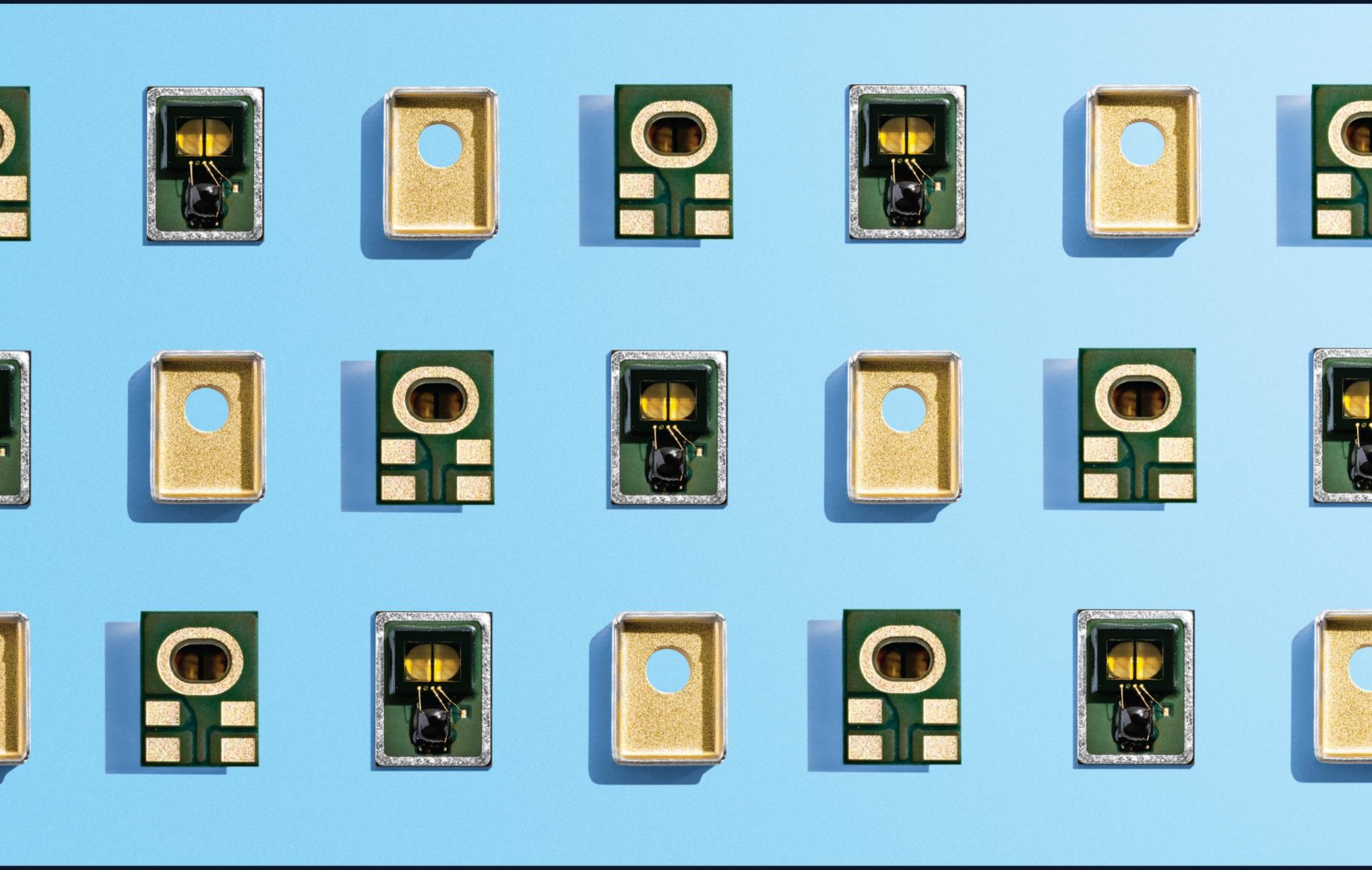
Soundskrit offers a suite of software algorithms to take full advantage of the utility our microphones provide. With a range from lightweight linear DSP tools to multichannel, machine learning based processing, we have a solution to meet any performance requirements. For more information, contact us or head to https://soundskrit.ca/software.

11. Revision History

Revision Label	Revision Date	Sections Revised
-	May 2025	Preliminary release

Soundskrit developed the first high-performance directional MEMS microphone on the market, leveraging years of research in bio-inspired MEMS based on how spiders and other insects in nature hear. In combination with Soundskrit's in-house audio processing algorithms, directional microphones can be used to capture and isolate any sound in an environment with a fraction of the size, power, and computation of traditional omnidirectional-based microphone arrays.

Soundskrit was founded in 2019 and is headquartered in Montreal, Quebec with an R&D facility in Ann Arbor, Michigan.



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