

1. Characteristics

- Dipole microphone
 - 65.5 dBA SNR
 - 4.8 dB DI
- Omnidirectional microphone
 - 68 dBA SNR
- Integrated meshes for IP57
- Pre-tested for >20 dB sealing
- Three acoustic ports on same surface
- 1830 μ A supply current
- 16.40 x 8.10 x 7.00 mm³

2. Applications

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

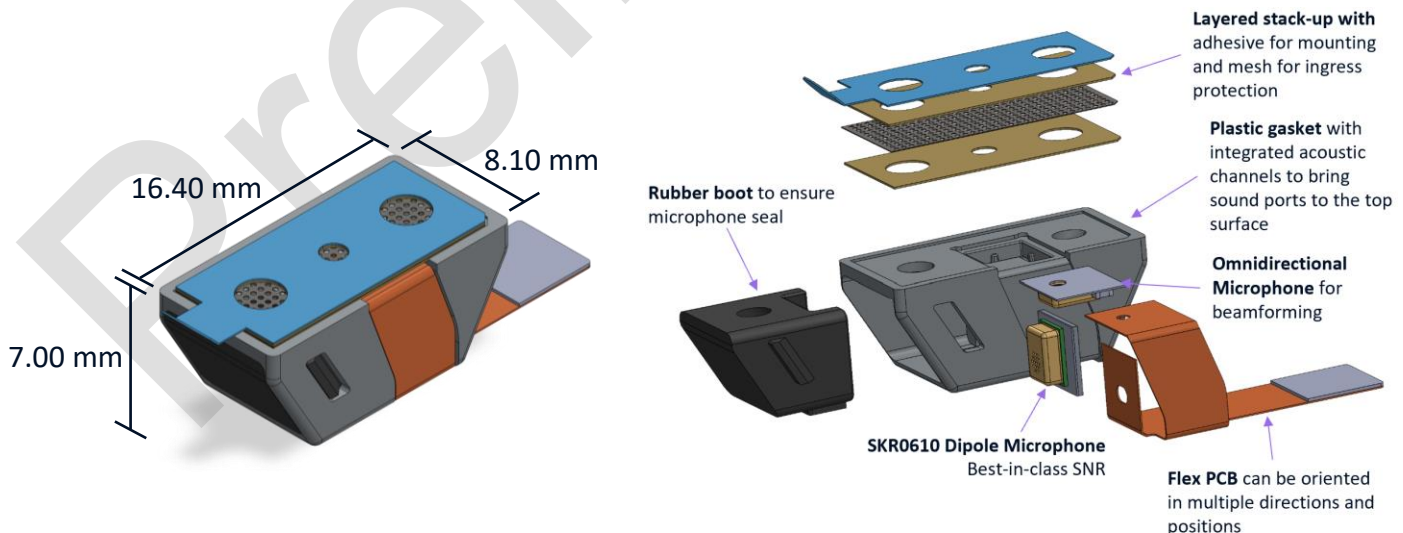
4. Design Features

3. Description

The SKM1610 is a plug-and-play digital microphone module for consumer electronics with a PDM output. The module incorporates an [SKR0610 dipole microphone](#) with an omnidirectional MEMS microphone. All acoustic ports are conveniently positioned on a single surface and protected by an ingress-resistant acoustic mesh, streamlining integration into devices.

When combined with digital signal processing, the omnidipole microphone pair allows for robust, switchable polar patterns (omnidirectional, dipole, cardioid, etc.) with a high signal-to-noise ratio. The omnidirectional microphone acoustic port is positioned relative to the two directional microphone acoustic ports to ensure optimal beamforming performance.

The SKM1610 enables customers to achieve high-quality audio pickup quickly and efficiently, making it ideal for applications where premium sound capture and directional flexibility are essential.



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6. Typical Application Circuit

The SKM1610 module pairs the SKR0610 with an omnidirectional microphone as shown in the stereo application circuit.

The recommended operating conditions are $CLK=3.072\text{ MHz}$ and $V_{dd}=1.8\text{ V}$. Using $CLK<3.072\text{ MHz}$ will increase high-frequency noise and decrease SNR due to insufficient oversampling of the PDM signal. $CLK>3.072\text{ MHz}$ will increase the current consumption without any improvement in SNR, AOP, or any other specification. Using $V_{dd}>1.8\text{ V}$ will increase current consumption without any improvement in SNR, AOP, or any other specification for the SKR0610, and will increase low-frequency noise for the omnidirectional microphone.

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 on both microphones.

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

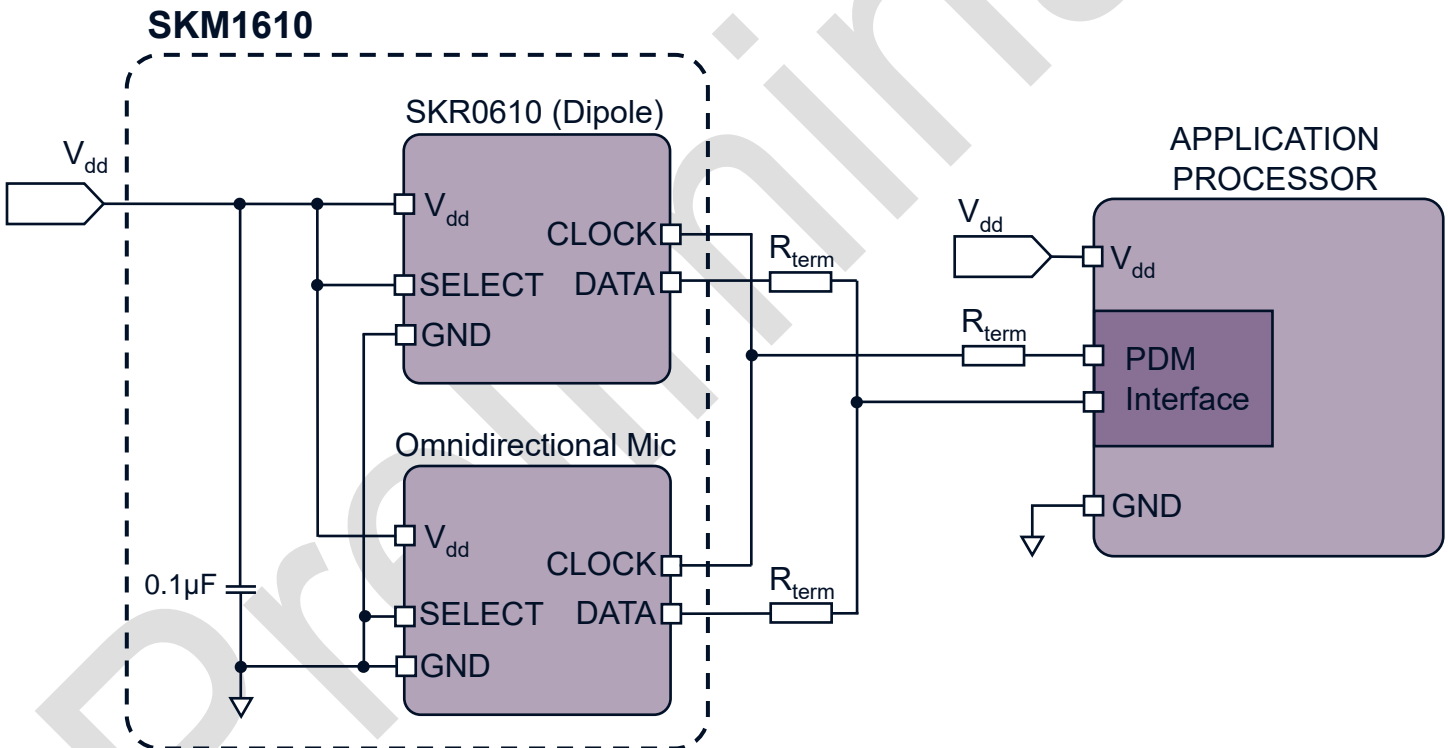


Figure 6.1: Typical stereo application circuit

7. Specifications

Test conditions throughout full datasheet unless otherwise indicated: 25 °C, 55 ± 20% R.H., $V_{dd} = 1.8\text{ V}$, $f_{\text{clock}} = 3.072\text{ MHz}$, $T_{\text{edge}} < 3\text{ ns}$, 3 m away, no load, connector facing toward loudspeaker and defined as 0° (front).

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}	$f_{\text{clock}} = 3.072\text{ MHz}$		1830		μA
	I_{standby}	$f_{\text{clock}} < 0.100\text{ MHz}$		10		
Output Load Capacitance	C_{load}	On DATA pin		200		pF
Clock Duty Cycle		$f_{\text{clock}} < 2.7\text{ MHz}$	45		55	%
		$f_{\text{clock}} \geq 2.7\text{ MHz}$	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 Dipole Microphone Specifications

The SKM1610 incorporates an SKR0610 dipole microphone.

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Pickup Pattern				Dipole		
Polarity		Increasing sound pressure at back (out-of-phase with omnidirectional microphone)		Decreasing density of 1's		
		Increasing sound pressure at front (phase-aligned with omnidirectional microphone)		Increasing density of 1's		
Average Directivity Index		Integrated from 20 Hz to 20 kHz		4.2		dB
Null Angle				90, 270		°
Sensitivity	S	$f_{\text{clock}} \geq 1.536\text{ MHz}$, 94 dB SPL, 1 kHz	-31	-30	-29	dBFS/Pa
		$f_{\text{clock}} = 0.768\text{ MHz}$, 94 dB SPL, 1 kHz	-15	-14	-13	
Noise Floor				-90		dBFS(A)
Signal to Noise Ratio ¹	SNR	20 Hz to 20 kHz, 94 dB SPL		65.5		dB(A)
Total Harmonic Distortion ²	THD	94dB SPL, 1kHz		<0.2		%
		1% THD, 1 kHz		109		
Acoustic Overload Point	AOP	10% THD, 1 kHz		127.5		dB SPL
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 Omnidirectional Microphone Specifications

The SKM1610 incorporates Merry Electronics' MMD201-028 omnidirectional microphone.

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Pickup Pattern			Omnidirectional			
Polarity		Increasing sound pressure at (PCB) port	Increasing density of 1's			
Average Directivity Index		Integrated from 20 Hz to 20 kHz		0.4		dB
Sensitivity	S	94 dB SPL, 1 kHz	-27	-26	-25	dBFS/Pa
Noise Floor				-94		dBFS(A)
Signal to Noise Ratio	SNR	20 Hz to 20 kHz, 94 dB SPL		68		dB(A)
Total Harmonic Distortion	THD	94dB SPL, 1kHz		<0.1		%
		1% THD, 1 kHz		104		dB SPL
Acoustic Overload Point	AOP	10% THD, 1 kHz		127		
Resonant Frequency	Fres			30		kHz
Power Supply Rejection Ratio	PSRR	200 mV _{pp} sine wave on V _{dd} at 1 kHz		54		dB
Power Supply Rejection	PSR+N	200 mV _{pp} 7/8 duty cycle rectangular waveform @ 217 Hz on V _{dd} , A-weighted, BW = 22.4kHz		-82		dBFS

7.4 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 ($\theta = 0^\circ$) 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.

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

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) 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 ($P_{\text{ref}}=20 \mu\text{Pa}$). 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](#).

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

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](#).

7.5 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	$^{\circ}\text{C}$
Operating Temperature	-40 to 85	$^{\circ}\text{C}$

7.6 Performance Curves

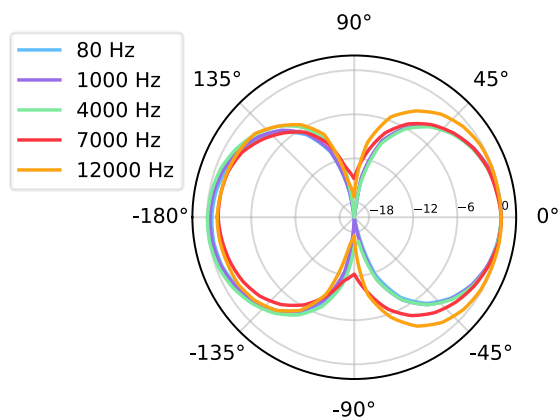


Figure 7.1: Polar pattern (dipole)

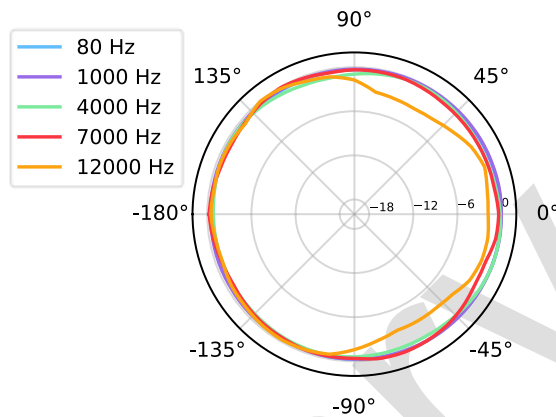


Figure 7.2: Polar pattern (omni)

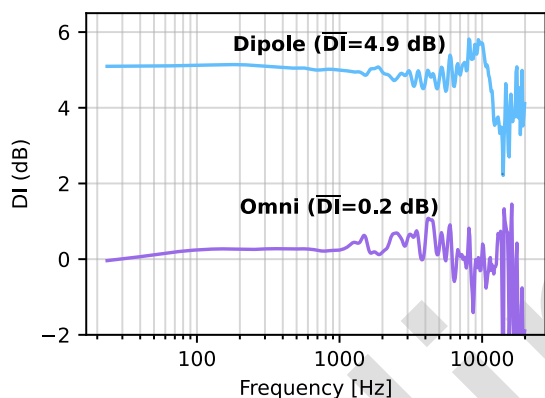


Figure 7.3: Directionality index vs frequency

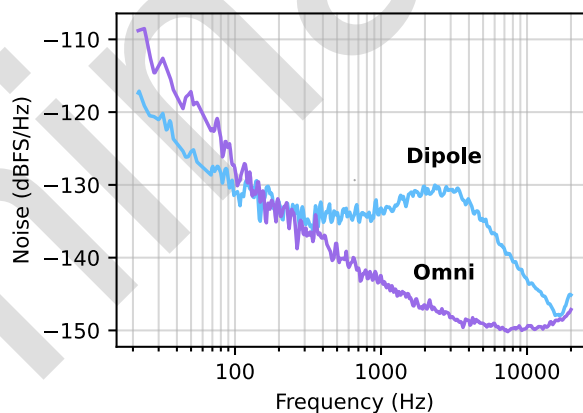


Figure 7.4: Noise floor

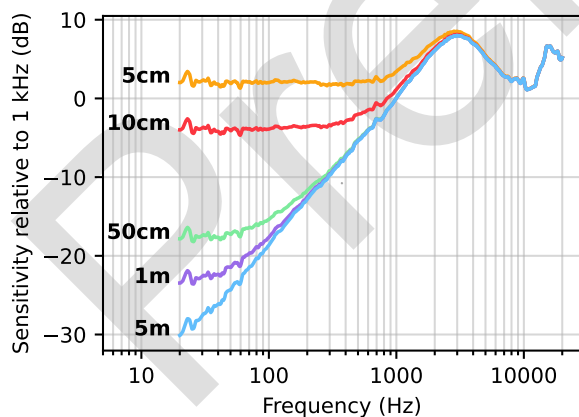


Figure 7.5: Magnitude response³ (dipole)

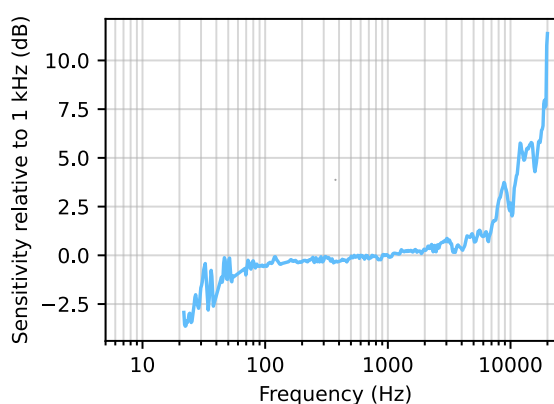


Figure 7.6: Magnitude response (omni)

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

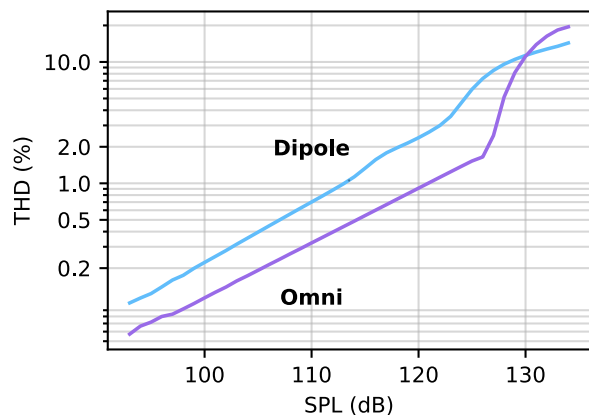


Figure 7.7: 1 kHz THD vs SPL

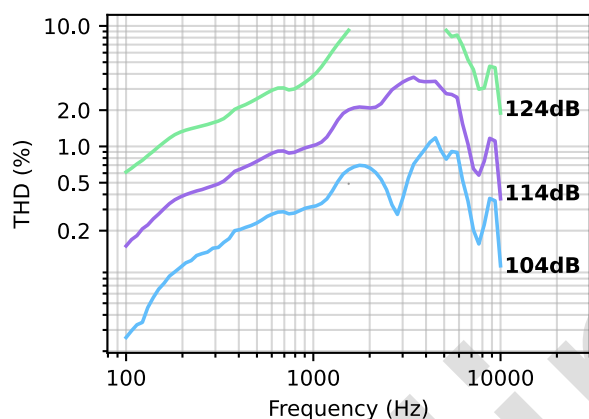


Figure 7.8: THD vs Frequency (dipole)

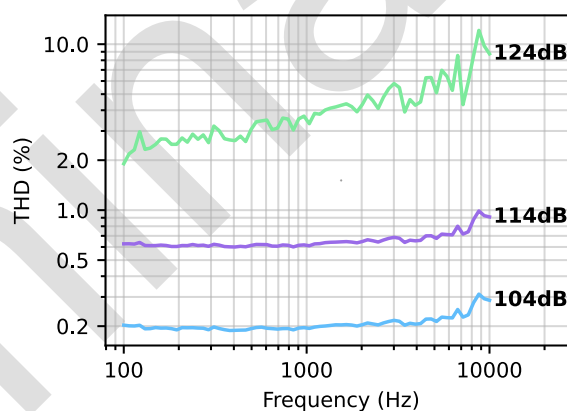


Figure 7.9: THD vs Frequency (omni)

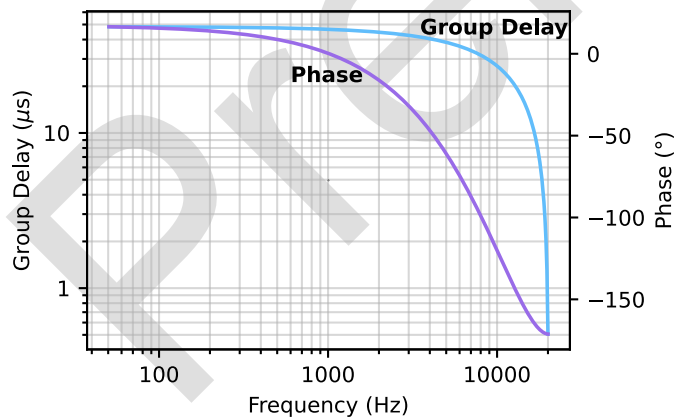


Figure 7.10: Phase and group delay (dipole)

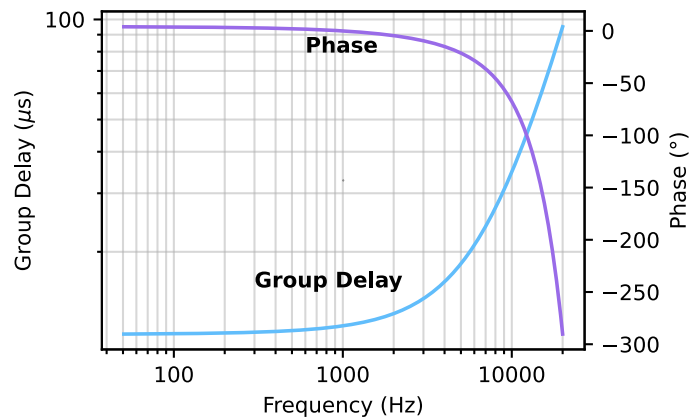


Figure 7.11: Phase and group delay (omni)

8. Mechanical Drawings and Integration Design

8.1 Mechanical Drawings and Pinout

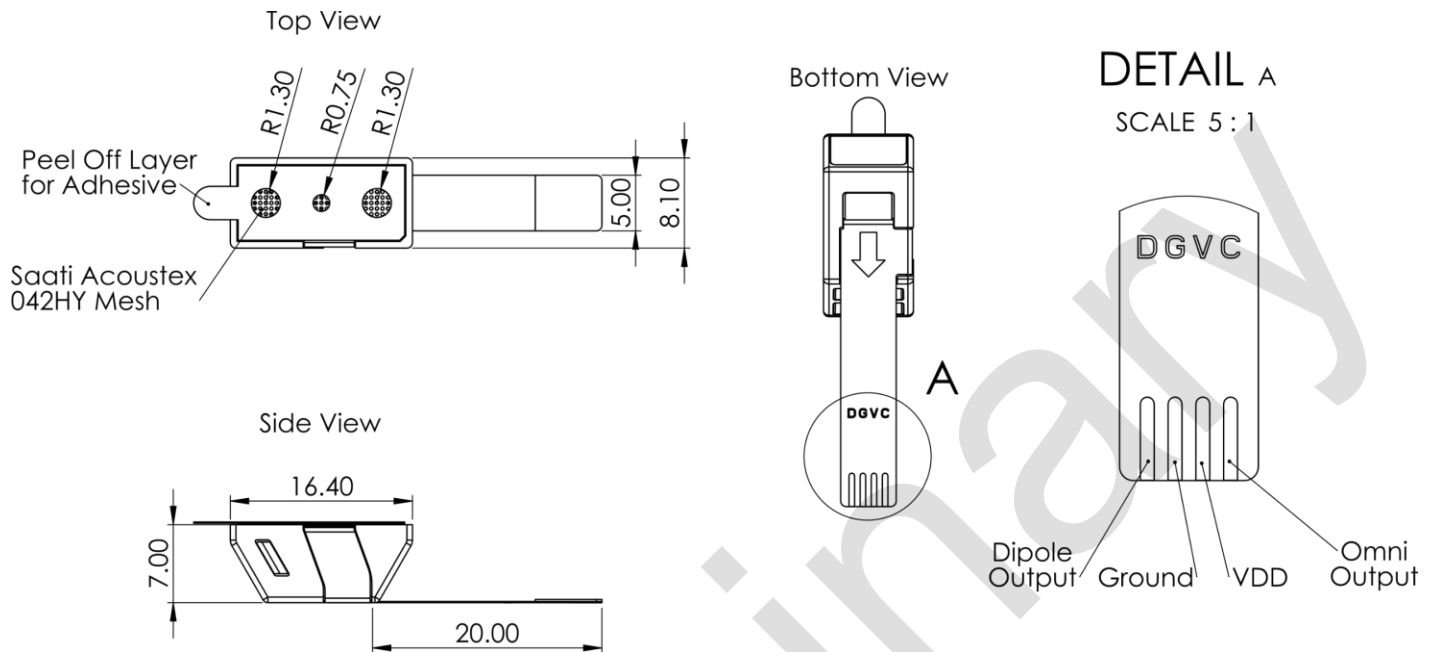


Figure 8.1: Mechanical drawings (mm)

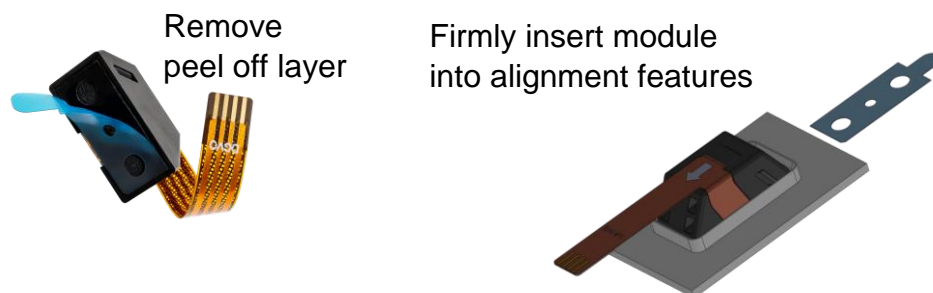
The SKM1610 incorporates a SAATI Acoustex 042HY mesh placed above all acoustic ports for IP57 (ingress and water immersion protection).

8.2 CAD Models

The CAD model for the module is available here: [STEP File](#).

8.3 Installation

The product shell should include two acoustic ports with a diameter $\geq 1.8\text{mm}$ for the dipole microphone and a center port with a diameter $\geq 1\text{mm}$ for the omnidirectional microphone to achieve the specifications listed in this datasheet. The product shell should also include a raised lip that the module fits into to help align the module during installation. To install the SKM1610, remove the peel-off layer to expose the adhesive, then align the module's acoustic ports to the device shell ports and press firmly for a secure acoustic seal. The adhesive will create an acoustic seal between the module ports and the product ports.



8.4 Packaging and Ordering Information

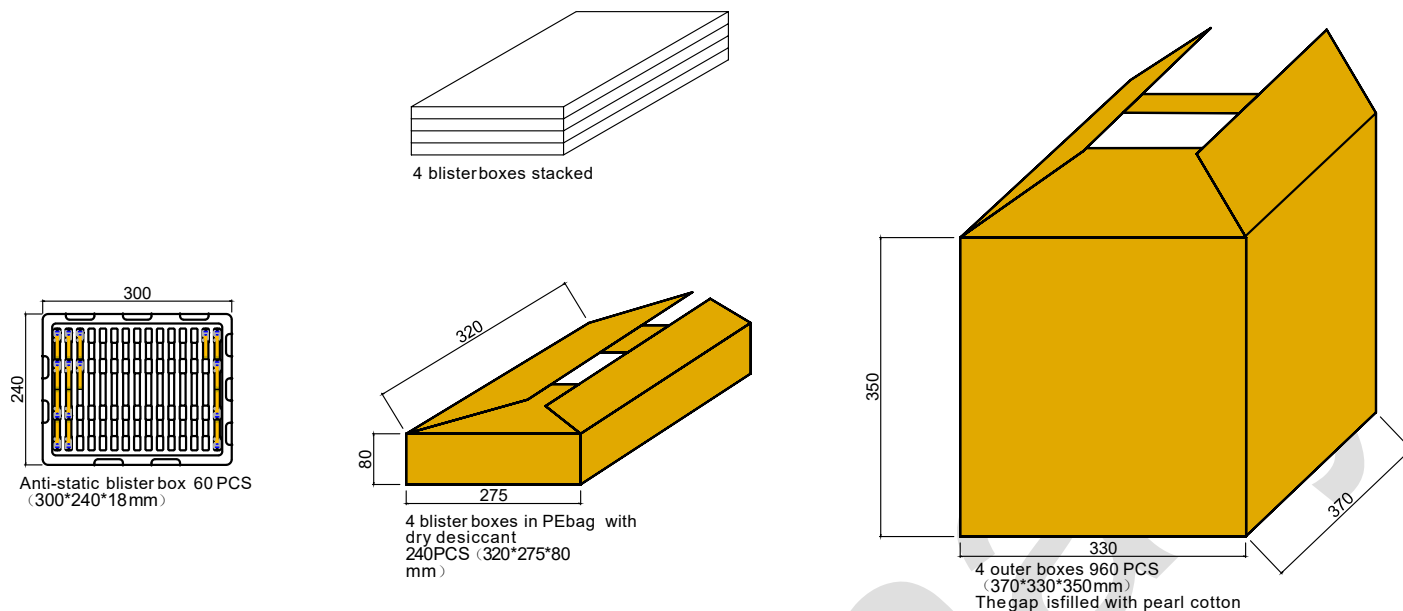


Table 8.4: Ordering Information

Model Number	Quantity per Box
SKM1610	960

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 components themselves have passed the standard microphone reliability tests listed in their respective datasheets ([SKR0610](#) and Merry MMA206-028).

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>.

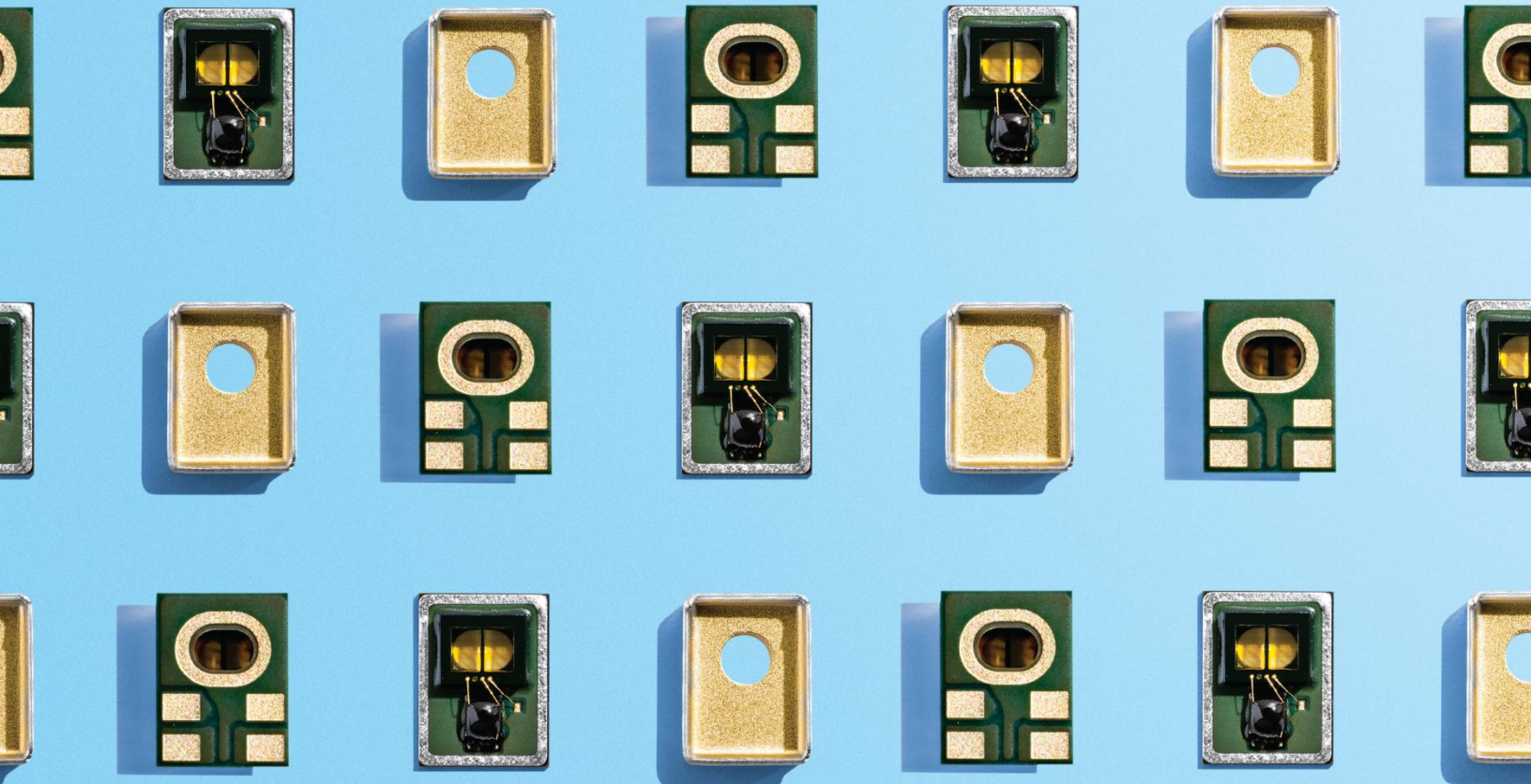
11. Revision History

Revision Label	Revision Date	Sections Revised
-	November 2024	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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