

# Acoustic Interface Design Guide



- MEMS MICROPHONES
- DYNAMIC SPEAKERS
- DYNAMIC RECEIVERS
- BALANCED ARMATURE SPEAKERS
- ELECTRET MICROPHONES
- BOOMS & SENSORS
- ACCELEROMETERS & ACOUSTIC DAMPER SCREENS
- ACOUSTIC SOFTWARE
- TECHNOLOGY BASICS



Discover your next acoustic interface solution.



## We can help

At Knowles, we understand the pace of innovation. Today's product ideas are tomorrow's market realities, and you can depend on us for rapid product ideation, design, development, manufacturing and delivery.



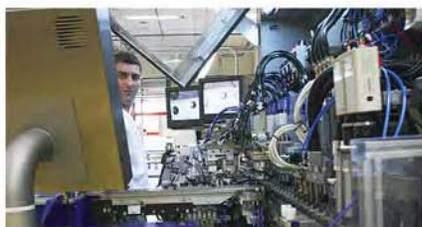
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# you every step of the way.

Knowles offers you a full spectrum of MEMS microphones, balanced armature speakers, dynamic speakers and receivers, specialty microphones, boom assemblies and sensors, custom assemblies, and sound conditioning software.

This application guide will help you select the right acoustic interface solution. It all starts with your application. Or it begins with an idea you may have.

For support from concept to design to sub-assembly, or any step along the way, just visit: [www.knowles.com](http://www.knowles.com)



Founded in 1946, Knowles is the leading supplier of microphones and receivers to the hearing health industry, the #1 supplier of MEMS microphones (SiSonic™), receivers and speakers for mobile devices, and the preferred choice in the professional audio market for balanced armature speakers. We have more than 6,500 employees residing in 17 facilities across 11 countries with 35 years of Asia manufacturing experience. Knowles is owned by the Dover Corporation, a multi-billion dollar diversified global manufacturer of innovative equipment and components, specialty systems and support services.

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# MEMS MICROPHONES

## SiSonic™ MEMS Microphones

Built on our CMOS/MEMS technology platform, the SiSonic™ silicon-based MEMS microphone series is a step ahead of the competition with product shipments exceeding 3 billion units to date. The proven and evolving design series continues to support high-performance, high-density innovation in such applications as cell phones, smart phones, laptop computers, sensors, digital still cameras, portable music players, and other portable electronic devices.

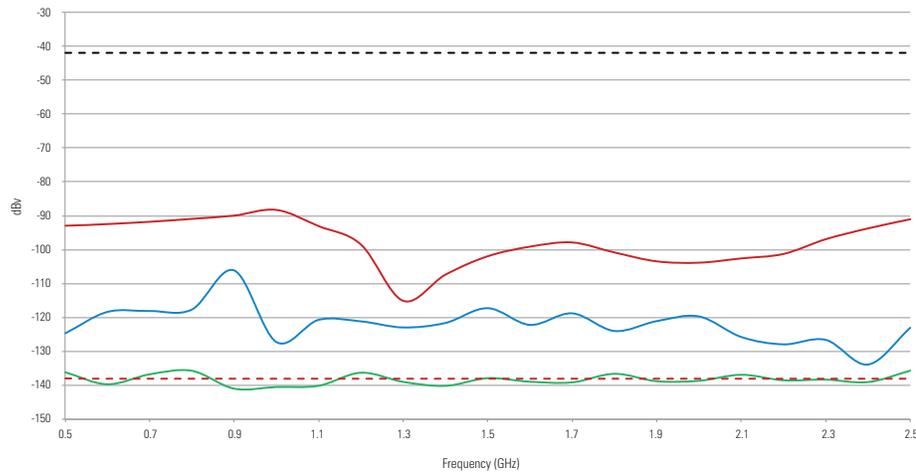
Design variables include ever-smaller sizes, lower profiles and mounting options, increased output capacities, and new digital audio options that eliminate analog noise. For manufacturers, surface mount designs eliminate off-line subassembly production costs. Customized designs are supplied on tape-and-reel and can be run through standard automatic pick-n-place equipment during in-line surface mount manufacturing.

The microphones can also be integrated with our patented IntelliSonic™ software and special porting designs to provide a precisely customized sound.



- MaxRF models eliminate GSM/TDMA burst noise and provide wide-band RF noise suppression
- Slim UltraMini footprint - less than 8.5mm<sup>2</sup> (SPQ Series)
- Integrated designs with differential and ultrasonic outputs
- Zero Height Mic™ for thinnest ever designs

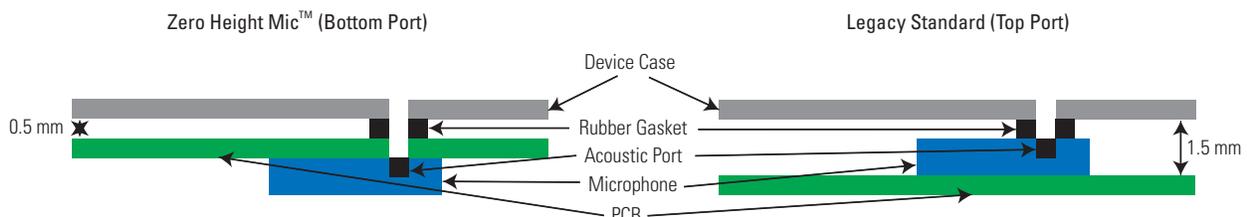
## Typical RF Performance of Microphone Families



| Key | Line Style   | Description |
|-----|--------------|-------------|
|     | Black dashed | Sensitivity |
|     | Red solid    | Standard    |
|     | Blue solid   | Enhanced RF |
|     | Green solid  | MaxRF       |
|     | Red dashed   | Noise Floor |

- **MaxRF:**  
Best in class filtering for RF applications; GSM mobile phones, near-antenna designs
- **Enhanced RF:**  
Good filtering for general RF applications; mobile phones with clean RF designs
- **Standard:**  
Best for non-RF applications; DSC, MP3, headsets

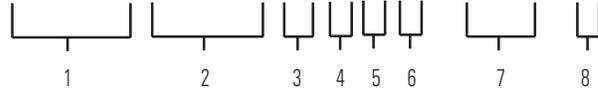
## Port Configurations



Bottom port mounting enables minimum PCB-to-case thickness, simple gasket designs, and best-in-class SNR

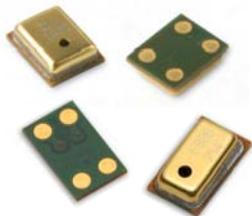
## Part Numbering

### SPU0410HR5H-PB-7



| 1  | 2   | 3                             | 4  | 5   | 6            | 7                                    | 8                                    |
|--|---|-------------------------------|--|---|--------------|--------------------------------------|--------------------------------------|
| Product Description  | Series  | Port Hole Type                | RF Filter  | Supply Voltage                            | Halogen Free | Version                              | Packaging QTY                        |
| SPY: (3.00 x 1.90)<br>SPQ: (3.76 x 2.24)<br>SPU: (3.76 x 2.95)<br>SPM: (4.72 x 3.76)<br>SPA: (3.35 x 2.50)<br>SPK: (4.00 x 3.00) | 0406: Differential<br>0409: Unity Gain<br>0410: Unity Gain<br>0414: Amplified<br>0415: Digital<br>0423: Digital<br>0824: Unity Gain<br>0833: Digital<br>1410: Unity Gain<br>1423: Digital<br>2410: Unity Gain | H: Top Port<br>L: Bottom Port | D: Standard<br>E: Enhanced<br>M: Enhanced<br>R: MAX-RF | 3: 1.5-5.5V<br>4: 1.6-3.6V<br>5: 1.5-3.6V |              | Knowles Internal<br>(Reference Only) | Product Specific<br>(Reference Only) |

## Top Port Analog

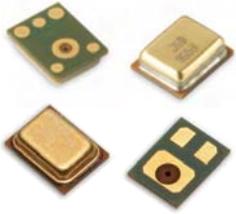


- SPU and SPQ (less than 8.5mm<sup>2</sup>) footprints are ideal for multiple microphone applications
- MaxRF technology provides wideband noise suppression, for compact devices with challenging routing and layouts
- All SiSonic™ microphones are designed with leading-edge MEMS technology for stable acoustic performance under extreme conditions such as high temperature, shock, and vibration

| Model       | Description | Size (mm)          | Supply Voltage (min-max) | RF Immunity | Sensitivity @1kHz (dBV/Pa) | Output Impedance (Ohms) | Maximum Current Drain (mA) |
|-------------|-------------|--------------------|--------------------------|-------------|----------------------------|-------------------------|----------------------------|
| SPQ0410HR5H | Unity Gain  | 3.76 x 2.24 x 1.10 | 1.5 to 3.6v              | MaxRF       | -42.0                      | <400                    | <0.25                      |
| SPQ2410HR5H | Unity Gain  | 3.76 x 2.24 x 1.10 | 1.5 to 3.6v              | MaxRF       | -42.0                      | <400                    | <0.25                      |
| SPU0409HD5H | Unity Gain  | 3.76 x 2.95 x 0.90 | 1.5 to 3.6v              | Standard    | -42.0                      | <100                    | <0.19                      |
| SPU0410HR5H | Unity Gain  | 3.76 x 2.95 x 1.10 | 1.5 to 3.6v              | MaxRF       | -42.0                      | <400                    | <0.16                      |
| SPU0414HR5H | Amplified   | 3.76 x 2.95 x 1.10 | 1.5 to 3.6v              | MaxRF       | -22.0                      | <400                    | <0.22                      |
| SPUL409HE5H | Unity Gain  | 3.76 x 2.95 x 1.10 | 1.5 to 3.6v              | Enhanced    | -42.0                      | <300                    | <0.19                      |

# MEMS MICROPHONES

## Bottom Analog

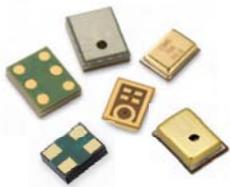


- SPU and SPA (less than 8.5mm<sup>2</sup>) footprints are ideal for multiple microphone applications
- SiSonic™ Zero Height Mic™ shrinks product thickness by up to 30%
- Minimizes the distance between PCB and device housing
- Enables the thinnest, highest density product designs

| Model        | Description  | Size (mm)          | Supply Voltage (min-max) | RF Immunity | Sensitivity @1kHz (dBV/Pa) | Output Impedance (Ohms) | Maximum Current Drain (mA) |
|--------------|--------------|--------------------|--------------------------|-------------|----------------------------|-------------------------|----------------------------|
| SPY0824LR5H  | Unity Gain   | 3.00 x 1.9 x 0.90  | 1.5 to 3.6v              | MaxRF       | -38.0                      | <400                    | <0.16                      |
| SPA2410LR5H  | Unity Gain   | 3.35 x 2.50 x 0.98 | 1.5 to 3.6v              | MaxRF       | -38.0                      | <400                    | <0.25                      |
| SPU0409LE5H  | Unity Gain   | 3.76 x 3.00 x 1.10 | 1.5 to 3.6v              | Enhanced    | -38.0                      | <200                    | <0.25                      |
| SPU0410LR5H* | Unity Gain   | 3.76 x 3.00 x 1.10 | 1.5 to 3.6v              | MaxRF       | -38.0                      | <400                    | <0.25                      |
| SPU1410LR5H  | Unity Gain   | 3.76 x 3.00 x 1.10 | 1.5 to 3.6v              | MaxRF       | -38.0                      | <400                    | <0.25                      |
| SPM0406HE3H  | Differential | 4.72 x 3.76 x 1.25 | 1.5 to 5.5v              | Enhanced    | -22.0                      | <500                    | <0.50                      |

\*Extended frequency response for ultrasonic applications

## Digital



- Helps reduce system noise on audio signal lines
- Easier, faster to route and layout digital traces without signal corruption
- Digital PDM (Pulse Density Modulation) output available, with integrated sleep mode and compatible with stereo input applications

| Model       | Description | Size (mm)          | Supply Voltage (min-max) | RF Immunity      | Sensitivity (dBFS/Pa) | Output Impedance (Ohms) | Maximum Current Drain (mA) |
|-------------|-------------|--------------------|--------------------------|------------------|-----------------------|-------------------------|----------------------------|
| SPK0833LM4H | Digital     | 4.00 x 3.00 x 1.00 | 1.6 to 3.6v              | Digital MaxRF    | -26.0                 | 160pf<br>Maximum Load   | <0.70                      |
| SPK0415HM4H | Digital     | 4.00 x 3.00 x 1.06 | 1.6 to 3.6v              | Digital Enhanced | -26.0                 | 100pf<br>Maximum Load   | <0.65                      |
| SPM0423HD4H | Digital     | 4.72 x 3.76 x 1.25 | 1.6 to 3.6v              | Digital Standard | -26.0                 | 100pf<br>Maximum Load   | <0.60                      |
| SPM0423HE4H | Digital     | 4.72 x 3.76 x 1.25 | 1.6 to 3.6v              | Digital Enhanced | -26.0                 | 100pf<br>Maximum Load   | <0.60                      |
| SPM0423HM4H | Digital     | 4.72 x 3.76 x 1.25 | 1.6 to 3.6v              | Digital Enhanced | -26.0                 | 100pf<br>Maximum Load   | <0.60                      |
| SPM1423HM4H | Digital     | 4.72 x 3.76 x 1.25 | 1.6 to 3.6v              | MaxRF            | -22.0                 | 100pf<br>Maximum Load   | <0.60                      |

# DYNAMIC SPEAKERS

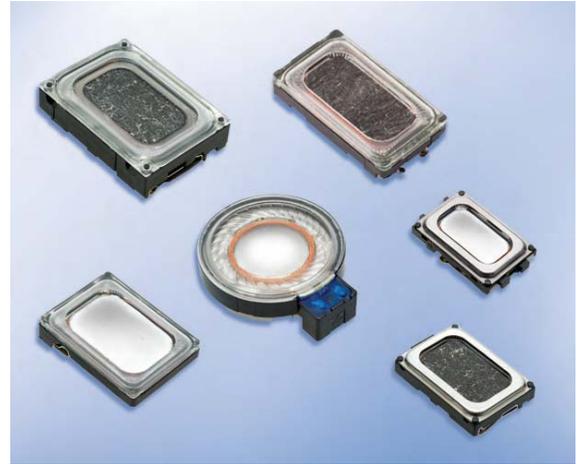
## Dynamic Speakers

Knowles dynamic speakers are designed to maximize space efficiency and provide superior audio performance for voice and music in small, slim consumer devices, such as mobile handsets or smartphones.

Knowles dynamic speakers are available in various sizes and performance levels, which can be customized to meet your specific requirements. Dedicated support is provided to realize the optimal sound performance in your application.

To assure the highest quality standards, the speakers are manufactured in a process that uses 100% in-line measurement of all specified acoustical and electrical parameters.

- High quality and robustness
- Maximized space efficiency
- Excellent audio performance-to-size ratio
- Optimized for all mobile sound applications (handsfree and ringtone)
- Multi-functional devices including vibration
- Dedicated application support

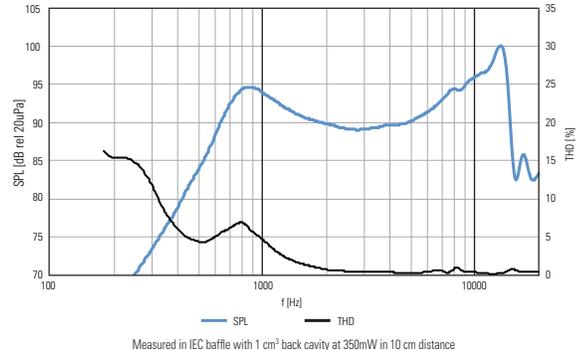


## DONAU – 11 x 15 x 3.5 (mm)

Typical applications: mobile phones, music phones, stereo solutions.



- Industry reference standard
- Compound membrane for minimum THD, Q-factor and tumbling
- Very good performance/price ratio
- Pre-loaded springs for mechanical robustness and easy handling



| Model          | Sensitivity (W/m)* | Air Pumping Capacity | Typical Backvolume (total volume)         | f0 (in typical backvolume) | Frequency Range (Hz)** | Nominal Power*** | SPL Max (@ max sine power)**** |
|----------------|--------------------|----------------------|---|----------------------------|------------------------|------------------|--------------------------------|
| 2403 260 00001 | 73 dB              | 69 mm <sup>3</sup>   | 1 cm <sup>3</sup> (1.57 cm <sup>3</sup> ) | 800 Hz                     | 650 – 16000            | 500 mW           | 89 dB (350 mW)                 |

Note: Impedance of all speaker devices is typically 8 ohms, all components feature contact springs except where otherwise noted

\* average value measured in baffle

\*\* in front firing application without mesh, at -3dB points after resonance peaks, without EQ correction

\*\*\* using noise shaped signal according to product data sheet

\*\*\*\* average value measured in baffle in 0.1 meter distance at max sine power, in typical backvolume

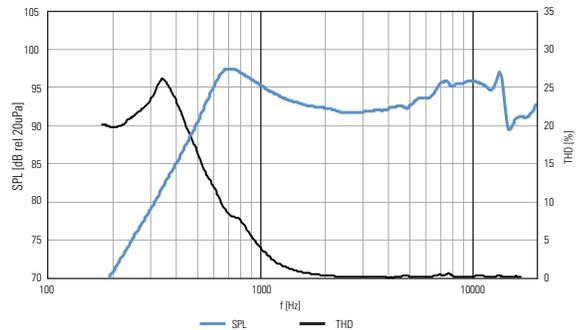
# DYNAMIC SPEAKERS

## DUMBO – 13 x 18 x 4.5 (mm)

Typical applications: waterproof, large bandwidth music and smart phones.



- Optimized for extended low frequencies through ultra-high excursion
- IPx7 waterproof standard compliant
- Unique Knowles silicone membrane providing minimum THD, Q-factor and tumbling
- Increased power-handling capacity
- Pre-loaded springs for mechanical robustness and easy handling



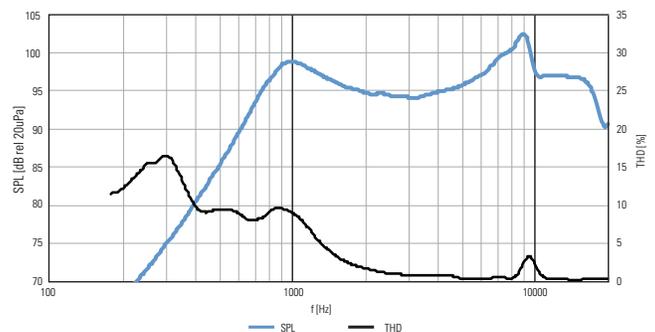
| Model          | Sensitivity (W/m)* | Air Pumping Capacity | Typical Backvolume (total volume)         | f0 (in typical backvolume) | Frequency Range (Hz)** | Nominal Power*** | SPL Max (@ max sine power)**** |
|----------------|--------------------|----------------------|---|----------------------------|------------------------|------------------|--------------------------------|
| 2403 260 00057 | 73 dB              | 140 mm <sup>3</sup>  | 1 cm <sup>3</sup> (2.05 cm <sup>3</sup> ) | 650 Hz                     | 500 - 16000            | 700 mW           | 91.5 dB (700 mW)               |

## SAMBO – 13 x 18 x 4.5 (mm)

Typical applications: multimedia and smartphones.



- Optimized for maximum SPL
- Compound membrane for minimum THD, Q-factor and tumbling
- Increased power-handling capacity
- Pre-loaded springs for mechanical robustness and easy handling



| Model          | Sensitivity (W/m)* | Air Pumping Capacity | Typical Backvolume (total volume)         | f0 (in typical backvolume) | Frequency Range (Hz)** | Nominal Power*** | SPL Max (@ max sine power)**** |
|----------------|--------------------|----------------------|---|----------------------------|------------------------|------------------|--------------------------------|
| 2403 260 00058 | 77 dB              | 100 mm <sup>3</sup>  | 1 cm <sup>3</sup> (2.05 cm <sup>3</sup> ) | 900 Hz                     | 700 – 16000            | 700 mW           | 95.5 dB (700 mW)               |

Note: Impedance of all speaker devices is typically 8 ohms, all components feature contact springs except where otherwise noted

\* average value measured in baffle

\*\* in front firing application without mesh, at -3dB points after resonance peaks, without EQ correction

\*\*\* using noise shaped signal according to product data sheet

\*\*\*\* average value measured in baffle in 0.1 meter distance at max sine power, in typical backvolume

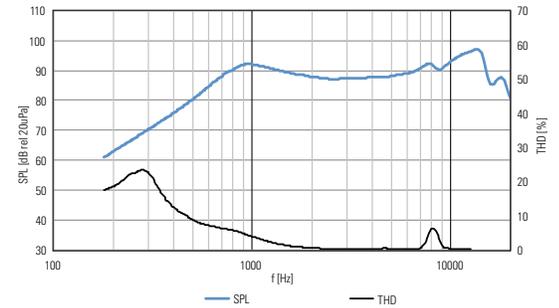
# DYNAMIC SPEAKERS

## FOX – 9 x 16 X 3.0 (mm)

Typical applications: multimedia phones.



- Easy mechanical integration due to small width
- Compound membrane for minimum THD, Q-factor and tumbling



Measured in IEC baffle at 500mW in 10 cm distance with 1 cm back cavity

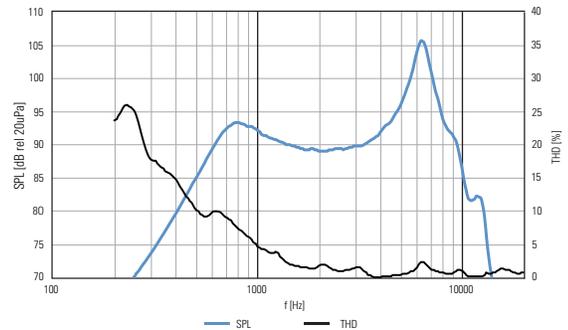
| Model          | Sensitivity (W/m)* | Air Pumping Capacity | Typical Backvolume (total volume)         | f <sub>0</sub> (in typical backvolume) | Frequency Range (Hz)** | Nominal Power*** | SPL Max (@ max sine power)**** |
|----------------|--------------------|----------------------|---|--|------------------------|------------------|--------------------------------|
| 2403 260 00086 | 70.5 dB            | 55 mm <sup>3</sup>   | 1 cm <sup>3</sup> (1.43 cm <sup>3</sup> ) | 850 Hz                                 | 700 - 20000            | 500 mW           | 86.5 dB (500 mW)               |

## NAUTILUS 180 – 11 x 15 x 4.0 (mm)

Typical applications: lateral sound outlets.



- Lateral sound outlet integrated in cover of speaker
- Significant height reduction for side-firing applications
- Based on mature 11 x 15 x 3.5 speaker
- Also available as NAUTILUS with sound outlets on opposite side (2403 260 00085)
- Pre-loaded springs for mechanical robustness and easy handling



Measured in IEC baffle at 700mW in 10 cm distance with 1 cm back cavity

| Model          | Sensitivity (W/m)* | Air Pumping Capacity | Typical Backvolume (total volume)         | f <sub>0</sub> (in typical backvolume) | Frequency Range (Hz)** | Nominal Power*** | SPL Max (@ max sine power)**** |
|----------------|--------------------|----------------------|---|--|------------------------|------------------|--------------------------------|
| 2403 260 00089 | 73 dB              | 69 mm <sup>3</sup>   | 1 cm <sup>3</sup> (1.66 cm <sup>3</sup> ) | 750 Hz                                 | 650 - 12000            | 500 mW           | 89 dB (350 mW)                 |

Note: Impedance of all speaker devices is typically 8 ohms, all components feature contact springs except where otherwise noted

\* average value measured in baffle

\*\* in front firing application without mesh, at -3dB points after resonance peaks, without EQ correction

\*\*\* using noise shaped signal according to product data sheet

\*\*\*\* average value measured in baffle in 0.1 meter distance at max sine power, in typical backvolume

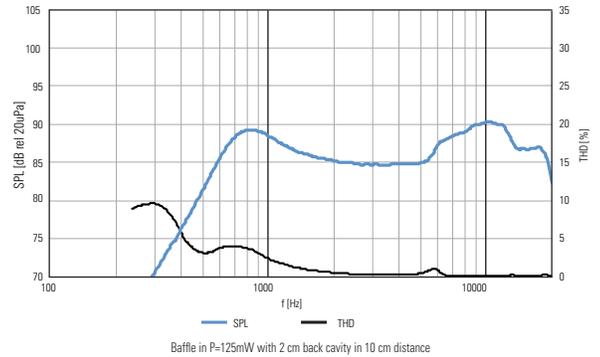
# DYNAMIC SPEAKERS

## MFD16 – 16 x 4.7 (mm)

Typical applications: vibrator, speaker and receiver combined.



- Usage as speaker/receiver/vibrator or speaker/vibrator
- Built-in vibrator saves cost
- Spring contacts for firm connection



| Model          | Sensitivity (W/m)* | Air Pumping Capacity | Typical Backvolume (total volume)         | f0 (in typical backvolume) | Frequency Range (Hz)** | Nominal Power*** | SPL Max (@ max sine power)**** |
|----------------|--------------------|----------------------|---|----------------------------|------------------------|------------------|--------------------------------|
| 2403 263 00077 | 74 dB              | 90 mm <sup>3</sup>   | 2 cm <sup>3</sup> (2.93 cm <sup>3</sup> ) | 740 Hz                     | 650 - 15000            | 500 mW           | 91 dB (500 mW)                 |

## Speaker Boxes

Speaker Boxes are designed for mobile phones, tablets and other consumer electronics. Knowles develops and manufactures integrated acoustic modules which are fully customized and provide an optimized acoustic design for any form factor.

- OEM/ODM solutions
- Optimized acoustic design
- Passive/Active
- Custom designed



Note: Impedance of all speaker devices is typically 8 ohms, all components feature contact springs except where otherwise noted  
 \* average value measured in baffle  
 \*\* in front firing application without mesh, at -3dB points after resonance peaks, without EQ correction  
 \*\*\* using noise shaped signal according to product data sheet  
 \*\*\*\* average value measured in baffle in 0.1 meter distance at max sine power, in typical backvolume

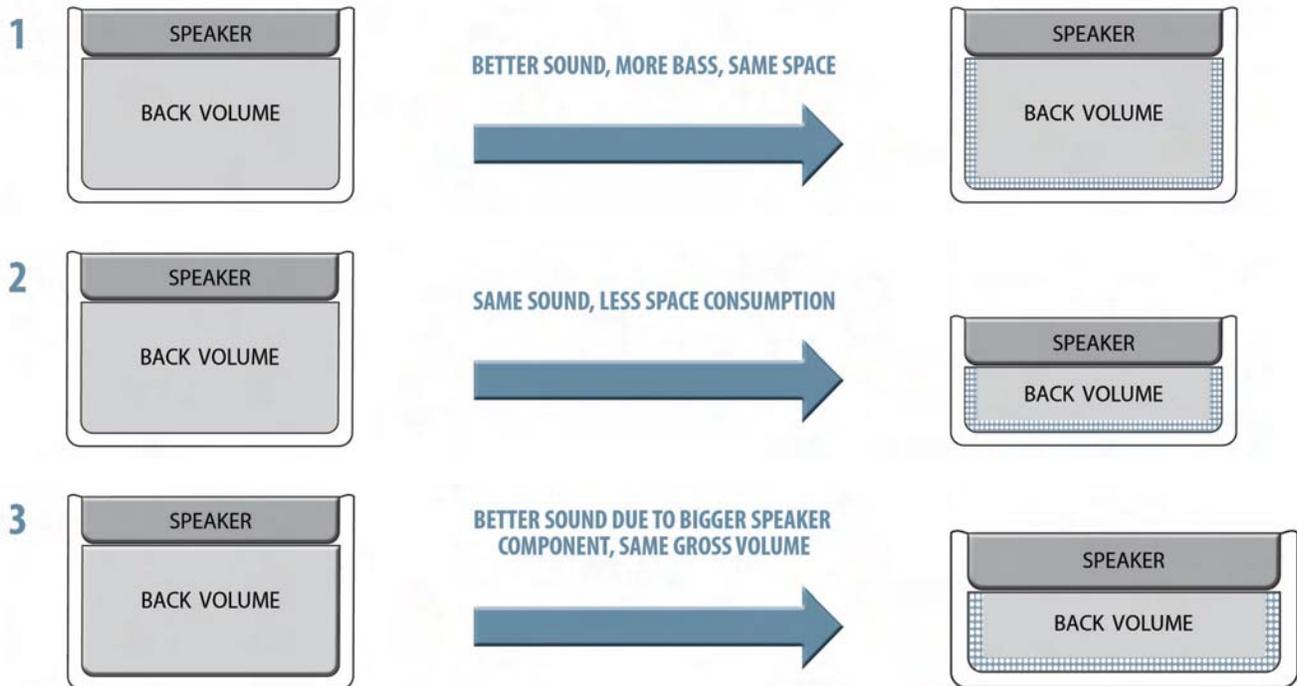
## N'Bass™ Virtual Back Volume Technology

N'Bass™ stands for "enhanced bass" and is a unique sound enhancing technology for miniaturized speaker systems developed by Knowles. Knowles is the only supplier who offers this specific technology for miniaturized speaker systems. N'Bass™ is a special material which increases the back volume seen by the speaker by up to 100% thus enabling either a better acoustic performance – specifically more bass – or smaller speaker box designs. It also enables the usage of bigger speakers with the same gross application volume. The N'Bass™ material has no negative influence on antenna performance compared to conventional materials.



**n'bass™**

## Speaker Design Options



# DYNAMIC RECEIVERS

## Dynamic Receivers

Knowles dynamic receivers are designed to maximize space efficiency and provide superior audio performance for voice and music in small, slim consumer devices, such as mobile handsets or smartphones.

Knowles dynamic receivers are available in various sizes and performance levels, which can be customized to meet your specific requirements. Dedicated support is provided to realize the optimal sound performance in your application.

To assure the highest quality standards, the receivers are manufactured in a process that uses 100% in-line measurement of all specified acoustical and electrical parameters.

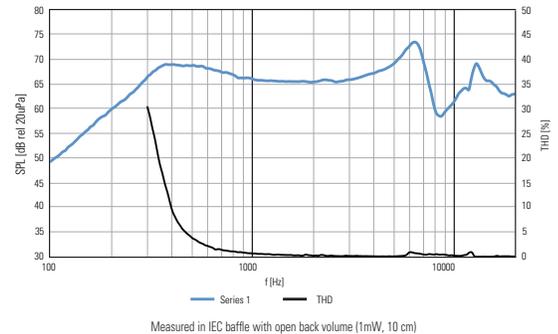
- High quality and robustness
- Maximized space efficiency
- Excellent audio performance-to-size ratio
- Optimized for all mobile sound applications (handsfree and ringtone)
- Multi-functional devices including vibration
- Dedicated application support



## PETRA – 8 x 12 x 2 (mm)

Typical applications: flat phones, hearing aid compatibles, wide band in hi-leak applications.

- Designed for 3GPP wide band
- 6 kHz peak optimized for extended range without additional resonators
- Hearing Aid Compatibility (HAC) according to ANSI C63.19-2006
- Pre-loaded spring contacts for pick & place with mounting possibility for flexprint
- Compound membrane for minimum THD, Q-factor and tumbling



| Model          | Sensitivity (W/m)* | Air Pumping Capacity | f <sub>0</sub> | Frequency Range (Hz)** | Maximum Sine Power | SPL Max (@ max sine power)*** |
|----------------|--------------------|----------------------|----------------|------------------------|--------------------|-------------------------------|
| 2403 260 00031 | 68 dB              | 20 mm <sup>3</sup>   | 350 Hz         | 300 - 7000             | 5 mW               | 110 dB                        |

Note: Impedance of all receiver devices is typically 32 ohms, all components feature contact springs except where otherwise noted  
 \* average value measured in baffle, subtract 10dB for value in dB/mW/0.1m  
 \*\* in typical application, at -3dB points after resonance peaks, without EQ correction  
 \*\*\* measured at 1 kHz in 3.2 high leak adapter

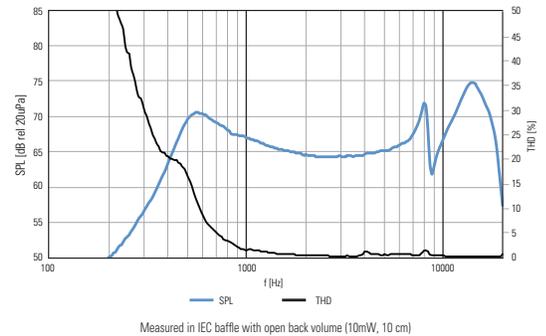
# DYNAMIC RECEIVERS

## M-STOUT – 4.8 x 10 x 2.2 (mm)

Typical applications: smartphones, small application space.



- World's smallest telecom receiver
- Integrated dust mesh for dust protection
- Integrated mounting parts for space positioning and/or flexprint connection
- Pre-loaded springs for mechanical robustness and easy handling



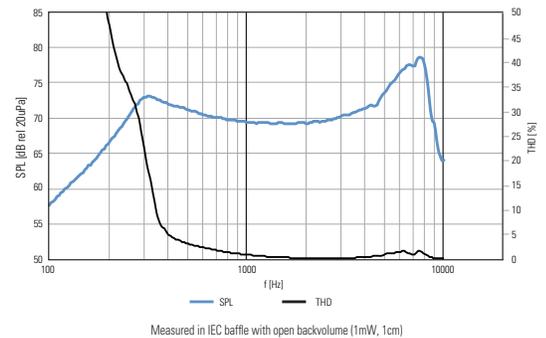
| Model          | Sensitivity (W/m)* | Air Pumping Capacity | f0     | Frequency Range (Hz)** | Maximum Sine Power | SPL Max (@ max sine power)*** |
|----------------|--------------------|----------------------|--------|------------------------|--------------------|-------------------------------|
| 2403 260 00041 | 65 dB              | 9 mm <sup>3</sup>    | 520 Hz | 450 - 8000             | 10 mW              | 110 dB                        |

## ZWEIGELT – 8 x 15 x 2.5 (mm)

Typical applications: wide-band, hearing aid compatibles, extended bass in hi-leak applications.



- Designed for 3GPP wide band with extended bass response in high leak applications
- Very high air pumping capacity
- Hearing Aid Compatibility (HAC) according to ANSI C63.19-2006
- 7 kHz peak optimized for extended range without additional resonators
- Compound membrane for minimum THD, Q-factor and tumbling



| Model          | Sensitivity (W/m)* | Air Pumping Capacity | f0     | Frequency Range (Hz)** | Maximum Sine Power | SPL Max (@ max sine power)*** |
|----------------|--------------------|----------------------|--------|------------------------|--------------------|-------------------------------|
| 2403 260 00045 | 69 dB              | 36 mm <sup>3</sup>   | 300 Hz | 160 – 7000             | 10 mW              | 114 dB                        |

Note: Impedance of all receiver devices is typically 32 ohms, all components feature contact springs except where otherwise noted  
 \* average value measured in baffle, subtract 10dB for value in dB/mW/0.1m  
 \*\* in typical application, at -3dB points after resonance peaks, without EQ correction  
 \*\*\* measured at 1 kHz in 3.2 high leak adapter

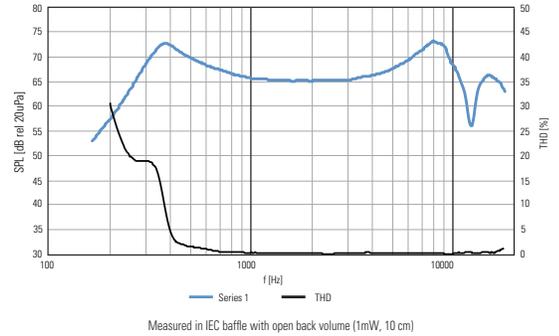
# DYNAMIC RECEIVERS

## LEAN – 6 x 12 x 2 (mm)

Typical applications: flat phones, hearing aid compatibles, extended range in hi-leak applications.



- Designed for 3GPP wide band
- 6 kHz peak optimized for extended range without additional resonators
- Hearing Aid Compatibility (HAC) according to ANSI C63.19-2006
- Pre-loaded spring contacts for pick&place with mounting possibility for flexprint
- Compound membrane for minimum THD, Q-factor and tumbling



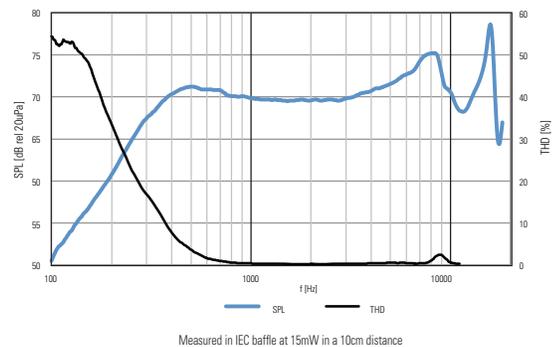
| Model          | Sensitivity (W/m)* | Air Pumping Capacity | f <sub>0</sub> | Frequency Range (Hz) ** | Maximum Sine Power | SPL Max (@ max sine power)*** |
|----------------|--------------------|----------------------|----------------|-------------------------|--------------------|-------------------------------|
| 2403 260 00051 | 65 dB              | 20 mm <sup>3</sup>   | 350 Hz         | 300 - 7000              | 10 mW              | 110 dB                        |

## COLEMAN 350 – 6 x 15 x 2 (mm)

Typical applications: flat phones, smartphones, hearing aid compatibles.



- Designed for 3GPP wideband
- Hearing Aid Compatibility (HAC) according to ANSI C63.19-2006
- Pre-loaded spring contacts for better handling and positioning
- Integrated rear mesh for dust protection, front mesh on request
- Also available with f<sub>0</sub>=300Hz as COLEMAN 300 (2403 260 00097)



| Model Id       | Sensitivity (W/m)* | Air Pumping Capacity | f <sub>0</sub> | Frequency Range (Hz)** | Maximum Sine Power | SPL Max (@ max sine power)*** |
|----------------|--------------------|----------------------|----------------|------------------------|--------------------|-------------------------------|
| 2403 260 00096 | 68 dB              | 28 mm <sup>3</sup>   | 350 Hz         | 300-7000               | 15 mW              | 115 dB                        |

Note: Impedance of all receiver devices is typically 32 ohms, all components feature contact springs except where otherwise noted  
 \* average value measured in baffle, subtract 10dB for value in dB/mW/0.1m  
 \*\* in typical application, at -3dB points after resonance peaks, without EQ correction  
 \*\*\* measured at 1 kHz in 3.2 high leak adapter

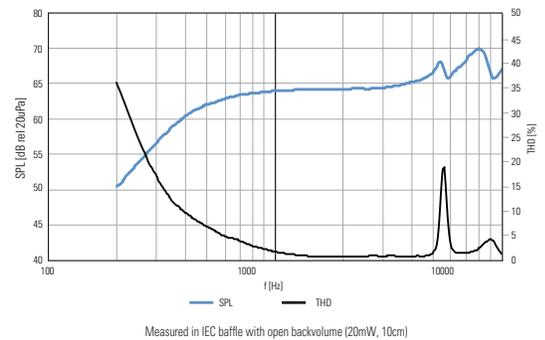
# DYNAMIC RECEIVERS

## JULIA HAC – 6 x 15 x 2.5 (mm)

Typical applications: mobile phones, hearing aid compatibles



- High Sensitivity
- Spring contacts for pick & place
- With integrated HAC coil in parallel (16 ohms total impedance)
- Also available in 32 ohms without HAC coil (2403 263 00047)



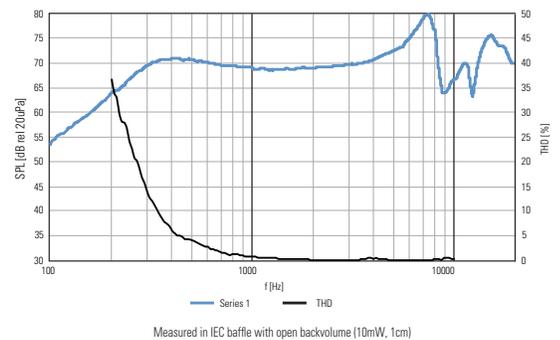
| Model Id       | Sensitivity (W/m)* | Air Pumping Capacity | f0     | Frequency Range (Hz)** | Maximum Sine Power | SPL Max (@ max sine power)*** |
|----------------|--------------------|----------------------|--------|------------------------|--------------------|-------------------------------|
| 2403 263 00052 | 70 dB              | 16 mm <sup>3</sup>   | 450 Hz | 400-4000               | 20 mW              | 111.5 dB                      |

## NITH – 8 x 15 x 1.5 (mm)

Typical applications: wide-band, hearing aid compatibles, extended bass in low-leak applications.



- Designed for 3GPP wide band with extended bass response in low leak applications
- Hearing Aid Compatibility (HAC) according to ANSI C63.19-2006
- 7 kHz peak optimized for extended range without additional resonators
- Triple magnet for high sensitivity



| Model Id       | Sensitivity (W/m)* | Air Pumping Capacity | f0     | Frequency Range (Hz)** | Maximum Sine Power | SPL Max (@ max sine power)*** |
|----------------|--------------------|----------------------|--------|------------------------|--------------------|-------------------------------|
| 2403 263 00092 | 69 dB              | 25 mm <sup>3</sup>   | 300 Hz | 160 - 7000             | 10 mW              | 114 dB                        |

Note: Impedance of all receiver devices is typically 32 ohms, all components feature contact springs except where otherwise noted  
 \* average value measured in baffle, subtract 10dB for value in dB/mW/0.1m  
 \*\* in typical application, at -3dB points after resonance peaks, without EQ correction  
 \*\*\* measured at 1 kHz in 3.2 high leak adapter

# BALANCED ARMATURE SPEAKERS

## Balanced Armature Speakers

Knowles sub-miniature speaker designs are based on balanced armature technology (BAX) and are utilized in a variety of high performance audio and communication products. Knowles balanced armature speakers are available in several sizes and efficiencies, which can be finely tuned to meet your specific performance requirements. They are designed for use in in-ear applications, including earphones and communication earpieces, or be sub-assembled by Knowles for premium consumer electronics accessories.

- High efficiency, stability and reliability
- Customizable performance and port locations
- Ideal for premium in-ear designs
- Component and subassembly solutions

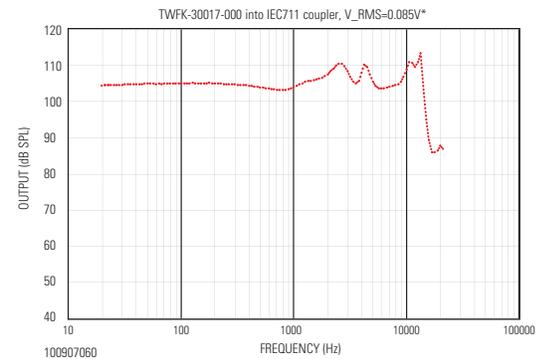


### TWFK SERIES – Dual Balanced Armature Speaker 5.00 x 2.73 x 3.86 (mm)

One of the smallest dual balanced armature speakers, the TWFK is designed for pro-audio in-ear applications. Enables customized cross-over systems to achieve target frequency response in a package size smaller than the ED Series.



- Single sound port for simplified earphone design
- Extreme wideband frequency response
- Unique woofer/tweeter combination
- Enables leading-edge earphone designs for miniature size and performance



| Model          | Port Location | Sensitivity @ 1kHz (dB SPL) | Sensitivity @ 1st Peak (dB SPL) | DC Resistance (Ohms) | Impedance @ 500 Hz (Ohms) |
|----------------|---------------|-----------------------------|---------------------------------|----------------------|---------------------------|
| TWFK-30017-000 | 12S           | 95                          | 103                             | 25                   | 31                        |

### FK/DFK SERIES – Balanced Armature Speaker 5.00 x 2.73 x 1.93 (mm) (FK), 5.00 X 2.73 X 3.86 (mm) (DFK)

One of the smallest balanced-armature speakers, the FK Series is designed for applications where size is the most important design concern.



- Two-terminal zero-bias configuration
- Undamped, screen damped, and internally damped responses
- Wide range of coil impedances
- DFK model is a dual FK



| Model         | Port Location | Sensitivity @ 1kHz (dB SPL) | Sensitivity @ 1st Peak (dB SPL) | DC Resistance (Ohms) | Impedance @ 500 Hz (Ohms) |
|---------------|---------------|-----------------------------|---------------------------------|----------------------|---------------------------|
| FK-23451-000  | 12S           | 95.5                        | 108.5                           | 360                  | 450                       |
| FK-23466-000  | 12S           | 95.5                        | 108.5                           | 360                  | 450                       |
| FK-26260-000  | 12S           | 96                          | 105                             | 135                  | 180                       |
| DFK-30041-000 | 12S           | 99.7                        | 105.5                           | 100                  | 133                       |

Note: All performance curves are typical

\*Note: Chart for reference only to show performance with insert earphone coupler

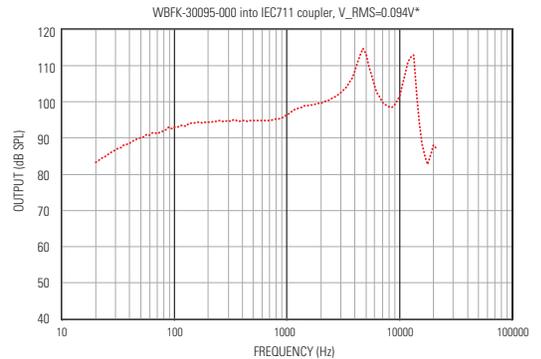
# BALANCED ARMATURE SPEAKERS

## WBFK SERIES – Wideband Balanced Armature Speaker 5.00 x 2.73 x 1.93 (mm)

Same package size as FK Series, WBFK has extended high frequency response. It is recommended as a high frequency component to be combined with low/midrange speaker for music earphones.



- Lower low/mid-band sensitivity compared to FK Series
- Best high frequency response of any Knowles element
- Combine with low/mid-range speaker for extended frequency response
- TWFK pairs WBFK with low frequency FK



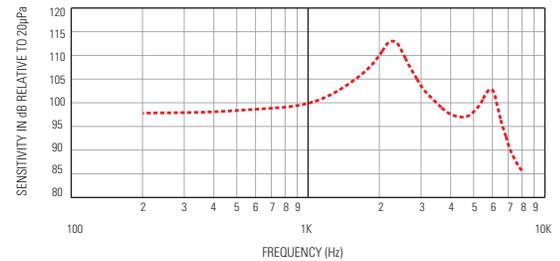
| Model          | Port Location | Sensitivity @ 1kHz (dB SPL) | Sensitivity @ 1st Peak (dB SPL) | DC Resistance (Ohms) | Impedance @ 500 Hz (Ohms) |
|----------------|---------------|-----------------------------|---------------------------------|----------------------|---------------------------|
| WBFK-30000-000 | 12S           | 95                          | 105                             | 100                  | 111                       |
| WBFK-30095-000 | 12S           | 91                          | 105                             | 12.5                 | 13.5                      |

## FH SERIES – Balanced Armature Speaker 5.09 x 2.80 x 2.59 (mm)

The FH speaker represents an unprecedented combination of ultra-compact size and high SPL output with efficiencies normally found only in much larger speakers. The FH speaker line brings true high-gain, high-output performance to earphone designs.



- Undamped, screen damped, internally damped, and Ferrofluid™ damped responses
- Various port locations, coil impedances, damping options, termination configurations, and frequency responses available
- Maximum SPL output of 123dB at resonance peak, 109dB at midband (500Hz)\*



| Model        | Port Location | Sensitivity @ 1kHz (dB SPL) | Sensitivity @ 1st Peak (dB SPL) | DC Resistance (Ohms) | Impedance @ 500 Hz (Ohms) |
|--------------|---------------|-----------------------------|---------------------------------|----------------------|---------------------------|
| FH-23371-000 | 12S           | 100                         | 113                             | 60                   | 90                        |
| FH-23375-000 | 12S           | 100                         | 113                             | 240                  | 335                       |
| FH-23377-000 | 12S           | 100                         | 113                             | 515                  | 685                       |
| FH-23821-000 | 12S           | 100                         | 113                             | 125                  | 174                       |
| FH-26553-000 | 12S           | 100                         | 113                             | 60                   | 90                        |

Note: All performance curves are typical

\*Note: Chart for reference only to show performance with insert earphone coupler

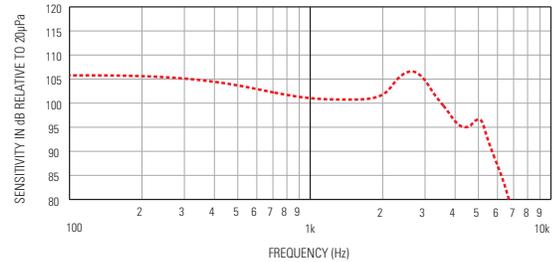
# BALANCED ARMATURE SPEAKERS

## HC SERIES – Balanced Armature Speaker 5.16 x 3.51 x 3.00 (mm)

Knowles balanced-armature, magnetic technology provides high efficiency, stability and reliability. HC Series provides increased low frequency dynamic range in a package size equal to FC.



- High-output technology provides double (+3dB) the maximum acoustic output of existing Knowles FC Series speakers
- Maximum output comparable to Knowles' ED Series speaker in a package size only 68% as large!
- Same size and dimensions as Knowles' EH Series
- Ideal for applications where small size and high output is required



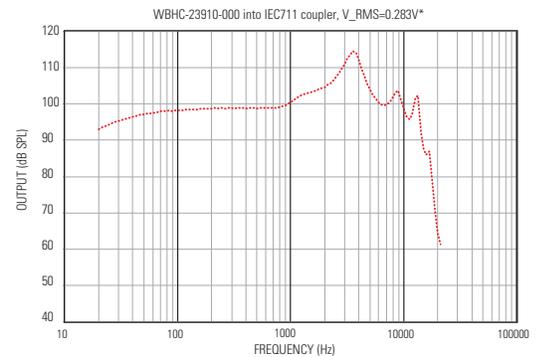
| Model        | Port Location | Sensitivity @ 1kHz (dB SPL) | Sensitivity @ 1st Peak (dB SPL) | DC Resistance (Ohms) | Impedance @ 500 Hz (Ohms) |
|--------------|---------------|-----------------------------|---------------------------------|----------------------|---------------------------|
| HC-23761-000 | 12C           | 101                         | 107                             | 4.9                  | 8.4                       |
| HC-23763-000 | 12C           | 101                         | 107                             | 11.5                 | 20                        |
| HC-23764-000 | 12C           | 101                         | 107                             | 15.5                 | 24                        |

## WBHC SERIES – Wideband Balanced Armature Speaker 5.16 x 3.51 x 3.00 (mm)

The advanced design of the HC Series speaker provides extended acoustic bandwidth for hi-fi in-ear speakers when paired with a low frequency speaker.



- Lower low/mid band sensitivity compared to HC series
- Combine with low/mid-range speaker for extended frequency response



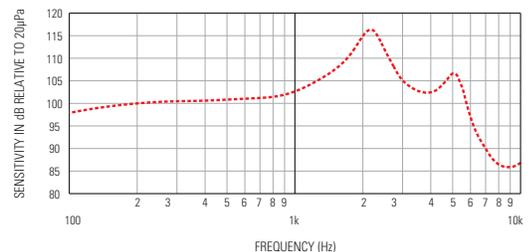
| Model          | Port Location | Sensitivity @ 1kHz (dB SPL) | Sensitivity @ 1st Peak (dB SPL) | DC Resistance (Ohms) | Impedance @ 500 Hz (Ohms) |
|----------------|---------------|-----------------------------|---------------------------------|----------------------|---------------------------|
| WBHC-23910-000 | 12C           | 95                          | 106                             | 120                  | 130                       |
| WBHC-30670-000 | 12C           | 95                          | 105                             | 44                   | 46                        |

## FC SERIES – Balanced Armature Speaker 5.18 x 3.55 x 3.00 (mm)

FC Series speakers may be used for small radio communication earphones where ED size does not meet package requirements. Rounded corners make it slightly smaller compared to EH Series speakers.



- Available in High-Output HC speaker version
- Two-terminal zero-bias and three-terminal center-tapped configurations
- Undamped, screen damped, internally damped, and Ferrofluid™ damped responses
- Rounded corners for improved fit rates; 10% smaller cross-section compared to EH speaker



| Model        | Port Location | Sensitivity @ 1kHz (dB SPL) | Sensitivity @ 1st Peak (dB SPL) | DC Resistance (Ohms) | Impedance @ 500 Hz (Ohms) |
|--------------|---------------|-----------------------------|---------------------------------|----------------------|---------------------------|
| FC-26171-000 | 12C           | 104                         | 117                             | 135                  | 170                       |
| FC-26465-000 | 12C           | 104                         | 117                             | 42                   | 57                        |
| FC-26654-000 | 12C           | 104                         | 113                             | 40                   | 60                        |
| FC-26887-000 | 12C           | 104                         | 105                             | 354                  | 425                       |
| FC-30814-000 | 12C           | 100                         | 106                             | 52                   | 60                        |

Note: All performance curves are typical

\*Note: Chart for reference only to show performance with insert earphone coupler

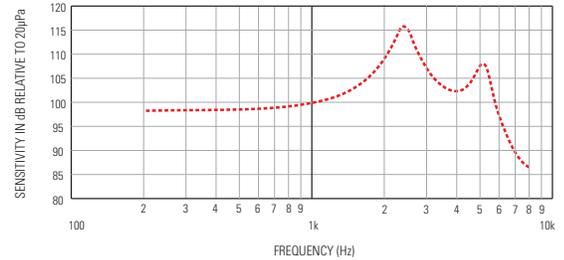
# BALANCED ARMATURE SPEAKERS

## EH SERIES – Balanced Armature Speaker 5.19 x 3.55 x 3.00 (mm)

EH Series speakers are approximately 2/3 the size of ED speakers and may be used for small radio communication earphones where ED size does not meet package requirements.



- *Balanced-armature, magnetic technology to give high efficiency, stability and reliability*
- *High sensitivity*
- *Various responses, including standard, damped and modified*
- *Low distortion*
- *Self-shielded for low magnetic radiation*



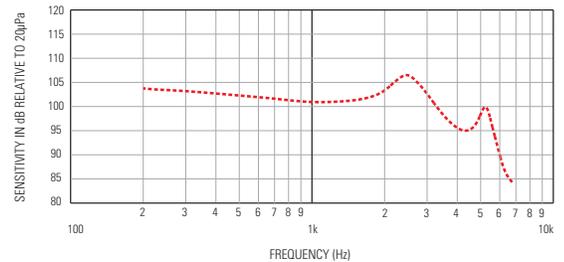
| Model        | Port Location | Sensitivity @ 1kHz (dB SPL) | Sensitivity @ 1st Peak (dB SPL) | DC Resistance (Ohms) | Impedance @ 500 Hz (Ohms) |
|--------------|---------------|-----------------------------|---------------------------------|----------------------|---------------------------|
| EH-23030-000 | 12C           | 100                         | 117                             | 395                  | 625                       |
| EH-23149-000 | 12C           | 100                         | 116                             | 68                   | 101                       |
| EH-27479-000 | 12C           | 100                         | 112.5                           | 118                  | 144                       |

## ES SERIES – Balanced Armature Amplified Speaker 5.18 x 3.54 x 3.04 (mm)

EH size speaker with integrated Class D power amplifier.



- *EH micro speaker, but with internal, highly-efficient, class D amplifier*
- *Lower current drain prolongs battery life*
- *Lower distortion*
- *Available in a range of SPL ratings*



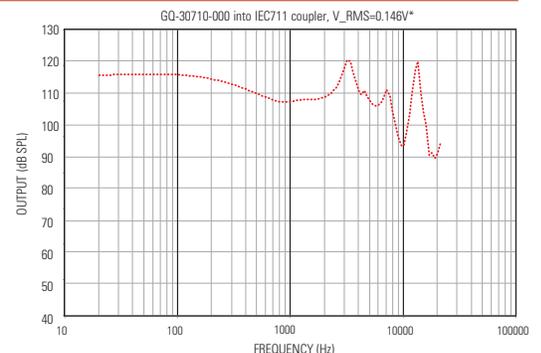
| Model        | Port Location | Sensitivity @ 1kHz (dB SPL) | Sensitivity @ 1st Peak (dB SPL) |
|--------------|---------------|-----------------------------|---------------------------------|
| ES-23127-000 | 12C           | 101                         | 107                             |
| ES-23140-000 | 12C           | 101                         | 105.5                           |

## GQ SERIES – Two-Way Balanced Armature Speaker 6.30 x 4.29 x 4.92 (mm)

The GQ is a two-way balanced armature system with added low frequency headroom, designed for pro-audio in-ear application. Enables customized cross-over response to achieve target frequency response.



- *Dual element with enhanced bass capabilities and wideband response*
- *Unique, subminiature woofer/tweeter combination for in-ear applications*
- *Single port for simplified earphone design*



| Model        | Port Location | Sensitivity @ 1kHz (dB SPL) | Sensitivity @ 1st Peak (dB SPL) | DC Resistance (Ohms) | Impedance @ 500 Hz (Ohms) |
|--------------|---------------|-----------------------------|---------------------------------|----------------------|---------------------------|
| GQ-30783-000 | 12S           | 109.5                       | 116                             | 12.5                 | 21.5                      |
| GQ-30710-000 | 12C           | 106                         | 119.5                           | 25.4                 | 51.7                      |

Note: All performance curves are typical

\*Note: Chart for reference only to show performance with insert earphone coupler

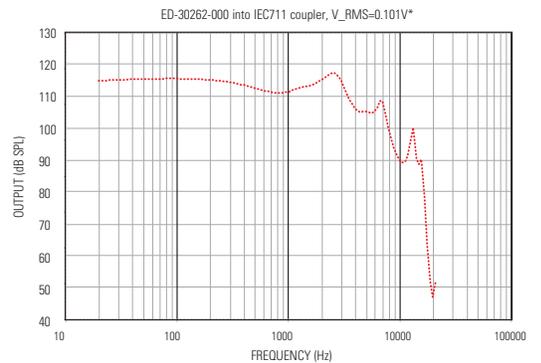
# BALANCED ARMATURE SPEAKERS

## ED SERIES – Balanced Armature Speaker 6.32 x 4.31 x 2.97 (mm)

One of Knowles' most versatile and most popular speakers, its compact size and appreciable output power make the ED speaker suitable for a variety of instruments.



- Undamped, screen damped, internally damped, and Ferrofluid™ damped responses
- Numerous port locations and coil impedances
- High efficiency and low distortion



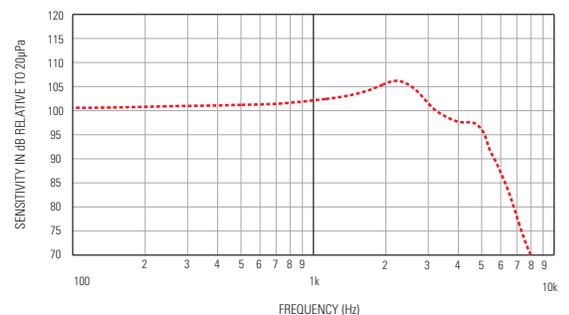
| Model        | Port Location | Sensitivity @ 1kHz (dB SPL) | Sensitivity @ 1st Peak (dB SPL) | DC Resistance (Ohms) | Impedance @ 500 Hz (Ohms) |
|--------------|---------------|-----------------------------|---------------------------------|----------------------|---------------------------|
| ED-21744-000 | 12C           | 104                         | 112.5                           | 825                  | 1700                      |
| ED-21913-000 | 12C           | 104                         | 117.5                           | 376                  | 780                       |
| ED-23147-000 | 12C           | 102.5                       | 110                             | 25                   | 48                        |
| ED-23619-000 | 12C           | 104                         | 117.5                           | 3.3                  | 7.1                       |
| ED-23801-000 | 12C           | 104                         | 113                             | 155                  | 196                       |
| ED-23814-000 | 12C           | 104                         | 112.5                           | 23                   | 50                        |
| ED-26245-000 | 12C           | 104                         | 113                             | 35                   | 55                        |
| ED-26598-000 | 12C           | 102.5                       | 106                             | 196                  | 395                       |
| ED-26821-000 | 12C           | 102.5                       | 111                             | 3.3                  | 7.1                       |
| ED-27045-000 | 9C            | 104                         | 113                             | 196                  | 395                       |
| ED-27230-000 | 12C           | 104                         | 117.5                           | 54.5                 | 79                        |
| ED-27304-000 | 12C           | 104                         | 117                             | 201                  | 290                       |
| ED-29689-000 | 12C           | 104                         | 118                             | 3.7                  | 7.1                       |
| ED-26805-000 | 12C           | 102                         | 110                             | 23                   | 26                        |
| ED-26876-000 | 12C           | 102.5                       | 111                             | 25                   | 48                        |
| ED-31305-163 | 12C           | 106.5                       | 119.5                           | 39.2                 | 58.8                      |

## FED SERIES – Balanced Armature Speaker 6.32 x 4.31 x 2.47 (mm)

The addition of *Ferrofluid™* to Knowles ED series speakers improves mechanical shock survival and provides peak damping to smooth frequency response.



- Ferrofluid™ damped with 2dB, 4dB, or 6dB peak amplitude
- Superior shock performance and reduced speaker vibration
- Two-terminal zero-bias and three-terminal center-tapped configurations
- Numerous port locations and coil impedances



| Model         | Port Location | Sensitivity @ 1kHz (dB SPL) | Sensitivity @ 1st Peak (dB SPL) | DC Resistance (Ohms) | Impedance @ 500 Hz (Ohms) |
|---------------|---------------|-----------------------------|---------------------------------|----------------------|---------------------------|
| FED-26792-I04 | 12C           | 102.5                       | 107                             | 116.5                | 65                        |
| FED-30048-I04 | 12N           | 102                         | 107                             | 116                  | 26                        |

# BALANCED ARMATURE SPEAKERS

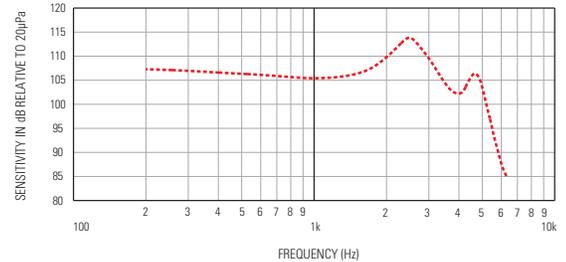
## EP SERIES – Balanced Armature Amplified Speaker 6.32 x 4.29 x 2.99 (mm)

Based on Knowles' versatile and popular ED speaker, the EP series adds the benefits of an internal Class-D amplifier. Its compact size and appreciable output power make the EP speaker suitable for a variety of designs.



- Class D amplified magnetic speaker
- Self-shielded to reduce magnetic radiation
- 125dB SPL maximum output
- Three-terminal electrical connection

| Model        | Port Location | Sensitivity @ 1kHz (dB SPL) | Sensitivity @ 1st Peak (dB SPL) |
|--------------|---------------|-----------------------------|---------------------------------|
| EP-24075-000 | 12C           | 106                         | 114                             |



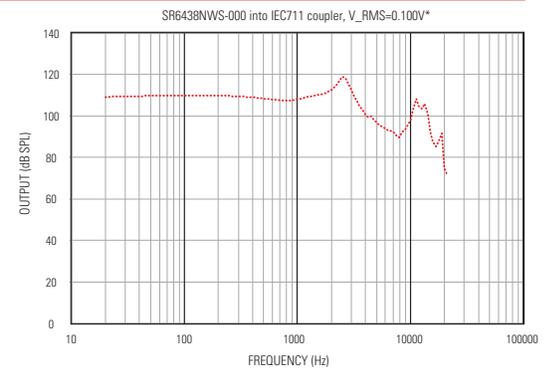
## SR SERIES – Balanced Armature Speaker 6.40 DIA x 4.00 (mm)

At 6.4mm diameter, the Mini SR is the smallest round balanced armature speaker in the marketplace. SR offers output equivalent to the FC series and maximizes bass performance.



- Round package facilitates earphone designs
- Drop-in upgrade for moving coil dynamic speakers
- Designed for high volume production
- Balanced armature technology

| Model          | Port Location | Sensitivity @ 1kHz (dB SPL) | Sensitivity @ 1st Peak (dB SPL) | DC Resistance (Ohms) | Impedance @ 500 Hz (Ohms) |
|----------------|---------------|-----------------------------|---------------------------------|----------------------|---------------------------|
| SR-6438NWS-000 | Face          | 109.5                       | 120                             | 25                   | 36.5                      |
| SR-6438NWS-158 | Face          | 109.5                       | 120                             | 25                   | 32.8                      |



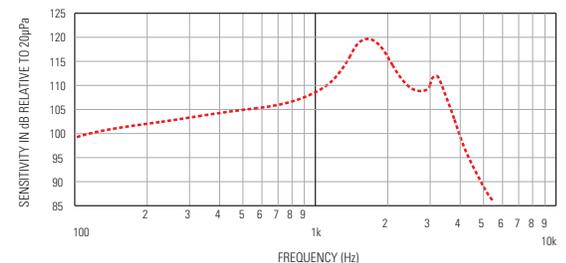
## EC SERIES – Balanced Armature Speaker 7.57 x 4.31 x 3.67 (mm)

EC Series speakers are commonly used in isolating earphones for radio communication.



- Similar SPL output to the BK Series
- Rounded corners on the face opposite the terminal pad
- 34% smaller volume than the BK Series

| Model        | Port Location | Sensitivity @ 1kHz (dB SPL) | Sensitivity @ 1st Peak (dB SPL) | DC Resistance (Ohms) | Impedance @ 500 Hz (Ohms) |
|--------------|---------------|-----------------------------|---------------------------------|----------------------|---------------------------|
| EC-23097-000 | 12S           | 108                         | 120                             | 92                   | 200                       |
| EC-23098-000 | 12S           | 108                         | 120                             | 196                  | 425                       |
| EC-26368-000 | 12S           | 108                         | 120                             | 26.3                 | 54                        |
| EC-23095-A33 | 12S           | 105                         | 120                             | 376                  | 800                       |



Note: All performance curves are typical

\*Note: Chart for reference only to show performance with insert earphone coupler

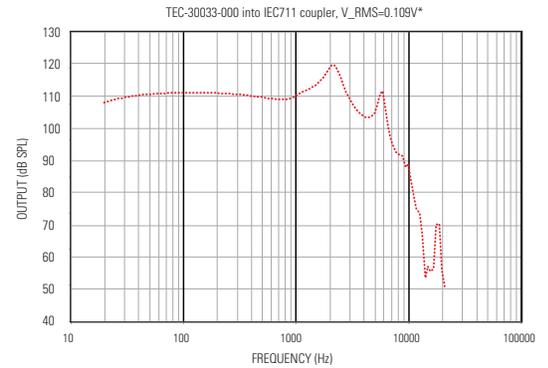
# BALANCED ARMATURE SPEAKERS

## TEC SERIES – Balanced Armature Speaker 7.87 x 4.09 x 2.79 (mm)

The TEC combines output comparable to the larger BK speaker in an ultra-thin package. The TEC is suitable for multi-element earphone designs.



- Ultra-thin
- Wideband output
- DTEC combines two TEC elements
- Enables small multi-element designs



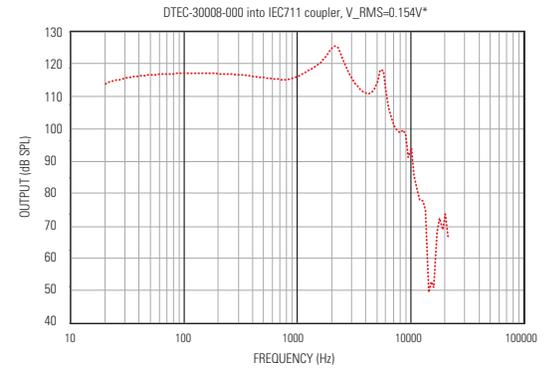
| Model         | Port Location | Sensitivity @ 1kHz (dB SPL) | Sensitivity @ 1st Peak (dB SPL) | DC Resistance (Ohms) | Impedance @ 500 Hz (Ohms) |
|---------------|---------------|-----------------------------|---------------------------------|----------------------|---------------------------|
| TEC-30033-000 | 12C           | 115                         | 119                             | 22                   | 31                        |
| TEC-30087-000 | 12C           | 115                         | 119                             | 46                   | 62                        |

## DTEC SERIES – Balanced Armature Speaker 7.87 x 4.09 x 5.59 (mm)

The DTEC Series combines two TEC speakers with a single round port. Case size is equivalent to BK/EF. DTEC provides increased output and reduced vibration compared to a single speaker.



- Dual elements with single sound port
- More output than BK in equal package size
- Reduced vibration compared to BK
- Improved frequency response compared to BK



| Model            | Port Location | Sensitivity @ 1kHz (dB SPL) | Sensitivity @ 1st Peak (dB SPL) | DC Resistance (Ohms) | Impedance @ 500 Hz (Ohms) |
|------------------|---------------|-----------------------------|---------------------------------|----------------------|---------------------------|
| DTEC-30008-000   | 12S           | 123                         | 122.5                           | 23                   | 31.5                      |
| HODTEC-31230-000 | 12S           | 120                         | 122.2                           | 26.5                 | 40.7                      |
| HODTEC-31516-000 | 25            | 120                         | 122.5                           | 102                  | 171                       |
| HODTEC-31618-000 | 12C           | 119                         | 115.5                           | 8.6                  | 21.8                      |

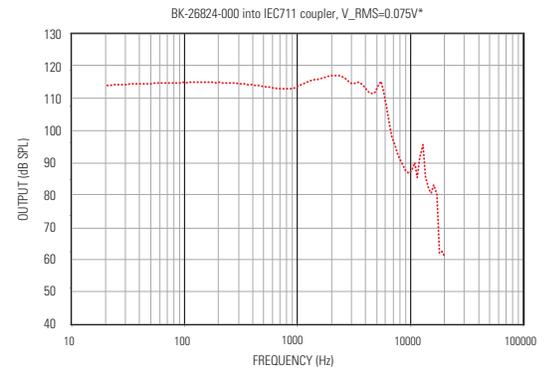
# BALANCED ARMATURE SPEAKERS

## BK SERIES – Balanced Armature Speaker 7.87 x 5.59 x 4.01 (mm)

BK Series speakers provide broadband performance at value pricing. They are commonly used for full range in-ear speakers and communications utilizing an earplug design.



- High efficiency and low distortion
- Various port locations, coil impedances, damping options, terminal configurations, and frequency responses available



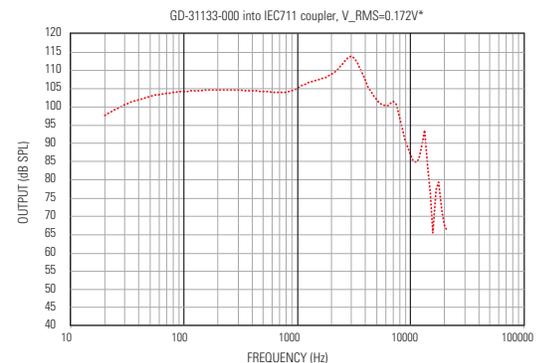
| Model        | Port Location | Sensitivity @ 1kHz (dB SPL) | Sensitivity @ 1st Peak (dB SPL) | DC Resistance (Ohms) | Impedance @ 500 Hz (Ohms) |
|--------------|---------------|-----------------------------|---------------------------------|----------------------|---------------------------|
| BK-21600-000 | 12S           | 123                         | 125                             | 100                  | 285                       |
| BK-21604-000 | 12S           | 123                         | 125                             | 895                  | 2320                      |
| BK-21610-000 | 12S           | 121                         | 126                             | 21                   | 60                        |
| BK-21613-000 | 1S            | 118                         | 125                             | 160                  | 450                       |
| BK-21615-000 | 12S           | 118                         | 125                             | 160                  | 450                       |
| BK-21669-000 | 12C           | 123.5                       | 125                             | 9                    | 22                        |
| BK-23134-000 | 12S           | 118                         | 125                             | 100                  | 285                       |
| BK-26824-000 | 12S           | 119                         | 120                             | 10.7                 | 16                        |
| BK-28507-000 | 12S           | 126                         | 126                             | 10.7                 | 13.3                      |
| BK-28510-000 | 12S           | 123                         | 127                             | 111                  | 320                       |
| BK-28562-000 | 12S           | 123                         | 124                             | 18.5                 | 23                        |
| BK-29725-000 | 12S           | 118                         | 119                             | 100                  | 285                       |

## GD SERIES – Balanced Armature Speaker 5.99 x 3.10 x 2.59 (mm)

The GD is a two-way balanced armature system with high output capabilities for professional in-ear applications. Enables customized cross-over response to achieve target frequency response.



- High performance, low-profile two-way system
- Customizable cross-over capabilities
- Dual ported to mechanically tune each driver



| Model        | Port Location | Sensitivity @ 1kHz (dB SPL) | Sensitivity @ 1st Peak (dB SPL) | DC Resistance (Ohms) | Impedance @ 500 Hz (Ohms) |
|--------------|---------------|-----------------------------|---------------------------------|----------------------|---------------------------|
| GD-31475-000 | 12S           | 98.5                        | 106.5                           | 33.5                 | 38.7                      |

\*Note: Chart for reference only to show performance with insert earphone coupler

# BALANCED ARMATURE SPEAKERS

## CI SERIES – Balanced Armature Speaker 9.47 x 7.18 x 4.10 (mm)

Knowles' largest and most powerful speaker, the CI series is the speaker of choice. With its high efficiency and a 143dB SPL maximum output, the CI speaker provides optimal low frequency performance.



- Two-terminal zero-bias and three-terminal center-tapped configurations
- Various port locations, coil impedances, termination configurations, and frequency responses available



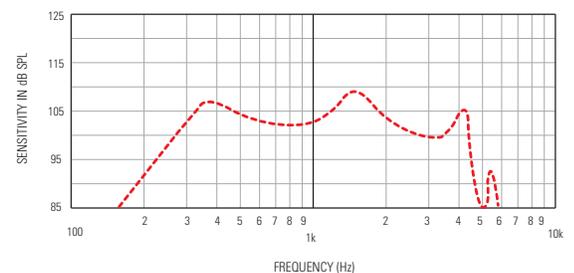
| Model        | Port Location | Sensitivity @ 1kHz (dB SPL) | Sensitivity @ 1st Peak (dB SPL) | DC Resistance (Ohms) | Impedance @ 500 Hz (Ohms) |
|--------------|---------------|-----------------------------|---------------------------------|----------------------|---------------------------|
| CI-22748-000 | 12C           | 125                         | 128                             | 75                   | 250                       |
| CI-22762-000 | 1S            | 125                         | 128                             | 51                   | 175                       |
| CI-22955-000 | 12C           | 125                         | 128                             | 20                   | 68 @ 1kHz                 |
| CI-22960-000 | 12C           | 125                         | 128                             | 100                  | 400                       |
| CI-28487-000 | 1S            | 125                         | 128                             | 24                   | 100 @ 1kHz                |
| CI-28597-000 | 11S           | 125                         | 128                             | 20                   | 68 @ 1kHz                 |

## CM SERIES – Balanced Armature Speaker 8.38 x 16.64 DIA (mm)

The CM Series delivers the benefits of balanced armature technology in a compact finished package. The CM is ideal for use in situations where a non-contacting headset is required, but signal voltage is limited – as is common for radios and wireless telephones. The CM also conserves battery power, and provides static shock protection for the user.



- Balanced-armature, magnetic technology to give high efficiency, stability and reliability
- High acoustic efficiency enables sufficient sound output even when limited power is available
- In-built static protection
- Lightweight, matt-black, plastic housing
- Ergonomically designed with rounded edge to fit the concha
- High-quality sound output
- Tailored bandwidth for superb speech intelligibility



| Model        | Port Location | Sensitivity @ 1kHz (dB SPL) | Sensitivity @ 1st Peak (dB SPL) | DC Resistance (Ohms) | Impedance @ 500 Hz (Ohms) |
|--------------|---------------|-----------------------------|---------------------------------|----------------------|---------------------------|
| CM-23152-000 | Face          | 103                         | 109                             | 69                   | 150                       |
| CM-23299-000 | Face          | 103                         | 109                             | 69                   | 150                       |
| CM-28421-000 | Face          | 103                         | 109                             | 100                  | 360                       |
| CM-28431-000 | Face          | 103                         | 109                             | 10.5                 | 30                        |
| CM-28452-000 | Face          | 103                         | 109                             | 100                  | 360                       |

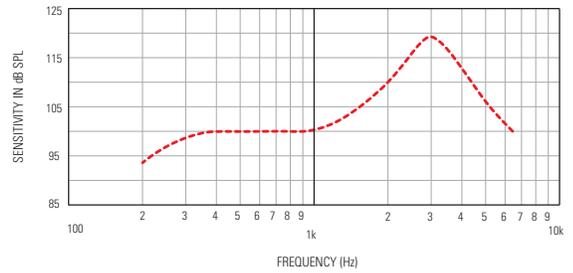
# BALANCED ARMATURE SPEAKERS

## MR SERIES – Waterproof Speaker 22.12 DIA x 9.3 (mm)

The MR Series Assemblies consist of a speaker element attached to a waterproof bellows assembly. They may be panel mounted, and are suitable for outdoor use or repeated submersion.



- Highly waterproof – no loss of performance after immersion in 15m water
- Corrosion resistant
- Withstands explosive decompression
- Design proven in rugged environments
- Leads attached
- High resistance to mechanical shock
- Acoustically transparent bellows
- Resists effects of mud, sand, and salt encrustation



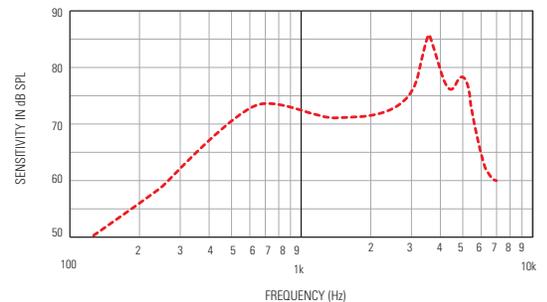
| Model        | Port Location | Sensitivity @ 1kHz (dB SPL) | Sensitivity @ 1st Peak (dB SPL) | DC Resistance (Ohms) | Impedance @ 500 Hz (Ohms) |
|--------------|---------------|-----------------------------|---------------------------------|----------------------|---------------------------|
| MR-23333-000 | Face          | 100                         | 119.5                           | 10                   | 21                        |

## CB SERIES – Balanced Armature Speaker 25.15 x 25.15 x 9.65 (mm)

The CB Series Transceiver offers high electro-acoustic efficiency to conserve power in push-to-talk radio handsets and other battery operated equipment. The CB is available with mounting pins to facilitate assembly to a PC board. Model CB-23817-000 is designed to survive submersion in water.



- Excellent sound quality
- High speech intelligibility, stability, and reliability
- Suitable for PCB mounting
- Can function as a microphone or beeper
- Various impedances
- Face and edge port locations available



| Model        | Port Location | Sensitivity @ 1kHz (dB SPL) | Sensitivity @ 1st Peak (dB SPL) | DC Resistance (Ohms) | Impedance @ 500 Hz (Ohms) |
|--------------|---------------|-----------------------------|---------------------------------|----------------------|---------------------------|
| CB-22849-000 | Edge          | 73                          | 86                              | 11.5                 | 24                        |
| CB-22850-000 | Edge          | 73                          | 86                              | 21.5                 | 48                        |
| CB-23817-000 | Edge          | 83                          | 97                              | 21.5                 | 48                        |

Note: All performance curves are typical

# ELECTRET MICROPHONES

## Electret Microphones

Hundreds of design possibilities can be applied to your product challenge with our electret microphone designs. Ideal for new product ideas that require premium audio and very small form factors, solutions include noise canceling, omni-directional and unidirectional performance. Other variables include size, shape, amplification, sensitivity, low noise, and resistance to vibration and mechanical shock. Our products are designed into high value applications in markets such as the following:

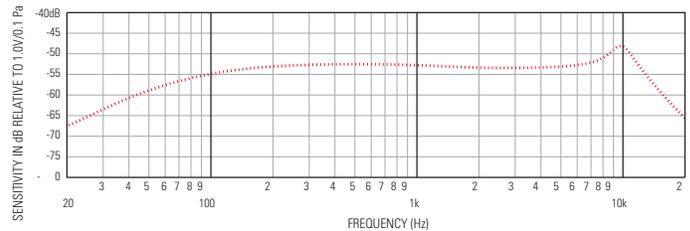
- *Communications – headsets, handsets, earpieces, telephony, voice recognition, emergency services, surveillance, radio*
- *Pro audio – in-ear speakers, lapel microphones, boom microphones*
- *Medical and more – sensors, audiometers, medical implants*



## GA SERIES – Microphone

### Omni-Directional 2.00 x 2.00 x 4.00 (mm)

The GA Series Microphone is a brand new microphone design with unique size and shape. Its elongated 2mm x 2mm x 4mm dimensions are ideal for directional applications, allowing you ultimate flexibility in terminal pad area placement. And the GA is using the new '38' circuit providing excellent sensitivity and noise performance for package size. The GA targets space efficiency in BTE and ITE designs; BTE: End-to-end configuration provides 8mm spacing for directionality while ITE: 20% smaller cross sectional area than FG Series.



- *Compact size providing superior fit rates (2mm x 2mm x 4mm)*
- *Excellent sensitivity and noise performance for package*
- *Integral RFI suppression*
- *Exceptionally low vibration sensitivity*
- *Multiple acoustic port placement versions*

| Model          | Sensitivity @ 1kHz (dB re1V/0.1Pa) | DC Supply (Vdc)  | Max. Amplifier Current Drain (uA) | Typical "A" Weighted Noise (1 kHz Equivalent SPL) | Nominal Output Impedance (Ohms) | Comments           |
|----------------|------------------------------------|------------------|-----------------------------------|---|---------------------------------|--------------------|
| GA38-30775-000 | -53.0±3                            | 1.3 nom. 1.6 max | 25                                | 2.5.0 dB  | 4400                            | Tubeless           |
| GA38-30870-000 | -53.0±3                            | 1.3 nom. 1.6 max | 25                                | 25.0 dB   | 4400                            | Micro-Tube Version |

# ELECTRET MICROPHONES

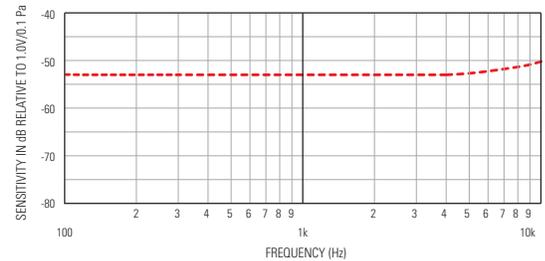
## FG/DFG SERIES – Microphone

### Omni-Directional (FG), Directional (DFG) 2.56 DIA x 2.56 (mm)

The FG Series microphone is one of the smallest electret condenser microphones. Its cylindrical shape and compact size facilitate compact designs. The FG can also be used in directional applications as a matched omni-directional pair.



- Smallest microphone option
- High resistance to mechanical shock
- Exceptionally low vibration sensitivity
- Various responses available
- Integral RFI suppression



| Model         | Sensitivity @ 1kHz (dB re1V/0.1Pa) | DC Supply (Vdc)  | Max. Amplifier Current Drain (uA) | "A" Weighted Noise * 1kHz Equivalent SPL ** re 1Vrms | Nominal Output Impedance (Ohms) | Comments                                     |
|---------------|------------------------------------|------------------|-----------------------------------|--|---------------------------------|--|
| FG-23329-D65  | -53.0±3                            | 1.3 nom. 3.0 max | 50                                | 30.0 dB*   | 4400                            | RFI Improved Version                         |
| FG-23329-P07  | -53.0±3                            | 1.3 nom. 3.0 max | 50                                | 30.0 dB*   | 4400                            | 3-Wire, 1015mm Shielded Cable                |
| FG-23629-P16  | -53.0±3                            | 1.3 nom. 3.0 max | 50                                | 28.0 dB*   | 4400                            | 3-Wire, 25.4mm Litz Wires                    |
| FG-23629-D65  | -53.0±3                            | 1.3 nom. 3.0 max | 50                                | 28.0 dB*   | 4400                            | RFI Improved Version                         |
| FG-23652-D65  | -53.0±3                            | 1.3 nom. 3.0 max | 50                                | 28.0 dB*   | 4400                            | RFI Improved Version                         |
| FG-23652-P16  | -53.0±3                            | 1.3 nom. 3.0 max | 50                                | 28.0 dB*   | 4400                            | 3-Wire, 25.4mm Litz Wires                    |
| FG-23742-D36  | -63.0±3                            | 1.3 nom. 3.0 max | 50                                | 36.0 dB*   | 4400                            | 3-Wire, 25.4mm Litz Wires                    |
| FG-26163-D65  | -58.0±3                            | 1.3 nom. 3.0 max | 50                                | -93.0 dB**   | 4400                            | RFI Improved Version<br>6dB/Octave Ski-Slope |
| DFG-30344-000 | -67.0±3                            | 1.3 nom. 3.0 max | 50                                | -93.0 dB**   | 700                             | Directional, Super Cardioid                  |
| DFG-30852-000 | -69.0±3                            | 1.3 nom. 3.0 max | 50                                | -93.0 dB**   | 1700                            | Directional, Cardioid                        |
| DFG-30851-000 | -73.0±3                            | 1.3 nom. 3.0 max | 50                                | -93.0 dB**   | 1700                            | Directional, Noise Canceling                 |

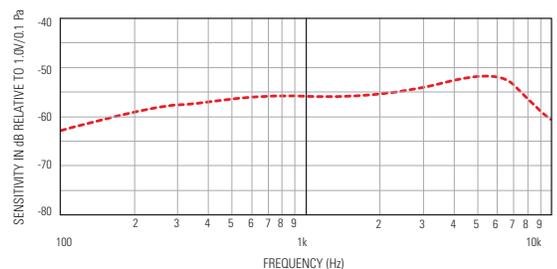
## EM SERIES – Microphone

### Omni-Directional 3.63 x 3.63 x 2.28 (mm)

The EM is a popular, alternative omni-directional microphone/ The EM can also be used in directional applications as a matched omni-directional pair.



- High resistance to mechanical shock
- Improved RFI and EMI
- Undamped, screen damped, and internally damped responses
- Numerous port locations
- Wide range of frequency responses



| Model        | Sensitivity @ 1kHz (dB re1V/0.1Pa) | DC Supply (Vdc)  | Max. Amplifier Current Drain (uA) | "A" Weighted Noise * 1kHz Equivalent SPL ** re 1Vrms | Nominal Output Impedance (Ohms) | Comments                                      |
|--------------|------------------------------------|------------------|-----------------------------------|--|---------------------------------|---|
| EM-23046-P16 | -56.0±3                            | 1.3 nom. 3.0 max | 50                                | 31.0 dB*   | 4400                            | 3-Wire, 25.4mm Litz Wire<br>Standard Response |
| EM-23069-000 | -56.0±3                            | 1.3 nom. 1.6 max | 50                                | 33.0 dB*   | 4400                            | Tubeless<br>Standard Response                 |
| EM-30081-D65 | -68.0±3                            | 1.3 nom. 3.0 max | 50                                | -98.0 dB*  | 4400                            | 12dB/Octave Ski-Slope                         |

# ELECTRET MICROPHONES

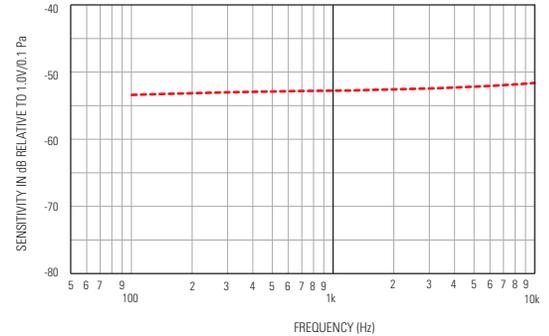
## EK/EL SERIES – Microphone

### Omni-Directional (EK), Unidirectional (EL) 4.00 x 5.59 x 2.28 (mm)

EK omnidirectional microphones provide a unique combination of size, performance and value. Its high electroacoustic sensitivity and low noise make this microphone an excellent choice for applications where space allows. These popular microphones are available in many model varieties.



- High resistance to mechanical shock
- Available with RFI suppression
- Various port locations available
- Wide range of frequency responses
- High S/N performance



| Model        | Sensitivity @ 1kHz (dB re1V/0.1Pa) | DC Supply (Vdc) | Max. Amplifier Current Drain (uA) | "A" Weighted Noise * 1kHz Equivalent SPL ** re 1Vrms | Nominal Output Impedance (Ohms) | Comments                                     |
|--------------|------------------------------------|-----------------|-----------------------------------|--|---------------------------------|--|
| EK-23024-C36 | -53.0±2                            | 1.3 nom. 10 max | 50                                | 26.0 dB*   | 4400                            | RFI Improved Version Standard Response       |
| EK-23024-P07 | -53.0±2                            | 1.3 nom. 10 max | 50                                | 26.0 dB*   | 4400                            | 3-Wire, 1 m Shielded Cable Standard Response |
| EK-23027-C36 | -53.0±2                            | 1.3 nom. 10 max | 50                                | 26.0 dB*   | 4400                            | RFI Improved Version Standard Response       |
| EK-23028-C36 | -57.0±3                            | 1.3 nom. 10 max | 50                                | -100.0 dB**  | 4400                            | RFI Improved Version 6dB/Octave Ski-Slope    |
| EK-23033-C36 | -53.0±2                            | 1.3 nom. 10 max | 50                                | 26.0 dB*   | 4400                            | RFI Improved Version Broadband Response      |
| EK-23132-000 | -53.0±2                            | 1.3 nom. 10 max | 50                                | 26.0 dB*   | 4400                            | Broadband Response                           |
| EK-23133-C36 | -53.0±2                            | 1.3 nom. 10 max | 50                                | 26.0 dB*   | 4400                            | RFI Improved Version Broadband Response      |
| EK-23142-C37 | -53.0±2                            | 1.3 nom. 10 max | 50                                | 26.0 dB*   | 4400                            | RFI Improved Version Broadband Response      |
| EL-23078-000 | -53.0±2                            | 1.3 nom. 10 max | 50                                | -100.0 dB**  | 4400                            | Dual Port Uni-Directional                    |

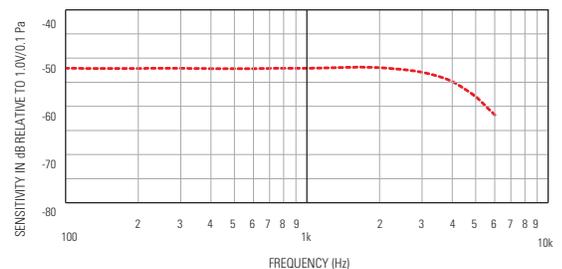
## NR SERIES – Microphone

### Noise Canceling 4.00 x 5.59 x 2.28 (mm)

The NR Series close talking microphones deliver state-of-the-art noise canceling performance. NR microphones are used as headset microphones in the most demanding communication and speech recognition environments. The NR Series microphones are available in boom microphone packages. (See the Specialty Transducers - Booms & Sensors section for details.)



- Integral FET amplifier
- Diaphragm responds to pressure differential giving high rejection of background noise
- Withstands severe environmental conditions
- Low vibration sensitivity
- High electroacoustical sensitivity
- Superior noise canceling performance
- Lead attachment available

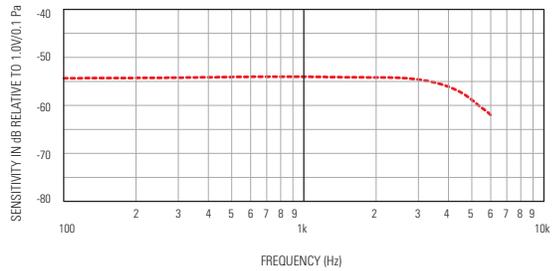


| Model        | Sensitivity @ 1kHz (dB re1V/0.1Pa) | DC Supply (Vdc) | Max. Amplifier Current Drain (uA) | Max. "A" Weighted Noise (dBV) | Nominal Output Impedance (Ohms) | Comments |
|--------------|------------------------------------|-----------------|-----------------------------------|-------------------------------|---------------------------------|----------|
| NR-23158-000 | -49.0±3                            | 1.3 nom. 10 max | 50                                | -100                          | 4400                            | 3-Wire   |
| NR-23159-000 | -65.0±3                            | 1.3 nom. 10 max | 200                               | -100                          | 2500                            | 2-Wire   |
| NR-23160-000 | -52.0±3                            | 1.3 nom. 10 max | 200                               | -100                          | 2500                            | 2-Wire   |
| NR-25994-000 | -49.0±3                            | 1.3 nom. 10 max | 50                                | -100                          | 4400                            | 3-Wire   |
| NR-25994-D63 | -55.0±4                            | 1.3 nom. 10 max | 300                               | -100                          | 2000                            | 2-Wire   |
| NR-30610-D63 | -59.0±3                            | 3.0 nom. 10 max | 550                               | -100                          | 2000                            | 2-Wire   |

# ELECTRET MICROPHONES

## WP SERIES – Waterproof Microphone Omni-Directional, Noise Canceling 3.99 x 5.56 x 2.21 (mm)

The WP Series' form factor is a very small size with low vibration sensitivity. The excellent noise canceling performance is useful for sensors and instrumentation. The WP Series are available in boom microphone packages. (See the FB Series for details.)

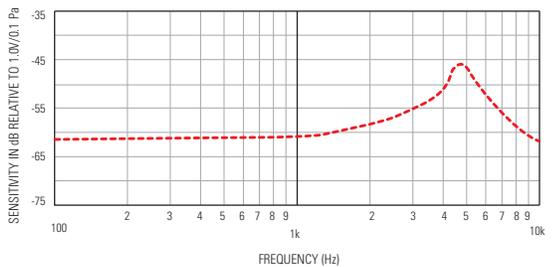


- Waterproofed to submersion in 1m water
- Close-talking (noise-canceling)
- Corrosion resistant
- Withstands explosive decompression
- Excellent environmental performance
- High resistance to mechanical shock

| Model        | Sensitivity @ 1kHz (dB re1V/0.1Pa) | Directivity      | DC Supply (Vdc) | Max. Amplifier Current Drain (uA) | "A" Weighted Noise * 1kHz Equivalent SPL ** re 1Vrms | Nominal Output Impedance (Ohms) | Comments                                 |
|--------------|------------------------------------|------------------|-----------------|-----------------------------------|--|---------------------------------|--|
| WP-23501-000 | -54.0±3                            | Noise Canceling  | 1.3 nom. 10 max | 300                               | -100 dB**  | 2500                            | 2-Wire                                   |
| WP-23502-000 | -52.0±3                            | Omni-Directional | 1.3 nom. 10 max | 50                                | 26.0 dB*   | 4400                            | 3-Wire                                   |
| WP-23502-P07 | -52.0±3                            | Omni-Directional | 1.3 nom. 10 max | 50                                | 26.0 dB*   | 4400                            | 3-Wire, w/ 1m Shielded Cable             |
| WP-23502-P16 | -52.0±3                            | Omni-Directional | 1.3 nom. 10 max | 50                                | 26.0 dB*   | 4400                            | 3-Wire, w/ 25.4mm Litz Wires             |
| WP-23849-C36 | -52.0±3                            | Omni-Directional | 1.3 nom. 10 max | 50                                | 26.0 dB*   | 4400                            | 3-Wire, RFI Improved + Extended Response |
| WP-25993-D63 | -55.0±4                            | Noise Canceling  | 1.3 nom. 10 max | 300                               | -100 dB**  | 2000                            | 2-Wire                                   |

## MR SERIES – Waterproof Microphone Omni-Directional

The MR Series Assemblies consist of a microphone element attached to a bellows assembly. They may be panel mounted, attached for boom applications, and are suitable for outdoor use or repeated submersion.



- Highly waterproof – no loss of performance after immersion in 15-20 m water
- Corrosion resistant
- Withstands explosive decompression
- Design proven in rugged environments
- Cable wire attached
- High resistance to mechanical shock
- Acoustically transparent bellows
- Resists effects of mud, sand, and salt encrustation

| Model        | Dimensions (mm)   | Sensitivity @ 1kHz (dB re1V/0.1Pa) | DC Supply (Vdc) | Max. Amplifier Current Drain (uA) | "A" Weighted Noise | Nominal Output Impedance (Ohms) | Comments            |
|--------------|-------------------|------------------------------------|-----------------|-----------------------------------|--------------------|---------------------------------|---------------------|
| MR-23151-000 | 22.12 DIA x 9.3   | -87.0±3                            | N/A             | N/A                               | 30.0 dB**          | 300                             | 2-Wire, 193mm Leads |
| MR-23793-000 | 22.12 DIA x 11.43 | -60.0±4                            | 1.3             | 50                                | 31.0 dB*           | 2500                            | 3-Wire, 201mm Leads |
| MR-28406-000 | 22.12 DIA x 7.6   | Omni-60.0±3                        | 1.3             | 50                                | 30.0 dB*           | 3500                            | 3-Wire, 202mm Leads |

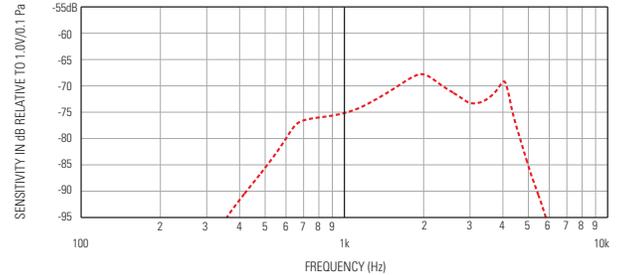
# MICROPHONES

## BJ SERIES – Electromagnetic Microphone Omni-Directional, Noise Canceling 7.87 x 5.59 x 4.01 (mm)

Knowles' Magnetic Microphones (BJ Series) are based on balanced armature technology and are self-shielded against external magnetic fields. The microphones offer high efficiency, stability, and reliability and are small in size. The diaphragm of the BJ Series responds to pressure differential, giving high rejection of background noise. Both face and edge ports are offered. In addition, there is a short distance between front and back ports resulting in improved noise rejection up to higher frequencies.



- Balanced armature technology
- High efficiency, stability and reliability
- Self-shielded against external magnetic fields
- Face and edge ports
- Diaphragm responds to pressure differential giving high rejection of background noise
- Short distance between front and back ports resulting in improved noise rejection up to higher frequencies



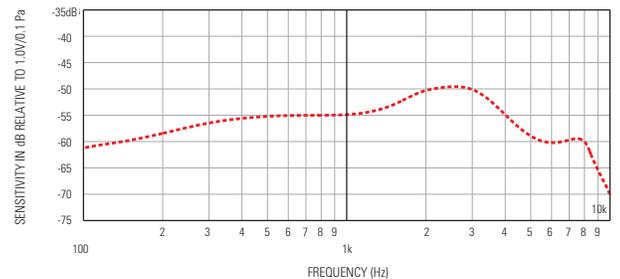
| Model        | Directivity      | Port Location | Nominal Impedance at 1kHz (Ohms) | Nominal DC Resistance at 20° C (Ohms) |
|--------------|------------------|---------------|----------------------------------|---------------------------------------|
| BJ-21590-000 | Omni-Directional | OJn           | 3900                             | 900                                   |
| BJ-28411-000 | Noise Canceling  | Dual          | 300                              | 75.5                                  |

## BL SERIES – Piezoceramic Microphone Omni-Directional

Knowles' Piezo Ceramic Microphones (BL Series) are rugged, stable and versatile. BL microphones are available in three different package sizes: standard, thin or 0.5" cylindrical shell and cable assembly. Both communication and broadband frequency response versions are offered. In addition, BL microphones have high vibration sensitivity and may be used as accelerometers.



- High sensitivity
- Wide frequency range
- Integral FET amplifier
- High resistance to mechanical shock
- Various responses
- Two case sizes available



| Model        | Dimensions (mm)    | Sensitivity @ 1kHz (dB re1V/0.1Pa) | DC Supply (Vdc) | Max. Amplifier Current Drain (uA) | "A" Weighted Noise | Nominal Output Impedance (Ohms) | Comments                                       |
|--------------|--------------------|------------------------------------|-----------------|-----------------------------------|--------------------|---------------------------------|--|
| BL-21671-000 | 7.87 x 5.54 x 4.06 | -54.0±3                            | 1.3             | 50                                | 32.0 dB            | 13000                           | Standard Response                              |
| BL-21671-140 | 7.87 x 5.84 x 4.06 | -54.0±4                            | 1.3             | 50                                | 32.0 dB            | 13000                           | Faster Overpressure Recovery Standard Response |
| BL-21785-000 | 7.87 x 5.54 x 2.24 | -69.0±3                            | 3               | 160                               | 34.0 dB            | 4000                            | Broadband Response                             |
| BL-21994-000 | 25.5               | -69.0±3                            | 3               | 160                               | 34.0 dB            | 4000                            | 965mm Shielded Cable Broadband Response        |
| BL-23497-000 | 25.5               | -69.0±3                            | 3               | 160                               | 34.0 dB            | 4000                            | 34.3mm Leads Broadband Response                |
| BL-27046-000 | 7.87 x 5.54 x 2.24 | -69.0±3                            | 1.3             | 160                               | 34.0 dB            | 4000                            | Broadband Response                             |

# BOOMS & SENSORS

## Booms & Sensors

Knowles boom microphones are designed for either flexible or rigid configurations and offer such performance options as noise rejection and high-frequency crossover of near and far field responses. Lengths and end terminations may be customized to meet your application needs. Knowles packaged microphones are suitable for sensor and outdoor use.

- Standard and waterproof
- Flexible and rigid styles
- Boom housing available in plastic and metal
- Customized lengths and end terminations



## Part Numbering

**FB-F I -30026-000**



**1**  
**Product Description**  
FB: Flexible Boom

**2**  
**Boom Diameter**  
A: 2.3mm OD Positionable Cable  
B: 2.7mm OD Gooseneck (w/shrink tube)  
D: 4.2mm OD Gooseneck (w/shrink tube)  
E: 5.4mm OD Gooseneck (w/shrink tube)  
F: 5.9mm OD Gooseneck (w/shrink tube)  
H: 5.0mm OD Gooseneck (w/shrink tube)  
M: 1.0mm OD Positionable Tube

**3**  
**Head Series**  
I: BJ Housing  
M: NR/WP Waterproof Housing  
O: Cylinder Housing  
U: FG/DFG Micro Housing  
W: Plastic Housing w/ Sinter Disc

**4**  
**Model #**

**VWP-F-30109-000**



**1**  
**Product Description**  
V: Value Added

**2**  
**Element Series**  
EK, EA, WP

**3**  
**Housing Series**  
B: Over Molded  
C: Custom Design  
F: Plastic Panel Mount  
H: ESD Shielded Plastic

**4**  
**Model #**

# BOOMS & SENSORS

## I SERIES



- Designed for headset customers who are looking for a noise canceling non-powered element in robust platform with waterproofing options from 1m down to 10m (based on IP67 rating)
  - Also available in Omni-Directional
- Plastic head design with metal flexible boom
  - Available in 5.9mm down to 4.2mm diameter metal flexible boom
- Tactical, Security and Police and other radio communication headsets
  - Mounted and un-mounted ground forces, armor units
- Designed for the BJ series elements

| Model           | *Rating | Microphone Element               | Directivity     | Boom Length Tip-To-Tip (mm) | Exit Wire Length (mm) | Nominal Boom Diameter (mm) | Microphone Configuration |
|-----------------|---------|----------------------------------|-----------------|-----------------------------|-----------------------|----------------------------|--------------------------|
| FB-EI-30026-000 | 1m      | BJ-28471-000<br>(150Ω Impedance) | Noise Canceling | 172                         | 60                    | 5.4                        | 2-Wire                   |
| FB-EI-30426-000 | 1m      | BJ-28486-000<br>(30Ω Impedance)  | Noise Canceling | 172                         | 60                    | 5.4                        | 2-Wire                   |

\*Rating done to IP67 test criteria

## M SERIES



- Designed for headset customers who are looking for a noise canceling electret element in robust waterproof housing
  - Available in Omni-Directional
  - Waterproof options from 1m down to 20m (per IP67, IP68)
- Plastic head design with metal flexible boom
  - Available in 6.0mm down to 2.7mm diameter metal flexible boom
- Tactical, Security, Fire and Police and other high end radio communication headsets
  - Over the ear, earcup or helmet designs
- Designed for EK, NR and WP series elements

| Model           | *Rating | † Microphone Element | Directivity      | Boom Length Tip-To-Tip (mm) | Exit Wire Length (mm) | Nominal Boom Diameter (mm) | Microphone Configuration |
|-----------------|---------|----------------------|------------------|-----------------------------|-----------------------|----------------------------|--------------------------|
| FB-EM-30342-000 | 1m      | NR-25994-D63         | Noise Canceling  | 167                         | 60                    | 5.4                        | 2-Wire                   |
| FB-EM-30343-000 | 3m      | WP-25993-D63         | Noise Canceling  | 167                         | 60                    | 5.4                        | 2-Wire                   |
| FB-EM-30344-000 | 10m     | NR-25994-D63         | Noise Canceling  | 167                         | 60                    | 5.4                        | 2-Wire                   |
| FB-EM-30345-000 | 20m     | NR-25994-D63         | Noise Canceling  | 167                         | 60                    | 5.4                        | 2-Wire                   |
| FB-EM-30346-000 | 1m      | EK-23132-C36         | Omni-Directional | 167                         | 60                    | 5.4                        | 2-Wire                   |
| FB-EM-30348-000 | 10m     | EK-23132-C36         | Omni-Directional | 167                         | 60                    | 5.4                        | 2-Wire                   |
| FB-EM-30349-000 | 20m     | EK-23132-C36         | Omni-Directional | 167                         | 60                    | 5.4                        | 2-Wire                   |

\*Rating done to IP67 test criteria † WP-Series elements are waterproof

# BOOMS & SENSORS

## W SERIES



- Designed for headset customers who are looking for small footprint and lightweight platform with waterproofing to 1m (based on IP67 rating)
- Plastic head design with metal flexible boom
  - Available in 4.2mm down to 2.7mm diameter metal flexible boom
- Security, Police, Fire dispatchers and other lightweight communication headsets
- Designed for the NR and WP elements, but can also accommodate EK and EA series

| Model           | *Rating | † Microphone Element | Directivity     | Boom Length Tip-To-Tip (mm) | Exit Wire Length (mm) | Nominal Boom Diameter (mm) | Microphone Configuration |
|-----------------|---------|----------------------|-----------------|-----------------------------|-----------------------|----------------------------|--------------------------|
| FB-DW-30294-000 | 3m      | WP-25993-D63         | Noise Canceling | 140                         | 60                    | 4.2                        | 2-Wire                   |
| FB-BW-30335-000 | 3m      | WP-25993-D63         | Noise Canceling | 160                         | 60                    | 2.7                        | 2-Wire                   |
| FB-DW-30296-000 | 3m      | WP-25993-000         | Noise Canceling | 140                         | 60                    | 4.2                        | 3-Wire                   |
| FB-DW-30293-000 | IP54 ‡  | NR-25994-D63         | Noise Canceling | 140                         | 60                    | 4.2                        | 2-Wire                   |
| FB-BW-30330-000 | IP54 ‡  | NR-25994-D63         | Noise Canceling | 160                         | 60                    | 2.7                        | 2-Wire                   |
| FB-DW-30295-000 | IP54 ‡  | NR-25994-000         | Noise Canceling | 1607                        | 60                    | 4.22                       | 3-Wire                   |

\*Rating done to IP67 test criteria † WP-Series elements are waterproof ‡ Splashproof meeting IP54 test criteria

## O SERIES



- Designed for headset customers who are looking for a noise canceling electret element in a metal EMI shielded housing
  - Available in Omni-Directional
  - Waterproof options down to 3m using WP elements
- Metal head design with metal flexible boom
  - Available in 8.0mm down to 4.2mm diameter metal flexible boom
- Tactical, Security, Fire and Police and other radio communication headsets
  - Over the ear, earcup or helmet designs
- Designed for EK, NR and WP element series

| Model           | *Rating | † Microphone Element | Directivity      | Boom Length Tip-To-Tip (mm) | Exit Wire Length (mm) | Nominal Boom Diameter (mm) | Microphone Configuration |
|-----------------|---------|----------------------|------------------|-----------------------------|-----------------------|----------------------------|--------------------------|
| FB-DO-23511-000 | 3m      | WP-23501-000         | Noise Canceling  | 142                         | 150                   | 4.2                        | 2-Wire                   |
| FB-DO-25946-000 | 3m      | WP-23501-000         | Noise Canceling  | 54                          | 30                    | 4.2                        | 2-Wire                   |
| FB-HO-25624-000 | 3m      | WP-23501-000         | Noise Canceling  | 142                         | 160                   | 5.0                        | 2-Wire                   |
| FB-FO-25581-000 | N/A     | EK-23024-000         | Omni-Directional | 104                         | 140                   | 5.9                        | 2-Wire                   |

\*Rating done to IP67 test criteria † WP-Series elements are waterproof

# BOOMS & SENSORS

## F SERIES



- Designed for ruggedized panel mounted applications for outdoor microphone and sensor applications
  - Available in Omni Directional
  - Waterproof options from 1m down to 20m (per IP67, IP68)
- Designed for the EK, NR and WP elements series

| Model           | *Rating | Microphone Element | Directivity      | Exit Wire Length (mm) | Sensor Diameter (mm) | Microphone Configuration |
|-----------------|---------|--------------------|------------------|-----------------------|----------------------|--------------------------|
| VEK-F-30350-000 | 1m      | EK-23132-C36       | Omni-Directional | 200                   | 16                   | 3-Wire                   |
| VEK-F-30351-000 | 10m     | EK-23132-C36       | Omni-Directional | 200                   | 16                   | 3-Wire                   |
| VEK-F-30352-000 | 20m     | EK-23132-C36       | Omni-Directional | 20                    | 16                   | 3-Wire                   |
| VEK-F-30460-000 | 1m      | EK-23132-C36       | Omni-Directional | 10                    | 16                   | 3-Wire                   |
| VEK-F-30300-000 | 20m     | EK-23132-C36       | Omni-Directional | 8                     | 16                   | 3-Wire                   |

\*Rating done to IP67 test criteria

## H SERIES



- Designed for ruggedized fixed position and mounted applications for outdoor sensor arrays
  - Available in Omni Directional
  - Waterproof options from 1m down to 20m (per IP67, IP68)
- Conductive plastic shielding housing with shielded cable assembly
  - Available with extra high SPL circuit design
  - Custom PCBA options available within the housing cavity
- Designed for EK, NR, GH and WP series elements

| Model           | *Rating | Microphone Element | Directivity      | Sensor Length (mm) | Sensor Diameter (mm) | Exit Wire Length (mm) | Microphone Configuration |
|-----------------|---------|--------------------|------------------|--------------------|----------------------|-----------------------|--------------------------|
| VWP-H-30109-000 | 3m      | WP-30113-P03       | Omni-Directional | 21                 | 12.7                 | 211                   | 3-Wire                   |
| VEK-H-30320-000 | 1m      | EK-23169-P03       | Omni-Directional | 21                 | 12.7                 | 211                   | 3-Wire                   |
| VEK-H-30352-000 | 1m      | EK-26899-P03       | Omni-Directional | 21                 | 12.7                 | 211                   | 3-Wire                   |

\*Rating done to IP67 test criteria † WP-Series elements are waterproof

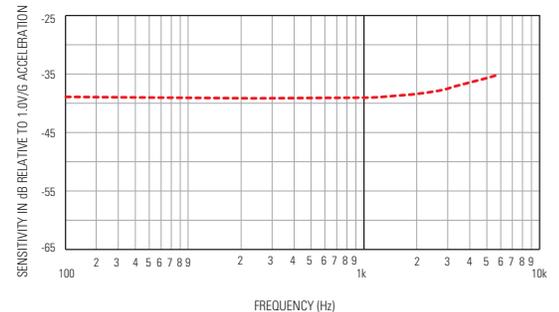
# ACCELEROMETERS & ACOUSTIC DAMPERS

## BU SERIES – Accelerometer 7.87 x 5.54 (mm)

BU Series Accelerometers are frequently used as contact microphones for radio communications in high noise environments. The accelerometers reproduce voice signals from vibrations at the throat or from bony parts of the head, and are compatible with helmet or headset applications.



- Ceramic vibration transducer
- High vibration sensitivity
- Small size
- Wide frequency range
- Integral FET amplifier
- High resistance to mechanical shock
- Withstands severe environmental conditions



| Model        | Thickness | Sensitivity @1 KHz (dB re 1Vg) | DC Supply (V) | Max. Current Drain (uA) | Nominal Output Impedance @1 KHz (Ohms) | "A" Weighted Noise (dBre. 1V) |
|--------------|-----------|--------------------------------|---------------|-------------------------|--|-------------------------------|
| BU-21771-000 | 4.06      | -45.0±4.5                      | 1.5           | 50                      | 5200                                   | -103                          |
| BU-23173-000 | 4.06      | -39.0±4.5                      | 1.5           | 50                      | 5200                                   | -103                          |
| BU-23842-000 | 2.24      | -40.0±4.0                      | 1.5           | 50                      | 5200                                   | -103                          |
| BU-27135-000 | 2.24      | -45.0±4.5                      | 1.5           | 300                     | 5200                                   | -103                          |

## BF Series – Acoustic Damper Screens

Dampers are acoustic cloth screens for insertion inside acoustic tubing. These damping elements are used between the speaker outlet and the ear canal to smoothen the frequency response.



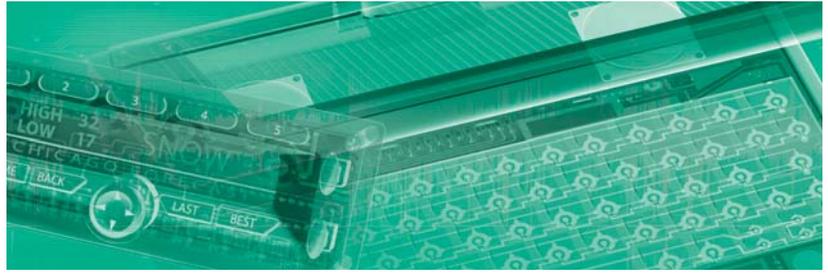
- Smoothen and shape frequency response
- Various acoustical resistances and sizes

| Model       | Thickness | Nominal Acoustic Resistance (Ohms) | PLUG (mm) | SCREEN (mm) |
|-------------|-----------|------------------------------------|-----------|-------------|
| BF-1859-000 | White     | 680                                | 2.08      | --          |
| BF-1860-000 | Brown     | 1000                               | 2.08      | --          |
| BF-1861-000 | Green     | 1500                               | 2.08      | --          |
| BF-1921-000 | Red       | 2200                               | 2.08      | --          |
| BF-1922-000 | Orange    | 3300                               | 2.08      | --          |
| BF-1923-000 | Yellow    | 4700                               | 2.08      | --          |
| BF-1988-000 | White     | 680                                | --        | 1.12        |
| BF-1991-000 | Green     | 1500                               | --        | 1.12        |
| BF-1995-000 | Red       | 2200                               | --        | 1.12        |
| BF-1997-000 | White     | 680                                | --        | 1.78        |
| BF-1999-000 | Grey      | 330                                | 2.08      | --          |
| BF-3034-000 | Grey      | 330                                | --        | 1.78        |
| BF-3035-000 | Brown     | 1000                               | --        | 1.78        |
| BF-3036-000 | Orange    | 3300                               | --        | 1.78        |
| BF-3037-000 | Red       | 2200                               | --        | 1.78        |
| BF-3038-000 | Green     | 1500                               | --        | 1.78        |
| BF-3039-000 | Green     | 1500                               | --        | 1.37        |
| BF-3163-000 | Yellow    | 4700                               | --        | 1.12        |

# ACOUSTIC SOFTWARE

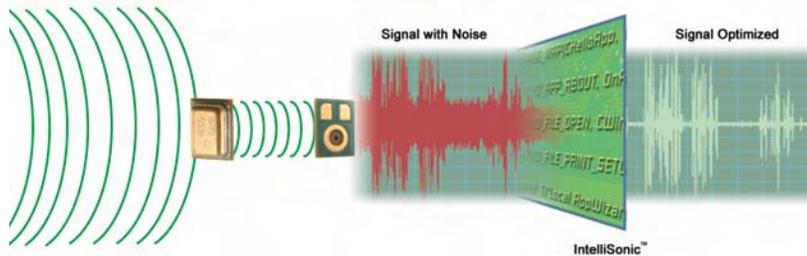
## INTELLISONIC™

The intelligibility and use of mobile communications are often impeded by the impact of noise from the immediate environment. IntelliSonic is a software-based speech enhancement technology that when coupled with Knowles' microphones, reduces the effects of reverberation, directionally interfering speech, background noise and annoying acoustic echo.



## COMPLETE SOLUTION – Integrated Systems

When you consider the interdependency of microphone design, acoustic porting, and sound signal conditioning, it's easy to see why Knowles Acoustics has taken an integrated approach to your acoustic system needs.



## FEATURES

- Noise suppression 12dB-16dB
- Interference cancellation via beam-forming array 25dB
- Acoustic echo cancellation 25dB
- Speech bandwidth 8kHz
- Adjustable acceptance and look angles
- Fully adaptive system adapts to changing acoustic environment
- Rich application programming interface (API) set
- Real-time processing
- Low speech distortion

## APPLICATIONS

Platforms such as tablets, laptops, ultra-mobile personal computers (UPCs), and other mobile computing devices have a number of applications that would benefit from IntelliSonic to enhance the user experience and final product perception.

- VoIP Telephony
- Command and Control
- Voice recognition
- Dictation
- Language Translation
- Voice Annotation
- Audio Note Taking

## PRODUCT MATRIX

| Product Code | # of Microphones | Noise Reduction | Array Processing | Echo Cancellation |
|--------------|------------------|-----------------|------------------|-------------------|
| DXEC01       | 1                | ✓               | –                | ✓                 |
| DXEC02       | 2                | ✓               | ✓                | ✓                 |



(Visual output of recordings using same microphone)

## SUPPORTED PLATFORMS (OS Support)

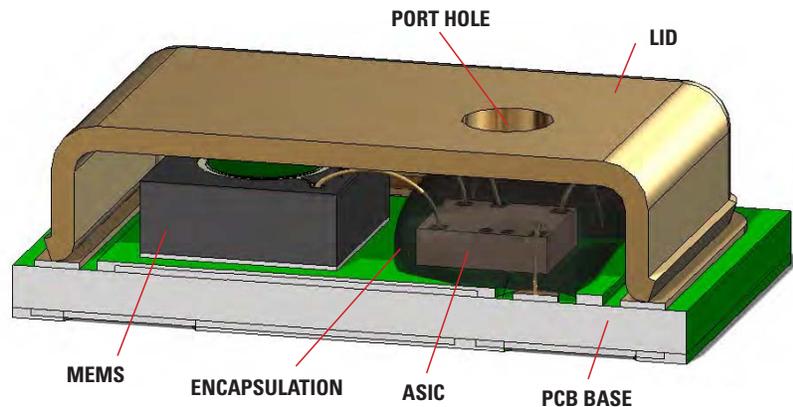
| OS   | Model  | Codec                       |
|--|--|-----------------------------|
| Microsoft Windows XP/2000                    | WDM Upper Filter   | AC'97 and HDAudio           |
| Microsoft Windows 7/Vista                    | WaveRT APO   | AC'97, HDAudio and USBAudio |
| Microsoft Windows Mobile and its Derivatives | Static library or integrated into codec driver binary (requires customization) |                             |

## SiSonic™ MEMS Microphones

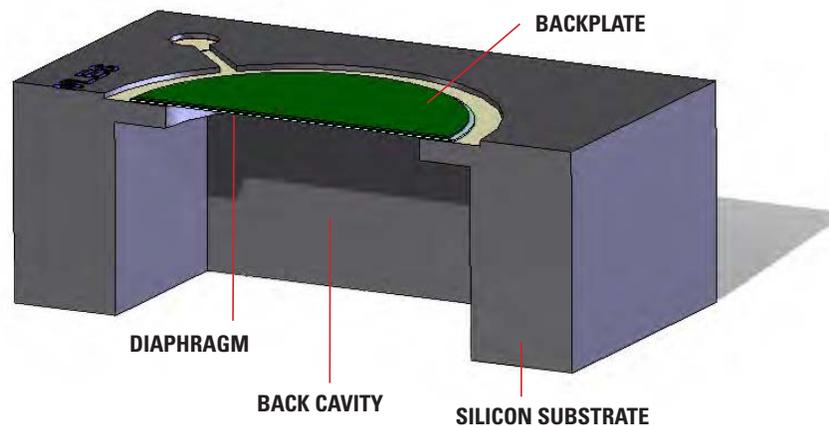
SiSonic™ microphones contain a silicon MEMS structure (diaphragm and backplate) and an ASIC (Fig. 1 and Fig. 2). Sound pressure causes the diaphragm to vibrate relative to the backplate creating a variable voltage. The ASIC buffers the resulting signal for external electrical connection. For digital SiSonic microphones, the microphone accepts a clock signal and converts the output to a synchronous PDM data format. SiSonic microphones are designed for surface mount (SMT) attach. The sensitivity of analog SiSonic microphones is measured in units of dBV relative to 1.0 Pascal while digital microphone sensitivity is measured in dBFS relative to 1.0 Pascal.

A charge pump in the ASIC provides a constant bias voltage to the diaphragm of the MEMS when the microphone is powered. This bias voltage does not degrade with time, temperature, or humidity. In conjunction with the floating diaphragm construction of the MEMS which is fabricated in standard silicon wafer processes, SiSonic microphones yield constant sensitivity distributions over a wide operating temperature range and after multiple reflow passes.

**Fig.1: Cross section of a SiSonic top port microphone**



**Fig. 2: Cross section of a SiSonic MEMS**



# TECHNOLOGY BASICS

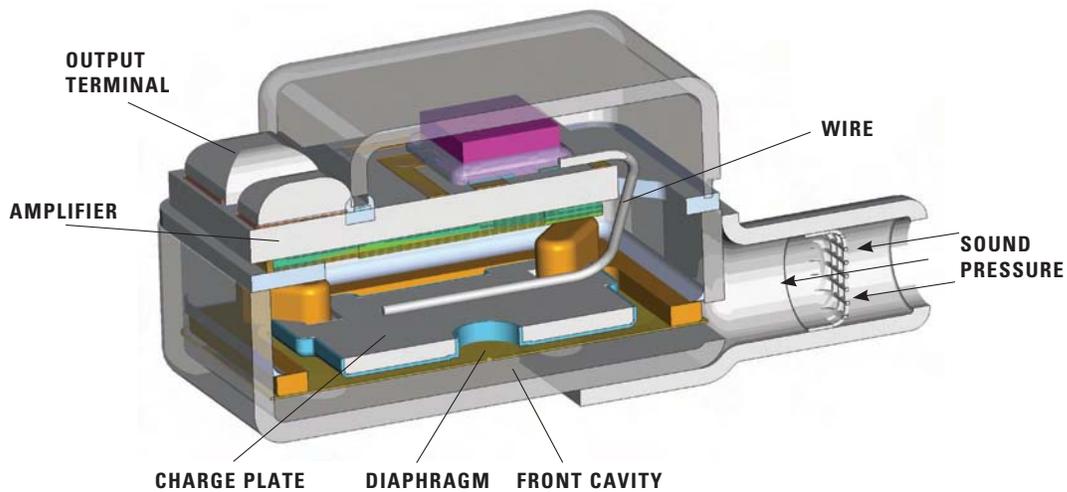
## Electret Microphones

Microphones measure sound pressure. Inside a Knowles microphone is a thin flexible diaphragm, an electrically charged plate, and an amplifier (Fig. 3). The output voltage is proportional to changes in the small separation between the diaphragm and the charged plate (Fig. 4).

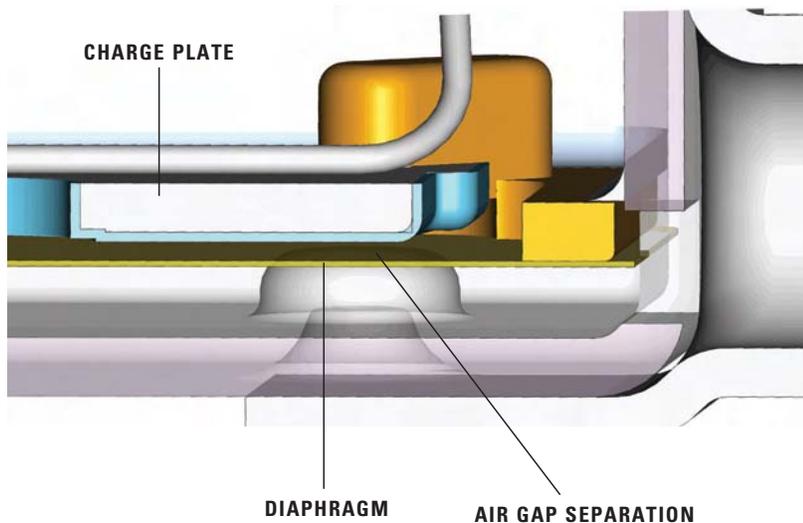
As sound pressure inside the front cavity increases, the diaphragm is pushed closer to the plate. As the pressure decreases, it moves further away. The motion of the diaphragm produces a small electrical signal that is amplified by a miniature circuit inside the microphone.

The sensitivity of a typical Knowles' microphone is measured in units of dB relative to 1 Volt per 0.1 Pascal.

**Fig 3: Cross section of a Knowles EM microphone**



**Fig. 4: EM diaphragm and electret**



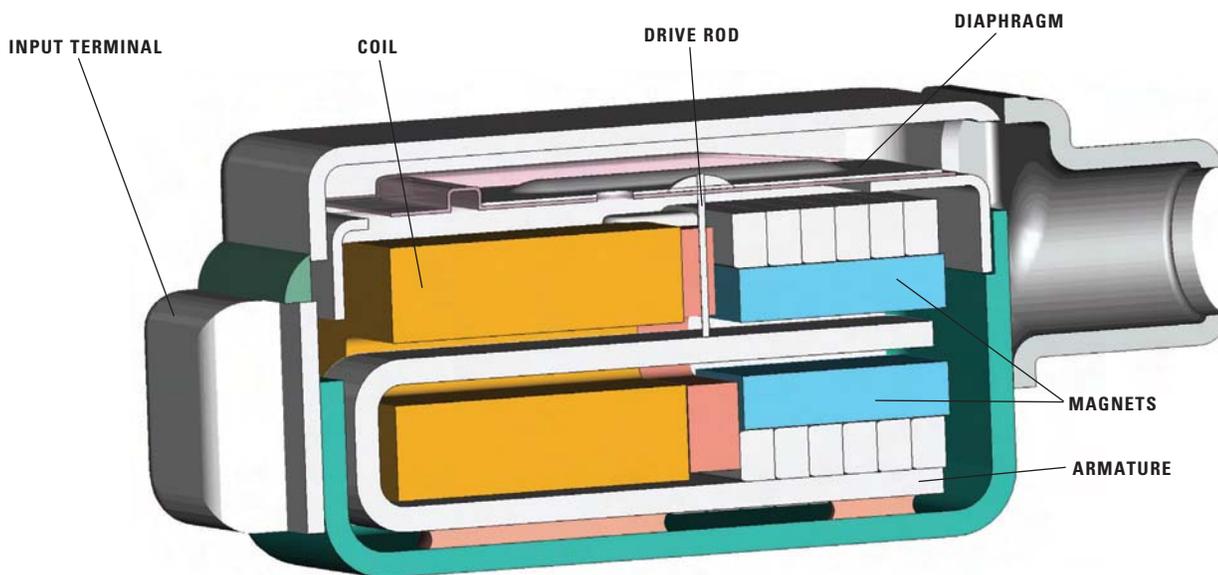
## Balanced Armature Speakers

The speaker converts an electrical signal into sound. A cross section of a typical Knowles speaker is shown in Fig. 5. The basic components of the speaker are: a coil of wire, a metal U-shaped reed called the armature, a pair of permanent magnets, a drive rod, and a diaphragm.

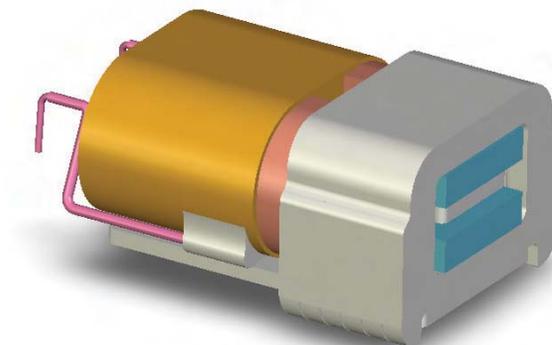
The coil and armature act as an electromagnet. An alternating current in the coil causes the polarity of the armature to switch back and forth from north to south. The free end of the armature bends slightly up and down as it is attracted alternately to the top and bottom magnets (Fig. 6). The diaphragm, pulled along by the drive rod, pumps air in and out of the speaker. The mechanical motion of the armature is thus converted into sound.

The sound output of a typical Knowles' speaker is measured in units of dB SPL (sound pressure level) relative to 20  $\mu$ Pa.

**Fig. 5: Cross section of a Knowles EH speaker**



**Fig. 6: The motor of the speaker has a coil, an armature, and a pair of permanent magnets.**



# Globally Positioned



*Knowles maintains sales, marketing, engineering and manufacturing globally.  
For further information, please visit our website.*

*[www.knowles.com](http://www.knowles.com)*

