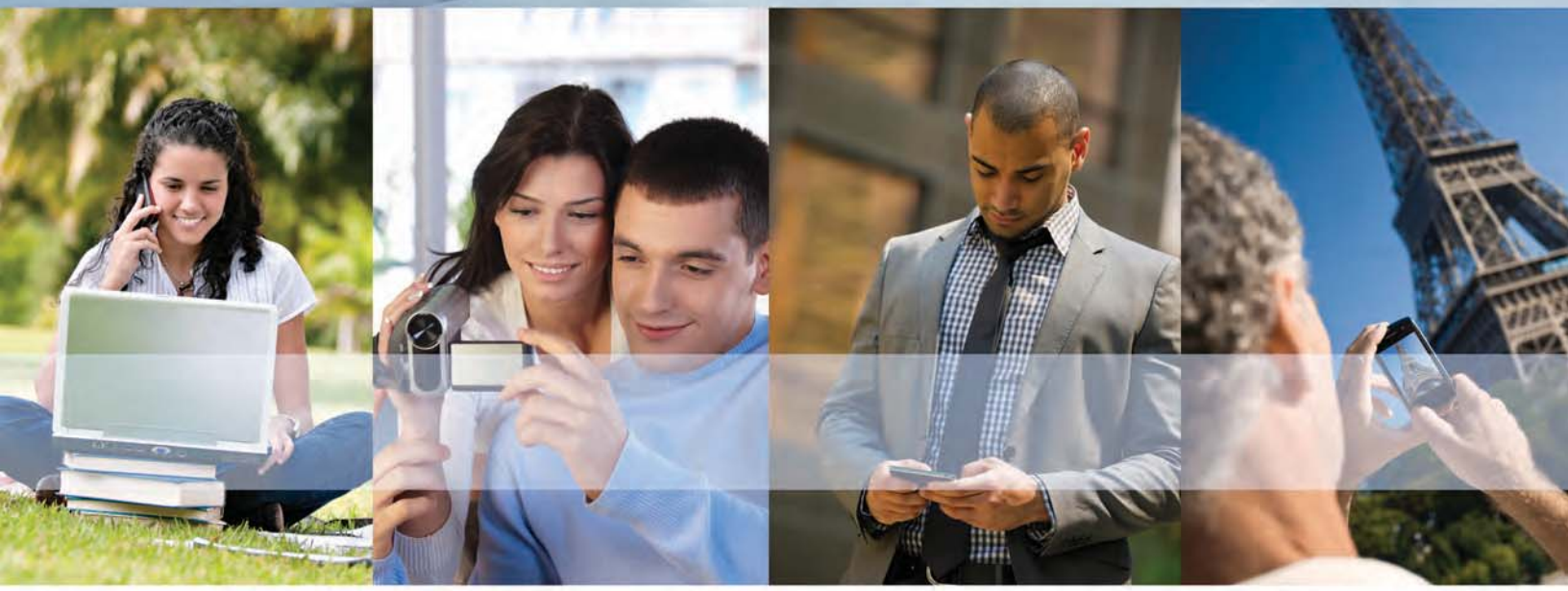
Acoustic Interface Design Guide



- MEMS MICROPHONES
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- BOOMS & SENSORS
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KNOWLES

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.

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*




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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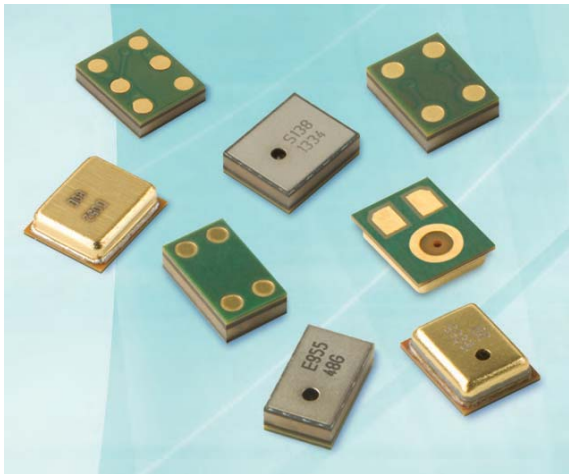
MEMS MICROPHONES

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.

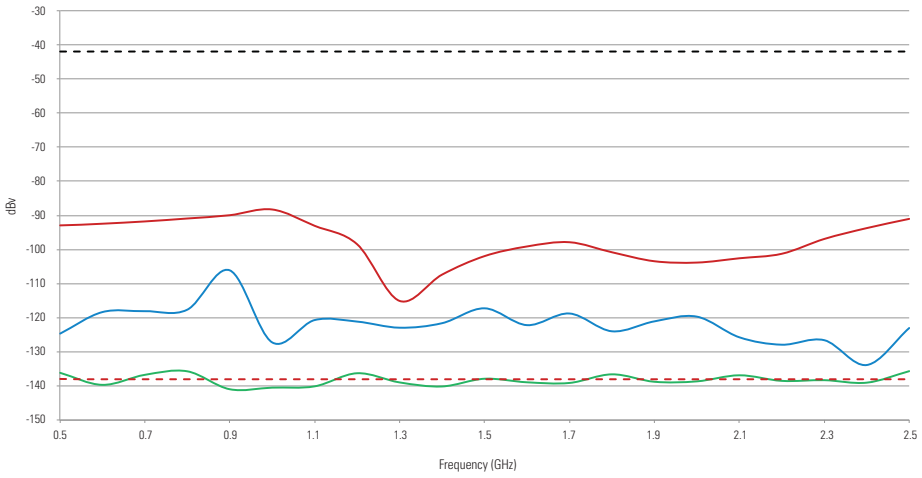


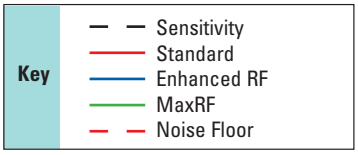
Design variables include ever-smaller sizes, lower profiles and mounting options, increased output capacities, and new digital audio options that eliminate analog noise. For manufacturers, surface mount designs eliminate off-line subassembly production costs. Customized designs are supplied on tape-and-reel 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 8.5mm² (SPQ Series)*
- *Integrated designs with differential and ultrasonic outputs*
- *Zero Height Mic™ for thinnest ever designs*

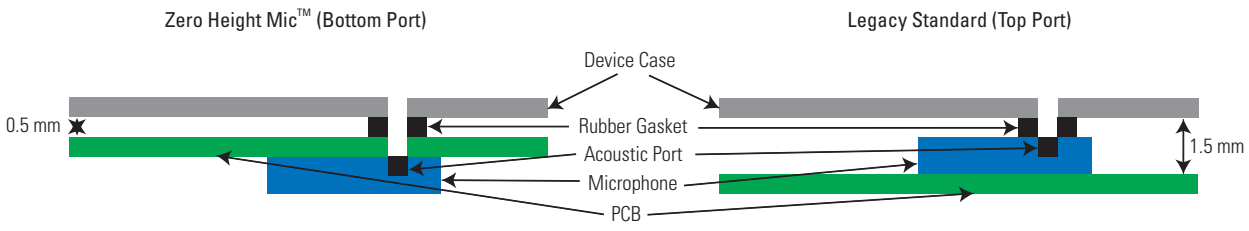
Typical RF Performance of Microphone Families





- ***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

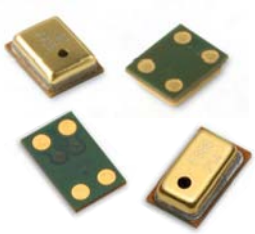


Bottom port mounting enables minimum PCB-to-case thickness, simple gasket designs, and best-in-class SNR

Part Numbering

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)	0406: Differential	H: Top Port	D: Standard	3: 1.5-5.5V		Knowles Internal	Product Specific
SPQ: (3.76 x 2.24)	0409: Unity Gain	L: Bottom Port	E: Enhanced	4: 1.6-3.6V		(Reference Only)	(Reference Only)
SPU: (3.76 x 2.95)	0410: Unity Gain		M: Enhanced	5: 1.5-3.6V			
SPM: (4.72 x 3.76)	0414: Amplified		R: MAX-RF				
SPA: (3.35 x 2.50)	0415: Digital						
SPK: (4.00 x 3.00)	0423: Digital						
	0824: Unity Gain						
	0833: Digital						
	1410: Unity Gain						
	1423: Digital						
	2410: Unity Gain						

Top Port Analog



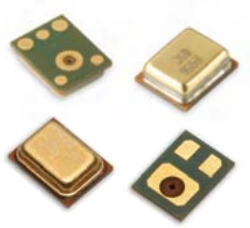
- *SPU and SPQ (less than 8.5mm^2) footprints are ideal for multiple microphone applications*
- *MaxRF technology provides wideband noise suppression, for compact devices with challenging routing and layouts*
- *All SiSonic™ microphones are designed with leading-edge MEMS technology for stable acoustic 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

Note: All performance curves are typical

MEMS MICROPHONES

Bottom Analog

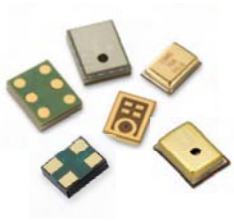


- *SPU and SPA (less than 8.5mm^2) footprints are ideal for multiple microphone applications*
- *SiSonic™ Zero Height Mic™ shrinks product thickness by up to 30%*
- *Minimizes the distance between PCB and device housing*
- *Enables the thinnest, highest density product designs*

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 Maximum Load	<0.70
SPK0415HM4H	Digital	4.00 x 3.00 x 1.06	1.6 to 3.6v	Digital Enhanced	-26.0	100pf Maximum Load	<0.65
SPM0423HD4H	Digital	4.72 x 3.76 x 1.25	1.6 to 3.6v	Digital Standard	-26.0	100pf Maximum Load	<0.60
SPM0423HE4H	Digital	4.72 x 3.76 x 1.25	1.6 to 3.6v	Digital Enhanced	-26.0	100pf Maximum Load	<0.60
SPM0423HM4H	Digital	4.72 x 3.76 x 1.25	1.6 to 3.6v	Digital Enhanced	-26.0	100pf Maximum Load	<0.60
SPM1423HM4H	Digital	4.72 x 3.76 x 1.25	1.6 to 3.6v	MaxRF	-22.0	100pf Maximum Load	<0.60

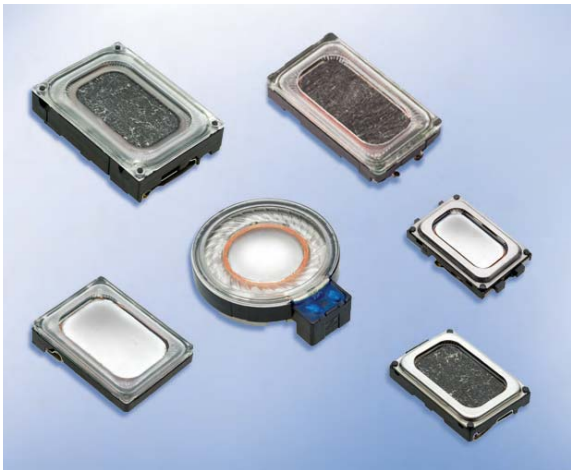
Note: All performance curves are typical

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.

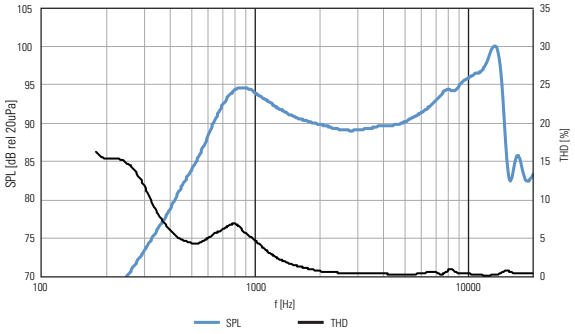


- *High quality and robustness*
- *Maximized space efficiency*
- *Excellent audio performance-to-size ratio*
- *Optimized for all mobile sound applications (handsfree and ringtone)*
- *Multi-functional devices including vibration*
- *Dedicated application support*

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*



Measured in IEC baffle with 1 cm^3 back cavity at 350mW in 10 cm distance

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^3	1 cm^3 (1.57 cm^3)	800 Hz	650 – 16000	500 mW	89 dB (350 mW)

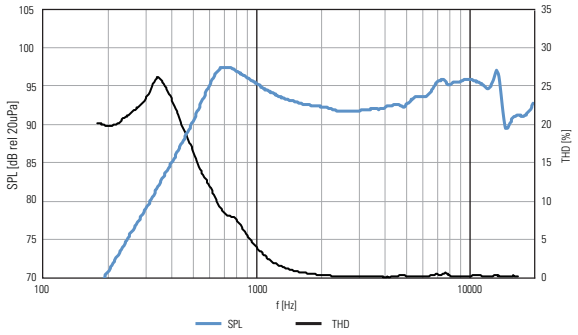
Note: Impedance of all speaker devices is typically 8 ohms, all components feature contact springs except where otherwise noted
* average value measured in baffle
** in front firing application without mesh, at -3dB points after resonance peaks, without EQ correction
*** using noise shaped signal according 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*



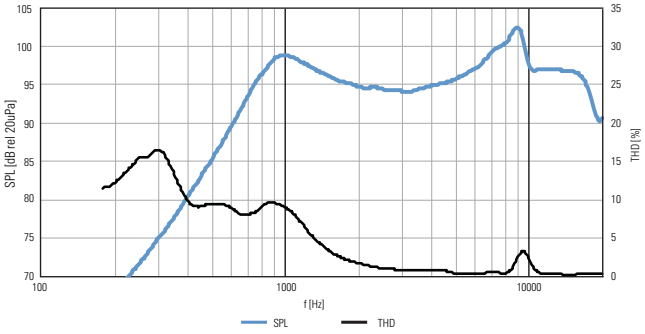
Measured in IEC baffle at 700mW in 10 cm distance with 1 ccm back cavity

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^3	1 cm^3 (2.05 cm^3)	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*



Measured in IEC baffle with 1 cm^3 back cavity at 700mW in 10 cm distance

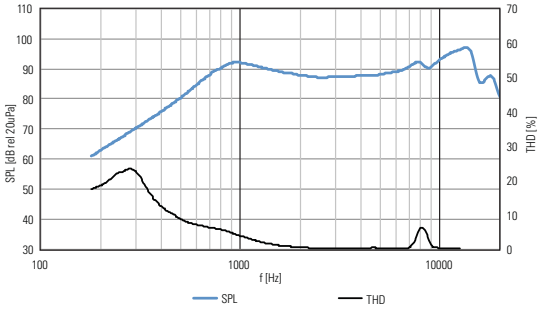
Model	Sensitivity (W/m)*	Air Pumping Capacity	Typical Backvolume (total volume)	f0 (in typical backvolume)	Frequency Range (Hz)**	Nominal Power***	SPL Max (@ max sine power)****
2403 260 00058	77 dB	100 mm^3	1 cm^3 (2.05 cm^3)	900 Hz	700 – 16000	700 mW	95.5 dB (700 mW)

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

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*



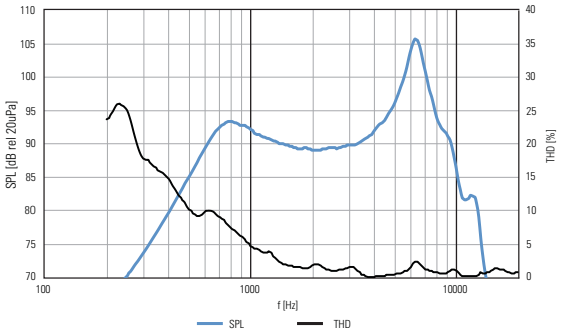
Measured in IEC baffle at 500mW in 10 cm distance with 1 ccm back cavity

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 00086	70.5 dB	55 mm³	1 cm³ (1.43 cm³)	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 ccm back cavity

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 00089	73 dB	69 mm³	1 cm³ (1.66 cm³)	750 Hz	650 - 12000	500 mW	89 dB (350 mW)

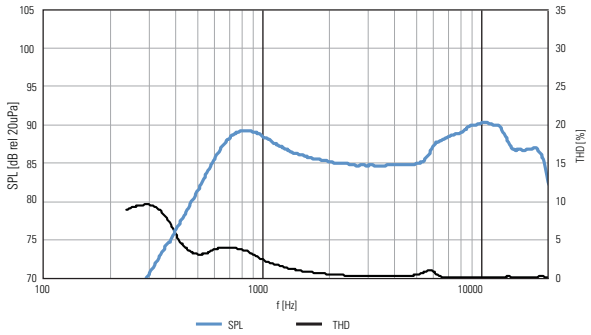
Note: Impedance of all speaker devices is typically 8 ohms, all components feature contact springs except where otherwise noted
* average value measured in baffle
** in front firing application without mesh, at -3dB points after resonance peaks, without EQ correction
*** using noise shaped signal according 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*



Baffle in P=125mW with 2 cm back cavity in 10 cm distance

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^3	2 cm^3 (2.93 cm^3)	740 Hz	650 - 15000	500 mW	91dB (500 mW)

Speaker Boxes

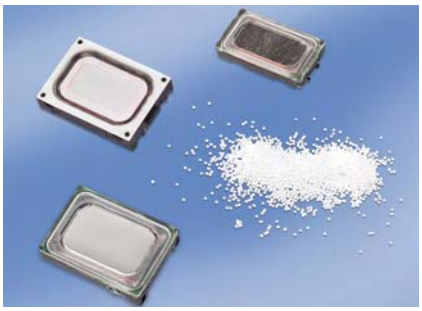
Speaker Boxes are designed for mobile phones, tablets and other consumer electronics. Knowles develops and manufactures integrated acoustic modules which are fully customized and provide an optimized acoustic design for any form factor.

- *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

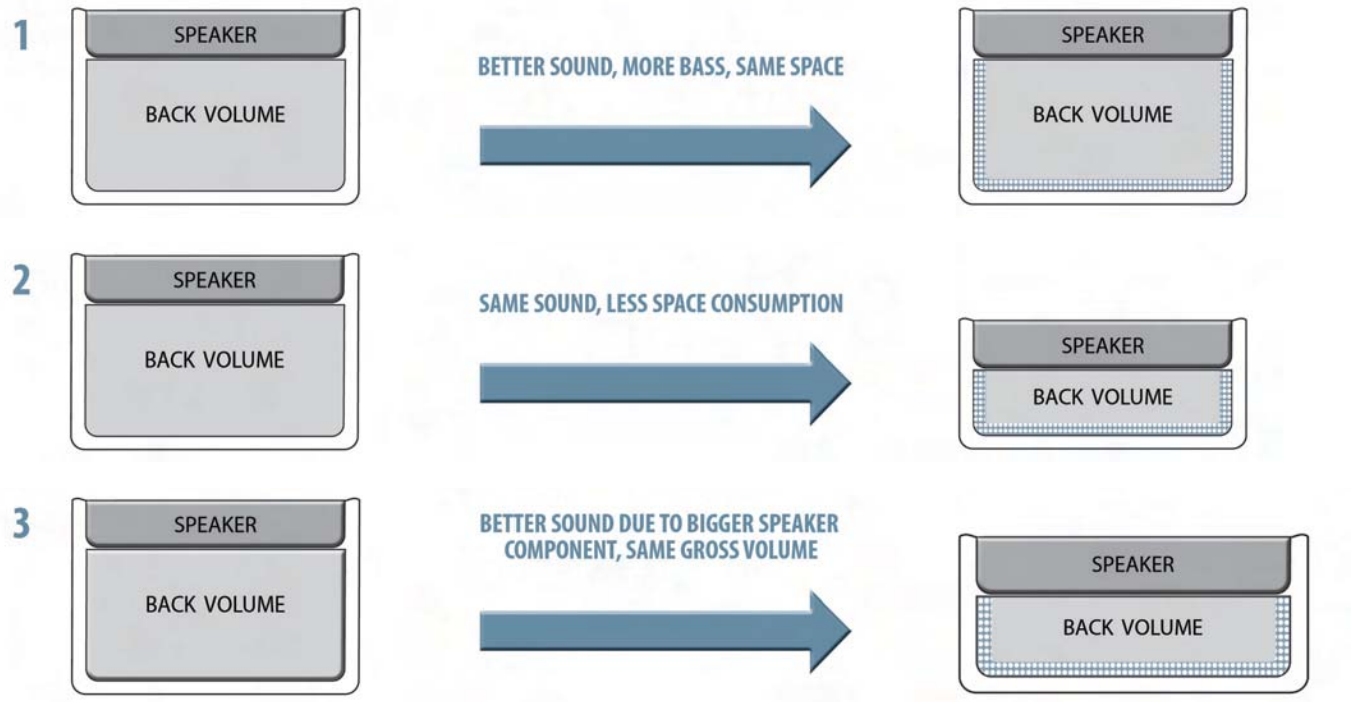
N'Bass™ Virtual Back Volume Technology

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



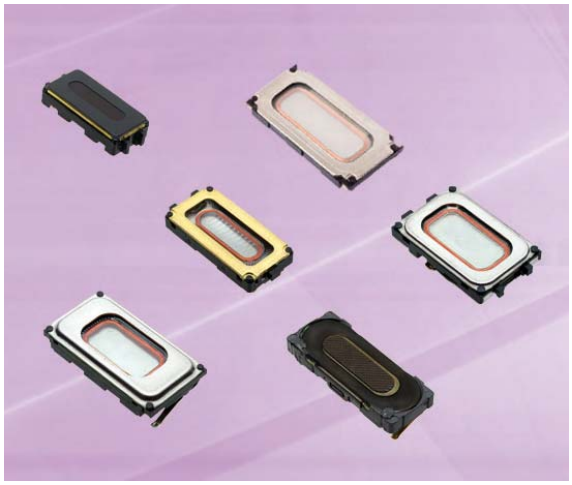
DYNAMIC RECEIVERS

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.

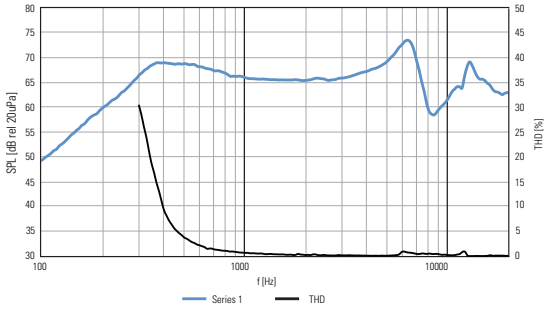


- *High quality and robustness*
- *Maximized space efficiency*
- *Excellent audio performance-to-size ratio*
- *Optimized for all mobile sound applications (handsfree and ringtone)*
- *Multi-functional devices including vibration*
- *Dedicated application support*

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*



Measured in IEC baffle with open back volume (1mW, 10 cm)

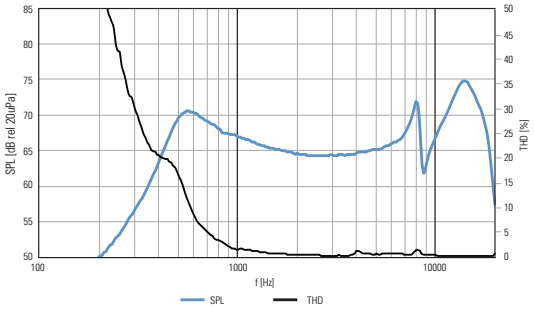
Model	Sensitivity (W/m)*	Air Pumping Capacity	f0	Frequency Range (Hz)**	Maximum Sine Power	SPL Max (@ max sine power)***
2403 260 00031	68 dB	20 mm^3	350 Hz	300 - 7000	5 mW	110 dB

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

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*



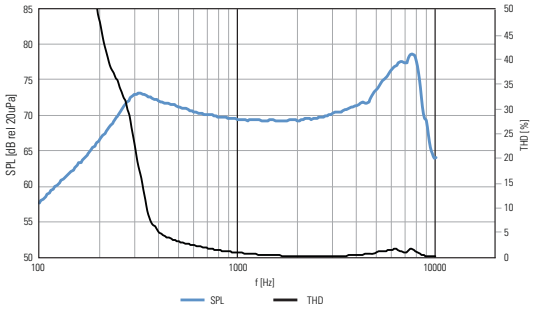
Measured in IEC baffle with open back volume (10mW, 10 cm)

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 mm³	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*



Measured in IEC baffle with open backvolume (1mW, 1cm)

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 mm³	300 Hz	160 – 7000	10 mW	114 dB

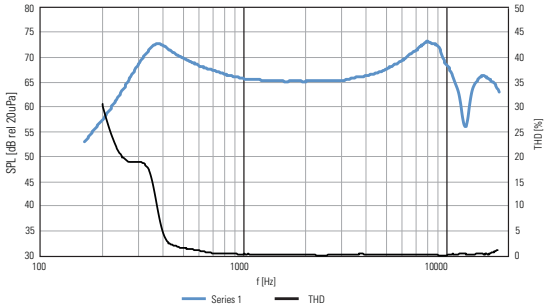
Note: Impedance of all receiver devices is typically 32 ohms, all components feature contact springs except where otherwise noted
* average value measured in baffle, subtract 10dB for value in dB/mW/0.1m
** in typical application, at -3dB points after resonance peaks, without EQ correction
*** measured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



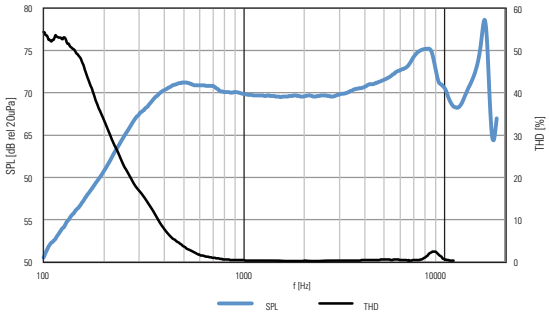
Measured in IEC baffle with open back volume (1mW, 10 cm)

Model	Sensitivity (W/m)*	Air Pumping Capacity	f0	Frequency Range (Hz) **	Maximum Sine Power	SPL Max (@ max sine power)***
2403 260 00051	65 dB	20 mm³	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 Compatability (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 f0=300Hz as COLEMAN 300 (2403 260 00097)*



Measured in IEC baffle at 15mW in a 10cm distance

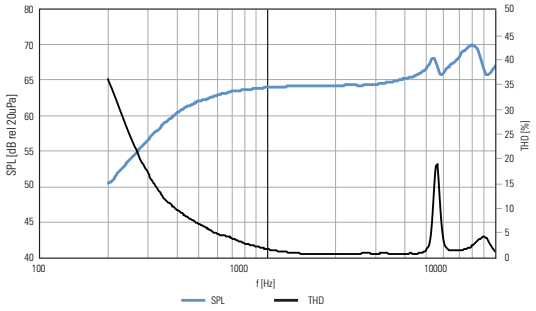
Model Id	Sensitivity (W/m)*	Air Pumping Capacity	f0	Frequency Range (Hz)**	Maximum Sine Power	SPL Max (@ max sine power)***
2403 260 00096	68 dB	28 mm³	350 Hz	300-7000	15 mW	115 dB

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

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)*



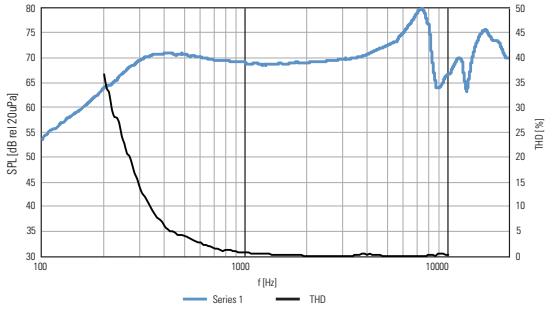
Measured in IEC baffle with open backvolume (20mW, 10cm)

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 mm³	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*



Measured in IEC baffle with open backvolume (10mW, 1cm)

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 mm³	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.

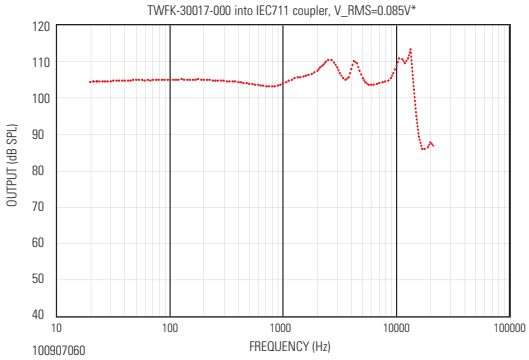
- *High efficiency, stability and reliability*
- *Customizable performance and port locations*
- *Ideal for premium in-ear designs*
- *Component and subassembly solutions*

BAX ENHANCED AUDIO

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*

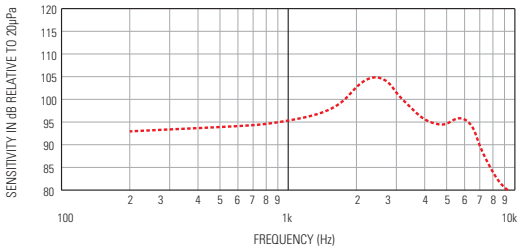


Model	Port Location	Sensitivity @ 1kHz (dB SPL)	Sensitivity @ 1st Peak (dB SPL)	DC Resistance (Ohms)	Impedance @ 500 Hz (Ohms)
TWFK-30017-000	12S	95	103	25	31

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

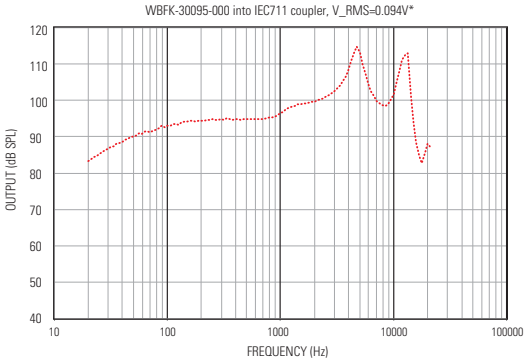
Note: All performance curves are typical

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

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*

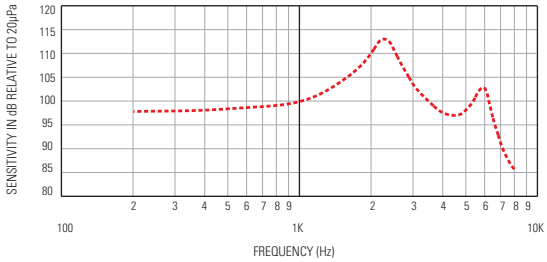


Model	Port Location	Sensitivity @ 1kHz (dB SPL)	Sensitivity @ 1st Peak (dB SPL)	DC Resistance (Ohms)	Impedance @ 500 Hz (Ohms)
WBFK-30000-000	12S	95	105	100	111
WBFK-30095-000	12S	91	105	12.5	13.5

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

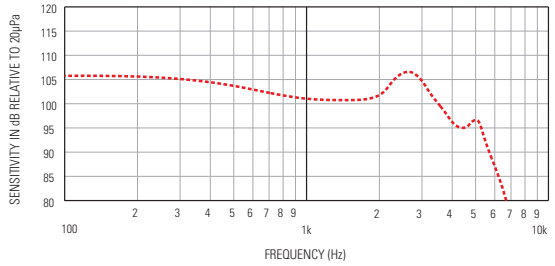
*Note: Chart for reference only to show performance with insert earphone coupler

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*

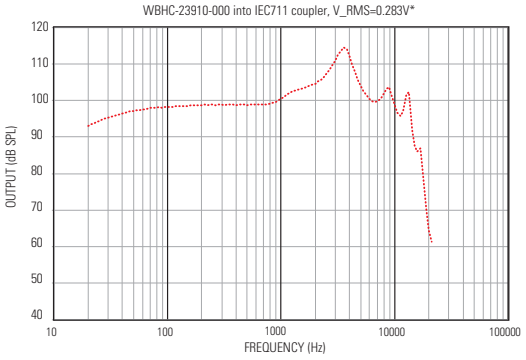


Model	Port Location	Sensitivity @ 1kHz (dB SPL)	Sensitivity @ 1st Peak (dB SPL)	DC Resistance (Ohms)	Impedance @ 500 Hz (Ohms)
HC-23761-000	12C	101	107	4.9	8.4
HC-23763-000	12C	101	107	11.5	20
HC-23764-000	12C	101	107	15.5	24

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*

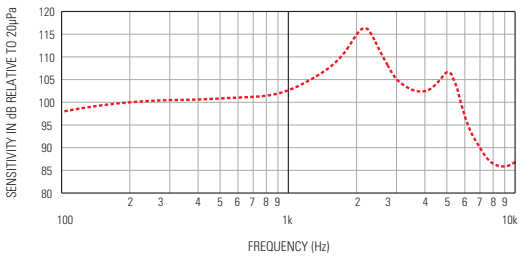


Model	Port Location	Sensitivity @ 1kHz (dB SPL)	Sensitivity @ 1st Peak (dB SPL)	DC Resistance (Ohms)	Impedance @ 500 Hz (Ohms)
WBHC-23910-000	12C	95	106	120	130
WBHC-30670-000	12C	95	105	44	46

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 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

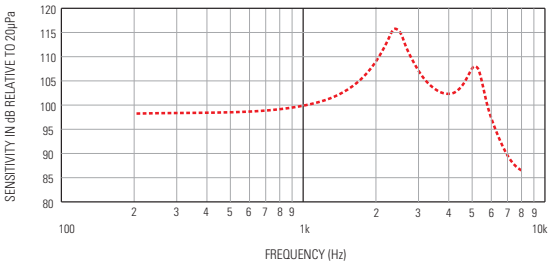
Note: All performance curves are typical

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

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*

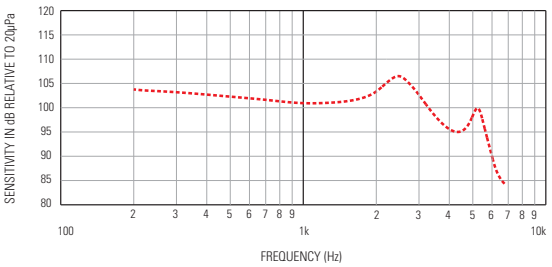


Model	Port Location	Sensitivity @ 1kHz (dB SPL)	Sensitivity @ 1st Peak (dB SPL)	DC Resistance (Ohms)	Impedance @ 500 Hz (Ohms)
EH-23030-000	12C	100	117	395	625
EH-23149-000	12C	100	116	68	101
EH-27479-000	12C	100	112.5	118	144

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*

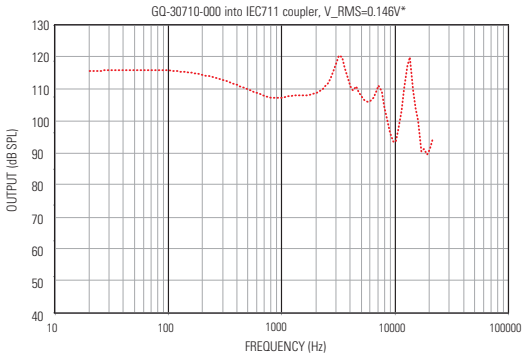


Model	Port Location	Sensitivity @ 1kHz (dB SPL)	Sensitivity @ 1st Peak (dB SPL)
ES-23127-000	12C	101	107
ES-23140-000	12C	101	105.5

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

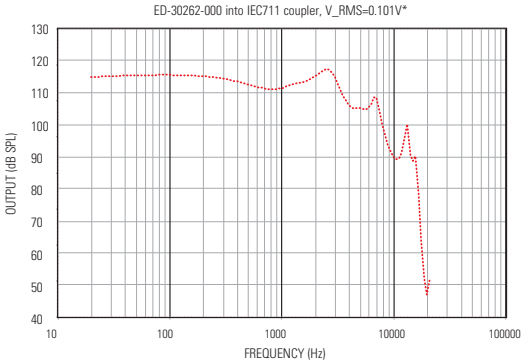
*Note: Chart for reference only to show performance with insert earphone coupler

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*

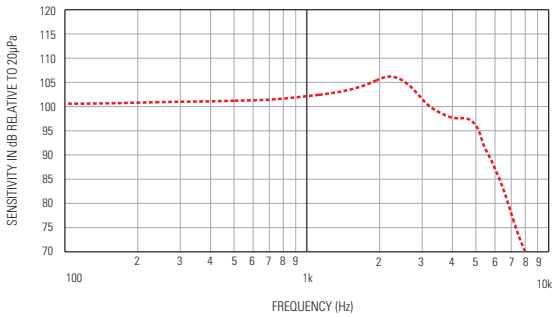


Model	Port Location	Sensitivity @ 1kHz (dB SPL)	Sensitivity @ 1st Peak (dB SPL)	DC Resistance (Ohms)	Impedance @ 500 Hz (Ohms)
ED-21744-000	12C	104	112.5	825	1700
ED-21913-000	12C	104	117.5	376	780
ED-23147-000	12C	102.5	110	25	48
ED-23619-000	12C	104	117.5	3.3	7.1
ED-23801-000	12C	104	113	155	196
ED-23814-000	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

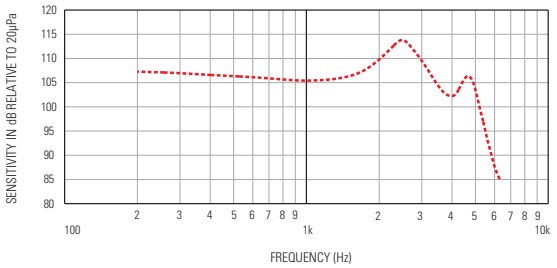
Note: All performance curves are typical

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

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*

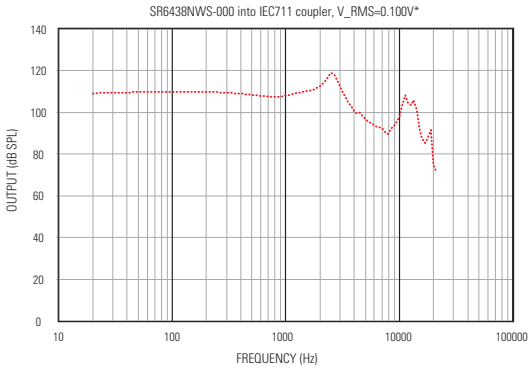


Model	Port Location	Sensitivity @ 1kHz (dB SPL)	Sensitivity @ 1st Peak (dB SPL)
EP-24075-000	12C	106	114

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*

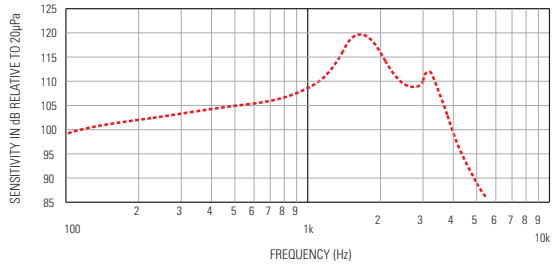


Model	Port Location	Sensitivity @ 1kHz (dB SPL)	Sensitivity @ 1st Peak (dB SPL)	DC Resistance (Ohms)	Impedance @ 500 Hz (Ohms)
SR-6438NWS-000	Face	109.5	120	25	36.5
SR-6438NWS-158	Face	109.5	120	25	32.8

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

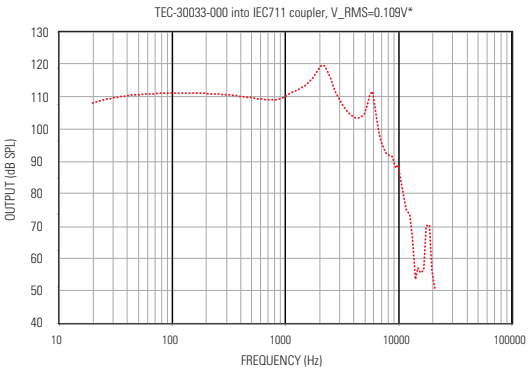
*Note: Chart for reference only to show performance with insert earphone coupler

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*

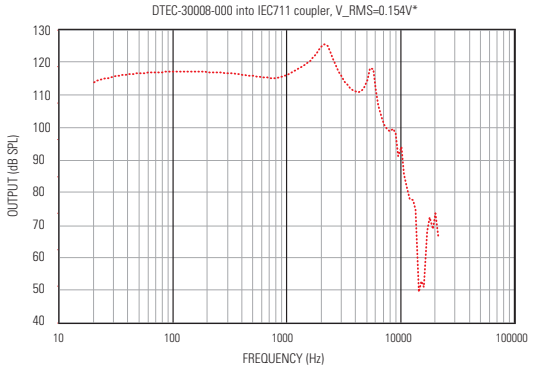


Model	Port Location	Sensitivity @ 1kHz (dB SPL)	Sensitivity @ 1st Peak (dB SPL)	DC Resistance (Ohms)	Impedance @ 500 Hz (Ohms)
TEC-30033-000	12C	115	119	22	31
TEC-30087-000	12C	115	119	46	62

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

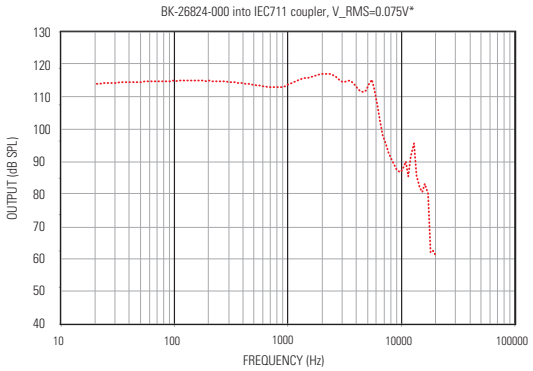
*Note: Chart for reference only to show performance with insert earphone coupler

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*

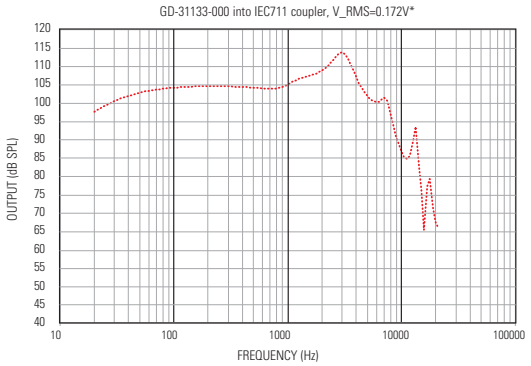


Model	Port Location	Sensitivity @ 1kHz (dB SPL)	Sensitivity @ 1st Peak (dB SPL)	DC Resistance (Ohms)	Impedance @ 500 Hz (Ohms)
BK-21600-000	12S	123	125	100	285
BK-21604-000	12S	123	125	895	2320
BK-21610-000	12S	121	126	21	60
BK-21613-000	1S	118	125	160	450
BK-21615-000	12S	118	125	160	450
BK-21669-000	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

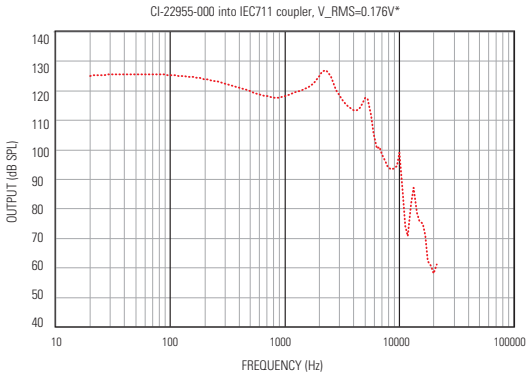
*Note: Chart for reference only to show performance with insert earphone coupler

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*

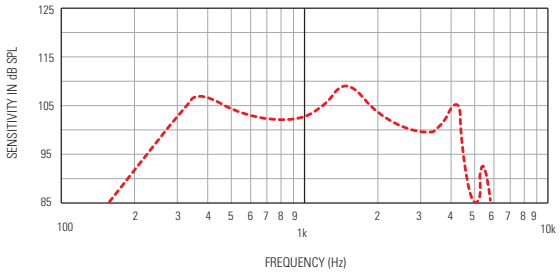


Model	Port Location	Sensitivity @ 1kHz (dB SPL)	Sensitivity @ 1st Peak (dB SPL)	DC Resistance (Ohms)	Impedance @ 500 Hz (Ohms)
CI-22748-000	12C	125	128	75	250
CI-22762-000	1S	125	128	51	175
CI-22955-000	12C	125	128	20	68 @ 1kHz
CI-22960-000	12C	125	128	100	400
CI-28487-000	1S	125	128	24	100 @ 1kHz
CI-28597-000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

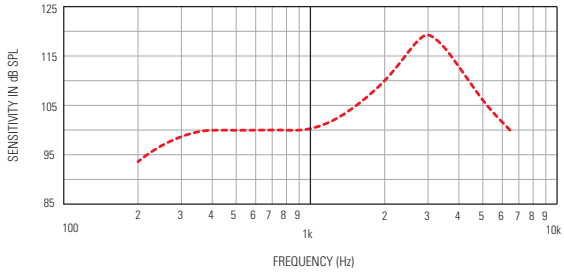
Note: All performance curves are typical

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

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*

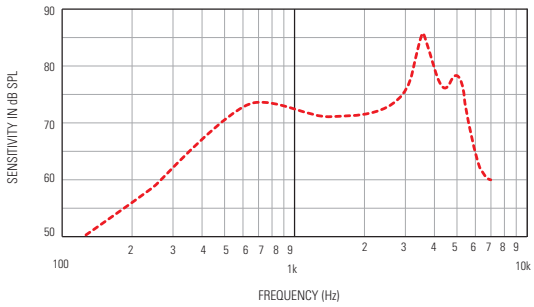


Model	Port Location	Sensitivity @ 1kHz (dB SPL)	Sensitivity @ 1st Peak (dB SPL)	DC Resistance (Ohms)	Impedance @ 500 Hz (Ohms)
MR-23333-000	Face	100	119.5	10	21

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

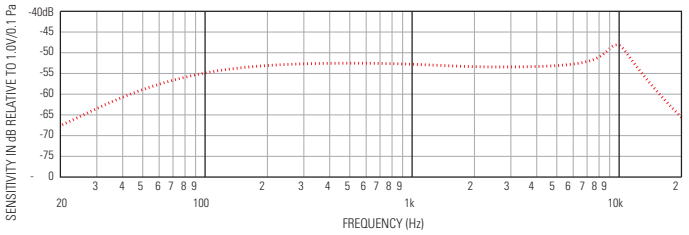
Electret Microphones

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

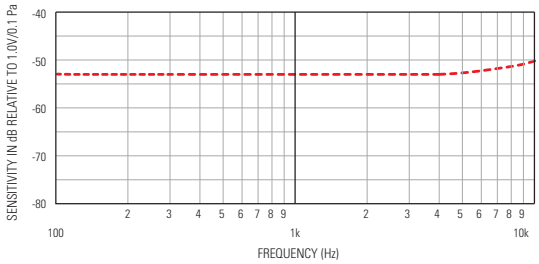
Note: All performance curves are typical

Note: All performance curves are typical

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*

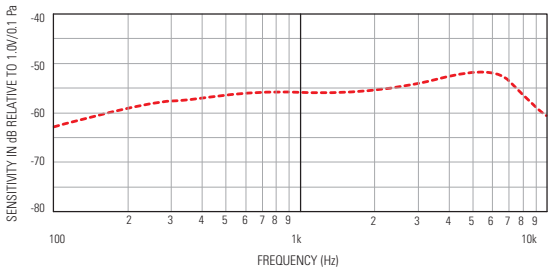


Model	Sensitivity @ 1kHz (dB re1V/0.1Pa)	DC Supply (Vdc)	Max. Amplifier Current Drain (uA)	"A" Weighted Noise * 1kHz Equivalent SPL ** re 1Vrms	Nominal Output Impedance (Ohms)	Comments
FG-23329-D65	-53.0±3	1.3 nom. 3.0 max	50	30.0 dB*	4400	RFI Improved Version
FG-23329-P07	-53.0±3	1.3 nom. 3.0 max	50	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 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 Standard Response
EM-23069-000	-56.0±3	1.3 nom. 1.6 max	50	33.0 dB*	4400	Tubeless Standard Response
EM-30081-D65	-68.0±3	1.3 nom. 3.0 max	50	-98.0 dB*	4400	12dB/Octave Ski-Slope

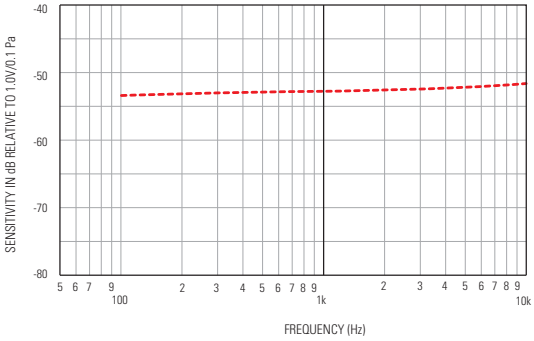
Note: All performance curves are typical

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*

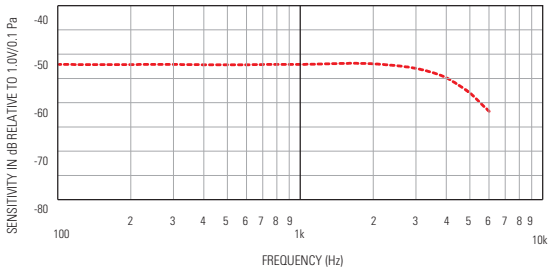


Model	Sensitivity @ 1kHz (dB re1V/0.1Pa)	DC Supply (Vdc)	Max. Amplifier Current Drain (uA)	"A" Weighted Noise * 1kHz Equivalent SPL ** re 1Vrms	Nominal Output Impedance (Ohms)	Comments
EK-23024-C36	-53.0±2	1.3 nom. 10 max	50	26.0 dB*	4400	RFI Improved Version Standard Response
EK-23024-P07	-53.0±2	1.3 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 electoacoustical sensitivity*
- *Superior noise canceling performance*
- *Lead attachment available*

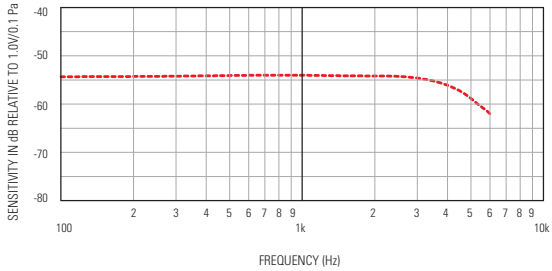


Model	Sensitivity @ 1kHz (dB re1V/0.1Pa)	DC Supply (Vdc)	Max. Amplifier Current Drain (uA)	Max. "A" Weighted Noise (dBV)	Nominal Output Impedance (Ohms)	Comments
NR-23158-000	-49.0±3	1.3 nom. 10 max	50	-100	4400	3-Wire
NR-23159-000	-65.0±3	1.3 nom. 10 max	200	-100	2500	2-Wire
NR-23160-000	-52.0±3	1.3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

Note: All performance curves are typical

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.)

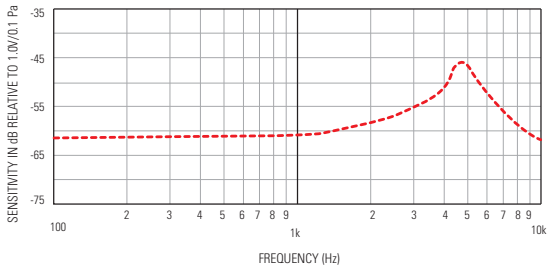


- *Waterproofed to submersion in 1m water*
- *Close-talking (noise-canceling)*
- *Corrosion resistant*
- *Withstands explosive decompression*
- *Excellent environmental performance*
- *High resistance to mechanical shock*

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*

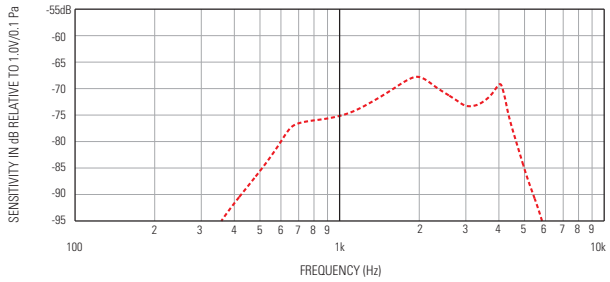
Model	Dimensions (mm)	Sensitivity @ 1kHz (dB re1V/0.1Pa)	DC Supply (Vdc)	Max. Amplifier Current Drain (uA)	"A" Weighted Noise	Nominal Output Impedance (Ohms)	Comments
MR-23151-000	22.12 DIA x 9.3	-87.0±3	N/A	N/A	30.0 dB**	300	2-Wire, 193mm Leads
MR-23793-000	22.12 DIA x 11.43	-60.0±4	1.3	50	31.0 dB*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

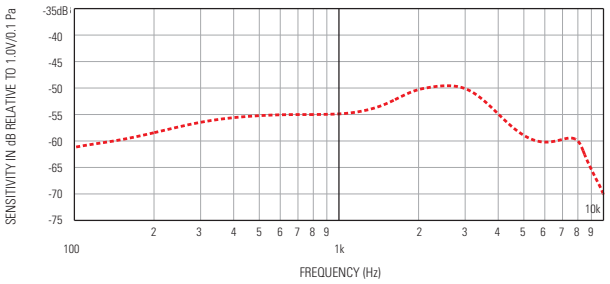


Model	Directivity	Port Location	Nominal Impedance at 1kHz (Ohms)	Nominal DC Resistance at 20˚ C (Ohms)
BJ-21590-000	Omni-Directional	OJn	3900	900
BJ-28411-000	Noise Canceling	Dual	300	75.5

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

Note: All performance curves are typical

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 2 3 4

1 **Product Description**	2 **Boom Diameter**	3 **Head Series**	4 **Model #**
FB: Flexible Boom	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	I: BJ Housing M: NR/WP Waterproof Housing O: Cyilnder Housing U: FG/DFG Micro Housing W: Plastic Housing w/ Sinter Disc	

VWP-F-30109-000

1 2 3 4

1 **Product Description**	2 **Element Series**	3 **Housing Series**	4 **Model #**
V: Value Added	EK, EA, WP	B: Over Molded C: Custom Design F: Plastic Panel Mount H: ESD Shielded Plastic	

Note: All performance curves are typical

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 (150Ω Impedance)	Noise Canceling	172	60	5.4	2-Wire
FB-EI-30426-000	1m	BJ-28486-000 (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

Note: All performance curves are typical

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

Note: All performance curves are typical

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-F-30352-000	1m	EK-26899-P03	Omni-Directional	21	12.7	211	3-Wire

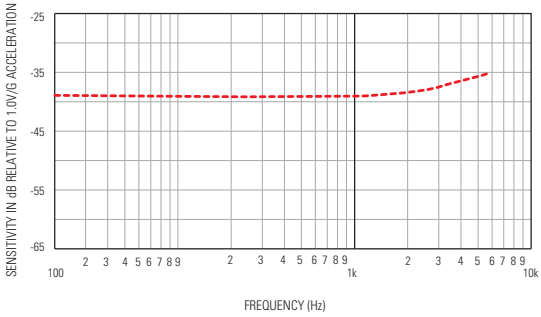
*Rating done to IP67 test criteria † WP-Series elements are waterproof

Note: All performance curves are typical

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

Note: All performance curves are typical

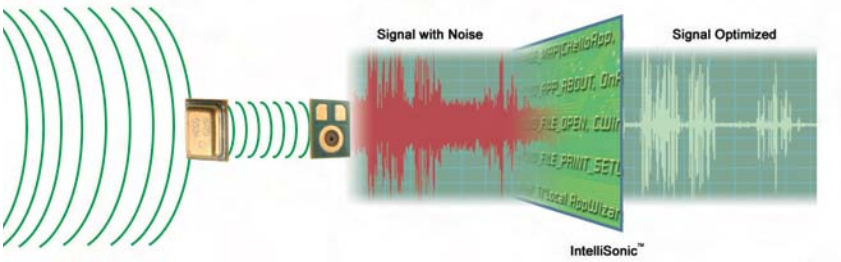
ACOUSTIC SOFTWARE

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-formin g 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

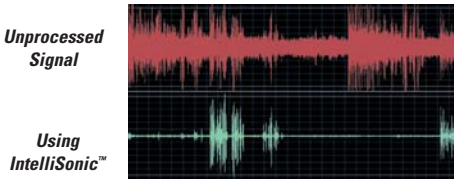
Platforms such as tablets, laptops, ultra-mobile personal computers (UPCs), and other mobile computing devices have a number of applications that would benefit from IntelliSonic to enhance the user experience and final product perception.

- *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	✓	✓	✓

IntelliSonic™ Attenuates Unwanted Sounds



(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 synchronus 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

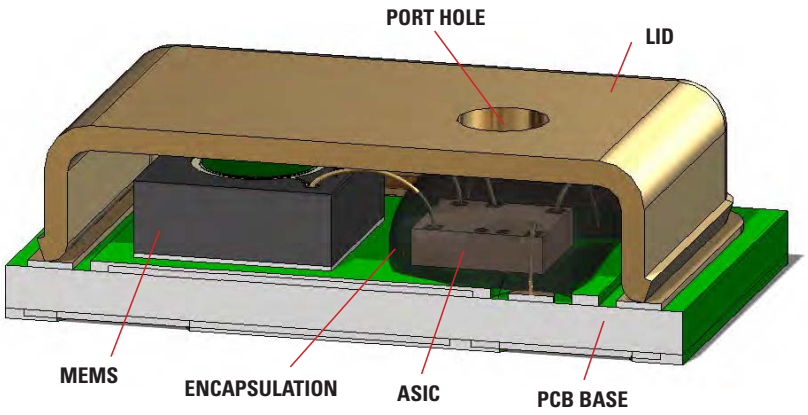
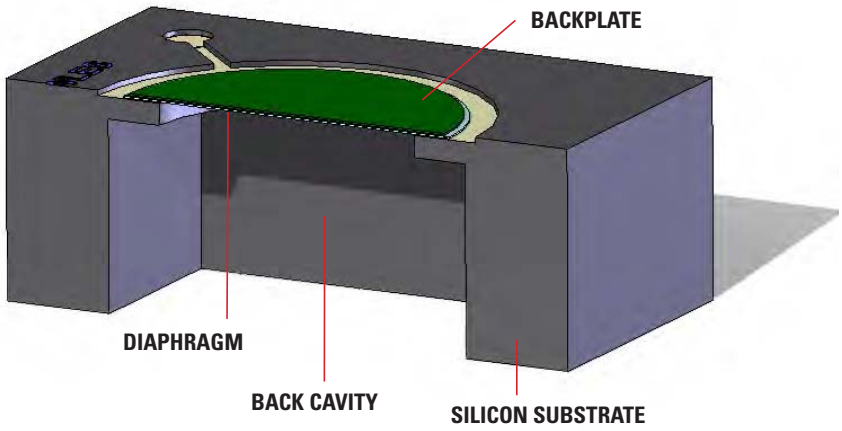


Fig. 2: Cross section of a SiSonic MEMS



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

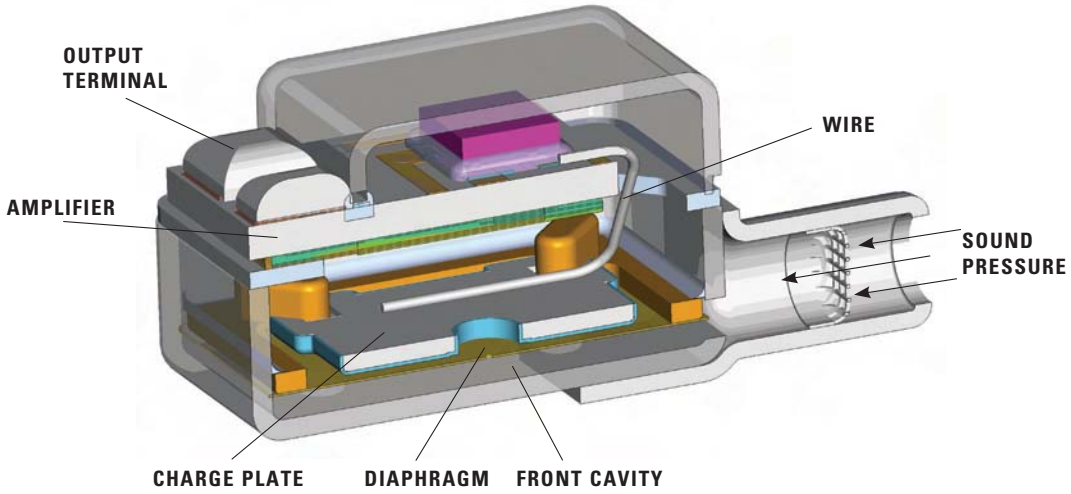
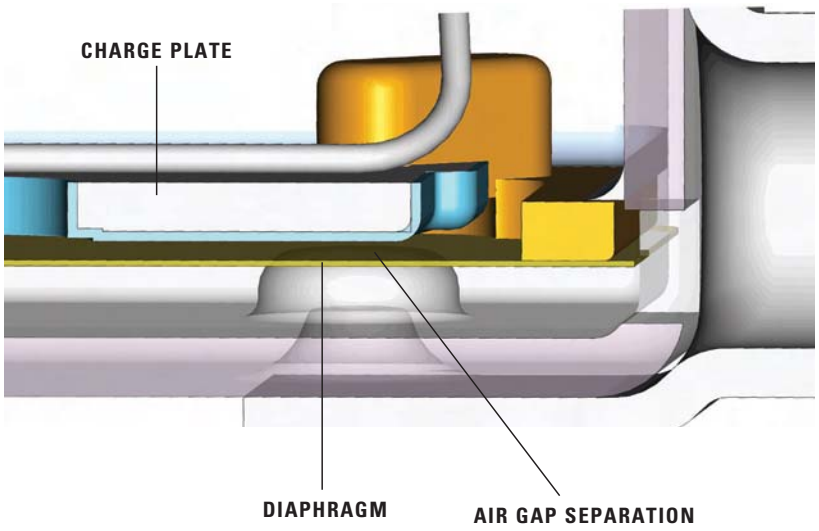


Fig. 4: EM diaphragm and electret



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 µPa.

Fig. 5: Cross section of a Knowles EH speaker

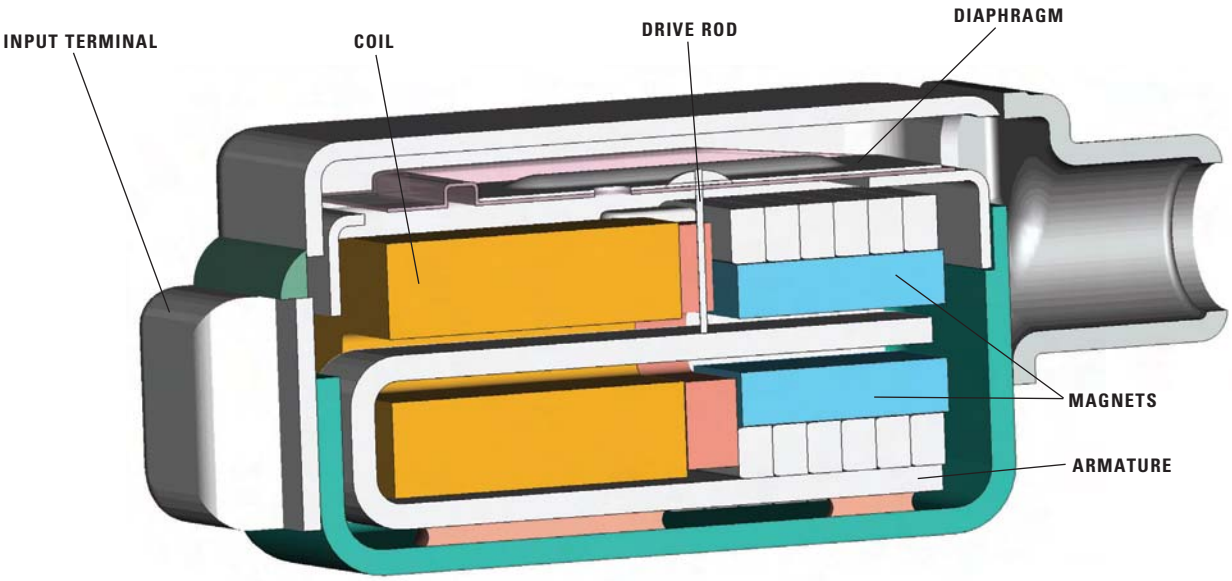
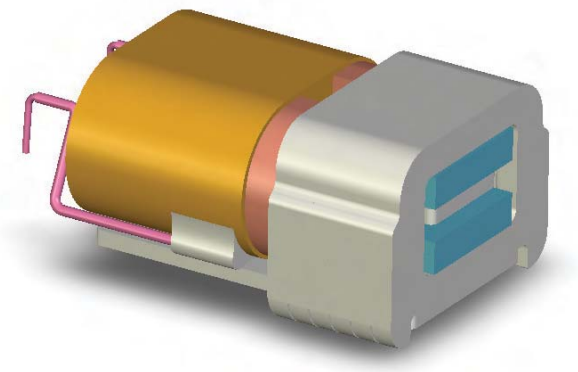


Fig. 6: The motor of the speaker has a coil, an armature, and a pair of permanent magnets.



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