KNOWLES ACOUSTICS

Application Note

Specialty Transducers (ST) Product Guide

Revision 1.0

www.knowlesacoustics.com

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

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AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

1. SPECIALTY TRANSDUCER OVERVIEW

Knowles Electronics was founded by Dr. Hugh Knowles in 1954 to provide the hearing device market with smaller and better-performing acoustic transducers. Knowles has continued since as the leader in hearing health components. Along the way, other markets utilized Knowles products, and Knowles occasionally would create products specifically for applications other than hearing health. In 1993, a small group was formed to focus on these non-core products and applications. This group eventually grew to become Knowles Acoustics.

Knowles Acoustics consists of five product groups:

- SiSonic (MEMS microphones)
- ECM Microphones
- Custom Assemblies
- IntelliSonic (signal processing software)
- Specialty Transducers (acoustic components other than SiSonic and ECM)

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

Application Note

The product group Specialty Transducers (ST) includes microphones, speakers, acoustic dampers, accelerometers, and assemblies (example: boom microphones). ST products are used in a variety of performance-driven markets:

- Professional Audio
- Radio Communications
- High-end Consumer Products
- Sensor
- Test Instrument
- Medical
- Surveillance

For applications where cost is the overriding factor, commodity products such as moving-coil dynamic speakers and ECM microphones are generally appropriate. ST products enable designs where requirements rule out the use of commodity products. Physical size is the most common reason for customers to choose an ST product from KA. Other considerations may include acoustic performance, efficiency, environmental performance, or some combination of these factors. This Product Guide is intended to answer many Frequently Asked Questions about ST and guide the reader to sources of more detailed information.

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Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
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Fax: 886-2-8919-1798

2. MICROPHONES

Over the decades, Knowles developed microphone products using the most current and appropriate technologies available. For many recent years, electret technology (capacitive, permanent bias) has been used almost exclusively. The notable exception is SiSonic, where the capacitive bias is drawn from the external supply voltage. KA also maintains some vintage microphone technologies once used in hearing aids, including piezoceramic and balanced armature. The technologies abandoned by the hearing health market continue to be attractive in other applications.

The ST product range also includes some unique waterproof/submersible microphone assemblies, and a variety of boom microphones for close talking.

For designers new to microphones or for those in need of a refresher, here are some common general microphone FAQs:

What is a Db?
What is SPL?
What is microphone noise?
What is Equivalent Noise Pressure (ENP)?
What is “A weighting”? Or, what is the maximum SPL a microphone will handle?
What is Dynamic Range?
Can we increase the overload SPL?
What does “near field” mean?
What does “far field” mean?
What is an omnidirectional microphone? Where is it used? How does it work?
What is a directional microphone?
What is a unidirectional microphone? Where is it used? How does it work?
What is Random Energy Efficiency?
What is Distance Factor and how is it determined?
What is a Close-talking (Noise Canceling) Microphone?
How do you convert Sensitivity into Output Voltage?

The answers to these FAQs are available at knowlesacoustics.com at the following link:

http://www.knowlesacoustics.com/html/mic_faqs.html

Other general information and application guidance for microphones:

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
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Republic of China
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Fax: 886-2-8919-1798

Application Note

- Microphone Basics
  - http://www.knowlesacoustics.com/images/pdf/KEMics.pdf
- AN 1 – Transducer Signal Port Location Key
  - http://www.knowlesacoustics.com/images/pdf/application/an1.pdf
- Application Note 13 – Soldering Transducers
  - http://www.knowles.com/green/documents/AN-13.pdf
- AN-10: Transducer warranty date code numbering system
  - http://www.knowleselectronics.com/engineering/pdf/an-10-issue00.pdf
- TB3 – Effects of Sound Inlet Variations on Microphone Response
  - http://www.knowlesacoustics.com/images/pdf/technical/TB3.pdf
- TB8 – The Transducer Environment
  - http://www.knowlesacoustics.com/images/pdf/technical/TB8.pdf
- TB9 – BT Condenser Microphone 2-Wire Application Notes (valid for microphones with a standard electret microphone circuit – not “coach class or “business class”)
  - http://www.knowlesacoustics.com/images/pdf/technical/TB9.pdf
- TB13 – Effects of Variation of Supply Voltage on the Sensitivity (valid for microphones with a standard electret microphone circuit – not “coach class or “business class”)
  - http://www.knowlesacoustics.com/images/pdf/technical/TB13.pdf
- TB19 – Vibration Sensitivity of Knowles Microphones
  - http://www.knowlesacoustics.com/images/pdf/technical/TB19.pdf
- TB21 – EB Directional Hearing Aid Microphone Application Notes (valid for EL series microphones)
  - http://www.knowlesacoustics.com/images/pdf/technical/tb21.pdf
- TR-14 Vibration Sensitivity Measurements on Subminiature Condenser Microphones
  - http://www.knowlesacoustics.com/images/pdf/reports/TR14.pdf
- AN-3: The measurement and suppression of RF interference from TDMA phones
  - http://www.knowleselectronics.com/engineering/pdf/AN-3-Issue03.pdf
- AN-4: Directional Microphone Applications
  - http://www.knowleselectronics.com/engineering/pdf/an-4-issue01.pdf
- AN-9: Thin Mic family microphones
  - http://www.knowleselectronics.com/engineering/pdf/AN-9-Issue01.pdf

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

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Tokyo 156-0051, Japan
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Knowles Acoustics
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Republic of China
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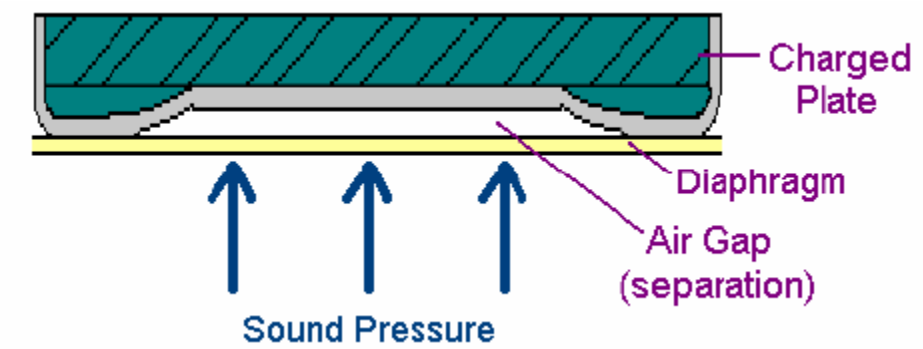
2.1 ELECTRET

Construction

For an electret microphone, the capacitive "motor" is a backplate and diaphragm spaced closely together that generates the electrical signal. Most ST microphones available from Knowles Acoustics are electret (permanent bias) type. The bias charge normally resides on a film that is laminated to the surface of the backplate. The exceptions are CA and CF series microphones, where the charge resides on the diaphragm film. CA and CF series are not recommended for new designs.



Older model series (BT, EA, EG) use a formed diaphragm. Newer model series (EK, EM, TM, TO, TD, FG, etc.) use a tensioned diaphragm. The tensioned diaphragm allows lower vibration sensitivity and higher electro-acoustic sensitivity. For series with tensioned diaphragms, acoustic sensitivity is slightly affected by humidity. Consult the series datasheets to find the typical humidity coefficient (Db/%R.H.).

The ST eletret product range includes omni-directional, uni-directional, and bi-directional (noise canceling) models.

Applications

Electret technology is appropriate for the vast majority of microphone applications. (Most electret microphones in the world are the commodity ECM type that cost less than $1 US.) Electret microphones within the ST product range provide the best acoustic sensitivity, lowest vibration sensitivity, best signal/noise, smallest size, and greatest variety/versatility.

A supply voltage is required to operate an electret microphone. The electret charge is stable in benign environments, but can be permanently degraded by excessive temperatures, solvent vapors, or condensing humidity. Microphone performance can also be permanently degraded or rendered non-functional by submersion or by introducing foreign material into the sound port(s).

2.1.1 STANDARD

Until recently, all Knowles electret microphones were “Standard” type. The introduction of “Coach Class” and “Business Class” required the distinction. Standard type electret microphones do not include the design modifications adopted for Coach Class and Business Class, and include all series not mentioned below.

2.1.2 COACH CLASS

The Coach Class modification upgrades RFI immunity to cell phone and cordless phone frequencies. The modification includes improved shielding, grounding, and filtering. Many models in the FG, EM, TM, TO, TD, and TP Series are affected.

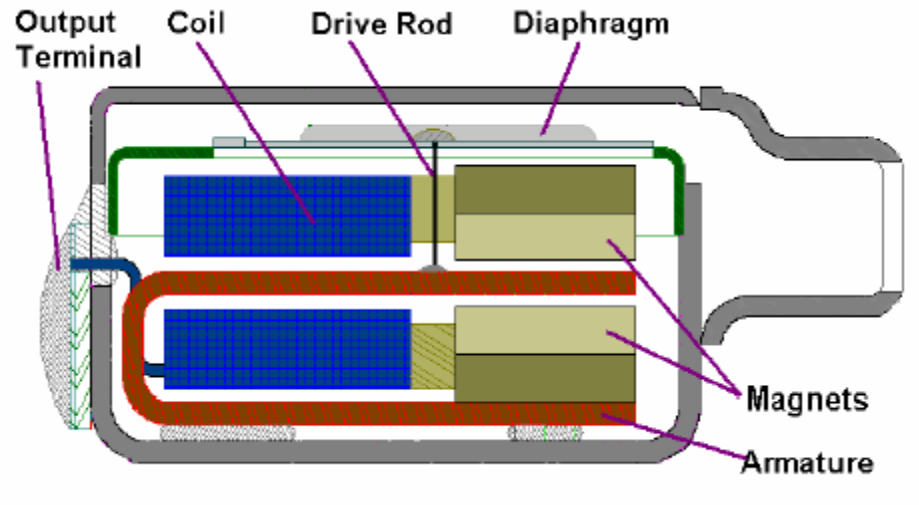
2.1.3 BUSINESS CLASS

The Business Class modifications include the Coach Class upgrades, plus improvements in power supply rejection and settling/recovery time. A user selectable high-pass filtering option is also included, and may improve signal/noise performance depending on the filtering selected. Business Class models have a “B” prefix on the Series (Example: EM becomes BEM)

2.2 BALANCED ARMATURE

Construction

There is only one series of balanced armature microphone in the ST product line – the BJ series. Balanced armature construction allows improved magnetic coupling efficiency compared to moving coil construction. With a balanced armature microphone, sound enters the sound port and vibrates the diaphragm paddle. The diaphragm is hinged at one end to define a vibration mode, and is connected to the armature with a stiff drive rod. The armature vibrates along with the diaphragm, and moves between two permanent magnets. The motion relative to the magnets produces a magnetic potential on the armature, which in turn induces an electric signal through the coil and to the output terminals.



The result is a bandpass frequency response that is appropriate for voice communication. The BJ Series includes omni-directional and bi-directional (noise canceling) models.

Applications

BJ series microphones are appropriate for applications where a supply voltage is not available. They may be substituted into applications where a dynamic microphone is used. Because there is no electret charge, a balanced armature microphone is more robust to heat and solvent vapor than an electret microphone. It is, however, more susceptible to mechanical shock.

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

Application Note

Balanced armature microphones can be an attractive choice for radio communications compared to electret microphones depending on electrical compatibility issues. KA has the ability to customize the impedance of the BJ element to match customer needs.

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

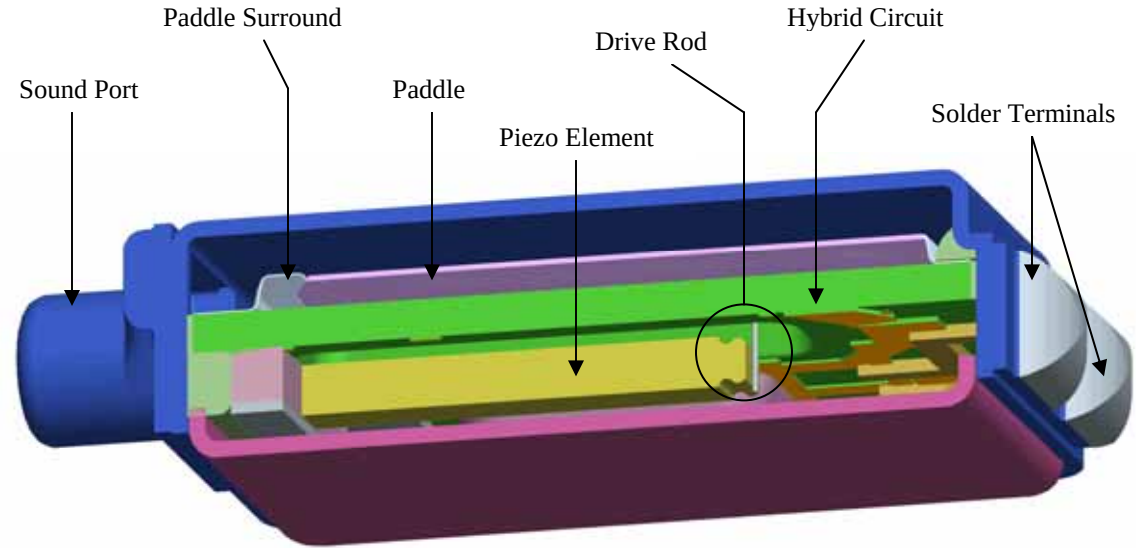
ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

2.2 PIEZOCERAMIC

Construction

There is only one series of piezo-ceramic microphone in the ST product line – the BL series. . For BL microphones, sound enters the sound port and vibrates the diaphragm paddle. The diaphragm is hinged at one end to define a vibration mode, and is connected to the piezo-ceramic element with a stiff drive rod. The piezo-ceramic element deflects between the drive rod and a fixed end connected to the hybrid circuit. The deflection creates an electric potential between the top and bottom terminals of the piezo-ceramic element, which in turn drives the gate of the JFET circuit.

BL Series microphones are available as transducer elements, or packaged in a rugged ½ inch diameter cylindrical housing with cable.



BL Section View

Applications

BL Series microphones are primarily used in sensor applications (sound level meter, audiometer, acoustic sensor). The principal advantage of piezo-ceramic construction is long-term

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
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Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

performance stability. Unlike elecrtret microphones with tensioned diaphragms, BL microphones are unaffected by humidity. Also, the sensitivity is determined by the properties of the piezo-ceramic material. There is no bias charge, so the microphone is more robust against heat or vapors than an electret.

The piezo-ceramic element is, however, much heavier than an electret diaphragm. As a result, the BL microphones are sensitive to mechanical vibration. If vibration sensitivity is a problem for a particular application, proper mounting design can minimize vibration transmission.

A flat frequency response to ~8kHz is available for BL. Flat response models are usually chosen for sensor applications.

Resource

- TR-1 Protection Against Shock and Vibration
  - http://www.knowlesacoustics.com/images/pdf/reports/TR1.pdf
- TR-4 Vibration Isolation of the BL Microphone
  - http://www.knowlesacoustics.com/images/pdf/reports/TR4.pdf
- TB1 – Stability of Amplifier Systems Connected to the BL Microphone
  - http://www.knowlesacoustics.com/images/pdf/technical/TB1.pdf
- TB12 – Application Notes for BL Series Microphones
  - http://www.knowlesacoustics.com/images/pdf/technical/TB12.pdf

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Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

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Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

2.3 WATERPROOF / SUBMERSIBLE

The ST product range includes two series of waterproof / submersible microphones: WP and MR. The two series address distinctly different performance requirements, so they are discussed separately here.

2.3.1 WP SERIES

Construction

WP Series microphones are available in both omni-directional and bi-directional versions. Both share an important and unusual attribute. The barometric vent is not in the acoustic sound path. To create a hermetically sealed microphone that survives submersion, it is necessary to modify the controlled leak that allows the air inside the microphone to reach equilibrium with the surrounding atmospheric pressure.

For WP, the vent is through a micro-porous material on the side of the element and out of the acoustic path. The material passes air while blocking water ingress to the internal components.

Applications

Though WP microphones survive submersion in water and return to their rated performance, they are not intended for applications where they are regularly submerged or for unprotected outdoor use. Liquid and particles may get trapped in the small volume between the sound port holes and the diaphragm(s) and degrade performance either temporarily or permanently.

WP microphones may, however, be used in or exposed to condensing humidity without degradation. This makes them appropriate for environments where the temperature drops rapidly such as walk-in freezers or cold climates.

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
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JAPAN:
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Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
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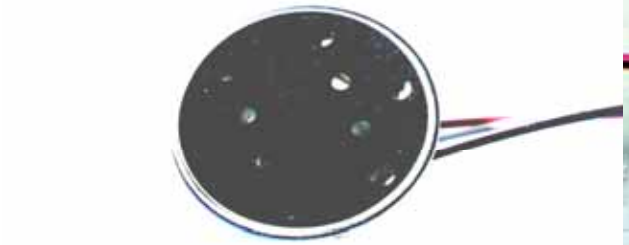
The bi-directional WP models are intended for close talking use on headset booms. The omni-directional WP models have consistent flat low frequency response, with a 3dB point of ~20 Hz.

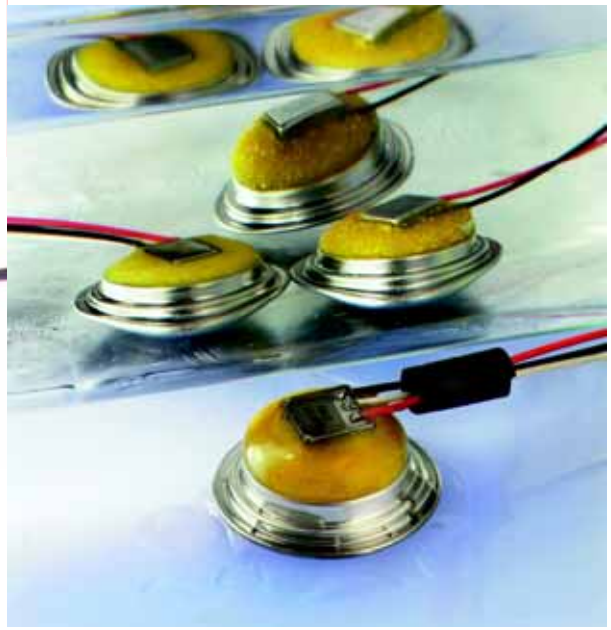
2.3.2 MR SERIES

Construction

MR Series microphones combine a conventional element with a waterproof bellows assembly. The bellows conducts sound to the element and survives 15m (50 feet) of submersion in water. The grill has large perforations and drains immediately, and the microphone may be cleaned with a hose. It should be mounted with the grill vertical or downward. Water may pool in the bellows if the grill faces upward.

The microphone is intended to be panel mounted through a hole: cemented from behind with the wide part of the flange exposed. Flying leads extend from the terminals of the microphone element. Models using BT and BJ elements are recommended. BL, CA, and WP series elements have also been used in MR assemblies.





Applications

Application Note

MR was originally designed to be used on air-dropped rescue beacons. It had to survive explosive decompression and submersion as the beacon was ejected from an airplane, plunged underwater, then surfaced for operation.

More recently, MR microphones have been used in a variety of challenging applications including:

- Dive helmet
- Noise canceling muffler
- Unmanned Ground Sensor
- Gunshot Detection
- Military Radio

Any outdoor application where the microphone is expected to get wet, dirty, or submerged is a good candidate for MR. It works for both communication and acoustic sensor applications.

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2.4 ELEMENT SERIES KEY

Series	Photo	Type	Description	Comment
BEM		Electret (tensioned diaphragm)	Business Class EM (omni-directional)	
BFG		Electret (tensioned diaphragm)	Business Class FG (omni-directional)	
BJ		Balanced Armature Magnetic	Omni-directional and Bi-directional models	Available in PBJ and FB Series boom microphone assemblies
BL		Piezo-ceramic	Element or in ½ inch diameter cylindrical housing assembly (omni-directional)	Element models are available in two thicknesses.
BT		Electret (formed diaphragm)	Omni-directional	
BTM		Electret (tensioned diaphragm)	Business Class TM (omni-directional)	
BTO		Electret (tensioned diaphragm)	Business Class TO (omni-directional)	
BW		Electret (formed diaphragm)	Bi-directional	Not recommended for new designs.
BXEM		Electret (tensioned diaphragm)	Business Class EM (omni-directional)	BX indicates extra back volume for increased sensitivity.
BXTM		Electret (tensioned diaphragm)	Business Class TM (omni-directional)	BX indicates extra back volume for increased sensitivity.
CA		Electret (tensioned diaphragm)	Omni-directional Charged diaphragm	Not recommended for new designs.

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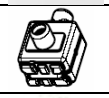
CF		Electret (tensioned diaphragm)	Bi-directional Charged diaphragm	Not recommended for new designs.
EA		Electret (formed diaphragm)	Omni-directional	
EB		Electret (formed diaphragm)	Uni-directional	Not recommended for new designs.
EG		Electret (formed diaphragm)	Omni-directional	
EK		Electret (tensioned diaphragm)	Omni-directional	
EL		Electret (tensioned diaphragm)	Uni-directional	
EM		Electret (tensioned diaphragm)	Omni-directional	
EY		Electret (tensioned diaphragm)	Omni-directional	Not recommended for new designs.
FB		Headset Flex-boom Assembly	Close talking	Models integrate NR, WP, EK, and BJ elements.
FG		Electret (tensioned diaphragm)	Omni-directional	World's smallest microphone.
MR		Submersible Microphone Assembly	Omni-directional	Models integrate BT, BJ, WP
NR		Electret (tensioned diaphragm)	Bi-directional	Stable directional pattern through 10 kHz
PBJ		Headset Fixed-boom Assembly	Bi-directional Balanced Armature	Uses BJ element.

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

PNR		Headset Fixed-boom Assembly	Bi-directional	Uses NR element.
PWP		Headset Fixed-boom Assembly	Bi-directional Waterproof	Uses WP element.
TD		Electret (tensioned diaphragm)	Uni-directional	
TM		Electret (tensioned diaphragm)	Omni-directional	
TO		Electret (tensioned diaphragm)	Omni-directional	
TP		Electret (tensioned diaphragm)	Uni-Omni Pair	
WP		Electret (tensioned diaphragm)	Omni or Bi directional	Waterproof

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

BOOM MICROPHONE ASSEMBLIES

For optimal signal to noise performance, it is always preferred to put the microphone as close as possible to the sound source. In a free-air environment signal level drops by 6Db for each doubling of distance between the sound source and microphone. Headset booms allow the microphone to be placed in the near field, where a noise canceling microphone responds the difference in acoustic pressure. The combination of a good close-talking microphone element and close proximity to the mouth provides excellent signal to noise even in extremely noisy conditions.

2.5.1 FIXED BOOMS

Construction

PNR, PWP, and PBJ Series boom microphones are made with 4mm O.D. nylon tube that is heat-formed to set a bend angle. The microphone housing is also nylon, and includes sintered metal sound port covers that are treated to be “splash-proof”.

Boom Series	Contains Element Series	Description
PNR	NR	Noise Canceling Eletret
PWP	WP	Waterproof Noise Canceling Electret
PBJ	BJ	Noise Canceling Balance Armature

All use enamel coated copper wire, and include a foam windscreen. An end cap is provided to facilitate customer assembly of an exit cable.

For PNR and PWP Series, both 3-wire and 2-wire versions are available. Some NR and WP elements include inbuilt RFI filter capacitors that are effective at GSM and CDMA frequencies.

PNR / PWP Boom Tube and Housing

PBJ Tube and Housing

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

Applications

All of these fixed shape plastic boom microphones are lightweight and low-profile. Typical applications:

- Lightweight noise-canceling headset for telephony, computer speech recognition, or other indoor use.
  - Excellent noise canceling allows intelligibility with "open office" floor plans.
  - Intended for swivel mounting to allow accurate positioning needed for noise canceling microphones.
- Helmet or face mask integration
  - The low profile shape of PNR, PWP, or PBJ fits into the small area in front of the mouth inside a helmet.
  - Using a small exit hole, these fixed booms may be installed in a mask that covers the nose and mouth (for firefighters, court stenographers, etc.)

Note: The microphone housings for NR, WP are available for separate purchase for customer assembly. Tubeless EK and EA models also fit. The microphone housings have a circular stem that can insert in a larger housing or PCB assembly.

VR-105 Housing Parts

VR-105 Parts Assembled

2.5.2 FLEXIBLE BOOMS

Construction

FB Series flex booms utilize a metal gooseneck that retains its position when bent. When the end of the boom is clamped, the free end can be positioned in front of, or away from the mouth as needed. Models are available with either 4mm or 6mm diameter gooseneck, depending on strength and weight requirements.

Application Note

6mm Gooseneck Material

Either NR or WP (waterproof) noise canceling microphones are used in FB booms. The standard housing is a brass cylinder plated matte black with monel screen in the sound port cutouts. The entire housing and gooseneck are isolated from the microphone element, and serve as a continuous EMI shield over the microphone and leads. A green shield wire is brought out with the microphone leads, and is available for chassis ground.

6mm FB Boom Microphone, 3-wire type

4mm FB Boom

6mm FB Boom

4mm FB Boom End showing leads

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
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M6 Threaded End Connector w/nut & washers

Flying leads are used for the electrical connections. 6mm models use 28 gage Teflon jacketed hookup wire, and can be fitted with an end connector: M6 threaded with washers and lock net. 4mm models use enamel insulated solid wire.

Two alternate housing designs are available:

- A waterproof microphone housing that uses an NR Series element and survives 1m submersion in water. 17mm O.D. on 4mm gooseneck. No shielding.
- An adapted PNR / PWP microphone housing on 4mm gooseneck. No shielding.

FB w/ VR-105 Plastic Housing

4mm Alternate Waterproof Housing

Windscreens are included, and windscreens treated for moisture resistance are available.

Applications

FB Series boom microphones are primarily intended for rugged circumaural (earcup style) headsets or helmets. Flying lead models terminate into an earcup swivel; models with end connectors may be fastened to a bulkhead. Typical headset applications:

- Radio Communication
  - Emergency Services

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

  - Military
  - Aviation
  - Motorcycle Helmet
  - Snowmobile Helmet
- Computer Voice Recognition
  - Warehouse Inventory
  - Field Applications

Custom FB booms are available to achieve the best match for form factor, noise canceling, weather resistance, etc. in rugged environments and demanding applications.

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

2.7 TEST CONSIDERATIONS

KA Microphones are 100% tested against their performance specification before they leave our factory. Many customers consider KA a "dock-to-stock" supplier, and do not perform incoming tests on our microphones.

Though the test condition presented on the product specification is accurate, customers who do wish to setup incoming testing on KA ST microphone product need to address the following issues:

- Physical test setup
  - Contacts
  - Fixturing
  - Acoustic Source
- Test platform
- Correlation (if the test condition differs from the specification)

It is common for a customer to inquire whether they can duplicate Knowles' test or purchase test fixtures. Unfortunately, it is not practical to do so.

2.7.1 HOW KNOWLES TESTS MICROPHONES

Knowles tests millions of microphones each year. The shapes, sizes, and specifications vary. Hundreds of model types must be accommodated. To address the requirements for throughput and variety, Knowles tests the great majority of microphones on a common platform (called FCAMT internally). FCAMT is controlled by a PC running custom software written in Labview. The base of FCAMT functionality is an FFT analyzer that measures much of the test performance. The system requires a custom test board for each distinct microphone geometry, and a custom test file for each model specification.

Noise testing requires special fixturing to decouple the microphone from vibration interference. The noise test cavity used by Knowles is within a heavy metal enclosure. Different nests are designed to allow testing of different microphone elements.

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

Knowles FCAMT System

Knowles Noise Test Setup

2.7.2 RESPONSE TESTING

Both the cost and custom nature of FCAMT make it unsuitable for customer incoming performance tests. Certain aspects of the system, however, also make sense for a customer test system.

Example: Most microphones are omni-directional and frequency response is specified for an acoustic pressure plane wave. An anechoic chamber provides a good approximation of a plane wave, but is suited only for low volume infrequent testing. "Test box" type enclosures also provide a good approximation, but must typically be opened and closed for each test unit. The cycle time may still be too expensive for an incoming test.

FCAMT uses a pressure-coupled test, which has the advantage of speed. No enclosure is needed. The acoustic response, however, is not a good plane wave approximation. For most tests requirements, correlation from a plane wave test to a pressure coupled test is acceptable.

A pressure coupled test required a consistent acoustic seal between the sound source and the test microphone. An acoustic pressure test fixture must be designed with a gasket that seals the microphone sound port to the sound source. Typical gaskets are designed with either "O"-rings or a flat piece of silicone RTV with a perforation for the sound port. The photos show an

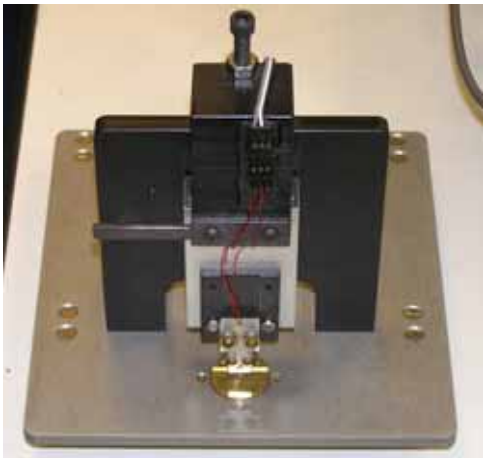
AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

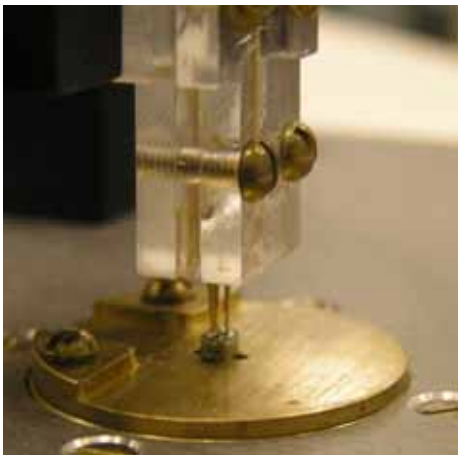
ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

FCART test board designed to test an FG Series microphone. The “O” ring shown on the bottom view couples to the sound source.



FCAMT Test Board

FCAMT Test Board Bottom



Test Board Contact Detail

Test Board Bottom Seal

2.7.3 NOISE TESTING

Some customers also want perform an incoming test for microphone noise performance. Typical ST microphone noise voltages are less than -100 dBVrms, so microphone isolation and low noise amplification are critical. The test enclosure must provide an acoustic seal, and the test cavity must not pass acoustic signals. The test cavity should be damped with sound absorbing material

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

(like wool or cotton) to eliminate any cavity resonances. The test cavity should also be decoupled from mechanical vibration. The mass of the cavity and stiffness of the mechanical support set the natural resonance of the test structure. Vibrations above the resonant frequency are decoupled. Knowles has used various heavy steel enclosures to test noise (see figures).

Production Noise Test Fixture

Nest Detail

Free-Standing Noise Test Chamber

Hinged Noise Chamber

The signal output goes to a low noise preamplifier, then to an “A”-weighting filter, and true RMS voltmeter.

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

2.7.4 SUGGESTIONS AND REFERENCES

To create an incoming electro-acoustic test for KA microphones, the following elements will be required:

- Sound source
- Test Fixture
- Preamplifier
- Audio Analyzer (or equivalent)
- KA Correlation samples and data
- Optional: Reference microphone (including preamp and power supply)

A frequency response test may be run with either a constant voltage sweep or a constant SPL sweep. A reference microphone is required for a constant SPL sweep to calibrate a known sound pressure.

Sound Source

For either a pressure coupled test or a near field test (for a boom microphone), a mouth simulator works well. A mouth simulator is basically a speaker in a metal can with an opening on top that approximates a mouth. The most common mouth simulator is made by Bruel and Kjaer – Model 4227:

http://www.bksv.com/pdf/Bp0505.pdf

For a constant voltage test, the speaker performance cannot vary. It may be possible to build a test around a less expensive speaker, but the designer is cautioned to verify both speaker performance and stability.

For a pressure coupled test, the test microphone must be acoustically coupled to the speaker to yield a repeatable test. For a near field test, the boom microphone housing must be fixtured to a repeatable position above the sound source (6mm per the specification test condition).

Test Fixtures

Text fixtures are designed to be compatible with the shape of a specific microphone. For a pressure coupled test, certain design elements are usually common:

- Nest, slot, or pocket to accept the microphone element.
- Gasket or "O"-ring seal to assure repeatable acoustic coupling.
- Spring-loaded electrical contacts to touch the solder pads

Dimensions needed for the nest, slot, or pocket can generally be taken from the outline drawing (first sheet of the product specification). The outline drawing also identifies the pin-outs. KA can also provide shrink-wrap dimensions for transducers upon request to the Account Manager.

Gaskets may be flat, or cast into a pocket using a microphone as a transfer mold. Knowles has had successful experience molding gaskets with Silastic® J silicone rubber from Dow Corning,

http://www.dowcorning.com/DataFiles/090007c880002e34.pdf

One type of small spring-loaded electrical contact is the "pogo pin". Pogo pins take up the variation in solder pad height, and allow solderless contact for testing. The following link offers both a variety of pogo pin products and an application note.

http://www.emulation.com/catalog/pogo/

Caution: If you are designing a reference microphone into your pressure coupled test, be sure to include a vent. Reference microphones do not respond well to large abrupt changes in static air pressure.

Preamplifier

KA has successfully used the *SR560 — Low-noise voltage preamplifier* from Stanford Research Systems Inc. This laboratory preamplifier includes adjustable gain and filtering.

http://www.thinksrs.com/products/SR560.htm

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

SR-560 Preamplifier

Audio Analyzer

KA tests most production items on proprietary test systems. Some products are tested with PC based Clio equipment and software from Audiomatica.

http://www.audiomatica.com/clioeng.htm

Customers who adopt Clio can expect KA Engineering to have some familiarity with the products.

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
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Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

2.8 ELECTRICAL INTERFACE

ST Microphone components must, of course, be integrated into an assembly or end-product to be useful. Users frequently have questions about both the physical and the electro-acoustic aspects of the components as they relate to their design. While applications may involve unique requirements, certain questions surface repeatedly.

2.8.1 PHYSICAL HOOK-UP

Q: How do I connect to the microphone elements?
A: Solder hook-up wire or cable to the microphone solder terminals. Stranded wire is recommended. 28 gage may be used for larger elements. 30 or 32 gage may be used for smaller elements.

Q: Are your microphones available with a connector?
A: KA offers value added assembly work, which commonly includes attaching wire and connectors to components. KA can also attach properly designed flex circuits to elements. Connectors do not mate directly to microphone elements, however.

Q: Can I surface mount your components?
A: Reflow temperatures will destroy ST components. SiSonic microphones are suited for surface mount.

2.8.2 DESIGN INTEGRATION

The microphone performance specification relates the sound pressure for a test condition to the electrical output of the microphone. The units and nomenclature related to the performance specification are explored in the general microphone FAQs. When an ST microphone is evaluated for a new design or as a replacement in an existing design, the designer must answer certain questions for successful integration.

SPL and Dynamic Range

Q: What sound pressure (or range of sound pressure) is expected at the microphone?
A: This might be known by the designer, or testing may be needed to find out. To measure the sound pressure, a sound pressure level meter should be used with the detecting microphone in the intended position.

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

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Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
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Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

An Inexpensive SPL Meter

Q: OK, I now know the sound pressure level or range for my application. How to I know whether the microphone will work?
A: A microphone "works" within its dynamic range – the range of sound pressures bounded by self-noise on the low end and signal voltage range on the high end. For microphones with an impedance conversion circuit, the self noise is generally listed in the performance specification, and the highest signal level is about 250mVrms. The values in between are related by the specified sensitivity.

Q: Alright, I'm confident that the microphone is doing what I need it to do. Now I need (amplification / filtering) to condition the signal for (the A/D board / line input / power amplifier). How should I condition my signal?
A: It depends on the gain and/or filtering required to convert your (known) microphone output voltage range and frequency response to your (known) next stage input requirements. You need to decide how to address preamplification.

Voltage Preamplifiers

A typical microphone signal is about 1mVrms, so a voltage preamplifier is almost always needed to increase the signal to a usable level. If the microphone is connected to a "mic level" input, the preamplifier is included in that circuit. When a "mic level" input is not available, the designer needs to choose a microphone preamplifier circuit to meet the requirements and constraints of the application. The next stage may be an A/D converter or power amplifier with specific signal requirements.

There are many suppliers to choose from for microphone preamplifiers. They typically provide suggested application circuits and may provide samples if requested. Some major suppliers:

http://www.maxim-ic.com/

http://www.analog.com/

http://www.linear.com/

http://www.ti.com/

http://www.national.com/

With known requirements and constraints, the designer may seek application support from these suppliers and their agents to condition the microphone signal for the next stage in the circuit.

2-wire Microphone Circuit

Knowles ST electret microphones are typically designed for 3-wire hookup, which allows the benefits of maximum sensitivity and minimum current drain. Frequently, however, an application will require 2-wire microphone operation. 2-wire operation may be needed for compatibility with a legacy design, size limitation, available conductors/connectors, or some other reason.

The simplest 2-wire modification is to install a 2.2k chip resistor between the output and negative terminals on the microphone. The + and – terminals may then be used for the 2-wire hookup. When connected to the test circuit shown, the 2-wire sensitivity will be about 3dB lower in comparison to the specified 3-wire sensitivity.

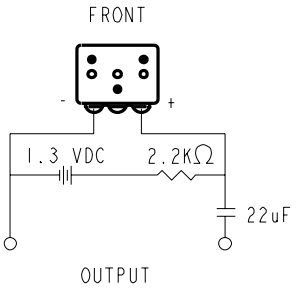
Example of installed chip resistor on NR

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798



Typical 2-wire test circuit

Many KA boom microphones and some NR and WP models are available and specified off-the-shelf for 2-wire operation. Note that the sensitivity, output impedance, current drain, etc. are dependent on the choice of test circuit.

Alternate 2-wire circuits are discussed for BT (works for other standard electret models) and CA.

- TB9 – BT Condenser Microphone 2-Wire Application Notes (valid for microphones with a standard electret microphone circuit – not "coach class or "business class")
  - http://www.knowlesacoustics.com/images/pdf/technical/TB9.pdf
- Application note for 2-Wire operation of CA and CF Series microphones
  - (available on request)

Signal Headroom Circuits

ST electret microphones are biased at about 0.5VDC. Signal levels that exceed about 1V p-p clip on the negative-going part of the waveform. Depending on the series, the typical headroom for ST microphones ranges from about 115 to 120 dBSPL maximum.

Applications may require reproduction of sound in excess of these maximums. Acoustic sensors and head-worn microphones are two examples.

Knowles Acoustics has some standard models available that satisfy high SPL requirements. These models may have reduced electret bias, a modified circuit specification, or both.

External circuits may be used to increase the signal headroom for typical 3-wire ST microphones. The voltage headroom circuit below works for ST electret microphones which specify an allowable supply voltage of at least 9VDC (this disqualifies FG series microphones). The signal load attenuator headroom circuit is OK for all standard 3-wire ST electret microphones.

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
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ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
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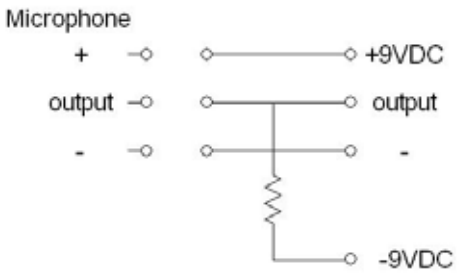
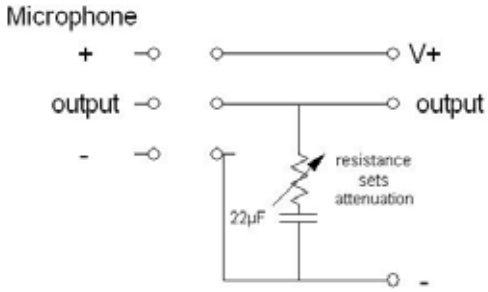


Voltage Headroom Circuit



Signal Load Attenuator Headroom Circuit

If these circuit suggestions do not provide adequate signal headroom, a custom microphone and/or circuit may be required.

2.9 CUSTOM ASSEMBLIES

If existing ST product offerings do not fulfill your requirements, or if you would like KA to quote additional assembly work for a product that uses our transducers, please contact your Account Manager. KA has the ability and capacity to take on higher level assembly work, and have done so successfully for many customers. Typical Value Added assemblies have included:

- Flex circuits
- Attached leads, cable, and connectors
- Boom microphone housings
- Housings for environmental protection
- Protective waterproof membranes
- PCBs

- Splash-proof acoustic covers
- Protective mechanical screen
- Integrated acoustic damping elements

The value-added parts may be specified by the customer, or may be proposed by KA. Minimum order quantities, tooling costs and other one-time costs may apply.

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
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JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

3. RECEIVERS AND SPEAKERS

The term “receiver” has its roots in the old two-piece telephones that consisted of a desk stand and receiver. The receiver was held directly to the ear to provide optimum sound pressure and isolation from background noise. KA balanced armature receivers rely on the same principle, and must be coupled directly into the ear canal to perform properly.

KA also offers a very few speakers that work at greater distance.

Virtually all KA receivers are shared with or adapted from model series designed for the hearing health market. This is because the design objectives of receivers for hearing aids, and receivers for communications or consumer applications have much in common:

- Small physical size
- Optimal electro-acoustic efficiency
- Wide acoustic bandwidth (this has become more popular in recent hearing aids)
- Mechanical shock protection

All KA receivers and speakers utilize balanced armature technology to enable the combination of small size and acoustic performance.

Other general information and application guidance for receivers and speakers:

- Receiver Basics
  - http://www.knowlesacoustics.com/images/pdf/KESpeaker.pdf
- AN 1 – Transducer Signal Port Location Key
  - http://www.knowleselectronics.com/engineering/pdf/AN-1-Issue03.pdf
- Application Note 13 – Soldering Transducers
  - http://www.knowles.com/green/documents/AN-13.pdf
- AN-10 Transducer warranty date code number system
  - http://www.knowleselectronics.com/engineering/pdf/an-10-issue00.pdf
- TB-6: Effects of acoustical termination upon receiver response
  - http://www.knowleselectronics.com/engineering/pdf/TB-06.pdf
- TB-7: Effects of source impedance upon receiver response
  - http://www.knowleselectronics.com/engineering/pdf/TB-07.pdf
- TB-8: The transducer environment
  - http://www.knowleselectronics.com/engineering/pdf/TB-08.pdf

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

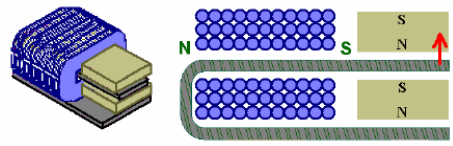
ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

- TB-14: The effect of acoustic damping plugs on receiver response
  - http://www.knowleselectronics.com/engineering/pdf/TB-14.pdf
- TB-17: Broader band BK application notes
  - http://www.knowleselectronics.com/engineering/pdf/TB-17.pdf
- TB-18: CB application notes
  - http://www.knowleselectronics.com/engineering/pdf/TB-18.pdf
- TB-20: Wideband receiver application bulletin
  - http://www.knowleselectronics.com/engineering/pdf/TB-20.pdf
- TB-22: Magnetic leakage for receivers
  - http://www.knowleselectronics.com/engineering/pdf/TB-22.pdf
- AN-6: Ferrofluid damped ED receivers
  - http://www.knowleselectronics.com/engineering/pdf/AN-6-Issue01.pdf
- AN-7: Ferrofluid damped receiver part numbering system
  - http://www.knowleselectronics.com/engineering/pdf/AN-7-Issue02.pdf
- AN-8: HC series high-output receivers
  - http://www.knowleselectronics.com/engineering/pdf/AN-8-Issue01.pdf
- AN-11: VEF Vibration Isolation receivers
  - http://www.knowleselectronics.com/engineering/pdf/AN-11-Issue01.pdf

3.1 BALANCED ARMATURE TECHNOLOGY

The receiver or speaker converts an electrical signal into sound. Efficiency is the measure of how much energy is converted to sound versus how much is lost to heat, magnetic leakage, etc. Balanced armature receivers are designed to optimize electro-acoustic efficiency in a small size package that delivers sound to the sealed air volume of the ear canal.

Compared to a moving coil dynamic of comparable size, a balanced armature receiver provides improved efficiency through better magnetic coupling. In a receiver motor an armature moves within a small gap through a coil and between two permanent magnets.



Receiver Motor Structure

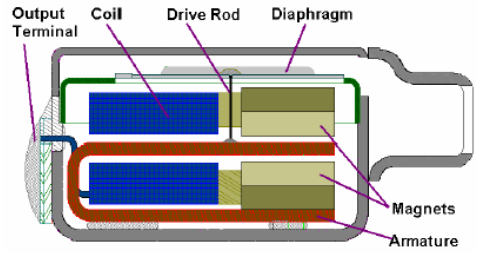
AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

In an assembled receiver, the motor is linked to a hinged diaphragm paddle by a stiff drive rod. A signal through the coil induces a magnetic signal in the end of the armature, causing it to move in the gap between the magnets. The linkage transmits the motion to the paddle and moves the air next to it. The air motion is conducted through an opening in the receiver case, and attached sound tube.

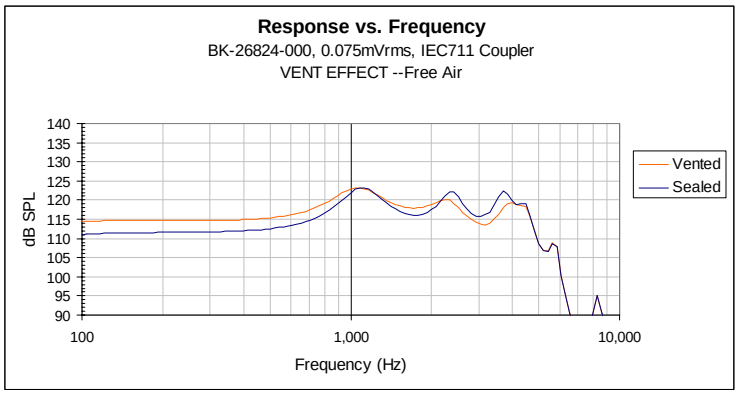


Typical KA Receiver Constuction

KA Balanced armature receivers and speakers range in size from the worlds smallest FK Series receiver to the CB Series speaker which is one inch square and audible at arm's length.

3.2 BACK VENTING

Low-frequency receiver output may be increased by approximately 3dB by venting the back volume into the housing of the earphone or headset. The air volume required in the housing to realize the low frequency benefit is minimal. Venting into minimum of half of the overall receiver volume will produce the desired effect.



Effect of Venting on Frequency Response

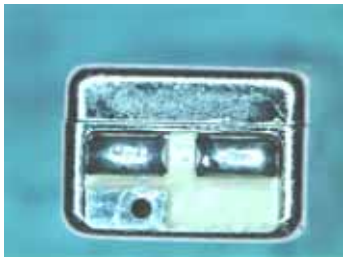
AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

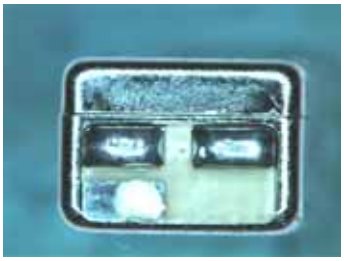
JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

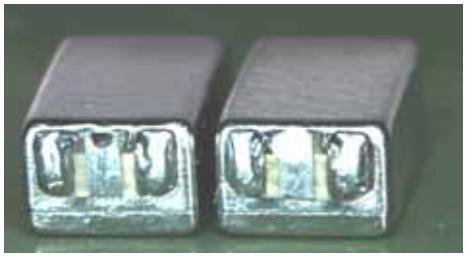
At the time of this writing, back venting has been implemented in BK, ED, and FK Model Series. The typical method for venting is through an unused terminal pad location. A removable rubber plug may be used to protect debris from entering the receiver prior to assembly. Check any samples and remove the temporary plug if needed.



BK Vent Open



BK Vent Plugged

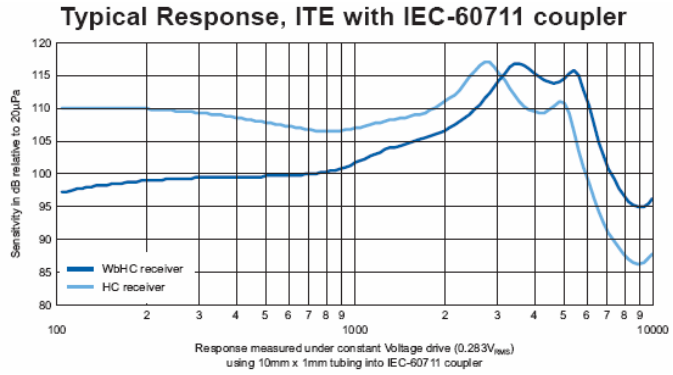


ED Vented and Plugged

Standard vented models are available, and KA has the ability to design custom vented models.

3.3 WIDEBAND RECEIVERS

In the pursuit of high-fidelity sound reproduction, KA offers "wideband" versions within some Model Series. The "wideband" models are optimized for high frequency performance at the expense of less low-frequency output. As such, they are well suited to designs that use two receivers in a woofer-tweeter combination. At this writing, WBHC and WBFK are the two wideband series available. These are variants of the standard HC and FK Series receivers. The chart below shows the comparative performance of WBHC receiver to a standard HC receiver. Note an extra 3kHz of acoustic bandwidth is realized at high frequencies in the wideband version, and that low frequency response is diminished.



AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

Wideband receivers may be used in combination with series such as CI or BK which have greater low frequency output. With the addition of crossover circuitry and acoustic plumbing (tubing and dampers), a designer has the tools to tailor the frequency response of an earphone in a wide audio band.

3.4 HI-FI PAIRS

KA has joined vented and wideband receivers with a crossover to a single sound port. The resulting pair covers a wide frequency band, and is easier to package than two individual receivers having separate sound ports. As of this writing, the available Hi-fi pairs are in the TWFK Model Series – comprised of a vented FK and WBFK.

TWFK with and without Outer Sleeve

Currently TWFK is available in two package types. One package uses an outer sleeve, which simplifies the solder connections and integrates the crossover capacitor. The other package does not use an external sleeve. It has the benefit of smaller size, but requires an external capacitor and connections to additional solder terminals. As with other vented receivers, the earphone package must allow an air volume for the vent. Half the volume of a single FK receiver is sufficient to realize the specified low frequency performance.

3.5 DAMPING

A typical receiver frequency response includes two resonant peaks. A designer may wish to smooth the frequency response by damping the amplitude of the peaks. KA has three methods for damping receivers:

- Screen in port tube
- Holes in diaphragm
- Ferro Fluid

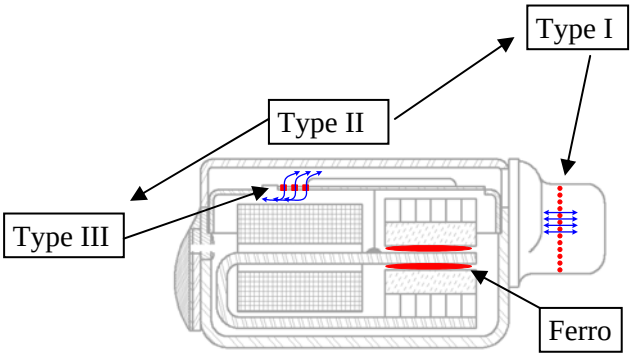
The methods have different damping effects, and may be used in combination.

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798



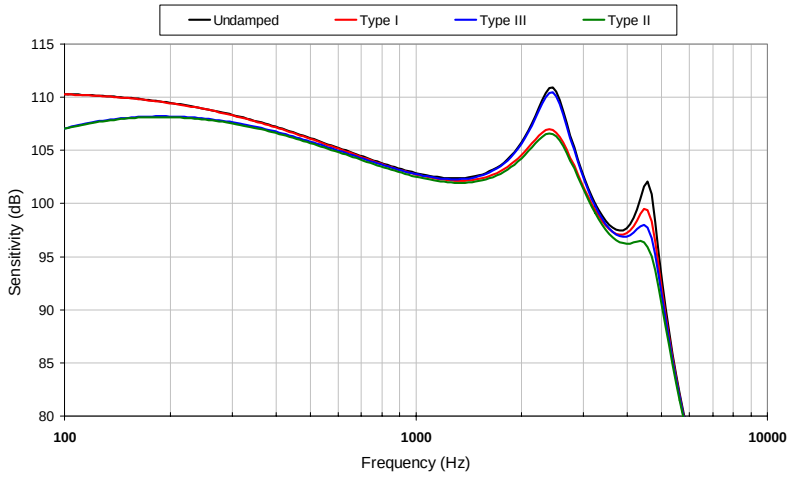
Placement of Damping in Receivers

3.5.1 TYPE I, II, AND III DAMPING

To explain the Knowles historic nomenclature:

- Type I = screen in tube
- Type III = holes in diaphragm
- Type II = Type I + Type III

These types of damping are listed on Knowles data sheets. (There is no typo – the order of naming is correct.)



Damping Effects: ED Series, 10mm x 1mm into 2cc

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
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ASIA:
Knowles Acoustics
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Shindian City, Taipei 231, Taiwan
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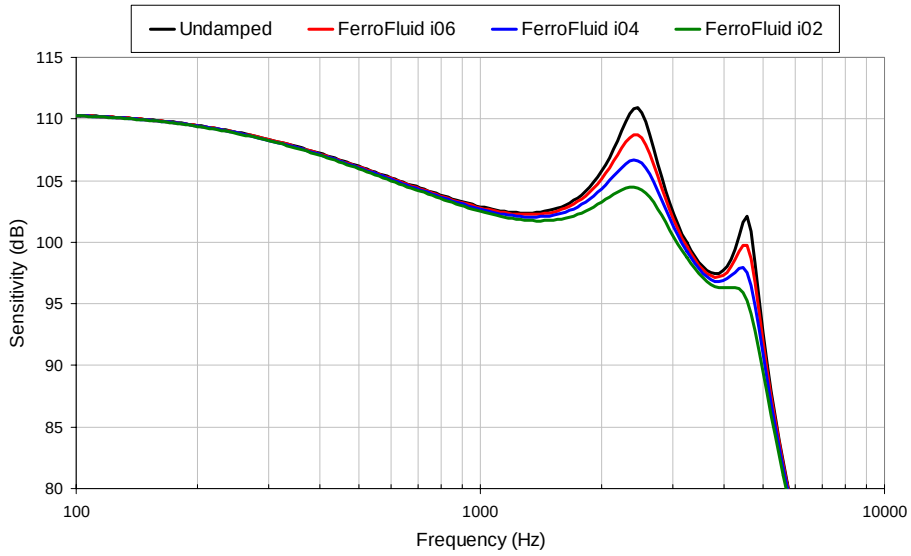
The effects of damping on frequency response are charted for reference. Type I damping assumes a specific acoustic resistance for the tube screen. Screen damping may be increased or reduced by choosing a different screen resistance.

3.5.2 FERRO FLUID

Ferro fluid damping is achieved by injecting a metered amount of oil into the gap between the reed and magnets of a receiver. The oil is loaded with iron particles which are attracted to the magnets; the iron particles help prevent the oil from leaving the gap.



Effect of Ferro fluid: ED Series, 10mm x 1mm into 2cc

KA specifies the amount of fluid by using a suffix to the model number:

- -i06 = resonance amplitude 6dB greater than 1kHz amplitude = light fluid
- -i04 = resonance amplitude 4dB greater than 1kHz amplitude = medium fluid
- -i02 = resonance amplitude 2dB greater than 1kHz amplitude = heavy fluid

Use of medium or heavy ferro fluid provides an improvement to mechanical shock survivability in the axis of reed motion (cover up and cover down directions). Side shock performance is not affected by ferro fluid.

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
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Fax: +44-1444-872772

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2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
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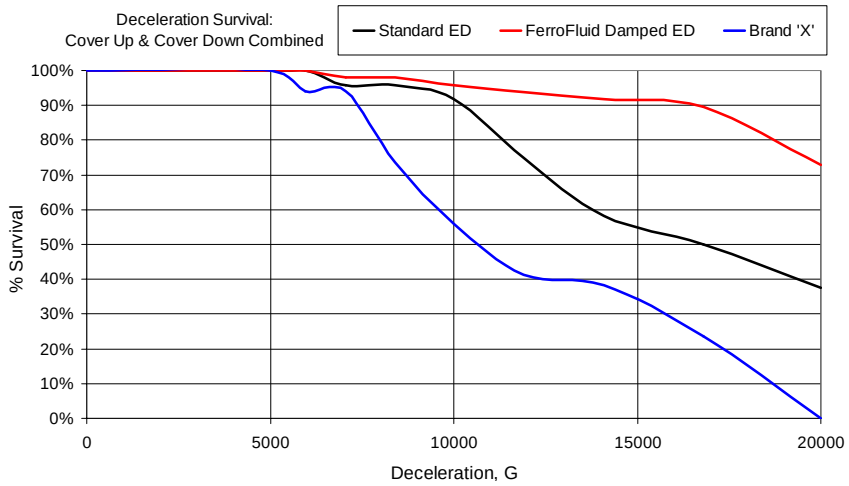


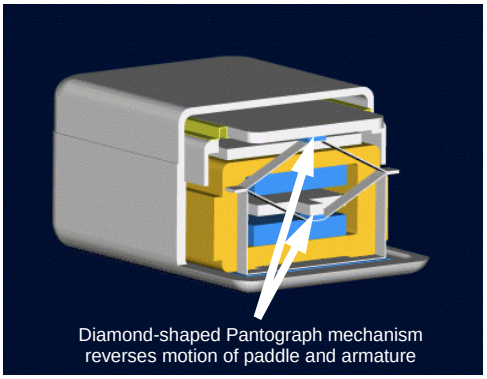
Effect of Ferro fluid on ED shock survival

The enhanced shock survivability provided by ferro fluid may help enable the design of earphones that better survive a drop to a hard surface.

3.6 PANTOGRAPH

Construction

Pantograph receiver technology refers to the mechanical linkage between the armature reed and the diaphragm paddle. The Pantograph mechanism moves the diaphragm in opposite phase to the reed, reducing vibration of the receiver case.



Section view of PHF Receiver

Pantograph technology is currently available in the PHF series only.

Application Note

Applications

Reduced external vibration reduces the possibility of feedback for earphone applications that include a microphone. Compared to an equivalent receiver without Pantograph technology (EF Series) a designer can achieve higher sound pressure levels before feedback. It may not be necessary to provide vibration mounting for the receiver if PHF is used.

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
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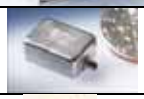
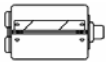
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

Application Note

3.7 ELEMENT SERIES KEY

Series	Photo	Description	Comment
BK		Standard ITE/BTE receiver Available in standard or broader band versions	Popular “value” series for earphone designs
BS		Beeper / Sounder	Low power
CB		Speaker / Microphone for radio handset applications	Available in a waterproof version
CI		Standard BTE / ITE receiver	Most powerful standard receiver
CK		Amplified BK receiver	
CL		Amplified CI receiver	
CM		Non-contact Headset Speaker Resists electro-static discharge to commercial aviation standards	Low power
DFK		Dual FK receiver package for increased SPL and reduced vibration output	
DTEC		Dual TEC receiver package for increased SPL and reduced vibration output	
EC		Standard ITE receiver	Rounded front corners
ED		Standard ITE receiver, available vented	Popular series for earphone designs
EF		Standard BTE/ITE receiver	
EH		Standard ITE receiver	

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

EJ		Dual ED receiver package for increased SPL and reduced vibration output	
EP		ED size receiver with integrated power amplifier	
ER		EC size receiver with integrated power amplifier	
ES		EH size receiver with integrated power amplifier	
FC		EH size receiver with improved output and increased headroom	
FD		ES performance with rounded corners	
FED		ED receiver with Ferro fluid damping	
FEF		EF receiver with Ferro fluid damping	
FEH		EH receiver with Ferro fluid damping	
FEP		EP receiver with Ferro fluid damping	
FES		ES receiver with Ferro fluid damping	
FFC		FC receiver with Ferro fluid damping	
FFD		FD receiver with Ferro fluid damping	
FFH		FH receiver with Ferro fluid damping	
FH		Standard ITC receiver	
FHC		HC receiver with Ferro fluid damping	
FJ		Dual FH receiver package for increased SPL and reduced vibration output	

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

Application Note

FK		Standard ITC receiver	Smallest receiver
HC		High output version of FC receiver	
MR		Waterproof submersible speaker	For use in handsets intended for use directly against the ear.
PHF		Pantograph version of EF receiver	Low vibration output
PK		EF performance for receiver with inbuilt vibration isolation and shock protection	
SR		Round ITE speaker using balanced armature technology and larger diaphragm	Upgrade option to dynamic speakers
TEC		Receiver is half the thickness of BK or EF	
TWFK		Tweeter / Woofer version of dual FK	For high fidelity – wide acoustic band
VEF		EF performance for receiver with inbuilt vibration isolation and shock protection	
VPHF		Pantograph version of VEF	
WBFK		FK modified for enhanced high frequency output	
WBHC		HC modified for enhanced high frequency output	

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

3.8 WATERPROOF / SUBMERSIBLE

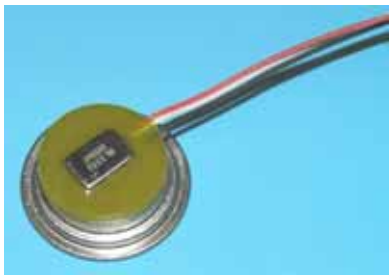
Model MR-23333-000

Construction

MR-23333-000 consists of a BK series balanced armature motor driving a large paper-stiffened diaphragm, and an MR waterproof bellows assembly. The MR bellows provides the waterproofing, and is rated to 50 feet (about 15m) of submersion. The grill has openings large enough to drain water quickly, so the speaker can operate immediately after removal from water. This rugged assembly may be hosed off for periodic cleaning. The MR diaphragm assembly (pictured) allows sound to pass and air pressure to equalize.

MR Diaphragm

MR-23333 reverse



MR Assembly

MR Assembly

Applications

The MR speaker is intended to be panel-mounted. It is commonly used in rugged radio handsets or headphones. The acoustic output is sufficient only when held against the ear. A larger speaker (CB Series) is needed for handsets which must be heard at a distance.

CB-23817-000

Construction

CB speaker's large balanced armature motor structure drives a large paper-stiffened diaphragm that moves enough air to be heard at arm's length. The rear of the case is vented to allow increased low frequency output. The speaker survives immersion by allowing water into both large front and rear sound ports. Water pressure is balanced on both sides of the diaphragm. When removed from water, the large sound ports drain quickly. Internally, the coil is potted and the leads are treated with conformal coating. Flying leads are provided for easy hook-up.

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

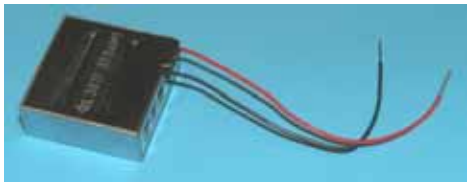
JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

CB-23817 Rear Port

CB-23817 Front Port

CB Front Port View



CB Rear Port View

Applications

Waterproof CB speakers are used in ruggedized radio handsets, or other applications where high sound output and low power consumption are required. Both sound ports must be kept open to the external environment so that water can enter and drain. Adding a movable partial cover over the rear sound ports will reduce canceled sound and maximize acoustic performance.

CB will also work as a microphone, and can be the only transducer required for a push-to-talk (PTT) handset.

Details for CB applications can be found at the following link:

http://www.knowleselectronics.com/engineering/pdf/TB-18.pdf

3.9 LARGER SPEAKERS

Nearly all speakers (receivers) within the ST product range are intended to work directly into the ear. A few series are intended to work close to the ear, or at a distance: BS, CB, CM, and MR Series. The MR Series is discussed above.

BS Series

Construction

BS is a large balanced armature speaker with a narrow resonant output and good resistance to mechanical shock. Low power consumption makes it a good choice for battery operation.

Application Note

BS Speaker / Beeper

Applications

Beeper or sounder with tones around 2kHz and/or 3kHz.

CB Series

As with the waterproof CB, the standard CB speaker's large balanced armature motor structure drives a large paper-stiffened diaphragm that moves enough air to be heard at arm's length. The rear of the case is vented to allow increased low frequency output. A dust cover protects the rear sound port from foreign material. The rear port may vent into a housing or enclosure. CB also works as a microphone. Mounting pins allow for easy attachment to a PCB.

CB-22850-000

Details for CB applications can be found at the following link:

http://www.knowleselectronics.com/engineering/pdf/TB-18.pdf

Applications

Push-to-talk (PTT) handset or low power band-pass speaker or beeper for a battery operated device.

CM Series

Construction

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

Application Note

Like the MR speaker, CM uses a BK motor to drive a large paper-stiffened diaphragm. It has a band-pass frequency response optimized for communications intelligibility. CM also protects against static shock in a dry environment, and was designed for use on commercial aircraft. The speaker is intended for use suspended near, but not touching, the ear.

CM Bottom View

CM Top View

Applications

Lightweight communications headsets. The non-contact speaker is ideal for shared headsets and/or prolonged wearing, such as in call centers. The comfort of a non-contact speaker is also a desirable feature for a premium office headset.

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

3.10 TEST CONSIDERATIONS

KA Receivers and Speakers are 100% tested against their performance specification before they leave our factory. Many customers consider KA a "dock-to-stock" supplier, and do not perform incoming tests on our products.

Though the test condition presented on the product specification is accurate, customers who do wish to setup incoming testing on KA ST receiver or speaker product need to address the following issues:

- Physical test setup
  - Contacts
  - Fixturing
  - Acoustic coupling
- Test platform
- Correlation (if the test condition differs from the specification)

It is common for a customer to inquire whether they can duplicate Knowles' test or purchase test fixtures. Unfortunately, it is not practical to do so.

3.10.1 HOW KNOWLES TESTS RECEIVERS

Knowles tests millions of receivers and speakers each year. The shapes, sizes, and specifications vary. Hundreds of model types must be accommodated. To address the requirements for throughput and variety, Knowles tests the great majority of receivers and speakers on a common platform (called FCART internally). FCART is controlled by a PC running custom software written in Labview. The base of FCART functionality is an FFT analyzer that measures much of the test performance. The system requires a custom test board for each distinct receiver or speakre geometry, and a custom test file for each model specification.

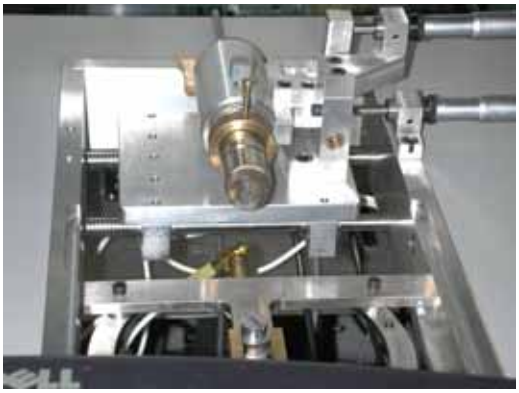
AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

FCART System



Detail of Coupler

3.10.2 Response Testing

Both the cost and custom nature of FCART make it unsuitable for customer incoming performance tests. Certain aspects of the system, however, also make sense for a customer test system.

A receiver or speaker test will require a signal source, acoustic coupler, reference microphone, and voltmeter.

Acoustic Couplers

Receivers, since they are intended to be coupled directly to the ear, are tested with acoustic couplers that approximate the volume of the ear canal and the connection to it. Because of Knowles history as a supplier of components to the hearing health industry, many of the test couplers simulate typical BTE (behind-the-ear) or ITE (in-the-ear) hearing aid performance. The couplers typically consist of some tube or series of tube that terminate in a small air volume.

The frequency response very much depends on the acoustic coupling used for test. Specified frequency response curves are not usually a very good prediction of what the end user will hear

in the end product. The final performance for a receiver will depend on the acoustic plumbing of the actual design, the quality of the seal to the ear canal, and the physical makeup of the individual user.

Unlike with loudspeakers, flat frequency response is generally neither a feasible nor desirable outcome for a receiver. When the ear canal is blocked with an earphone, the natural resonance (around 2kHz) of the ear is lost. This is known as the occlusion effect. KA receivers are usually designed to replace this lost emphasis.

Most earphones designs have an exit tube which is covered by a replaceable eartip. The exit tube affects the frequency response, and can be used as a design tool to extend high frequency performance.

The coupling condition is always noted on the model specification of the receiver or speaker:

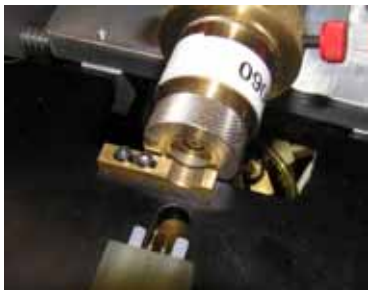
NOTES:

1. MEASUREMENTS MADE USING 10m (.394") X 1mm (.039") ID TUBE CONNECTED TO A SIMULATED ANSI S3.7-1973 TYPE HA-3 COUPLER. (IEC 126).

Example ITE Coupler Specification

10mm x 1mm tubing into IEC 126 coupler, attached to ½ inch reference microphone

10mm x 1mm tubing into IEC 126 coupler, intended for 1 inch reference microphone



FCART fitted with coupler and test board 1

BTE type coupler intended for 1 inch reference microphone

BTE type coupler (longer tube)

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

IEC 711 coupler attached to 1/2 inch reference microphone

IEC 711

Bruel and Kjaer 4153 Artificial Ear (IEC 318)

The IEC 711 is a good choice for testing insert earphones. Larger speakers intended for handsets or earpads may be tested on an IEC 318, which simulates coupling more accurately for those applications. Any leaks or vents in the fixturing must be very small and/or well controlled, because leaks affect low frequency performance.

3.10.3 DISTORTION TESTING

Typical distortion on most models at nominal drive is less then 1 percent. Distortion is tested in production as THD at about half of the first peak frequency, 1/3 of the first peak frequency, or both. Maximum allowable distortion is usually specified at 5 percent or less.

Signal headroom (defined as output before 10 percent distortion) is typically at least 10dB above nominal drive.

3.10.4 SUGGESTIONS AND REFERENCES

To create an incoming test for KA receivers or speakers, some basic hardware is required:

- Signal source
- Specified acoustic coupler
- Reference microphone (with preamplifier and power supply as needed)
- Voltmeter
- Distortion meter (if measuring distortion)

- Optional: analyzer can be used to measure frequency response and distortion

Acoustic Couplers and Reference Microphones

Both Bruel and Kjaer and G.R.A.S Sound and vibration have acoustic couplers available.

http://www.bksv.com/

http://www.gras.dk/

Audio Analyzer

KA tests most production items on proprietary test systems. Some products are tested with PC based Clio equipment and software from Audiomatica.

http://www.audiomatica.com/clioeng.htm

Customers who adopt Clio can expect KA Engineering to have some familiarity with the products.

3.11 ELECTRICAL INTERFACE

ST Receiver and Speaker components must, of course, be integrated into an assembly or end-product to be useful. Users frequently have questions about both the physical and the electro-acoustic aspects of the components as they relate to their design. While applications may involve unique requirements, certain questions surface repeatedly.

3.11.1 PHYSICAL HOOK-UP

Q: How do I connect to the receiver elements?
A: Solder hook-up wire or cable to the terminals. Stranded wire is recommended. 28 gage may be used for larger elements. 30 or 32 gage may be used for smaller elements, or litz wire if vibration coupling is a concern. For earphone applications using smaller receivers, a PCB or flex circuit may be needed to connect larger gage cable wires to smaller gage wires needed for receiver attach. Strain relief is required between headphone cable and receiver solder terminals.

Q: Are your receivers and speakers available with a connector?

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

A: KA offers value added assembly work, which commonly includes attaching wire and connectors to components. KA can also attach properly designed flex circuits to elements. Connectors do not mate directly to receiver elements, however. Some CB Series speakers include PCB mounting pins.

Q: Can I surface mount your components?
A: No, reflow temperatures will destroy ST components.

3.11.2 DESIGN INTEGRATION

KA receiver and speakers products are used in a variety: consumer earphones, radio communication earsets and handsets, telephony, instrumentation, etc. Generally, the element will be connected directly to a voltage drive source.

Acoustic Headroom and Impedance

Maximum acoustic output for a receiver or speaker is limited by its physical construction. By matching the nominal voltage drive to the specified nominal voltage drive of the receiver or speaker, the designer can align the dynamic range for the application. KA receivers and speakers are available in a variety of impedances. The nominal drive level corresponds to the impedance – higher drive for higher impedances.

Crossover

If more than one receiver element is to be used simultaneously, a passive crossover may be needed for optimal performance. KA dual transducers such as TWFK have simple crossover instructions as part of the specification. Contact your Account Manager for technical assistance for a specific application question.

3.12 CUSTOM ASSEMBLIES

If existing ST product offerings do not fulfill your requirements, or if you would like KA to quote additional assembly work for a product that uses our transducers, please contact your Account Manager. KA has the ability and capacity to take on higher level assembly work, and have done so successfully for many customers. Typical Value Added assemblies have included:

- Flex circuits
- Attached leads, cable, and connectors

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

- Earphone housings
- PCBs
- Integrated acoustic damping elements

The value-added parts may be specified by the customer, or may be proposed by KA. Minimum order quantities, tooling costs and other one-time costs may apply.

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Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
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ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

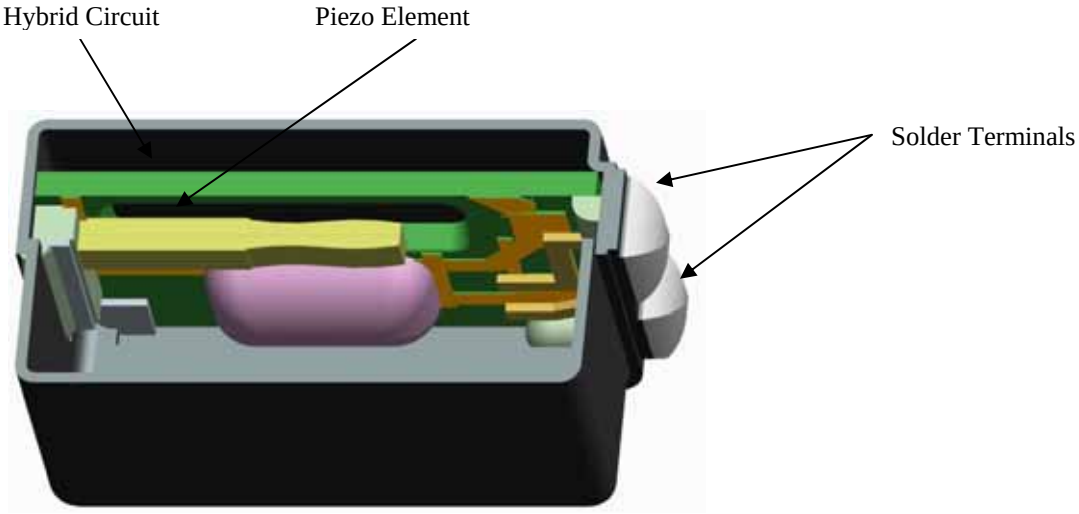
4. ACCELEROMETERS

The BU Series piezo-ceramic accelerometer has output from 20 Hz to above 10 kHz, and is used primarily as a contact microphone for use in high noise environments. It may also be used as an accelerometer with lightweight structures.

Construction

The signal is generated by inertial motion between the case and the cantilevered piezo-ceramic beam. An FET amplifier converts the signal impedance to about 4 kohm. Some models have mass added to the end of the beam to boost sensitivity.

The case size is either standard (pictured) or thin (half of standard thickness), and is hermetically sealed.



BU Accelerometer Section View

BU (thick case type)

BU (thin case type)

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

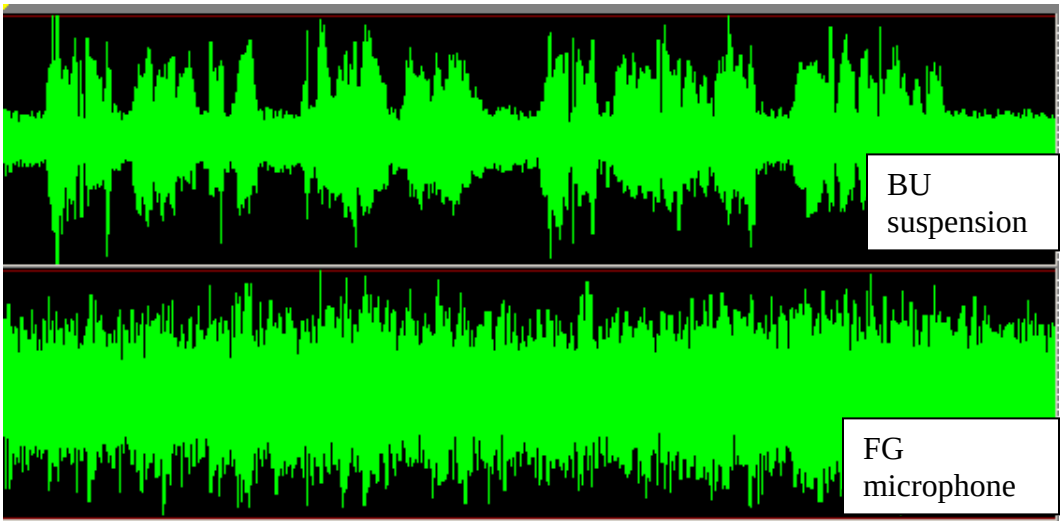
Application Note

Applications

As a contact microphone, the BU may be worn on the throat, or touching a bony part of the head (top, temple, or mastoid bone). BU has been integrated into helmet designs for emergency services.

The benefits are:

- Voice intelligibility in a noisy environment
- Convenience of wearing (when integrated onto another worn article such as a helmet)
- Unobtrusive compared to a close talking boom microphone



Waveform illustration comparing BU to FG microphone

Suspension Mounting

The challenging aspect of using BU as a contact microphone is that performance depends on two conflicting design goals:

- Achieve adequate contact force to couple vibration
- Do not mass-load the element (this dampens high frequency vibrations)

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

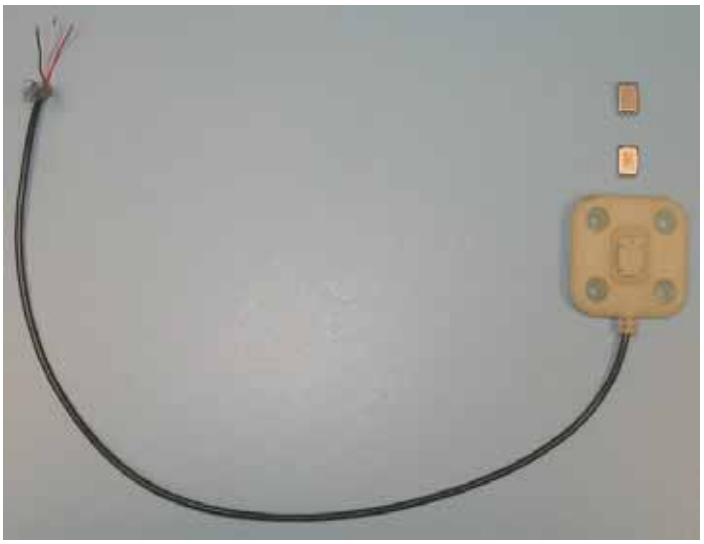
EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

ASIA:
Knowles Acoustics
5F, No. 129, Lane 235, Bauchiau Rd.
Shindian City, Taipei 231, Taiwan
Republic of China
Phone: 886-2-8919-1799
Fax: 886-2-8919-1798

Application Note

To simplify the mounting challenge and demonstrate the communication function of the BU, KA has designed a prototype suspension mounting. The package absorbs most of the contact force, and controls the contact pressure on the element. A flexible "trampoline" suspension allows the element to vibrate along with the contact point. The package includes holes for screw or rivet mounting to a helmet strap.



BU Suspension prototype package

Contact side view w/element

Reverse view

Side view w/elements

AMERICAS:
Knowles Acoustics
1151 Maplewood Drive
Itasca, IL 60143
U.S.A.
Phone: 630-250-5930
Fax: 630-250-5932

EUROPE:
Knowles Acoustics
York Road, Burgess Hill
West Sussex, RH15 9TT
England
Phone: +44-1444-235432
Fax: +44-1444-872772

JAPAN:
Knowles Acoustics
Kyodo Bloom Building
2-19-1 Miyasaka, Setagaya-Ku,
Tokyo 156-0051, Japan
Phone: 81-3-3439-1151
Fax: 81-3-3439-8822

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5. ACOUSTIC DAMPERS

KA offers discrete acoustic damping elements and assemblies – the BF Series product range. Acoustic dampers in combination with tubing can shape the frequency response of a microphone or receiver to more closely match an application requirement. Acoustic dampers are analogous to electrical resistors. The effect of dampers and tubing can be modeled using the PSpice circuit simulation program. Knowles offers electrical analog models for most transducers on the http://www.knowleselectronics.com web site.

5.1 ELEMENTS

BF Series damper elements are available in two types:

- Formed cups (three sizes)
- Metal ferrule with inserted screen

The elements are color coded to indicate the acoustic resistance (in ohms).

BF Series (formed cups, ferrule, and damped coupling tubes)

The formed cups are intended for permanent insertion into a tube slightly larger than the specified outer diameter.

The metal ferrules are intended for insertion into a tube that will accommodate the 0.05mm tolerance of the outer diameter (a rubber sleeve is recommended).

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5.2 ASSEMBLIES

A Damped Coupling Tube assembly is available that acts as a modified horn to reinforce a receiver's high frequency sounds. The assembly consists of a stepped diameter tube, a rubber compression sleeve, and a BF ferrule damper. It can act as a practical wax guard when used in an earphone.

Damped Coupling Tube Detail

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