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AUDIO FACTS

ON LOCATION • IN THE STUDIO • ON THE AIR

Vol. 1 Issue 1

Introduction to the Basics of Microphone Behavior

The quality of studio audio is influenced by a complete set of parameters within the environment, studio, concert hall or remote location, and the choice of microphone. The most frequently asked question: which microphone should I use for interviews? Or, which microphone do you suggest in a control room? While it is not our intention to single out the Irish—you'll recall the story about an American visitor talking to an Irishman in a pub . . . "The one thing I don't understand about you Irish is that you always answer a question with a question." To which the Irishman replays, "Do we?" Questions about microphone selection often generate more questions. They cannot be answered simplistically. Before you can choose the best microphone for a particular application, you should consider the acoustical conditions under which it must perform.

An example would be in interview situations where background noise is not a problem—the omni which picks up sound throughout 360° in all planes would be ideal. An omni would be less than satisfactory, however, for interview use in a noisy environment such as a machine shop. Here, unwanted sound must be supressed to allow for intelligibility. Various forms of cardioid microphones (directional) or shotgun mics (highly directional) would be obvious choices for this noisy environment. They reject sound to the sides of the mic, while further rejection increased (or cancellation) is toward the rear of the mic. The result is an increase in "working distance." This working distance advantage over the omni enables the mic to "reach out" (a distance of 1.7 times) for a given ratio of on-axis (desired) signal to ambient (not wanted) noise.

These examples have been chosen to briefly introduce, while illustrating, to you a few of the fundamental aspects of microphone behavior.

In order to make a satisfactory selection from the vast array of microphones in the marketplace, it is necessary to have a thorough understanding of the performance characteristics of various types. Once the information contained within these pages is put into practice and the personality of each microphone understood, the selection process becomes a combination of knowledge and logic. There is, of course, no substitute for experience, experimentation, and your ability to anticipate problems and solutions. But along the way you'll find that, like the Irishman in the story, one question often leads to another. ***Audio Facts*** *is our way of providing some useful answers.*

SECTION ONE

1. Basic Principles of Microphone Operation

1.1 *What is a diaphragm?*

All microphones have two basic components: the diaphragm and the generating element which make up the transducer. The diaphragm is a membrane to which the generating element is attached. The diaphragm vibrates in accordance with the sound, music or noise presented to it. For illustration, the microphone diaphragm is the analogue of the speaker cone.

1.2 *What is a generating element?*

A voice coil and magnet, or a ribbon (also a diaphragm) and magnet, a condenser, or ceramic/crystal which convert the vibrations of the diaphragm into an output voltage are all generating elements.

Sound hits the diaphragm and the diaphragm moves backward and forward between A and B. As the diaphragm moves, the coil moves between C and D, within the magnetic field. As the flux (magnetism) is cut by the coil's movement, a voltage is generated. A loudspeaker utilizes the same "motor action" as the dynamic microphone.

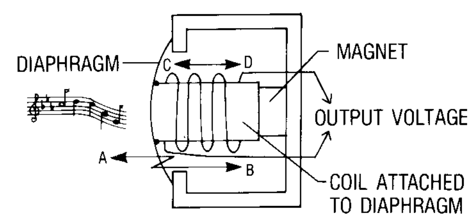


FIGURE 1.2
Voice coil and magnet "Dynamic Microphone"

1.3 *What is a polar (pickup) pattern?*

A polar pattern shows how the microphone responds to sound presented to the front, sides and rear of the mic. It will indicate the point of maximum sensitivity (0° on axis) and throughout a 360° plot will show the electrical output as a function of induced angle of sound.

Pickup patterns include:

1.3.1 *Omnidirectional or spherical (pressure):*

Microphone sensitive to all sounds originating in front, behind, beside or below the unit. As these types are

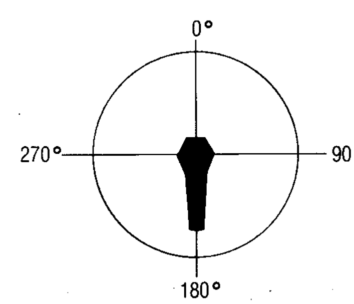


FIGURE 1.3.1
Omnidirectional Polar Pattern

pressure operated, they have no way of rejecting or cancelling sound presented to the capsule from any direction. High frequencies are attenuated by the diffraction effects (the microphone case, shape and size, gets in its own way) of the microphone case, towards the rear of the microphone.

The omni microphone is, generally speaking, the easiest type to make, offers the smoothest response and is the most durable.

1.3.2 Hemispherical (pressure) ½ of an omni:

This microphone type operates on the principle that all sound arriving at the microphone capsule and its associated boundary/barrier plate arrives at the same time, or is in phase. Microphones of this type are commonly referred to as "Pressure Zone Microphones®, or PZM®.

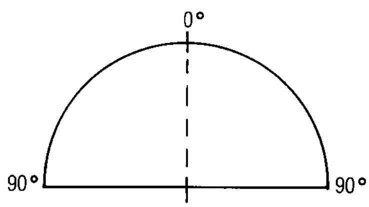


FIGURE 1.3.2A

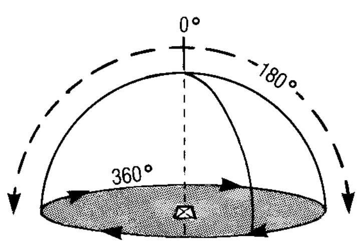


FIGURE 1.3.2.B

1.3.3 Cardioid or heart shaped (pressure gradient):

Variations on directional microphones include:

1.3.3A Uni-directional/cardioid:

Rejects majority of sound commencing 90° off axis (−6 dB) and increasing to a maximum attenuation at 180° off axis. The angle of acceptance varies

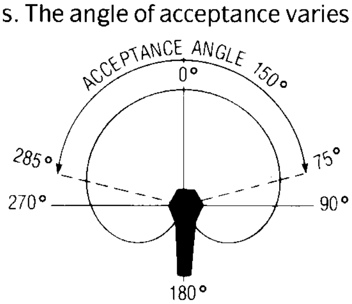


FIGURE 1.3.3A
Cardioid Polar Pattern

with the design of the microphone, however, typically will be 150°.

1.3.3B Super-cardioid:

A "more directional" cardioid. The 90° off axis attenuation (−8.72 dB) is increased approximately 3 dB and further increases sharply such that at 125° and 235° maximum rejection is achieved. The rear lobe offers about

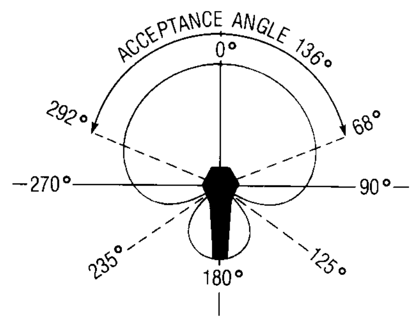


FIGURE 1.3.3B
Super-Cardioid Polar Pattern

20 dB of rejection at 180° off axis. 125° offers the same attenuation as the 235° position and at 180° this microphone offers approximately 3 dB LESS attenuation than the cardioid type. Typically, the acceptance angle is 136°.

1.3.3C Hyper-cardoid:

Similar to the super-cardioid, the hyper-cardioid's angle of acceptance is reduced to approximately 120°. 90° off axis is attenuated approximately 12 dB. The 110° and 250° off-axis points offer maximum attenuation.

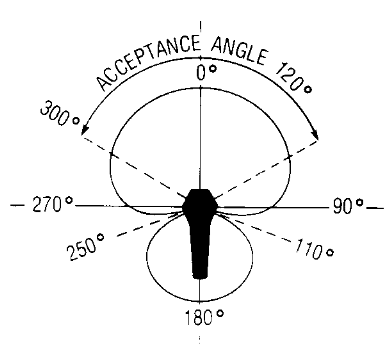


FIGURE 1.3.3C
Hyper-Cardioid Polar Pattern

The rear lobe at 180° off axis offers approximately 10-12 dB of attenuation, which is about 5-8 dB less than the super-cardioid. However, this most useful mic has greater rejection at the sides.

1.3.3D Shotgun types: Cardiline®, in-line, phase interference tube:

With these microphones, maximum directivity is achieved in in the middle and high frequency range. From approximately 35° off axis and increasing to 90° and greater, depending on design sound originating off axis is rapidly attenuated (angle of acceptance approximately 70°). "Working distance" is greatly increased over cardioid types, since ability to reject unwanted sound at the sides and rear is considerably greater, the rear lobe behaves somewhat like a hyper-cardioid. All shotguns work on the phase cancellation technique.

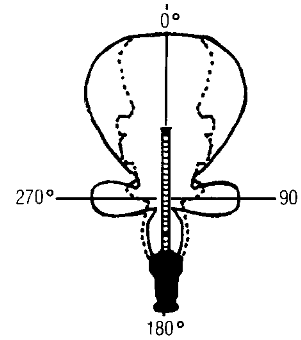


FIGURE 1.3.3D
Shotgun Polar Pattern

On axis (0°) sound waves are not affected by this interference tube. However, the directional effects of this system commence at 20° off axis (−3 dB @ 6 kHz). As the off axis sound waves enter the sides of the tube at different times, phase cancellation takes place and significant attenuation is the result. From 35° to 60° 22 dB of attenuation may take place.

1.3.4 Bi-directional (pressure gradient):

As its name implies, this microphone is most sensitive to sound at both 0° (A) in front and 180° at the rear. The signal (B) originating at 180° is reversed in phase! Of all microphones, it offers maximum rejection at 90° off axis. The most popular types are either ribbon or dual condenser capsule microphones. For ease of illustration, the ribbon will be described.

As both sides of the ribbon are exposed (front "+" and rear "−", Figure 1.3.4B), it will be equally sensitive to sound A and sound B at the rear. Sound C & D will be reduced at the sides. Its operation is governed by the *difference* in pressure at the front and rear of the ribbon. This type of microphone is also known or referred to as a velocity or pressure gradient

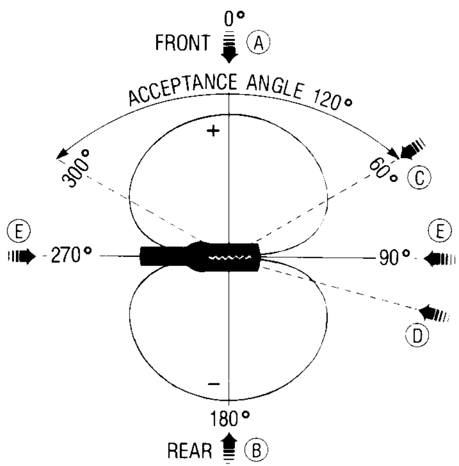


FIGURE 1.3.4A
Bi-directional Ribbon Polar Pattern

mic. Sounds which occur 90° off axis (side) arrive at the front and rear of the ribbon simultaneously and at the same loudness. The net pressure gradient (difference) is zero (sound E). Consequently, there is no output.

Since bi-directional microphones have this ability to cancel off-axis sound, they are commonly used in classical music recording, especially to isolate closely spaced instruments. This is achieved through the use of positioning the mic such that the 90° and 270° off-axis positions face the *unwanted* sound. In many cases, the negative lobe may point up to the ceiling!

SECTION TWO

2. Frequency Response

2.1 *What is frequency response?*

Frequency response is the ability of the microphone system to respond to the audio information presented to it. The range (pitch) of frequencies extends from a low end around 20 Hz (bass) to high frequencies (top-treble) of 20 kHz. Not all microphones necessarily have a 20 Hz-20 kHz response.

2.2 *What is a frequency response curve?*

The curve is a graphic representation of the frequency response showing dips, peaks and other irregularities (which MAY be desirable) in the response. Most response curves are made "on axis" at 0°. This is commonly referred to as the "axial" response or curve. However, this common curve does not reveal the true overall performance.

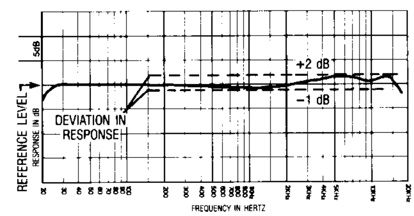
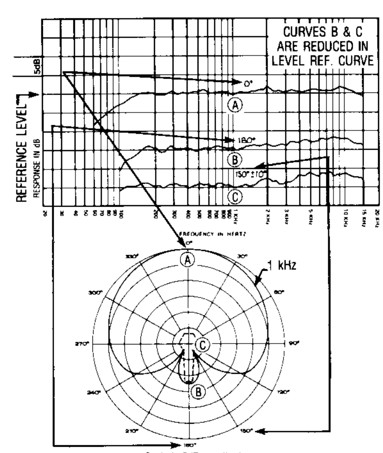


FIGURE 2.2
Typical Axial Frequency Response
Illustration shows excellent performance.
Microphone Specification: 20 Hz-18 kHz ± 2.5 dB

2.3 *What is a back or side frequency response curve?*

These curves assist in determining the off-axis performance which is also known as off-axis coloration. The performance will vary throughout the 360° polar plot and depends on frequency. Normally, there will be little or no change throughout the acceptance angle. However, depending on microphone design, drastic anomalies from 90° and on around the rear of the microphone to the 270° position will reveal a multitude of facts.



A = Axial C = 150° (−25 dB)
B = 180° (−15 dB)

FIGURE 2.3A
EV Model RE15
Very Good Off-Axis Performance

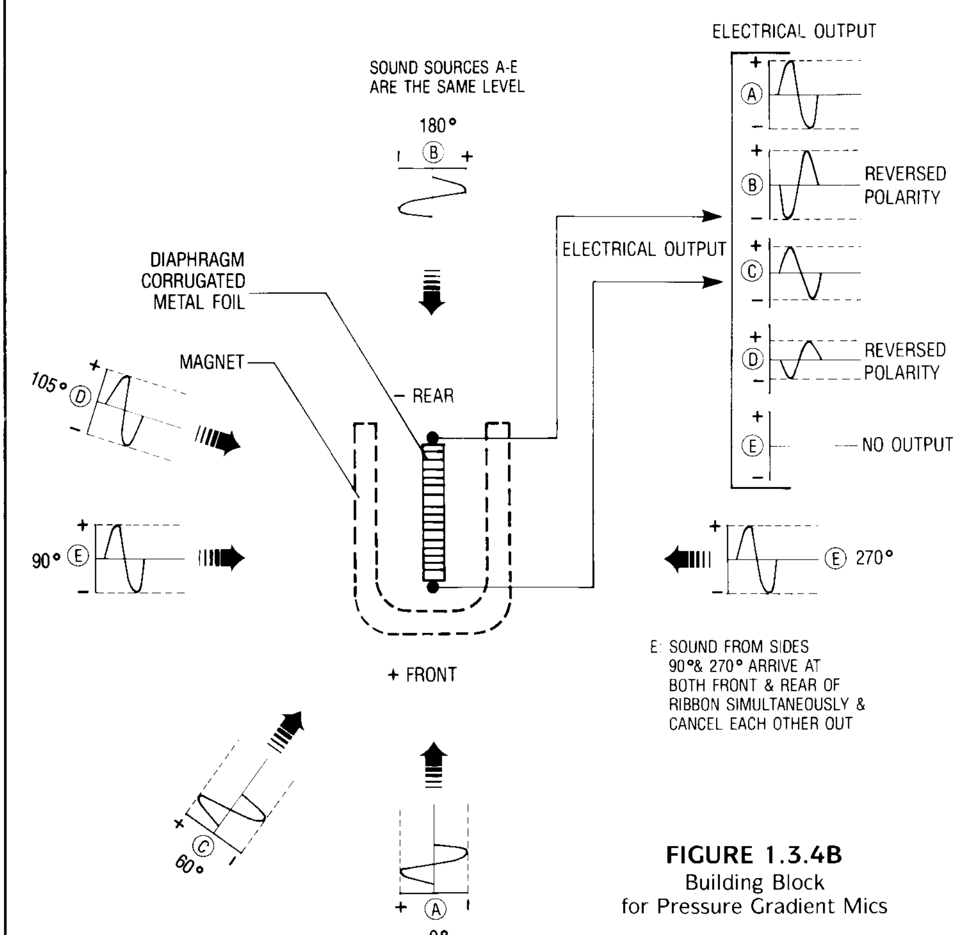


FIGURE 1.3.4B
Building Block
for Pressure Gradient Mics

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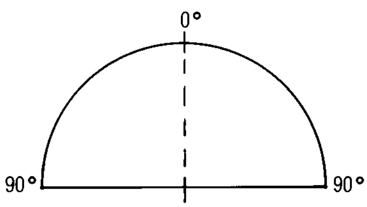

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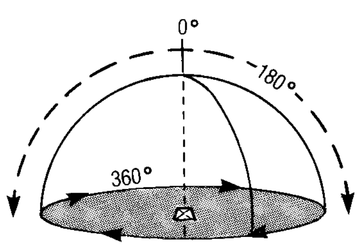

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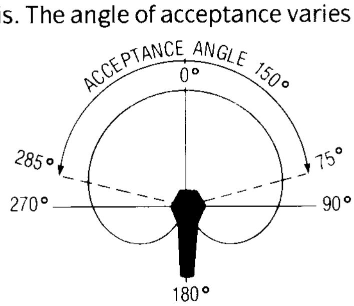

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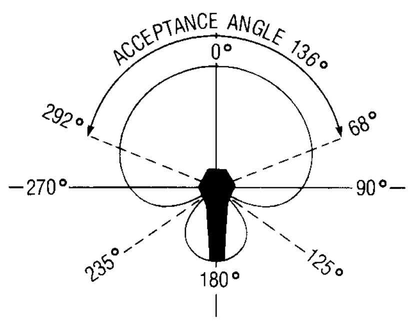

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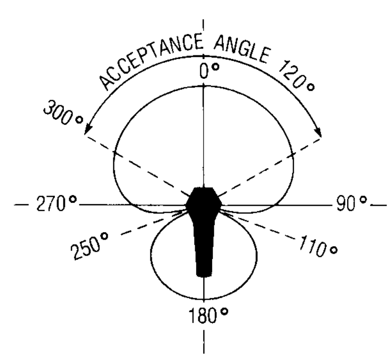

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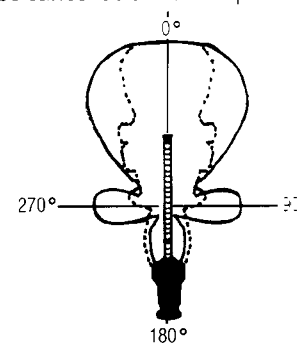

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