THE PA BIBLE

ADDITION NUMBER THREE
MICROPHONE TYPES

In our prior P. A. Bible material we have dealt with acoustic transducers that convert electrical energy into sound (loudspeakers). Another type of acoustic transducer is the microphone. The microphone is similar to the loudspeaker, but its function is to convert sound into electrical energy.

The following discussion will describe the various types of microphones in terms of four factors that help define them. In addition, some information will be given that should help in selecting a microphone type and a few important operating tips will be mentioned. It is not our intent to go deeply into applications in this supplement. We intend to reserve that complex topic for a later issue.

MICROPHONE TYPES AND OPERATION

All microphones have two basic components: the diaphragm, and the generating element. The diaphragm is a membrane which vibrates in accordance with the pressure variations of sound. The generating element converts the diaphragm vibrations into electrical voltage. This generating element is one of four factors which determine the type of microphone. The kinds of generating elements vary greatly in expense, fidelity, complexity, ruggedness, and longevity.

Ceramic and Crystal Generating Elements. The diaphragm of a crystal or ceramic microphone is attached to a special material which produces an electric output voltage when it is moved. Such materials are termed "piezoelectric." A typical ceramic microphone is diagrammed in Figure 1. Such microphones generally provide insufficient fidelity and ruggedness, even for the most modest requirements of the professional and serious amateur.

![Ceramic/Crystal Generating Element](image)

Ribbon (or "Velocity") Generating Elements. Ribbon microphones are similar to dynamics, except that a very thin metal-foil ribbon serves as both diaphragm and voice coil. In order to obtain adequate frequency response and output level, the thin ribbon must be exceedingly light. Older ribbon microphones could easily be destroyed by mechanical shock or a sudden blast of air which would stretch and destroy the fragile ribbon. However, the best current designs have been improved for satisfactory durability.

Dynamic Generating Elements. The diaphragm of a dynamic microphone is attached directly to a coil of wire (voice coil) located close to a magnet. When the voice coil vibrates, a voltage is produced. A dynamic microphone is shown in Figure 2.

The dynamic microphone is a proven tool for the public address and instrumental miking requirements of the professional performer. It provides excellent fidelity, extremely stable performance characteristics, and a high degree of ruggedness — all at a reasonable price. These same characteristics are ideal for conventional sound reinforcement and recording, as well. In addition, the diaphragm of a well-designed dynamic microphone is able to withstand the close miking and high sound levels often employed by musicians; all without damaging the microphone or distorting its output. The many desirable features inherent in the dynamic microphone make it a good choice for most applications.

Condenser Generating Elements. The diaphragm of a condenser microphone is a movable plate of a condenser (capacitor), a common component in electrical circuits (Figure 2A). When polarized by applying a direct current voltage, motion of a diaphragm in relation to a fixed backplate produces an output voltage. The extremely high impedance of the condenser generating element is matched to typical inputs by an impedance converter in the microphone. Condenser microphones, many of which are capable of very wide frequency response, have been widely used in recording studios for years. For the performer, due to their relatively high output level, condensers may produce input overload distortion (distortion caused by too great an input signal to a mixer) unless appropriate precautions are taken.

Modern day electret type condenser microphones can offer ruggedness comparable to dynamic microphones. The electret microphone can often yield superior performance at the frequency extremes (high and low) when compared to dynamic types. Because electrets utilize an impedance converter to match the diaphragm signal to the mixer input, they require either a battery or phantom power for operation. Phantom power is a means by which power is supplied to the microphone from either a mixer or power supply by way of the microphone cable. Phantom power eliminates the need for batteries and the problem of replacing dead batteries. Even though electret microphones are more complex in construction, their performance advantages are making them an increasingly attractive choice for exacting applications.

MICROPHONE PICKUP PATTERNS

A microphone's pickup pattern is three dimensional in character and shows how the microphone responds to sound from different directions. Omnidirectional microphones pick up sound from all directions. Unidirectional microphones reject or reduce sound from their sides or rear. The pickup pattern is the second of four factors which determine the type of microphone.

Omnidirectional Pickup Pattern. The pickup pattern of an omnidirectional microphone may be represented as an inflated balloon with the microphone at the center, as shown in Figure 3. Usually a polar pattern is used to represent the pickup pattern, illustrated in Figure 4. The polar pattern shows the loss in output (in dB) experienced as a constant-output sound source moves 360° around a fixed microphone at a fixed distance from the microphone.

How does an Omnidirectional Microphone Work? The case of the microphone shown in Figure 5 is totally sealed, so that sound pressure can strike only the front of the diaphragm.
Pressure variations passing over the diaphragm move it no
matter how the unit is oriented with respect to the sound
source! This phenomenon is shown in Figure 6. Thus, micro-
phone output is constant regardless of orientation.

Why an Omnidirectional Microphone? In systems where
extremely close working distances are employed, say
touching the lips to six inches, the omnidirectional micro-
phone, if it can be used, has several advantages in its favor:
1. For a given price, an omnidirectional microphone
generally has a smoother frequency response than its
cardioid counterpart. Such smoothness of response
is important because any roughness invites feedback.
2. An omnidirectional microphone is significantly less
susceptible to breath pops than its cardioid
counterpart.
3. An omnidirectional microphone is significantly less
sensitive to mechanical shock than its cardioid
counterpart.
4. An omnidirectional microphone is often more rugged
than its cardioid counterpart.

Unidirectional Pickup Pattern. The most common
unidirectional microphone is called a cardioid. Cardioid is a
mathematically descriptive term that denotes the geometric
form of the pickup pattern. The pattern happens to be
cruelly heart-shaped (hence the term “cardioid”). Side
pickup is moderately reduced in a cardioid microphone and
rear pickup is dramatically reduced. The polar pattern of a
cardioid microphone is shown in Figure 7. The apple shown
in Figure 8 would be a good three-dimensional model of the
cardioid pattern with the stem representing the microphone.

Why a Cardioid Microphone? The pickup pattern of a
cardioid microphone — relatively dead at the sides and rear —
tends to increase the working distance (the distance between
the sound source and the microphone). The limiting factor is
when the distance becomes so great that amplifier gain must
be increased until:
1. The sound becomes over-reverberant due to room
reflections.
2. The pickup of random background noise becomes
excessive.
3. Sound system feedback results from P.A. or monitor
speakers.

This increase in working distance is theoretically 1.7 to 1, as
shown in Figure 11. For instance, if the maximum effective
working distance of an omnidirectional microphone is ten
inches, then theoretically a cardioid mic can be used at
seventeen inches with the same effectiveness!

The feedback-reducing characteristics of cardioid micro-
phones would seem to make a clear-cut case for the use of a
cardioid microphone by professional performers. In marginal
feedback situations, the cardioid will produce a higher level
in the room before feedback occurs. This situation is often
encountered in portable P.A. systems and other systems
employing high-level stage monitors, where high levels of
direct speaker sound reaches the microphone from the sides
or rear. Usually in such instances, the loudspeakers are closer
to the microphones than would be desirable from a sound-
system design standpoint, and care must be taken to
maintain proper gain without feedback.

Two vastly Different Types of Cardioid Microphones. A
“Single-D” cardioid gives big bass. The simple cardioid
microphone described previously (the one with a single port
located in the case) has a frequency response which varies
strongly with working distance! As shown in Figure 12, at
one-quarter inch, the bass response is boosted fifteen dB over
the response at 24 inches and beyond! In engineering terms,
this type of cardioid is called a “Single-D”, named for the
single distance between the rear sound entrance and the
diaphragm.

The close-up emphasis of bass tones of the Single-D cardioid,
called “proximity effect”, provides a big, no-mistake-about-
it bass sound — and for certain vocal applications, this is a
popular sound. The Single-D sound, however, may not
provide the super-clarity often desired by today’s performer.

A “Variable-D” cardioid emphasizes clarity. In order to
reduce bass-boosting proximity effect, Electro-Voice
developed and patented the “Variable-D” microphone. In a
Variable-D, multiple ports are used with high frequencies
entering the port closest to the diaphragm, mid frequencies
entering midway along the length of the microphone case,
and low frequencies entering the port farthest from the
diaphragm. A Variable-D microphone is shown in Figure 13.
The virtual elimination of proximity effect of a Variable-D microphone is shown in Figure 14 in comparison to the strong bass boost of the Single-D cardioid microphone.

Latest Electro-Voice designs employ a variation called "Continuously Variable-D" where the mid- and low-frequency ports are replaced by a long, slotted entrance which has a continuously varying frequency acceptance along its length, with the lowest frequencies entering at the farthest point from the diaphragm. The frequency discrimination of Variable-D or Continuously Variable-D microphone ports can be effectively demonstrated by speaking, with lips touching, into the front, then mid, then rear openings. The change in vocal character will be readily apparent, with the sound very "bassy" at the rear port of the microphone and with much more "treble" evident toward the front port. A Continuously Variable-D microphone is shown in Figure 15.

In addition to reduction of the Single-D's proximity effect, Variable-D and Continuously Variable-D cardioids have reduced breath popping and shock sensitivity. Thus, the popularity of the Variable-D microphone is due to its combining of the omnidirectional's clarity and inherent pop and shock resistance with the cardioid's feedback reduction and working distance advantages.

Variable-D and Continuously Variable-D (CV-D) are registered trademarks of Electro-Voice, Inc.

MICROPHONE FREQUENCY RESPONSE

The third factor which determines microphone type is frequency response. Response information for each microphone will help you select for special results. For instance, a microphone with "rising" response will emphasize the brightness of a trumpet or other brass instrument; one with proximity effect (single "D" cardioid) will add bass boost to a close working "thin voiced" singer. Communications microphones almost always have rising response or a "presence peak" to add intelligibility to voice transmission. A flat response, for most accurate sound reproduction as shown in Figure 16, would be typical for studio recording under ideal room and low noise conditions.

MICROPHONE IMPEDANCE

Choosing Between Low-Z and High-Z Microphones. Microphone impedance is the fourth factor that determines microphone type. High impedance microphones have higher output than low impedance types (about 20 dB). However, low-Z microphones permit the use of longer cables without high-frequency rolloff. Therefore, if microphone cables will be longer than fifteen or twenty feet, only low-Z microphones should be used if the maximum clarity of extended high-frequency response is desired! Low impedance microphones have become the industry standard due to their versatility and the availability of equipment which accept low impedance inputs.

HOW TO CHOOSE THE RIGHT MICROPHONE

Knowing how microphones operate and taking into consideration frequencies of sound, pickup patterns, impedance, and proximity effect, you should now be able to choose an appropriate microphone. To accomplish this use the chart shown in Figure 19. It will allow you to pick the microphone that fits the application. Start at the top of the chart and work your way down. Answer the questions in each box and the chart will indicate the type of microphone recommended for your application.

OPERATING TIPS

Since we are dealing with the subject of microphones, a few tips on applications should be of interest. As mentioned earlier, we intend to devote a future supplement totally to applications, but we would like to include a few of the more important topics right now.
Impedance Matching for Dynamic Microphones. In usual practice, high-Z microphones operate properly when connected to high-Z mixer inputs only. Connection to a low-Z input results in drastic low-frequency attenuation. Low-Z microphones are designed to operate through low-Z inputs. However, they will usually operate in high-Z inputs when the sound system has sufficient gain, and the microphone output level is large. This technique, incidentally, is often used to control input overload since a voltage drop of approximately 20 dB usually results when a low-Z microphone is moved from the mixer's low-Z input to its high-Z input.

Connecting the Microphone to the Mixer Input.

Hi-Z Cable. High impedance microphone cables are single conductor shielded, as shown in Figure 20. The output of a dynamic microphone voice coil is carried by the inner conductor and the shield, which acts as ground to prevent hum. High impedance mixer inputs have two connections, with the shield going to the mixer's ground. Because one of the microphone voice-coil leads is connected to ground in such hook ups, the inputs are called unbalanced.

Lo-Z Cable and Inputs. Low impedance microphone cables have two inner conductors and a shield, as shown in Figure 21. In such low impedance cables, the voice coil signal is carried on the two inner conductors, while the shield acts only as a hum and noise protector. This configuration is termed balanced line since neither voice coil wire is connected to ground. The balanced line arrangement provides hum and noise protection superior to the unbalanced lines used with high-impedance microphones. Low impedance microphone mixer inputs generally have three connections, with the shield going to ground.

Occasionally, mixer inputs for low-impedance microphones will have two connections like typical high-impedance inputs. Such low-impedance inputs are unbalanced similar to their high-impedance counterparts. In order to use an unbalanced input with a standard low-impedance microphone cable,