THE PA BIBLE

ADDITION NUMBER NINETEEN
CONDENSER MICROPHONES

Introduction

In prior additions of the PA Bible, we have covered microphone types (addition number three), microphone techniques (addition number eight) and barrier miking (addition number fifteen). This addition is an expansion of Addition Number Three's discussion of condenser microphone types; what the major differences are, why they are important and when each type would be used.

The Principle of Condenser microphones: Changing Capacitance and Biasing

All condensers work by converting a changing capacitance to a changing electrical signal. A condenser microphone consists of two parallel plates, the diaphragm and the backplate. A polarizing voltage is applied to the plates; which gives a fixed static charge between them. When the diaphragm vibrates in response to sound, the distance between it and the backplate changes. This movement produces a change in the capacitance and therefore the voltage. This changing voltage is the audio signal.

The differences in the types of condenser microphones are in how the charge is developed between the plates. Condenser microphones, in general, exhibit very desirable performance characteristics over other types of microphones. Because the diaphragm has very little weight, it can respond to transients (rapidly changing sound) quickly, giving it excellent high-frequency response.

What is Biasing?

Biasing is the application of voltage to the diaphragm and backplate. It is how this biasing voltage is produced that distinguishes the four major types of condenser microphones. In each case, the changing capacitance is too weak to produce a usable output, so additional gain stages will follow this conversion process.

The Four Types

- diaphragm electret
- back electret
- voltage-biased (true condenser)
- rf biased

How the Different Types of Condensers are Biased: Electret Designs — Two Types

The required bias voltage for electret designs comes from a long-term electrically charged stable film of plastic placed between the conductive diaphragm layer and the conductive backplate. When this plastic is laminated to make the diaphragm, it is referred to as a diaphragm electret. (see Figure 1) When it is laminated to the surface of the backplate it is referred to as a back electret. (see Figure 2)

Although electret designs offer significant size, sensitivity, and cost advantages, there are some compromises. The diaphragm design increases the thickness and mass of the diaphragm which may compromise the high-frequency response of the transducer. The back-electret compromise is a little more complicated, because the design engineer must strike a balance between the best acoustic porting and the optimum electret-biasing charge. The condenser microphone backplate requires acoustic ports in the form of small holes. In the case of back electrets, the size and number of these holes is limited because the bias field is generated from the flat area between these holes. As the number and/or size of these acoustic ports (holes) increase, the areas biased by the electret decreases. Thus, neither the acoustic performance nor the bias voltage (which stabilizes the sensitivity and signal-to noise) can be at their optimum.

In addition to the biasing-charge compromise, all electret designs also include a wider space between the diaphragm and the back plate to make room for the electret material. Increased space lowers the capacitance, which in turn increases the noise floor of the transducer and reduces the efficiency of the basic conversion of sound energy into varying capacitance.

The charge level also varies across the electret surface and can decrease with time or events such as p-pops and wind noise. These events drive the diaphragm into the back plate, significantly reducing electret field strength. Situations that expose the electret material to unusually high temperatures (such as leaving the microphone in the trunk of a car parked in the sun) can also permanently impact the strength of the electret field strength.

Even with these disadvantages, high-quality acoustical performance, nearly that of a true condenser, is achievable with well-designed electret microphones. Electrets often offer high sensitivity in a small package, wide frequency response and inexpensive electronics circuitry. For all but the most demanding applications, electret-condenser microphones offer performance that is quite adequate.

Figure 1: Diaphragm-Electret Condenser Generating Element

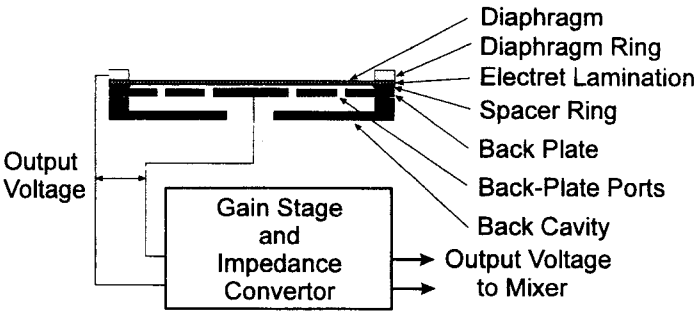
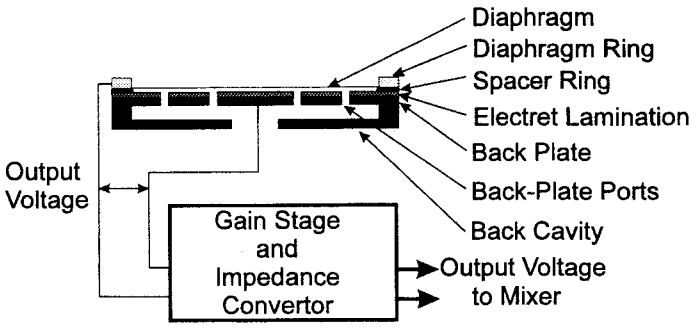


Figure 2: Back-Electret Condenser Generating Element

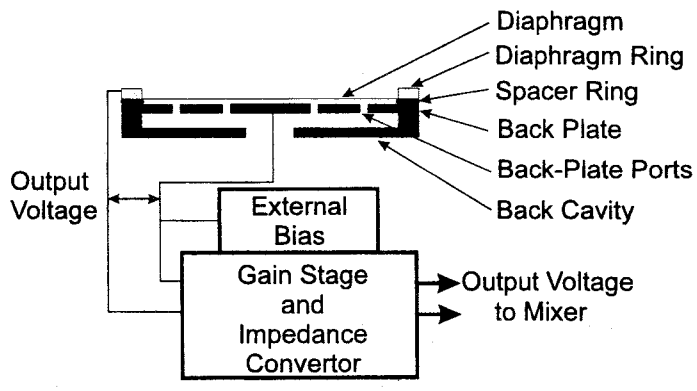


Voltage Biased

The voltage-biased condenser microphone is also referred to as true condenser, in recognition of their design being the basis for the condenser microphone's excellent reputation. This method was first employed before the introduction of stable electret materials in the early 1960's. Voltage-biased condensers develop their charge from external electronic circuits, either by battery, dc/dc converter or directly from the console's 48-volt phantom supply. The true-condenser microphone typically offers better stability, sensitivity and performance characteristics over the "more-modern" electret design.

First, the sensitivity is directly related to the uniformity and stability of the polarization voltage between the diaphragm and the back plate. Unlike the electret design, the polarization voltage for the true-condenser design is developed by an external circuit and is uniform across the transducer's entire back-plate surface. Since the entire surface of the back plate is active in converting sound pressure into electrical energy, sensitivity of each microphone and even between microphones is very consistent. Second, the back plate can then be optimally designed for acoustic performance without concern for electret requirements. Without additional laminating materials occupying the air gap the plates of the true-condenser element can be placed closer, increasing the total capacitance. This ultimately lowers the self-noise generated by the microphone and reduces the problem areas that generate stray capacitance that, in turn, reduces the output of the transducer.

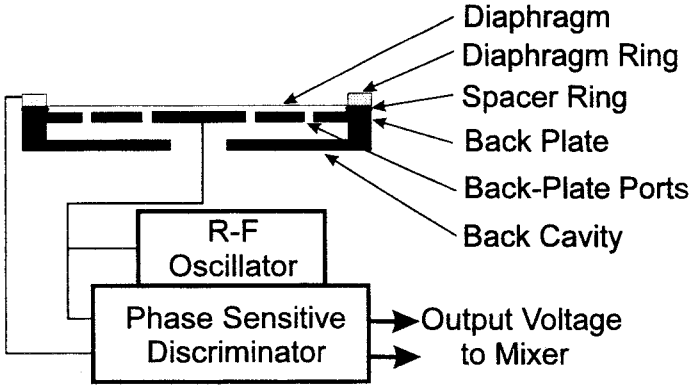
Figure 3: Voltage-Biased True-Condenser Generating Element



rf Biased

The rf-biased condensers have the advantage of no electrostatic attraction between the diaphragm and the back plate. This means that the tension on the diaphragm can be adjusted to increase that microphone's sensitivity and extend the low-end roll-off frequency of the transducer. Long-term stability, however, can often be a problem because the transducer is actually a part of the rf circuit; so anything that could detune the circuit, such as dropping the microphone or temperature extremes, will effect the stability, sensitivity and linearity (which will increase distortion levels) of the microphone. Aging or mechanical changes in the rf-biasing components can also effect performance. rf designs are very expensive to manufacture, but can offer good sensitivity and low self-noise.

Figure 4: rf-Biased Condenser Generating Element



Condenser Microphone and the Environment

Condenser microphones can be sensitive to temperature and humidity changes. Reasons for this can include (1) temperature changes effecting the diaphragm tension, and thus the tuning or sound of the element (2) humidity changes causing condensation between the plates (the diaphragm and the back plate). This condensation can cause arcing between the plates, producing audible snaps and crackles.

High humidity can significantly impact voltage biased and electret condensers. In the case of voltage-biased condensers, the effects last as long as the transducer's insulators are moist.

Operation of a voltage-biased condenser in this moist state can produce exceptionally high noise, low-end roll-off and significant changes in the frequency response. These effects totally cease once the transducer is dry.

Exposure of an electret to high humidity, whether in operation or not, can result in a permanent bias-field loss. The higher the required field and the easier the entry of moisture, the greater the likelihood of permanent loss.

Operating electrets are somewhat less likely to produce extreme noise than voltage-biased transducers when operated moist. The biasing supply of the voltage-biased condenser can support conduction across insulators. The electret layer, being an insulator, effectively stops this conduction.

Moisture can effect the tuning somewhat and the frequency response of rf mics even more, but it won't make them noisy or severely roll-off the bass response.

Conclusion

The first condenser microphones were true condensers and because of their size, cost and fragility were used mostly in recording and broadcast studios. Electret transducers gave up some performance, but the reduced expense and size of the biasing circuitry provided some advantages. The performance advantages of the true condenser microphones have always made them the choice of recording studios. With the evolution of surface-mount technology, circuits have become smaller in size, less expensive, and more rugged. Electro-Voice engineers have adopted this advance in electronics making true condensers suitable for other applications. This has given the RE series of condenser microphones an exceptional marriage of performance and durability.

The PA Bible has been prepared to help you understand audio principles and solve difficult applications. Electro-Voice intends to expand on the PA Bible in future additions, covering other topics of interest to our customers. Let us know if you have any specific subjects you would like us to tackle. If you are reading a friend's copy of the "Bible" and would like to get your very own

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