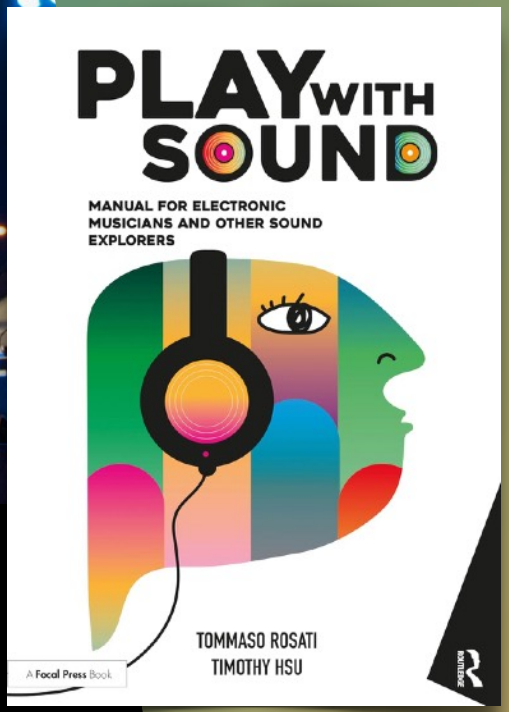
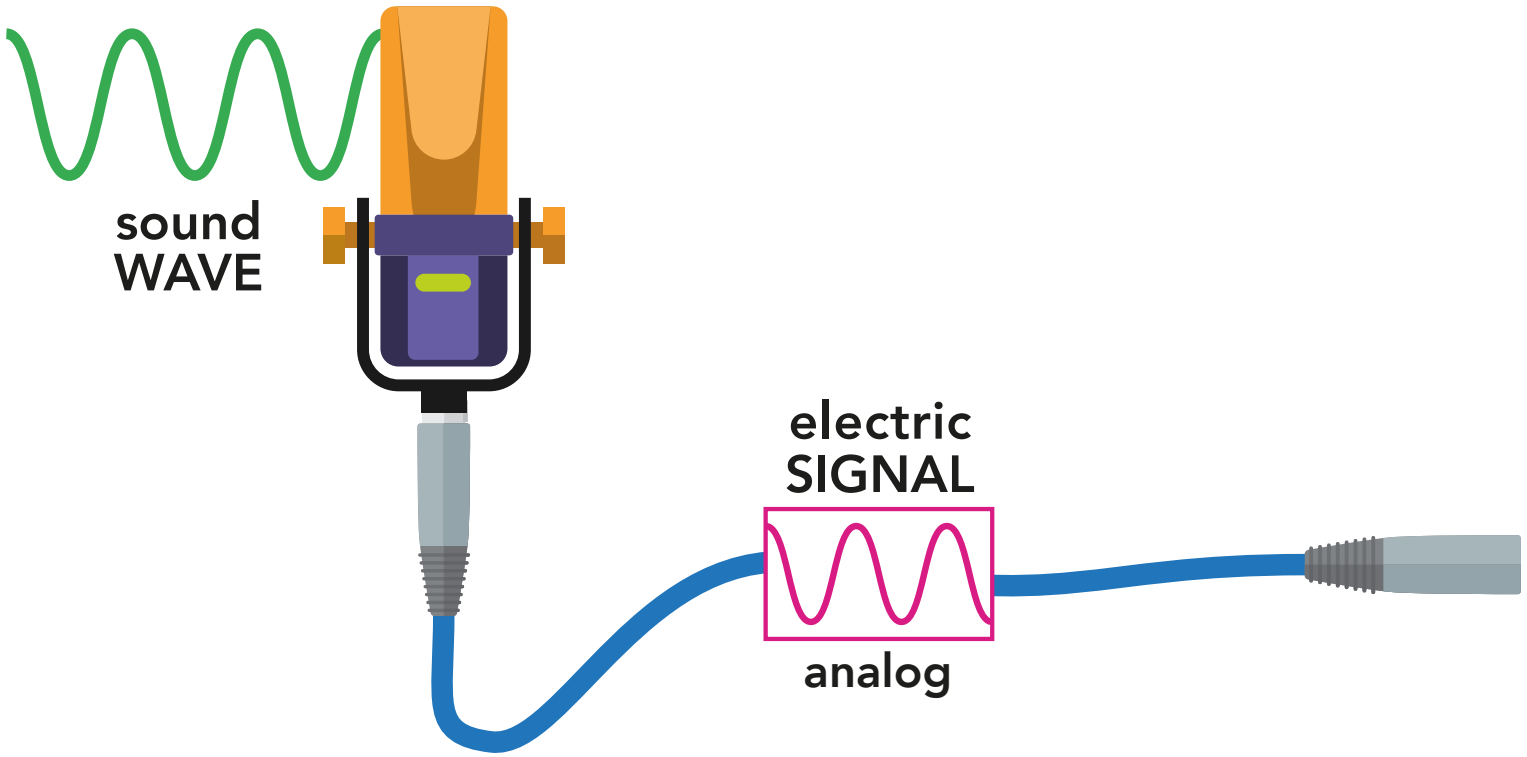
THE BOOK IS NOW AVAILABLE!



MICROPHONES AND PICKUP

Microphones

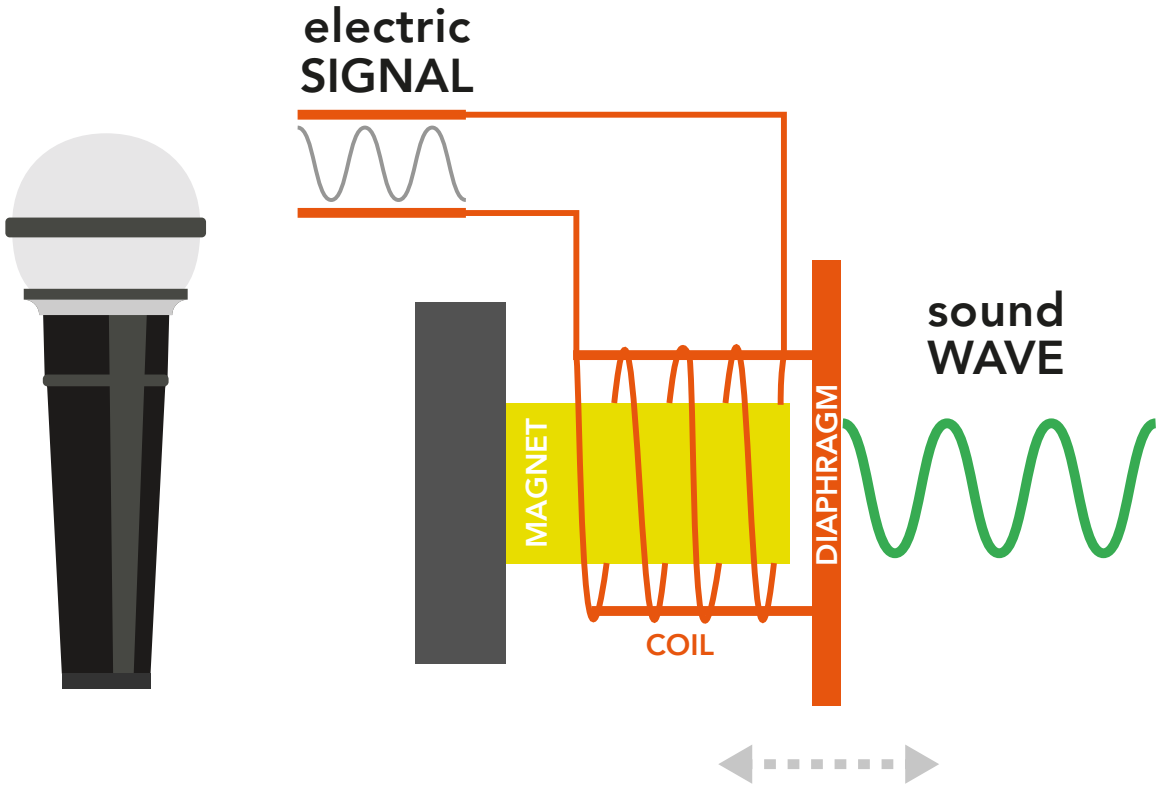


A microphone is a **transducer**, transforming an acoustical sound wave that propagates in the elastic medium (air or water) into an analogous electrical signal.

Operation: Dynamic microphones consist of a diaphragm that is rigidly connected to a moving coil that surrounds a fixed magnet. Faraday's law* is the electromagnetic concept that states that when a coil moves around a magnet, the magnetic field changes, thereby inducing a voltage change.

Dynamic

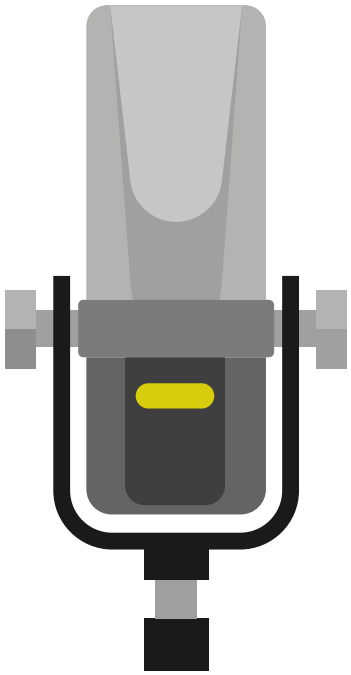
microphones are popular in live concert situations because it is more "selective" in capturing sounds and consequently less subject to the Larsen effect.

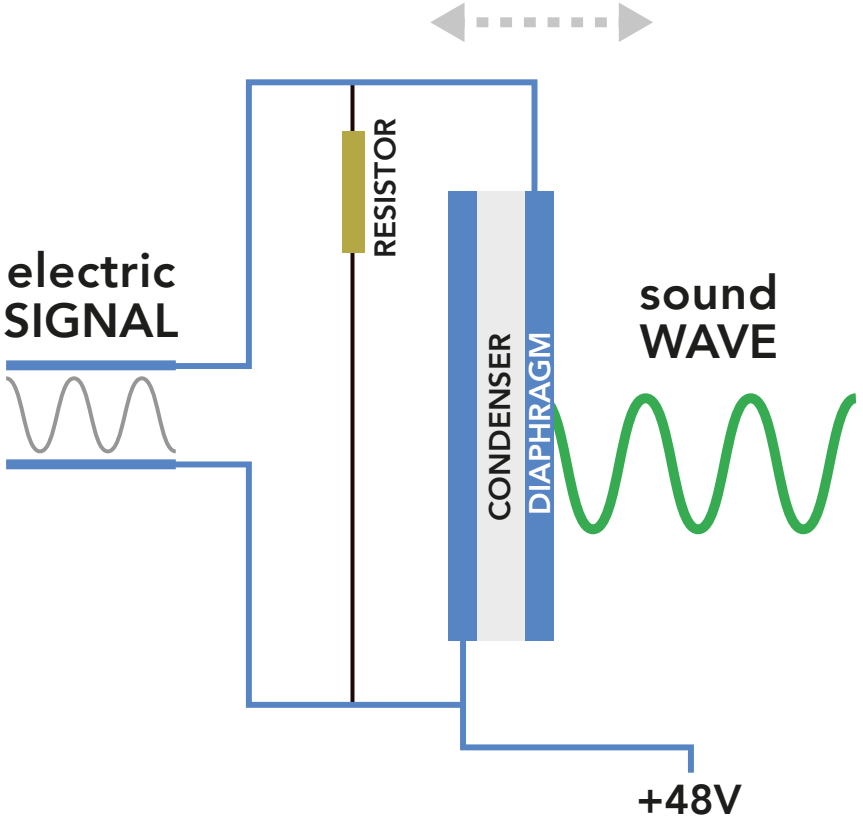


Operation: A condenser microphone functions as a capacitor, with the diaphragm and back plate forming the two charged plates. As the diaphragm vibrates proportionally to the sound wave hitting it, the electric field, and thus the electric voltage, also varies accordingly. The output voltage is then usually sent to a preamplifier and then to a mixer or a DAW, where it is recorded.

Condenser

microphones are the most popular microphone in recording studios due to the high quality, sensitivity, and versatility. They need the **phantom power (+48V)**



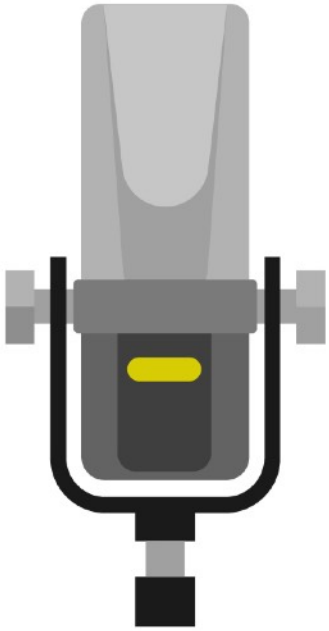


Microphones

Diaphragm size

Small diaphragm
Condenser
< = 1 inch (2.5 cm)

Large diaphragm
Condenser
> 1 inch (2.5 cm)



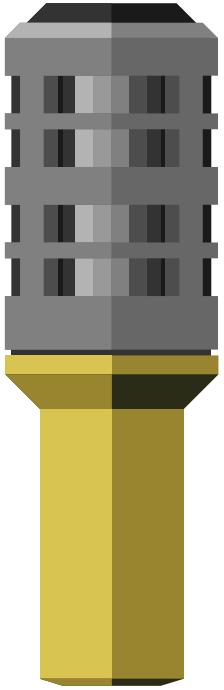
Microphones

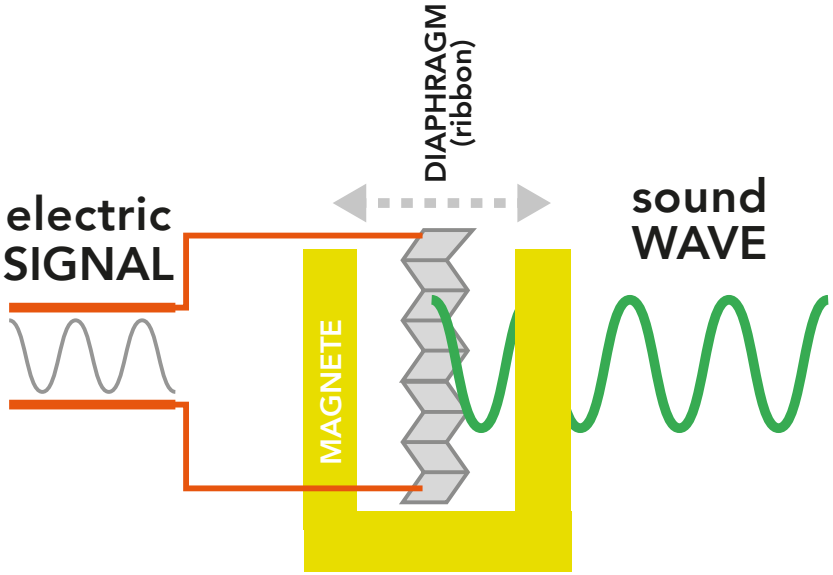
Diaphragm size

	Small diaphragm Condenser	Large diaphragm Condenser
Self noise	Higher ↑	Lower ↓
Sensitivity	Low ↓	High ↑
SPL handling capability	High ↑	Lower ↓
Frequency range	Wide ↑	Narrower ↓
Influence on the soundfield	Small ↓	Large ↑
Dynamic range	Higher ↑	Lower ↓

Operation: Ribbon microphones use Faraday's law with a corrugated metal ribbon as the diaphragm instead of a coil. This ribbon-diaphragm vibrates analogously to the sound wave that strikes it, while the magnet remains stationary. The voltage is output at the ends of the metal ribbon and can be recorded into a DAW as our analog audio signal.

Ribbon microphones are electromagnetic microphones known to be very precise and accurate, while being fragile to mechanical shock.

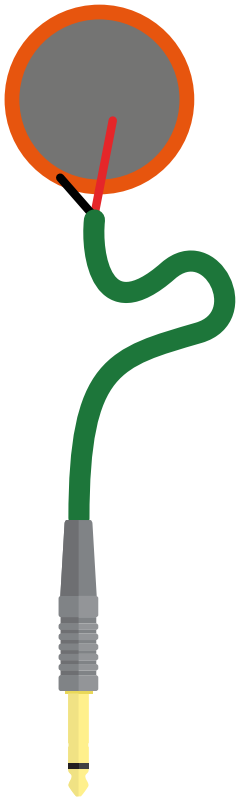




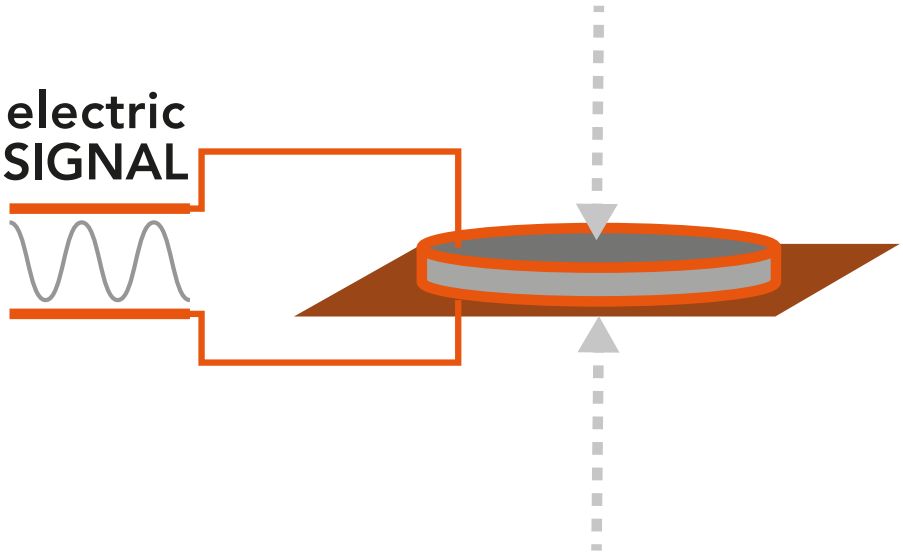
Special microphones

Contact piezo microphones

generally physically attach to the vibrating body of an instrument, directly transforming mechanical vibrations into an electrical signal.



Operation: Piezo microphones utilize piezoelectric crystals, special crystals that generate an electric charge when pressure is applied to it, causing a deformation. In this case, the mechanical vibration of an instrument body creates a mechanical compression onto the piezoelectric crystal, resulting in a changing voltage that is the analog audio signal.

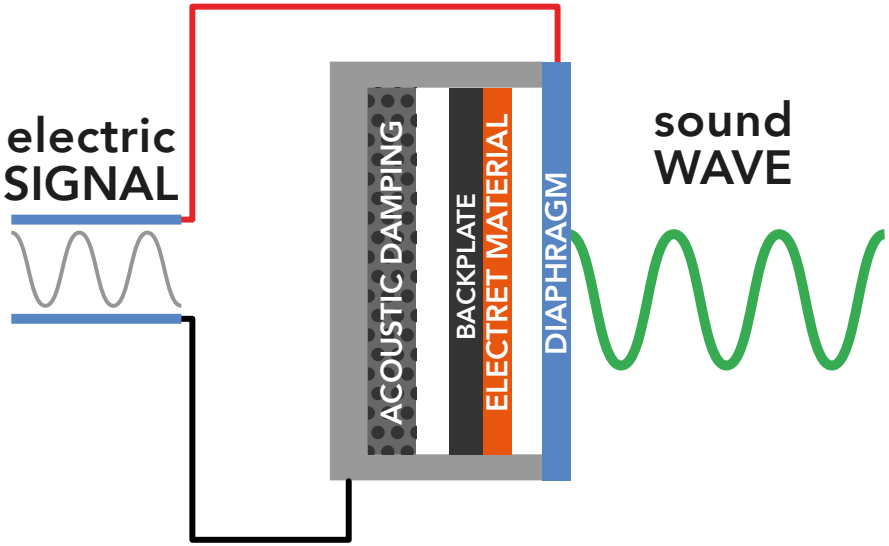


Special microphones

Operation: uses a back plate with a permanently charged electret material, eliminating the need for +48V to create the electric field. However, other internal components like a preamplifier or transmitter may still require external power.

Electret

microphones are a subset of condenser microphones that do not require phantom power. Instead, the electric field is created with a permanently charged back plate.

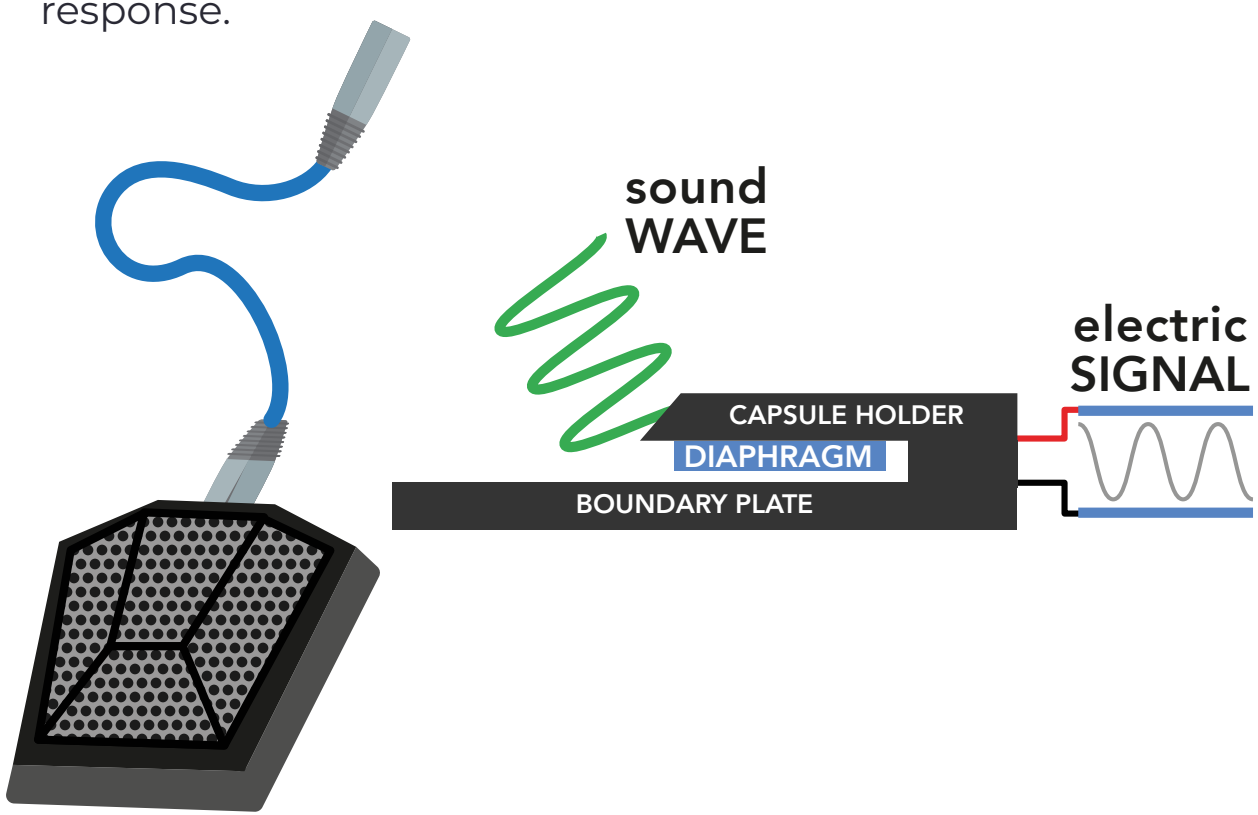


Special microphones

Operation: A small microphone, often piezo or condenser, is mounted close to a surface and captures air pressure variations at the boundary. This placement boosts amplitude due to the pressure maxima at the boundary. A larger surface improves bass frequency response.

Boundary layer microphones (or pressure zone microphones, PZM)

are a type of microphone that sits in very close proximity to a large flat surface. These microphones are used on stages, on walls, and along other flat surfaces such as piano lids.

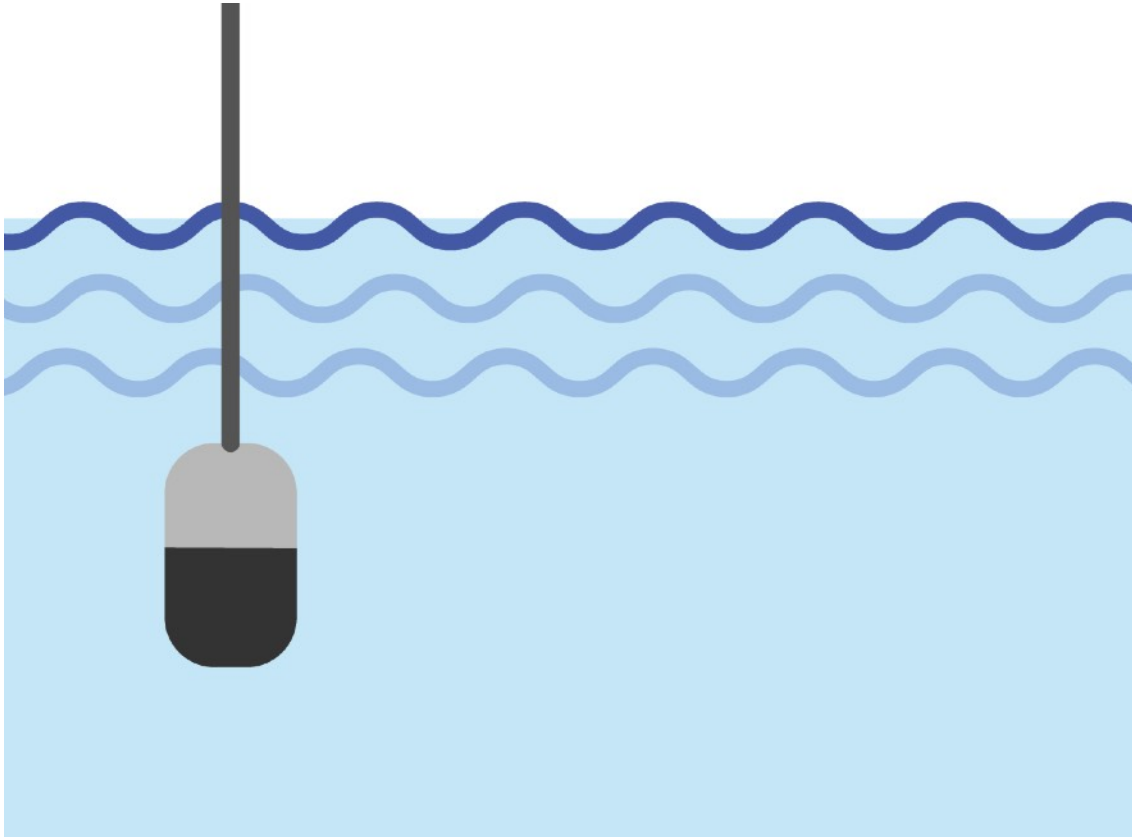


Special microphones

Hydrophones

are used to pick up sound underwater and are often used for scientific research and musical or sound design effects.

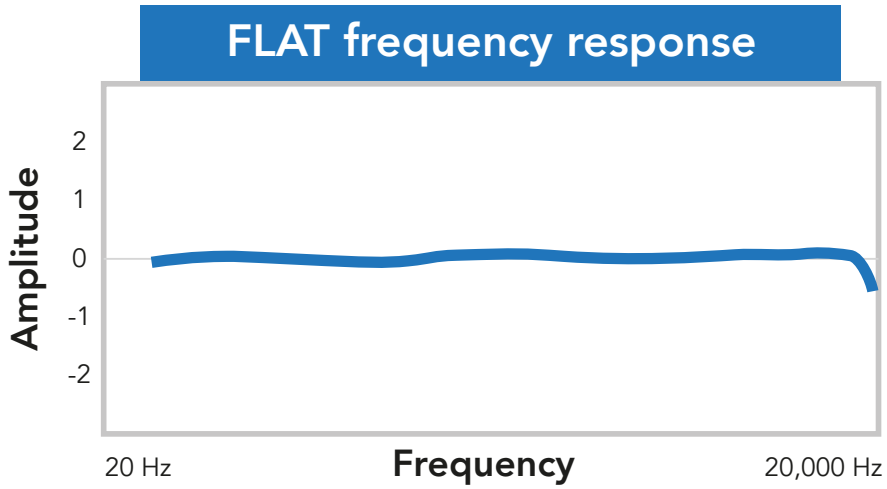
Operation: Hydrophones can be dynamic or condenser microphones. The only difference with these hydrophones, from the traditional varieties described above, is that they have a protective waterproof capsule.

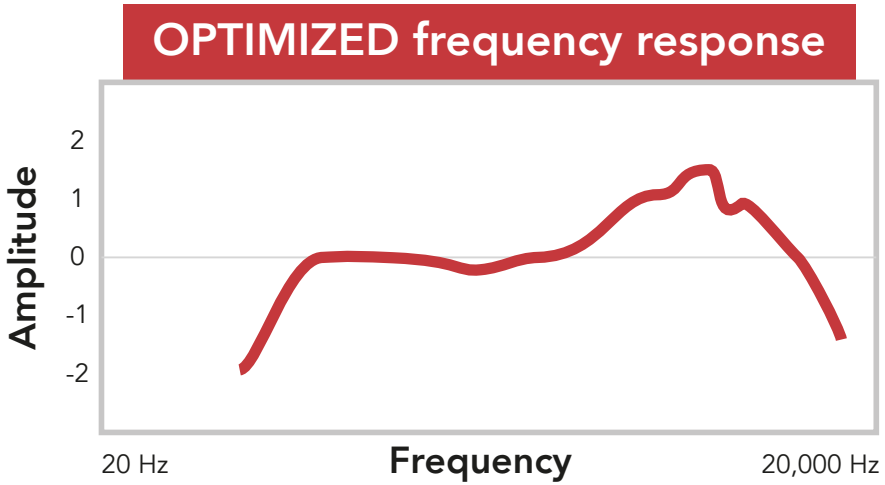


Microphones

Frequency response

The **frequency response** of a microphone is defined as its sensitivity to different frequencies. The frequency response is a curve that represents the frequency on the graph's X-axis and the corresponding amplitude, usually in dB, on the Y-axis.

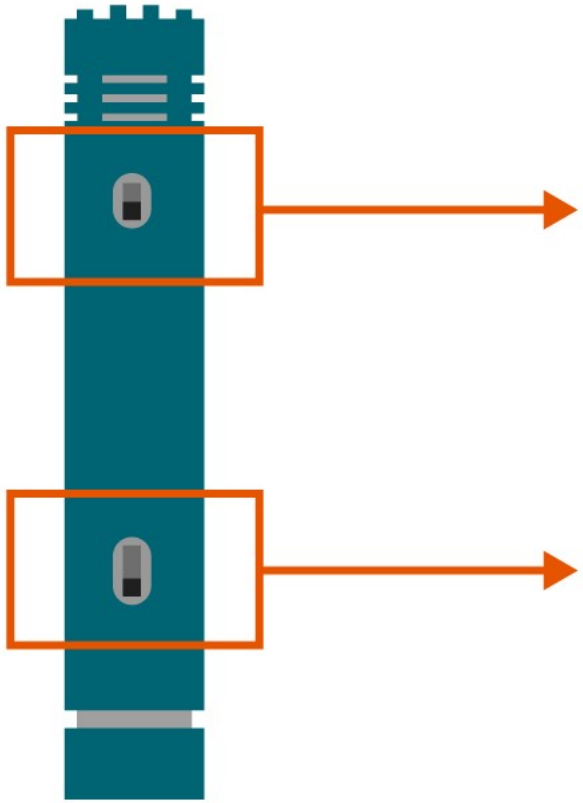


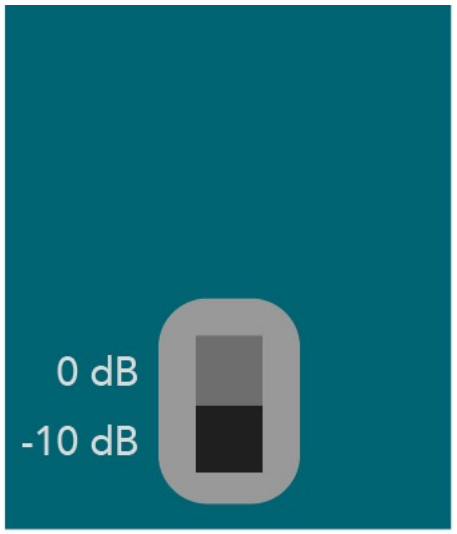


Microphones
Adjustments

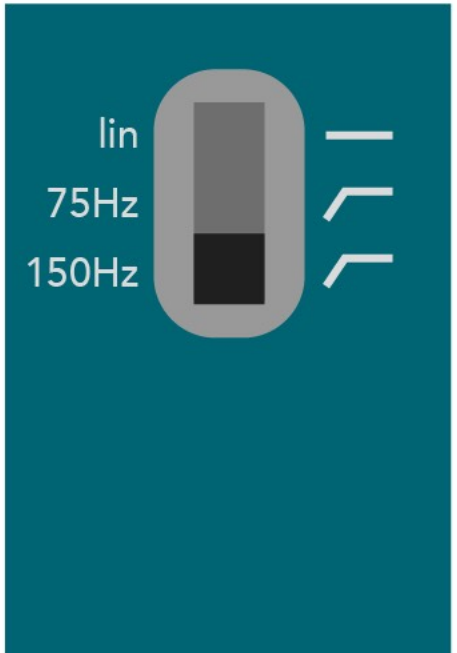
PAD
A Passive Attenuation Device (PAD) can be used on a microphone when the incoming sound wave is excessively loud and needs to be attenuated to prevent overloading the microphone and causing distortion.

LOW-CUT filter
This filter can attenuate low frequencies by activating a high-pass filter. Some microphones offer multiple cutoff options. Low-cut filters are used to reduce wind noise, building vibrations, and plosive sounds in vocal recordings.





PAD

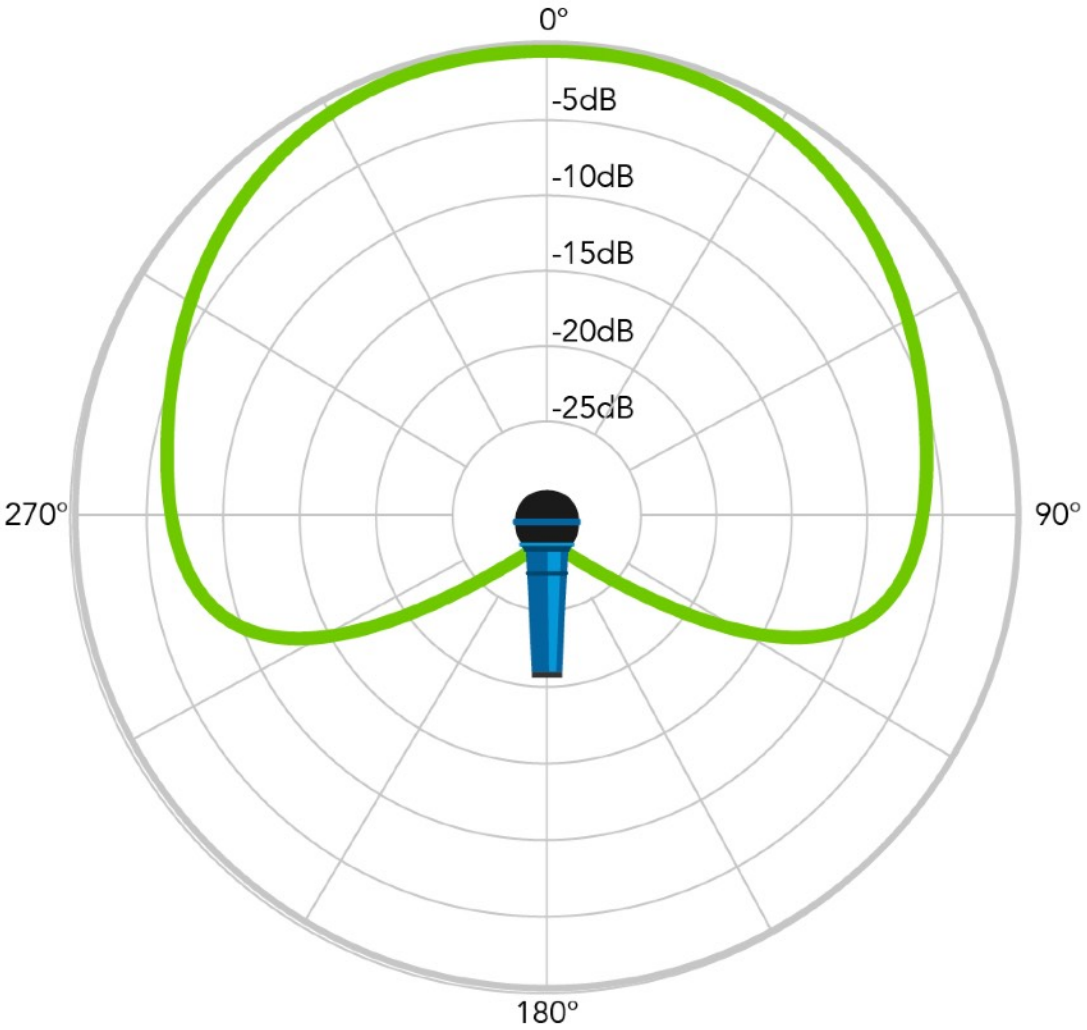


FILTER

Microphones

Polar pattern

Each microphone has preferred pick-up angles based on directionally characteristics of the microphones. We show the microphone's directionality with its **polar pattern** or describe it with its polar characteristic.

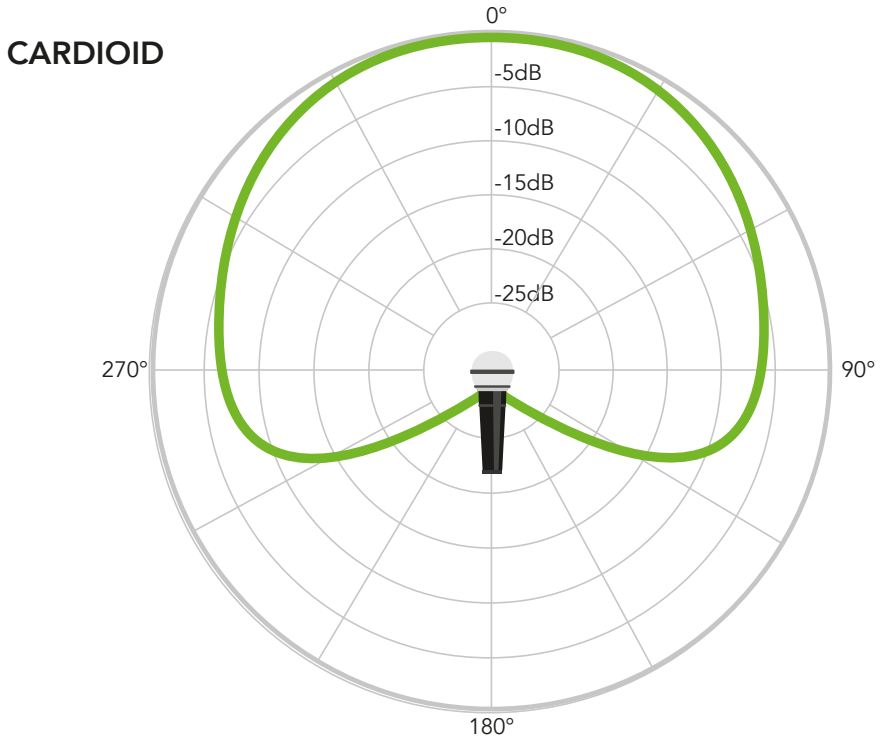


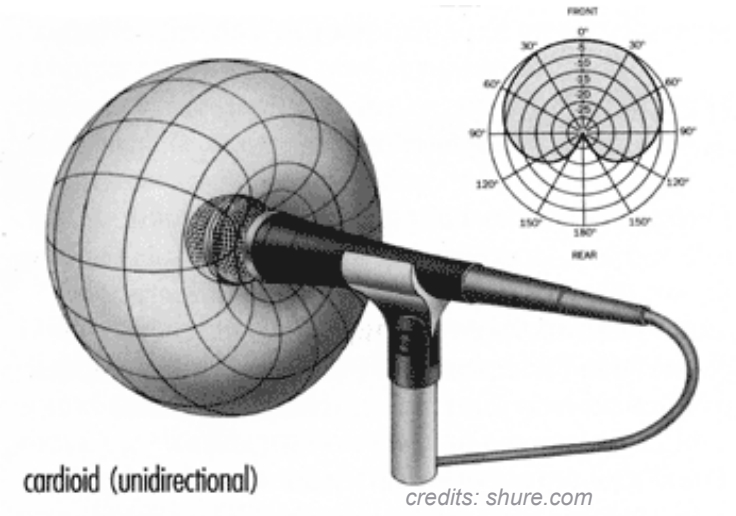
Microphones

Polar pattern

Cardioid

It has the highest sensitivity directly on-axis in front of the capsule (0°) and the lowest sensitivity at 180°, behind the capsule. Theoretically, there is a null point at 180°, meaning that there is infinite attenuation for sounds coming from behind the microphone.

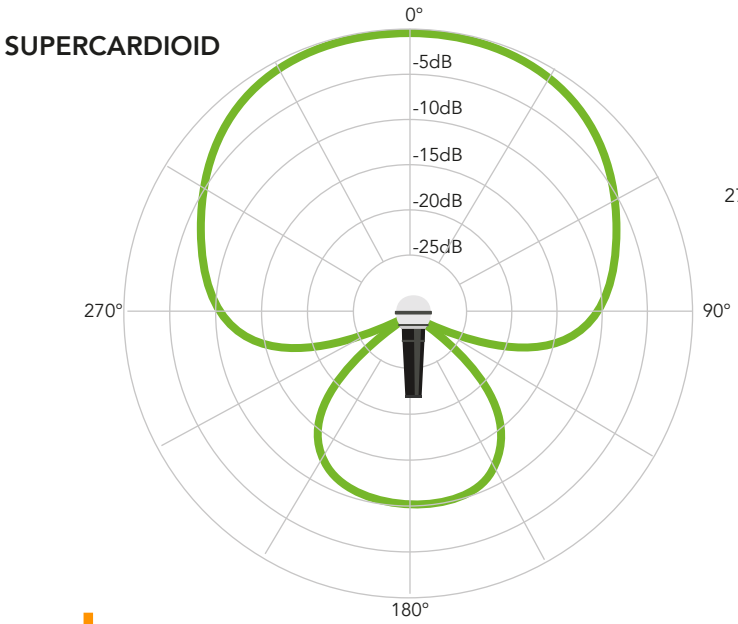


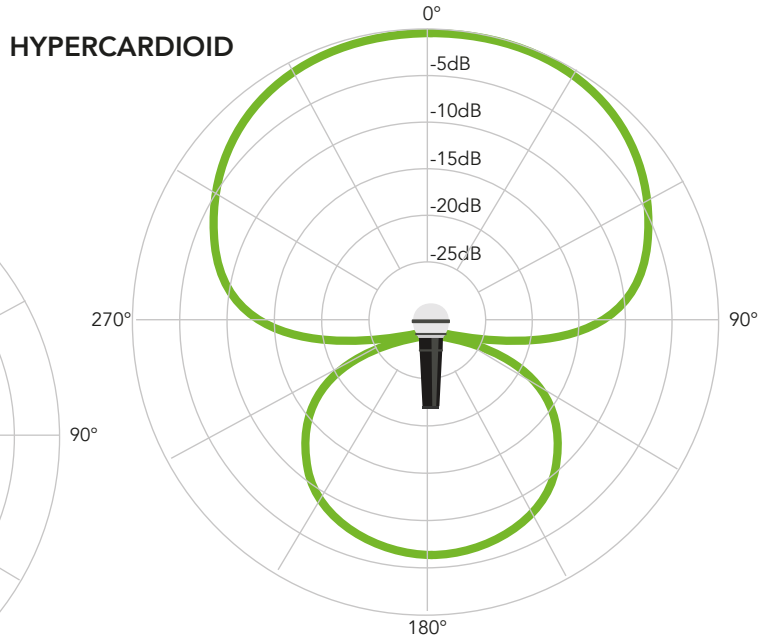


credits: shure.com

Microphones

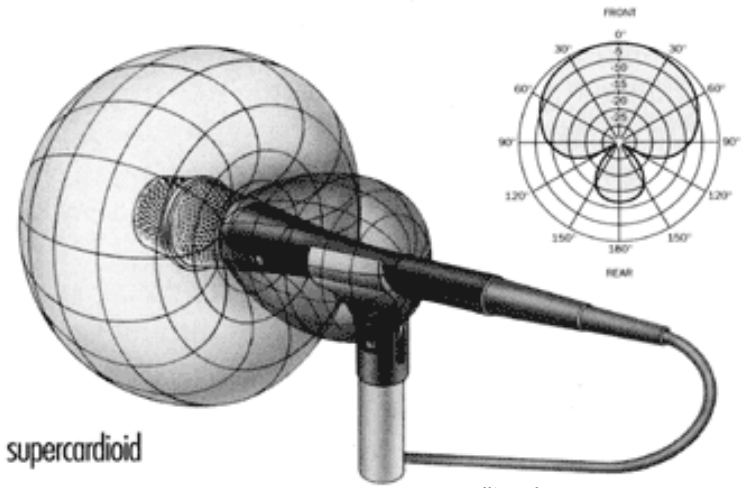
Polar pattern





Supercardioid and Hypercardioid

microphones exhibit similar patterns that exhibit a narrower on-axis pick-up angle, when compared to cardioids, and have two null points slightly displaced from 180°. At 180°, the microphone's sensitivity is less than the on-axis response, but it is not completely null as with cardioid microphones.

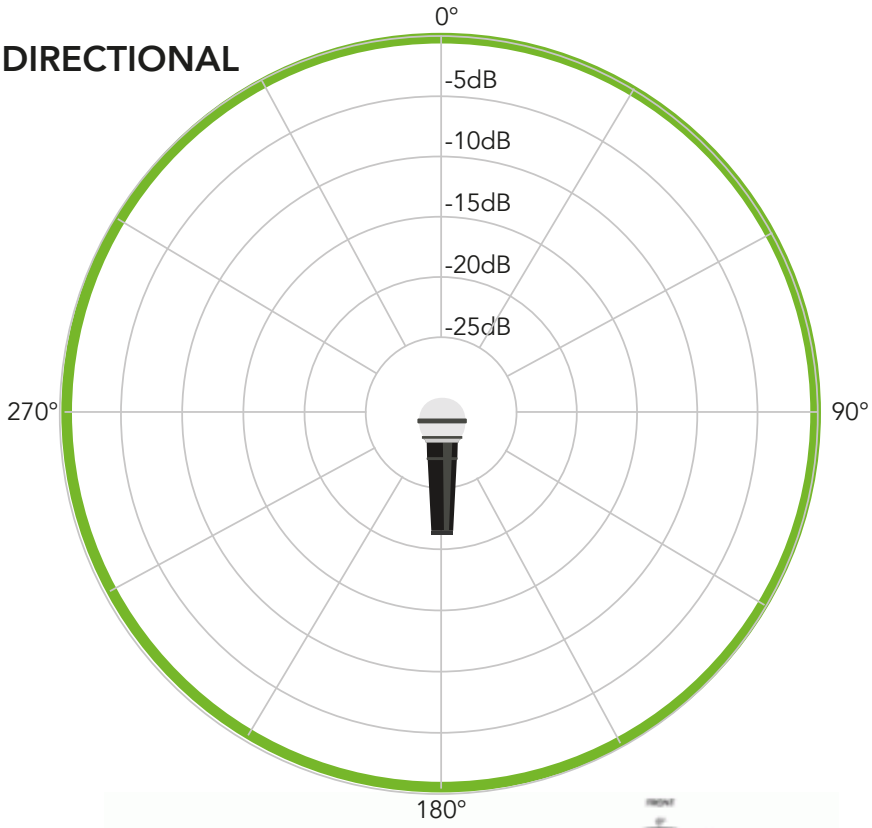


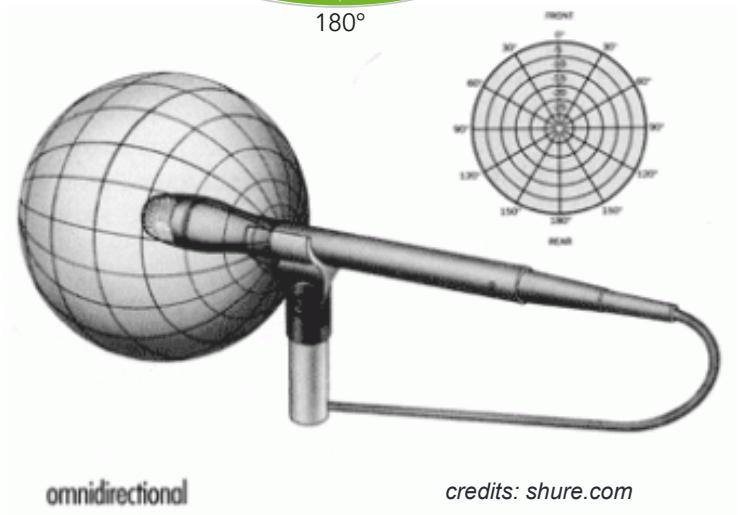
credits: shure.com

Microphones
Polar pattern

Omnidirectional

The microphone has uniform sensitivity for sounds coming from all directions.



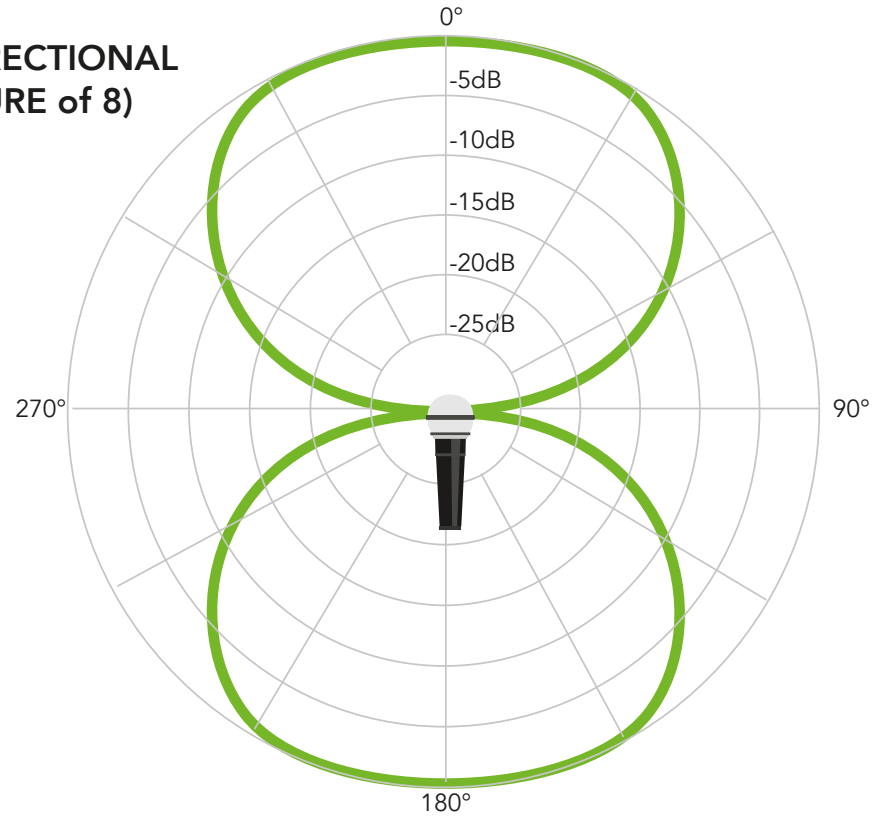


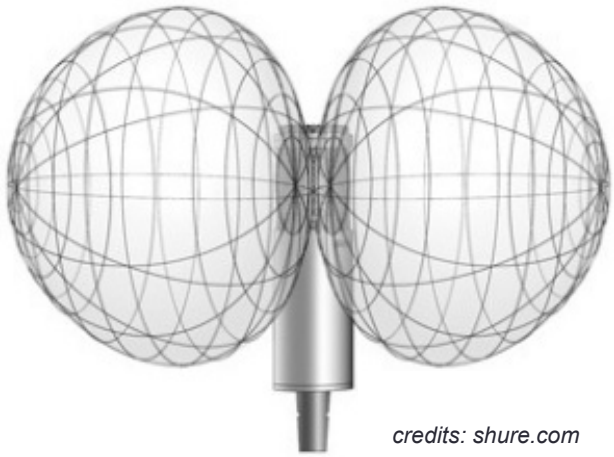
credits: shure.com

Microphones
Polar pattern

Bidirectional (Figure of 8)

This polar pattern indicates that the microphone receives sound equally from the front and the back. The exciting feature of these microphones is that the two main lobes, or pick-up angles, are quite narrow, making the microphones very selective.

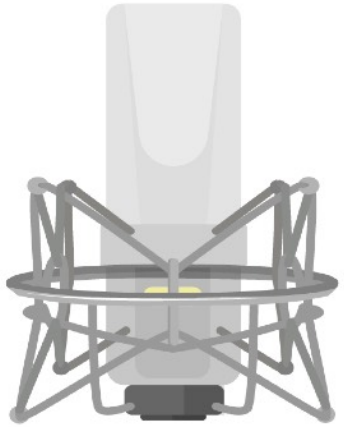




credits: shure.com

Microphones

Accessories



Shockmount

Shockmounts are a system of elastic bands that suspends the microphone in the air that isolate the microphone from these vibrations. The shockmount absorbs the vibrations before they reach the microphone. It is intended to isolate the mechanical vibrations coming from the stand and the ground from the microphone itself.

credits: AI generated

Microphones

Accessories

Pop filter

These are physical mesh screens that are used in vocal recordings, especially in the studio, to reduce or eliminate artifacts caused plosive sounds.

credits: AI generated

Microphones
Accessories

Windscreen

A spongy or furry casing mounted over the microphone capsule, a windscreen, as the name suggests, helps to reduce the disturbance caused by wind and sibilant consonants.

credits: Rinaldo Marti

Microphones
Accessories

Parabolic reflector

The parabolic reflector is a concave structure made of usually plastic material that is attached so that it surrounds the microphone capsule. The parabolic reflector physically collects the sounds that are funneled into it and direct it to the capsule

Microphones

Stereo microphone techniques

In order to recreate the spatial width of a single instrument or ensemble, we need at least two microphones to provide our ears the information needed to spatialize the sound.

credits: AI generated

Microphones

Stereo microphone techniques

COINCIDENT PAIR

In these techniques, two microphones are placed, theoretically, in the same location in space. Thus, both microphones receive signals at the same time and be in sync with respect to phase.

Because the microphones are in phase, we will not have phase cancellation problems due to frequencies not in phase. This characteristic is called **mono-compatibility** and is stereo recordings made with coincident pairs excel at this characteristic.

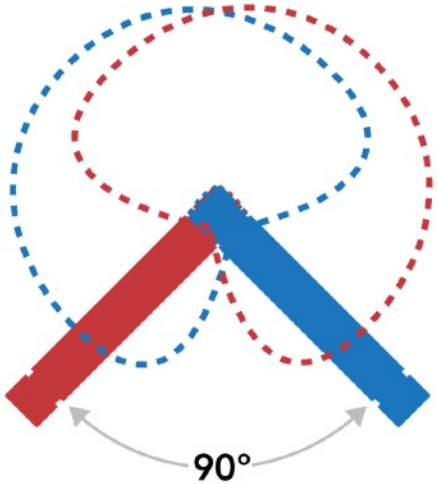
Stereo microphone techniques

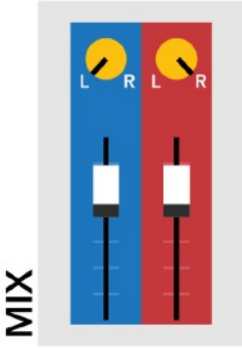
Microphones:
two cardioids, usually condenser

X/Y technique

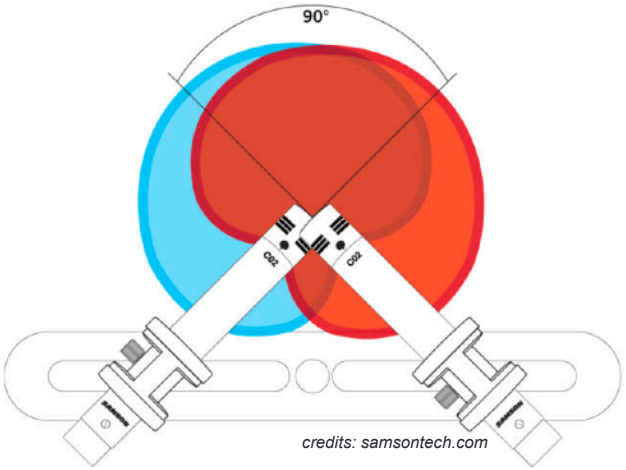
The microphones are placed with the capsules positioned in very close proximity with each other (coincident). The capsules are oriented such that the axes along their length are 90° - 135° apart, depending on the size of the sound source and the desired width of the stereo image.

Because of the proximity of the two microphones, the sound arrives at the two capsules at the same time, reducing phase-shifting problems.





X/Y technique



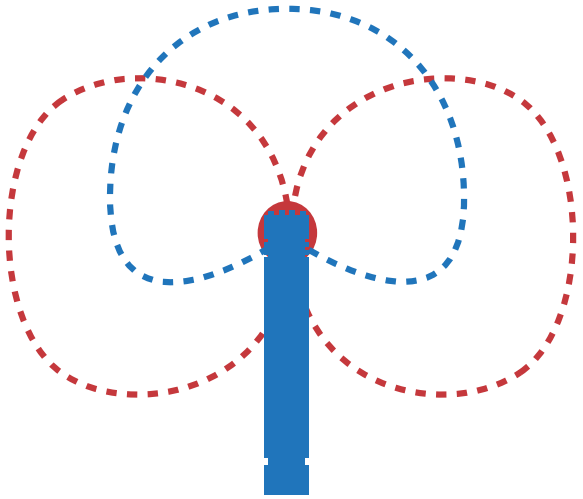
credits: samsontech.com

Stereo microphone techniques

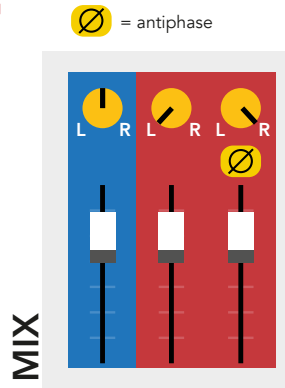
Microphones:
one cardioid and one bidirectional,
usually both condensers

Mid/Side (M/S) technique

Two microphones are placed coincidentally, with a cardioid capsule aimed at the sound source and a bidirectional capsule capturing side sounds. In mixing, the cardioid is centered, while the bidirectional signal is duplicated, polarity-inverted, and panned left and right. This allows for a variable stereo image and ensures mono compatibility, making the M/S technique useful in TV and radio.



M/S



Mid/Side (M/S) technique

credits: zoomcorp.com

Microphones

Stereo microphone techniques

NEAR-COINCIDENT PAIR

These techniques involve using two microphones placed 15-30 cm apart. This distance is approximately related to the average distance between the ears on a human head.

With this configuration, because the microphone capsules occupy different locations in space, in addition to amplitude differences, there will also be phase differences between the two signals.

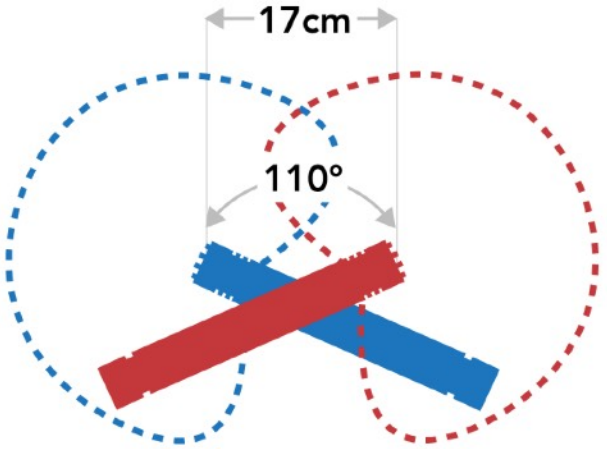
This, on the one hand, improves the width and quality of the stereo effect, but affects this technique's mono-compatibility.

Stereo microphone techniques

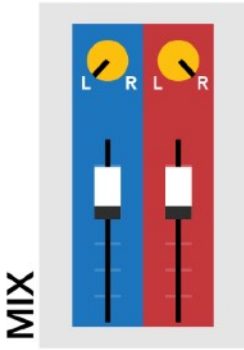
Microphones:
two cardioids, usually condenser

ORTF technique

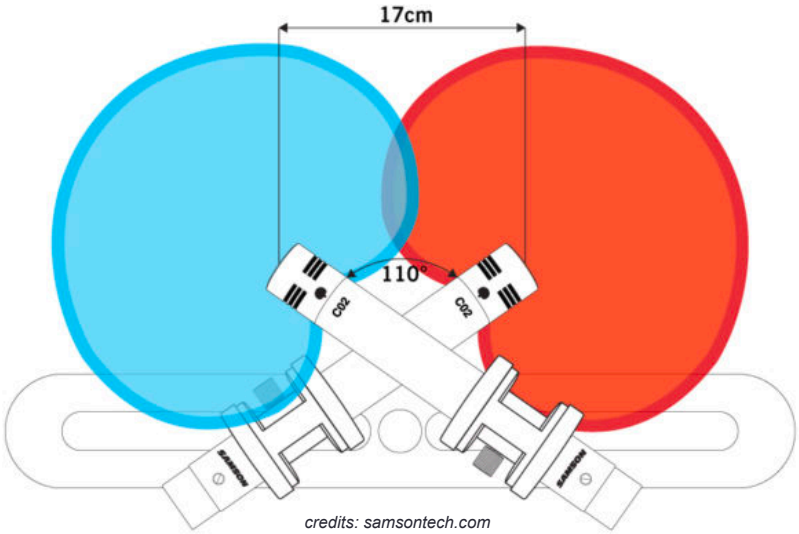
This French technique uses two cardioid microphones 17 cm apart and angled at 110°. The signals are panned left and right, creating a wide stereo field, ideal for mid to large ensemble recordings.



ORTF



ORTF technique



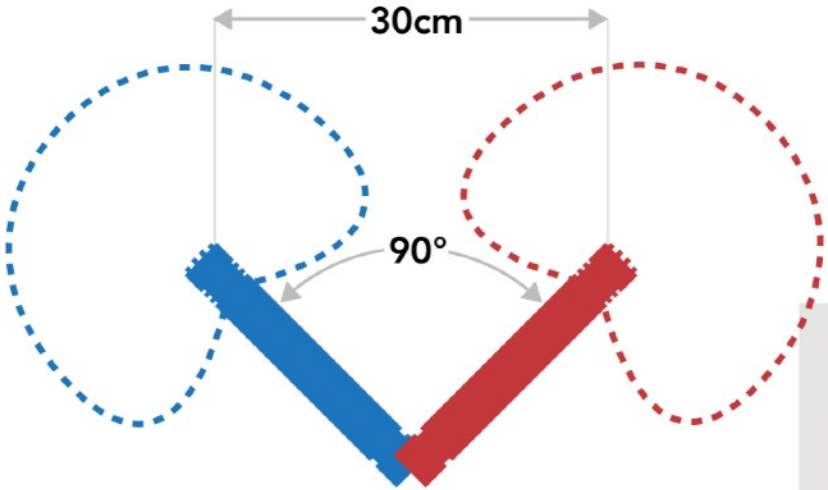
credits: samsontech.com

Stereo microphone techniques

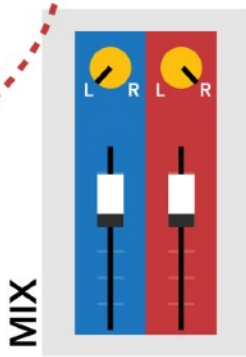
Microphones:
two cardioids, usually condenser

NOS technique

This Dutch technique uses two cardioid microphones 30 cm apart and at a 90° angle. The signals are panned left and right, creating a wide stereo field, though not as wide as ORTF. This technique is suitable for mid to large ensemble recordings.

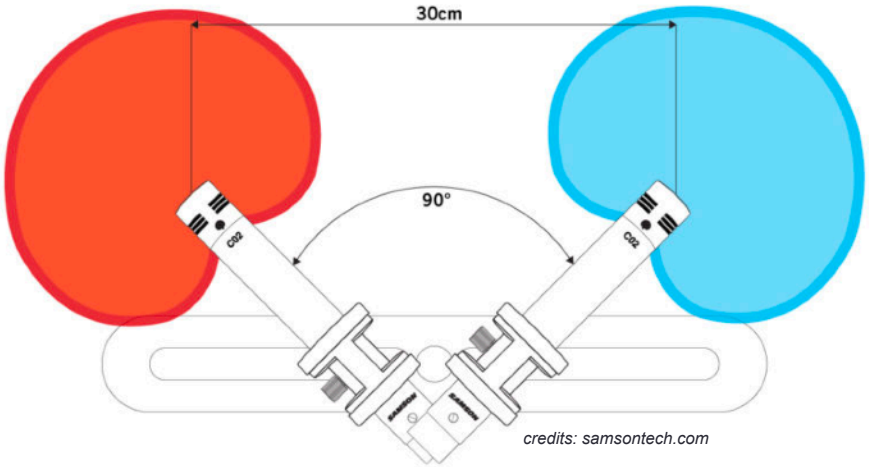


NOS



MIX

NOS technique



credits: samsontech.com

Microphones

Stereo microphone techniques

SPACED PAIR

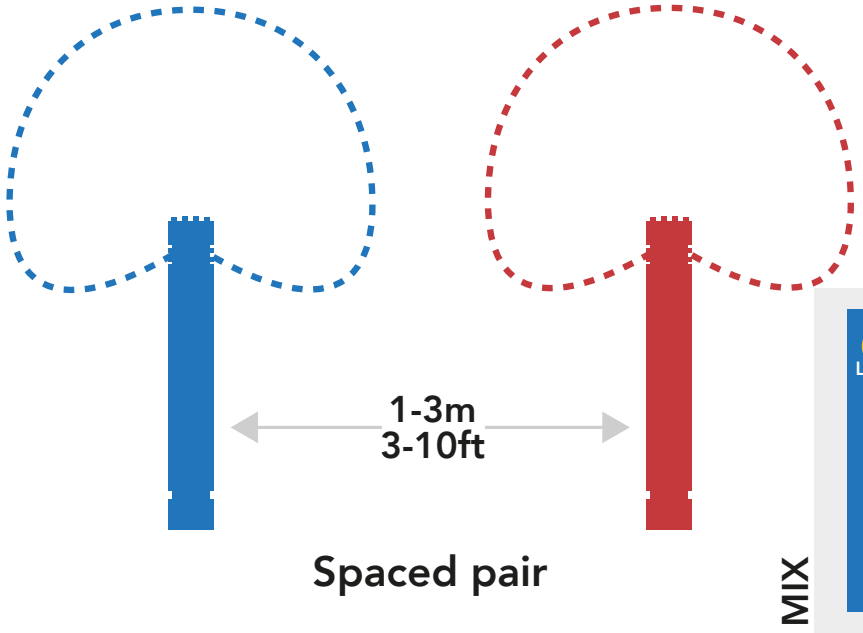
To avoid phase cancellation, the 3:1 ratio rule is applied, requiring the second microphone to be at least three times farther from the first than the distance to the sound source. For example, if I am recording a chamber music group and I place the microphones six feet away from the musicians, I have to separate the two microphones by at least 18 ft. Due to significant phase differences, these techniques are generally not mono-compatible and are used mainly in non-broadcast contexts.

Stereo microphone techniques

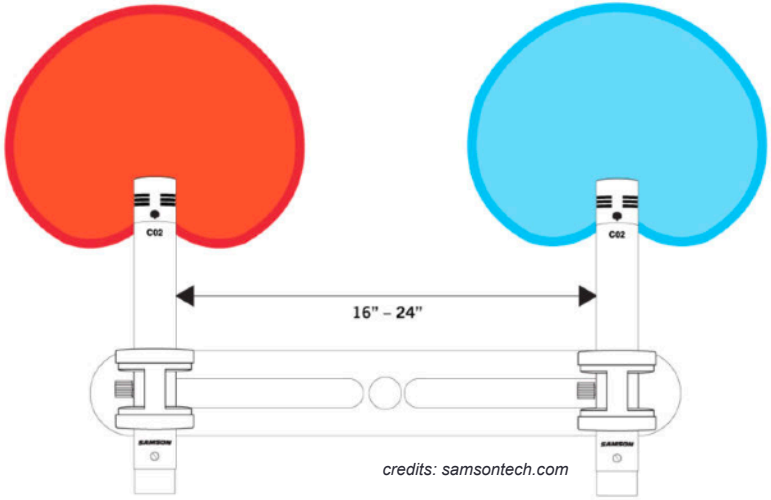
Microphones:
two cardioids, usually condenser

A/B and spaced pair technique

The distance between the microphones, in this case, can be vast. For the A/B technique, the cardioid or omnidirectional microphones are spaced 12”-48” inches apart. For the spaced pair, the two microphones are separated by a distance of at least 1-3 meters (3-10 ft) and the signals are panned hard left and hard right in the mix. In both these cases, the microphones face forward with no angle difference between the two.



A/B and spaced pair technique

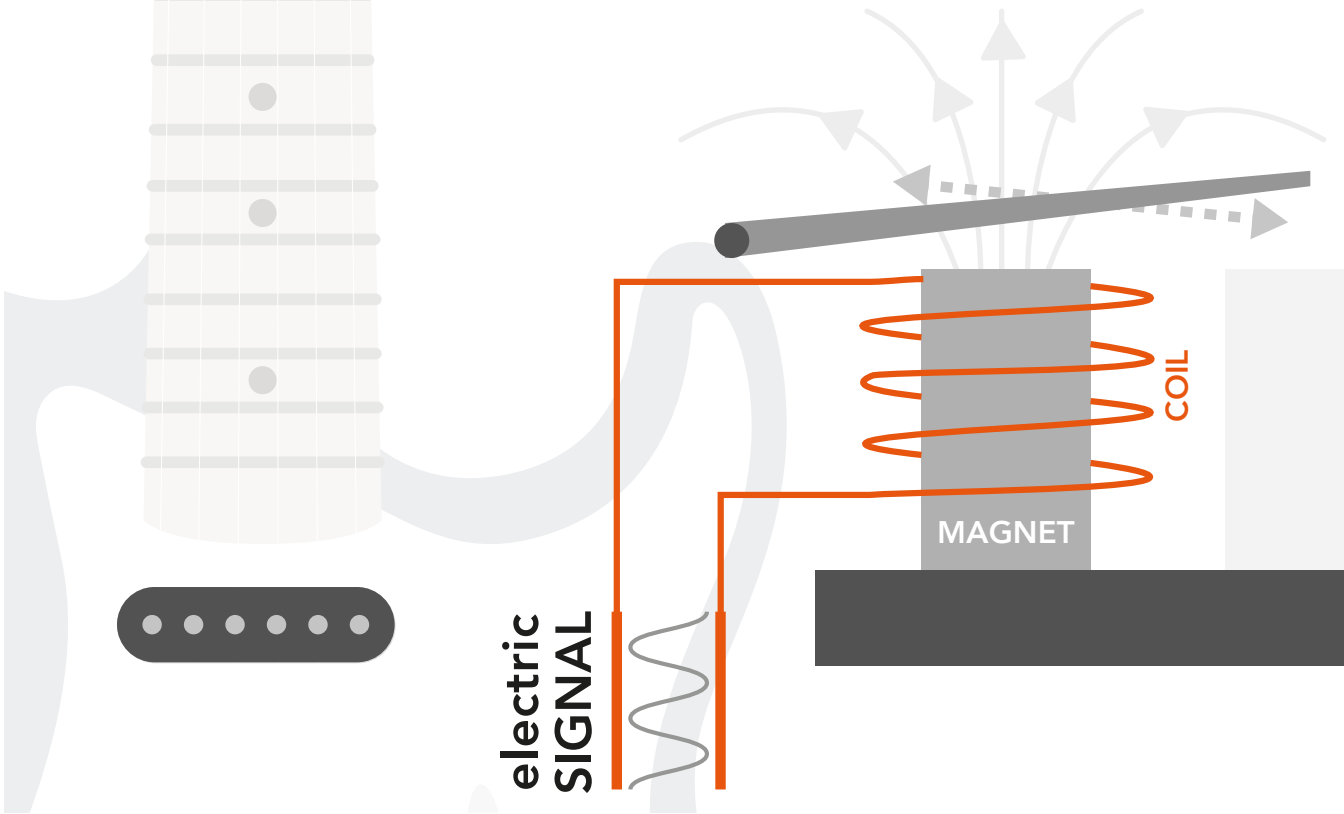


credits: samsontech.com

Magnetic pickups

Magnetic pickups convert mechanical motion into electrical energy. Used in **electric guitars, basses, and pianos**, pickups have cylindrical magnetic poles and coils of thin wire.

Operation: Taking advantage of the ***Faraday effect***, the vibration of a metal string or a tiny metal cylinder produces a change in electromagnetic field around the magnetic pole, thus creating an alternating electric current in the coils. This alternating current, derived from the motion of the strings, is the analog electric signal that the instrument produces.

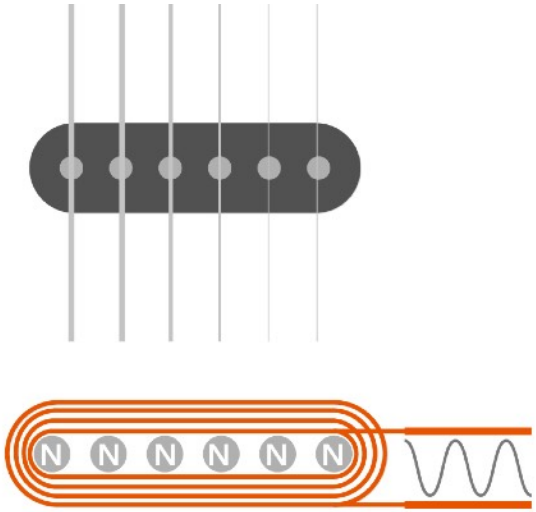


Magnetic pickups

GUITARS and ELECTRIC BASS

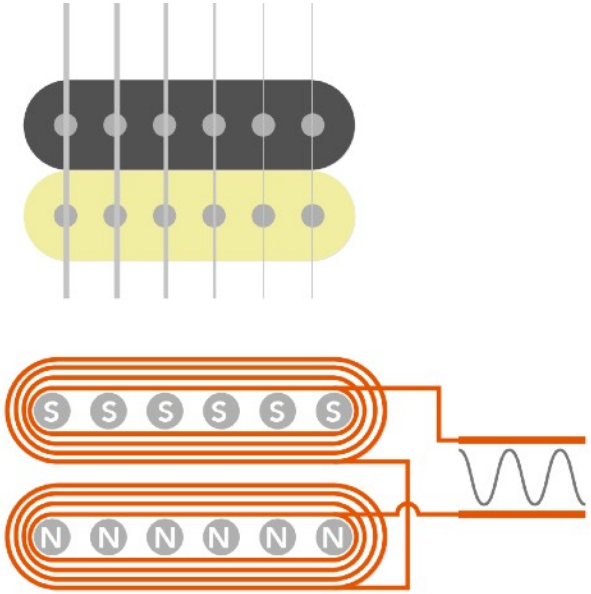
single coil

This pickup uses a single coil of thin wire around magnetic poles. The vibrating string creates a weak signal that is prone to noise. Single coil pickups produce a bright sound with prominent lows and highs but less mids. They are often used with clean or gently overdriven signals, especially in blues and funk.



humbucker

Humbucker pickups consist of dual coils that are wound in opposite directions and magnets oriented in opposite directions to each other. They offer a fuller sound with richer sustain and more midrange presence compared to single coil pickups.



Magnetic pickups

GUITARS and ELECTRIC BASS

credits: accordo.it

Magnetic pickups

GUITARS and ELECTRIC BASS

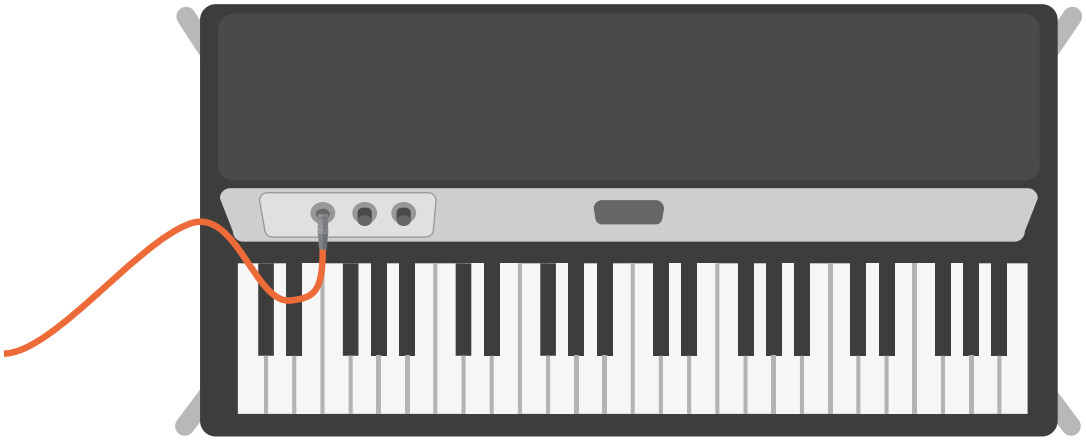
The **pickup's distance** from the strings and its position on the instrument affect the tone. When the pickup is closer to the strings and bridge, the output has more volume, more high frequency energy, and less sustain. When the pickup is further away from the strings and bridge, the output has less volume, has more midrange energy with less high end energy, and more sustain

credits: AI generated

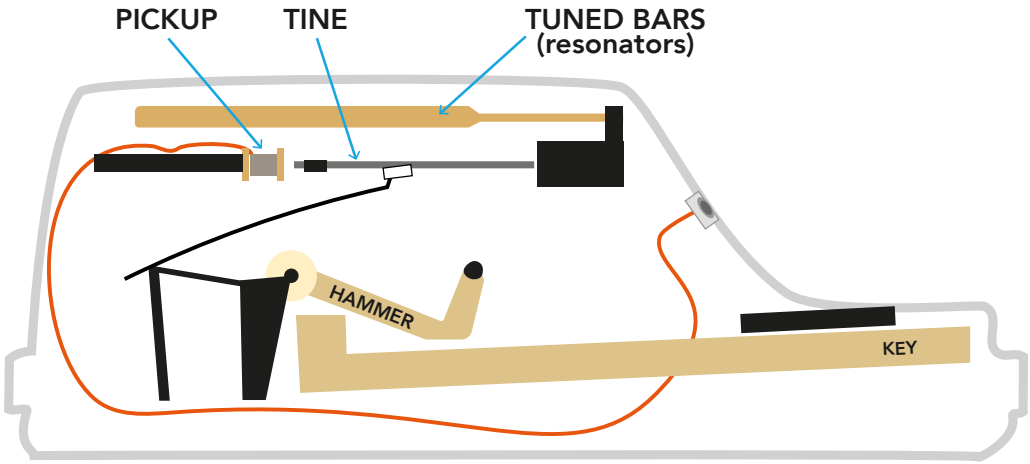
Magnetic pickups

ELECTRIC PIANO

In a Fender Rhodes electric piano, hammers strike metal **tines** instead of strings, producing a metallic sound. The vibrating tines and **resonators** enhance the timbre. A **magnetic pickup** converts the sound into an electrical signal, which is then amplified.



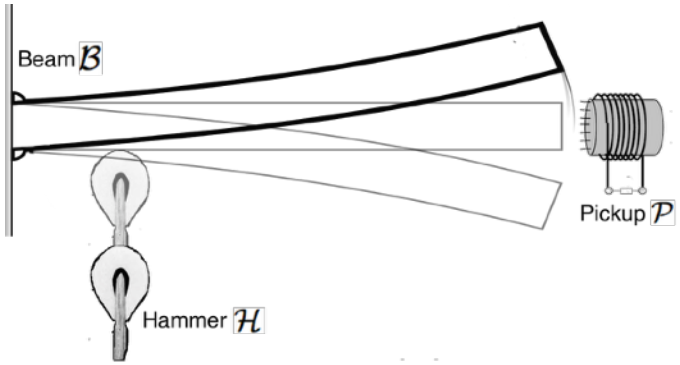
The **amplifier** adjusts the volume and can add distortion, enriching the sound with additional harmonics.



Magnetic pickups

ELECTRIC PIANO

Resonators

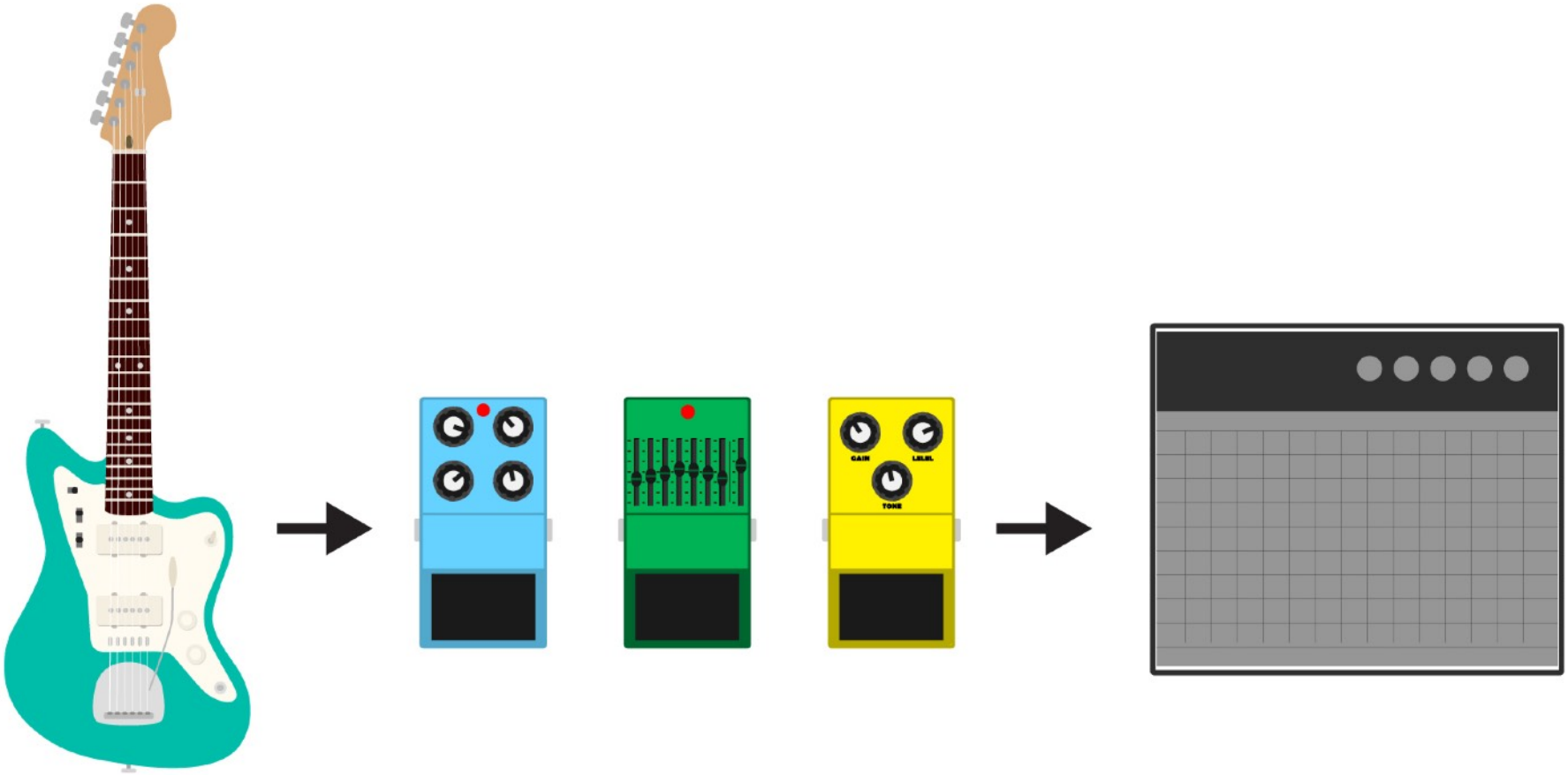


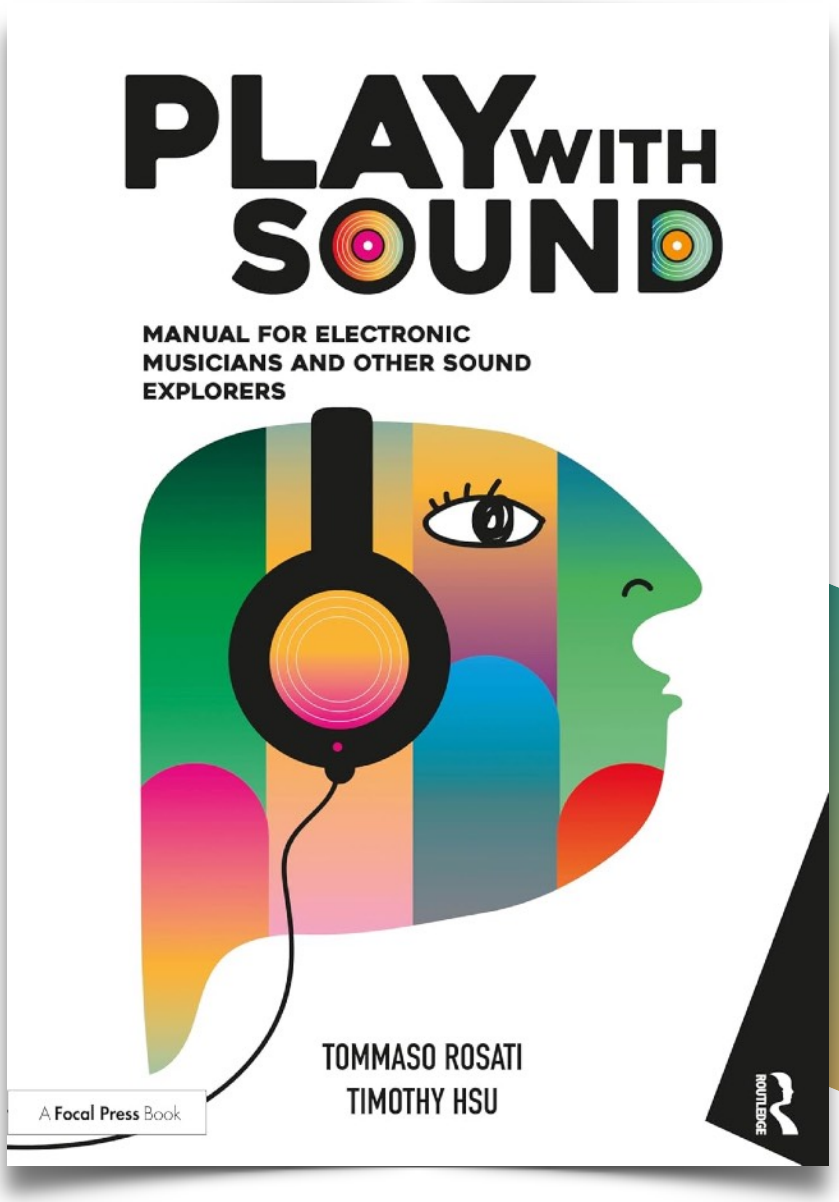
Hammer-tine-pickup

Amplifier

Electric instruments

Unlike acoustic instruments, the timbre of electric instruments depends less on their construction and more on the entire signal chain. This includes the pickup, audio effects, and amplification system, all of which color, distort, and enrich the sound.





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