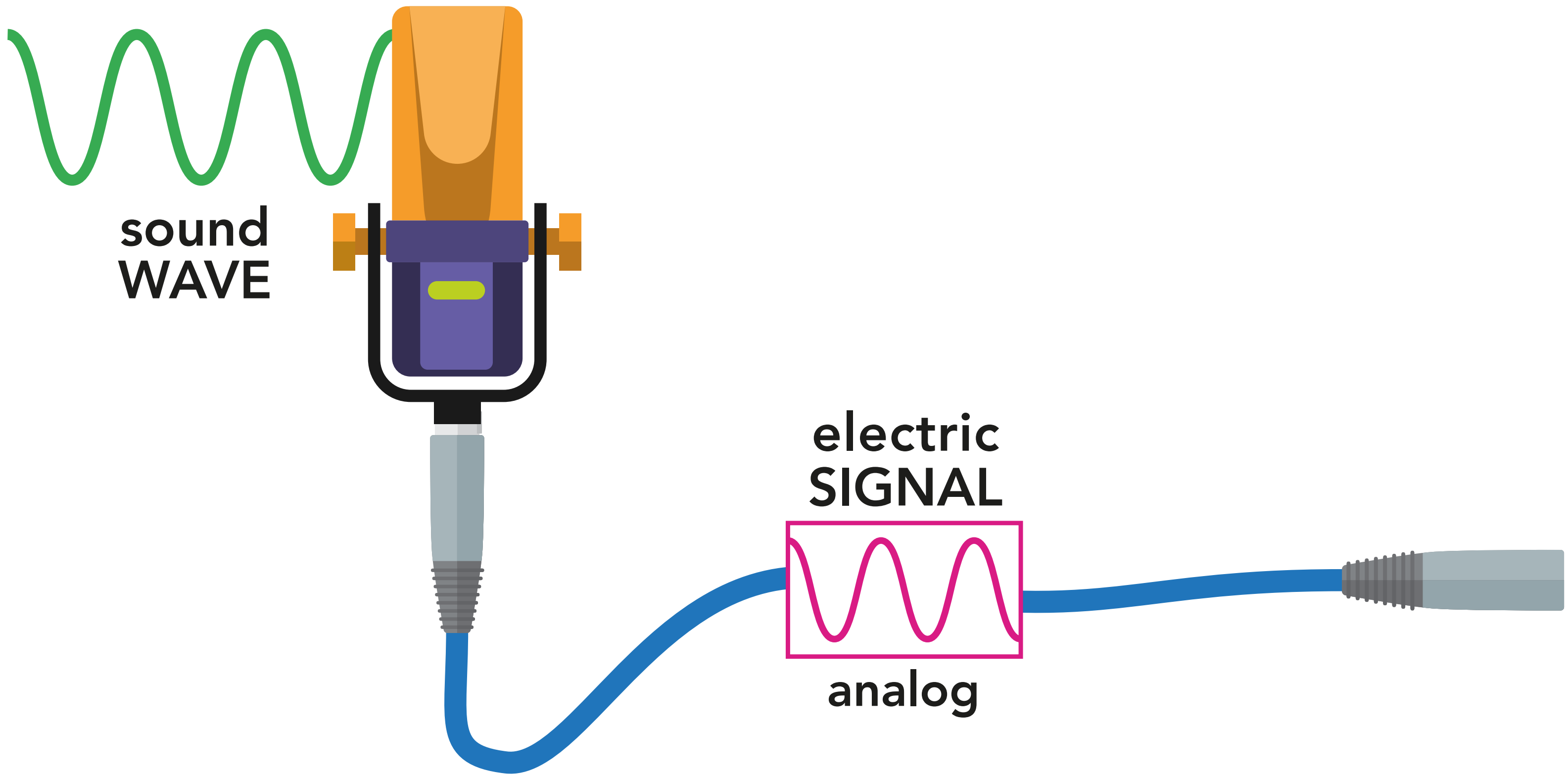
Photo: Augusto Biagini

MICROPHONES AND PICKUP

Microphones



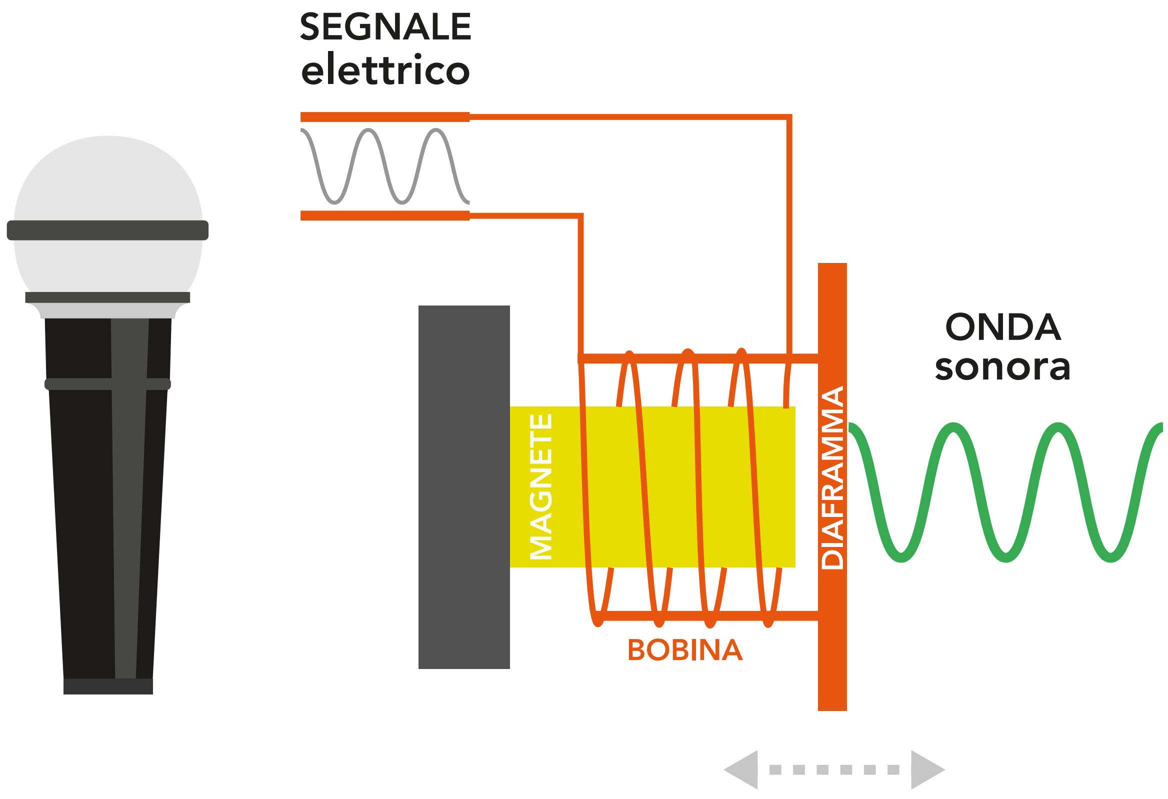
A microphone is a **transducer**, transforming an acoustical sound wave that propagates in the elastic medium into an analogous electrical signal.

Microphones

Operation: Dynamic microphones use a diaphragm attached to a coil that moves around a fixed magnet. According to Faraday's law, this movement induces a voltage proportional to the sound wave hitting the diaphragm. Essentially, dynamic microphones are the inverse of speakers; they generate voltage from a moving coil rather than using voltage to move a coil.

Dynamic

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



Microphones

Dynamic

Shure
SM58

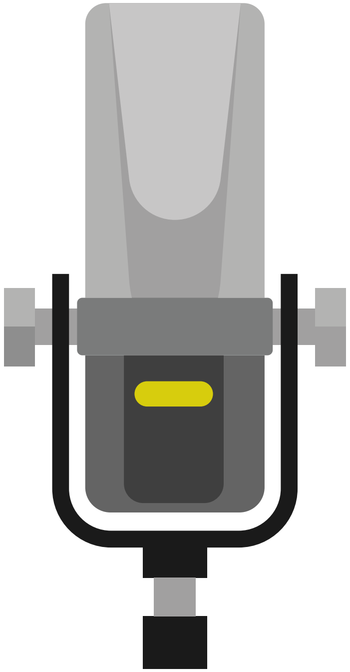
Shure
SM57

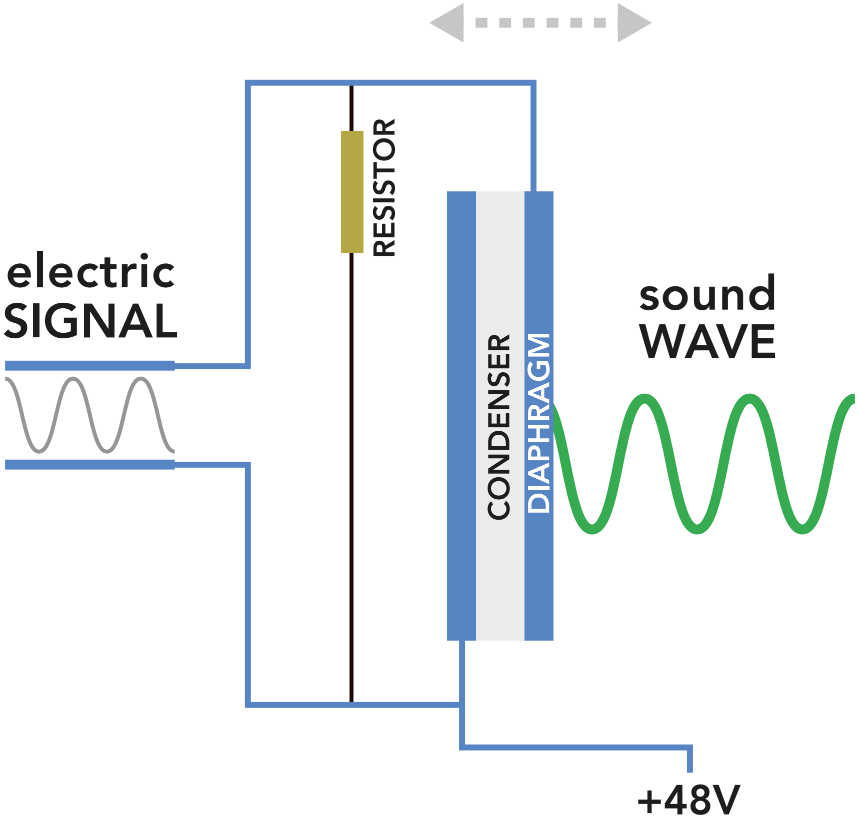
AKG
D112

operation: A condenser microphone functions as a capacitor, with the diaphragm and back plate forming the two plates. When the diaphragm moves due to sound waves, the distance between the plates changes, affecting the electric field and voltage. This varying voltage, powered by +48V, corresponds to the sound wave and is sent to a preamplifier and then recorded.

Condenser

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



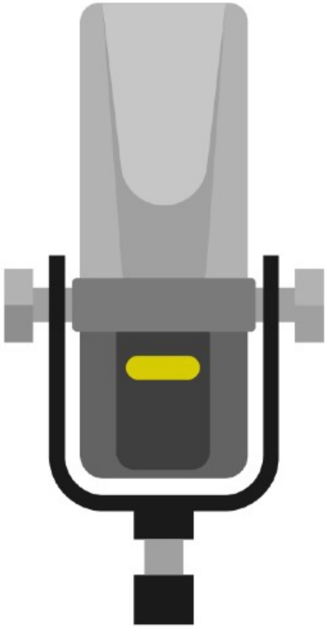


Microphones

Diaphragm size

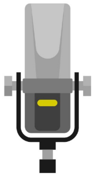
Small diaphragm
Condenser
< 1 inch (2,5 cm)

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

Microphones

Condenser

**Neumann
M149**

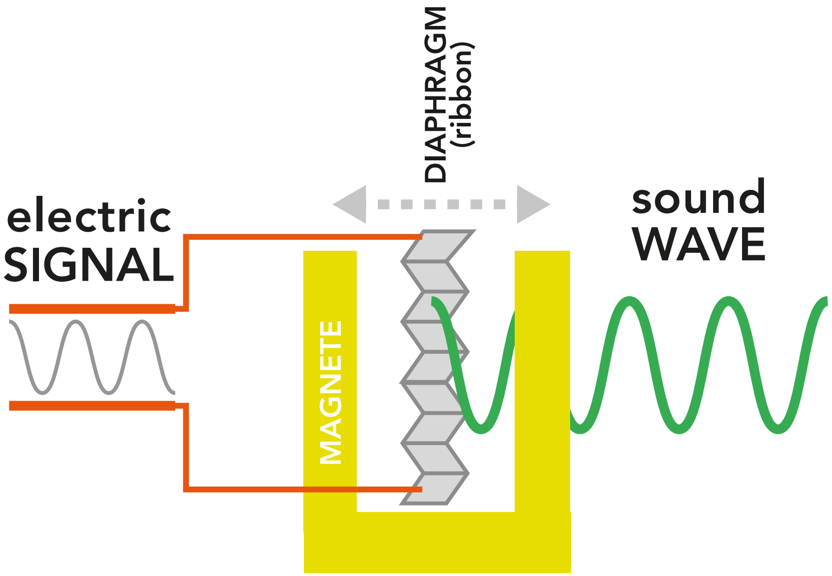
**AKG
P170**

**SE Electronics
SE 4400A**

operation: Ribbon microphones use Faraday's law with a corrugated metal ribbon as the diaphragm instead of a coil. The ribbon vibrates with sound waves while a magnet stays stationary, generating voltage. This voltage is recorded as the analog audio signal.

Ribbon

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



Microphones

Ribbon

Royer Labs
R-122V

RCA
44BX

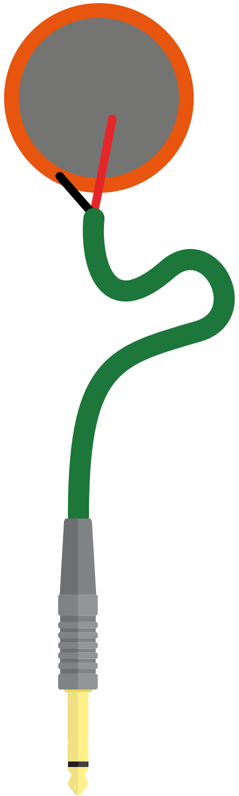
Sontronics
Apollo
(stereo)

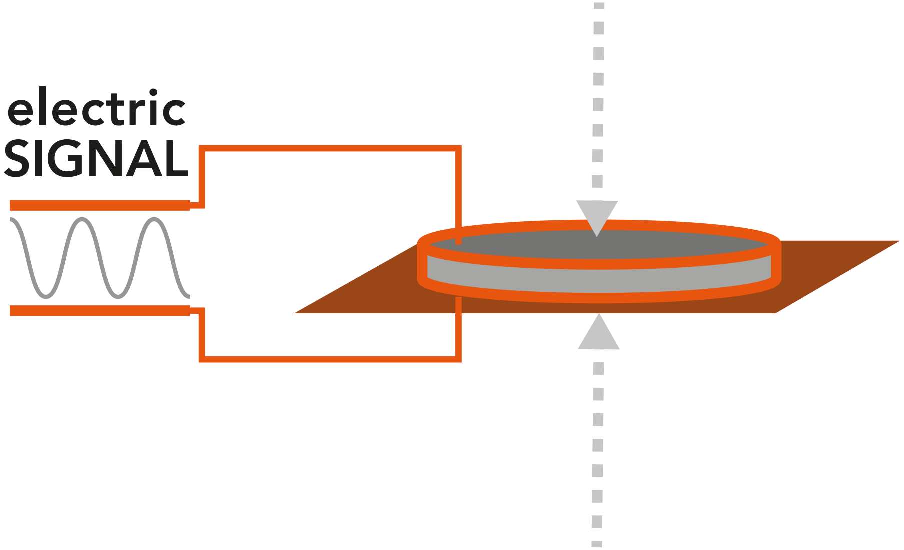
Special microphones

Operation: Piezo microphones use piezoelectric crystals that generate an electric charge when deformed by pressure. The vibration of an instrument body compresses the crystal, creating a voltage that becomes the analog audio signal. Placement is important due to the instrument's vibration properties, and these microphones typically output an unbalanced signal.

Contact piezo microphones

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



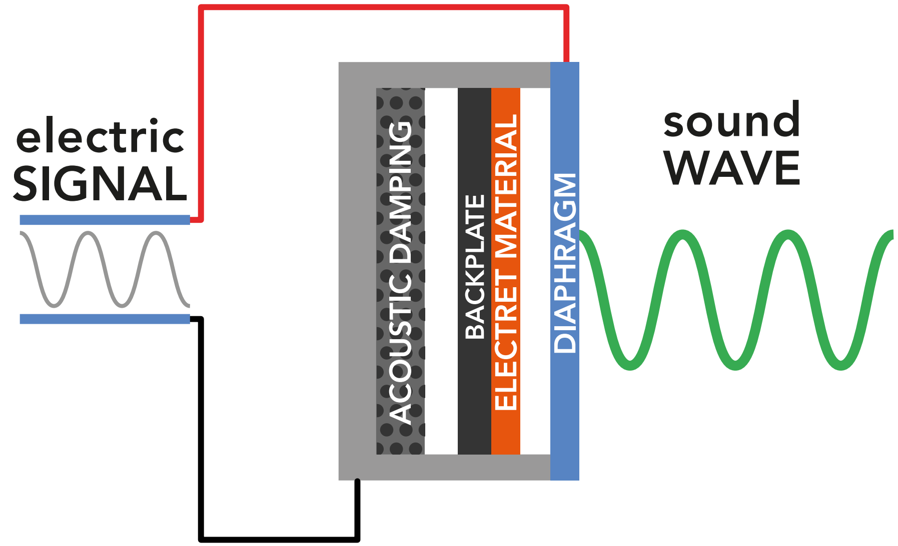


Special microphones

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

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.

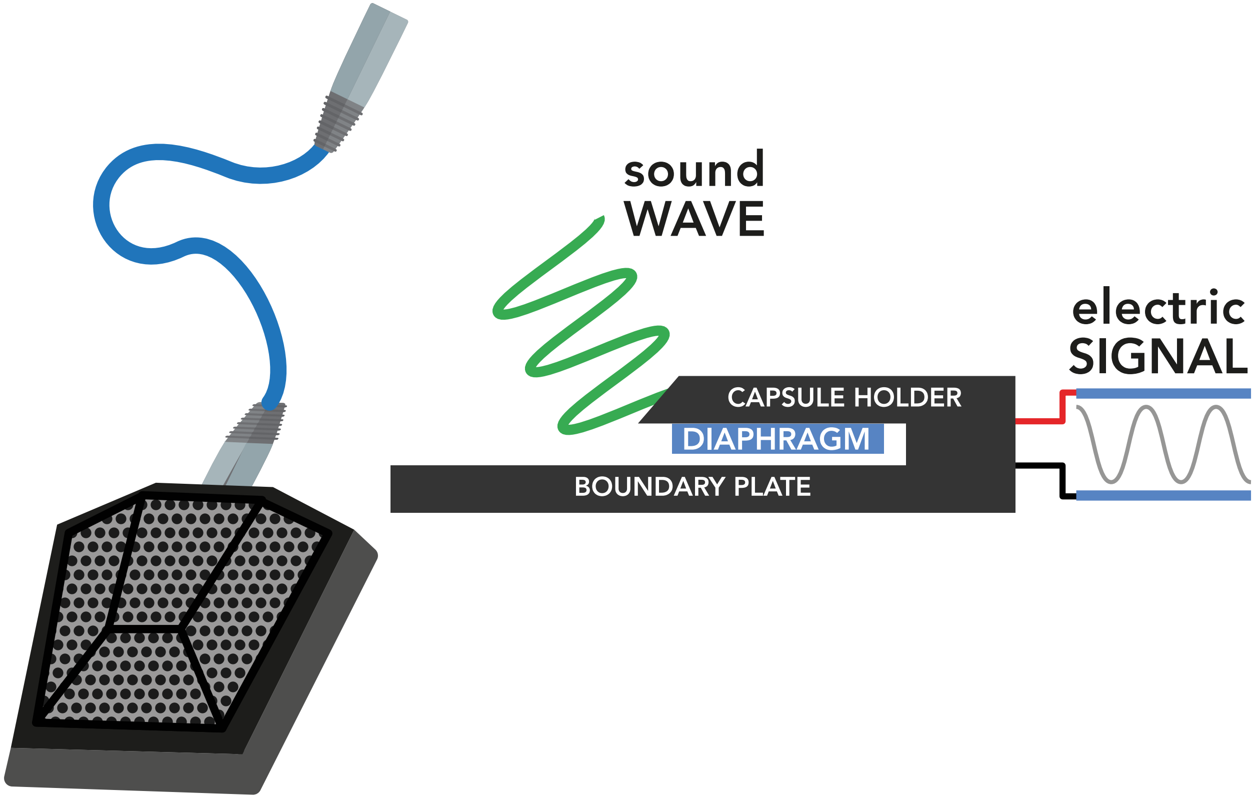


Special microphones

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 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.

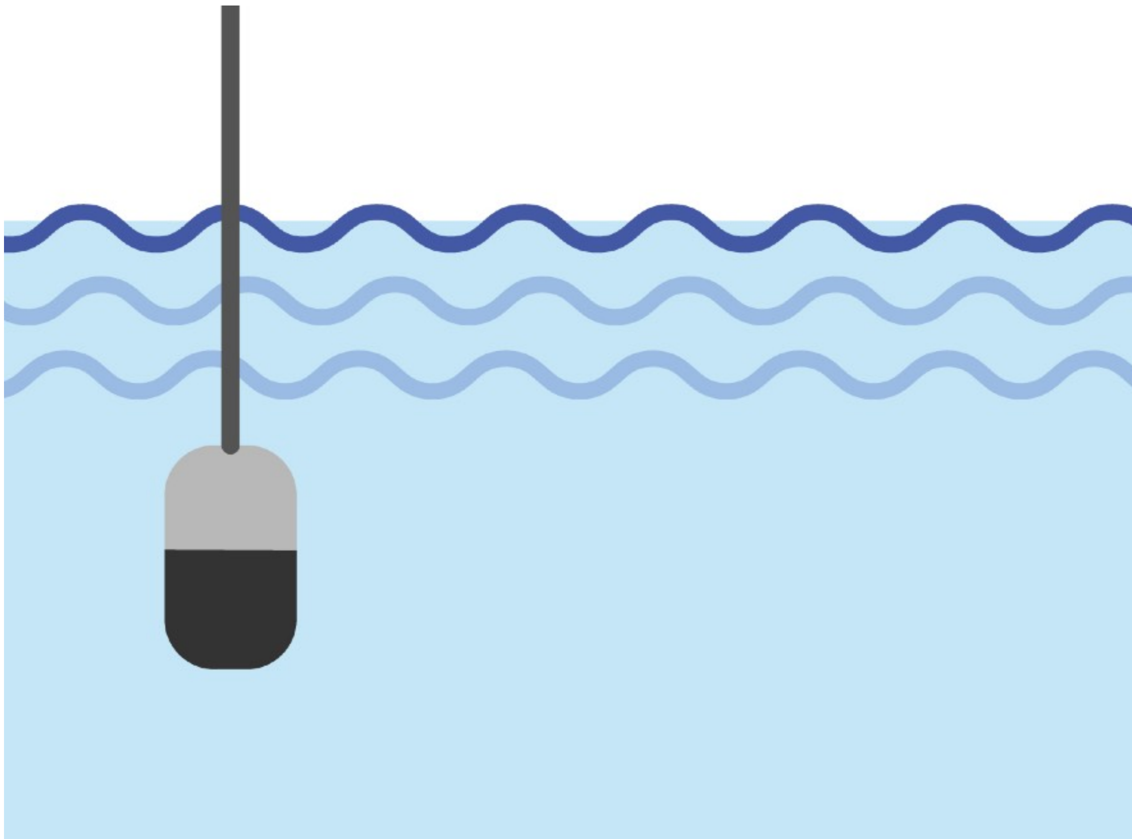


Special microphones

operation: Hydrophones, which can be dynamic or condenser, are similar to traditional microphones but include a protective waterproof capsule.

Hydrophones

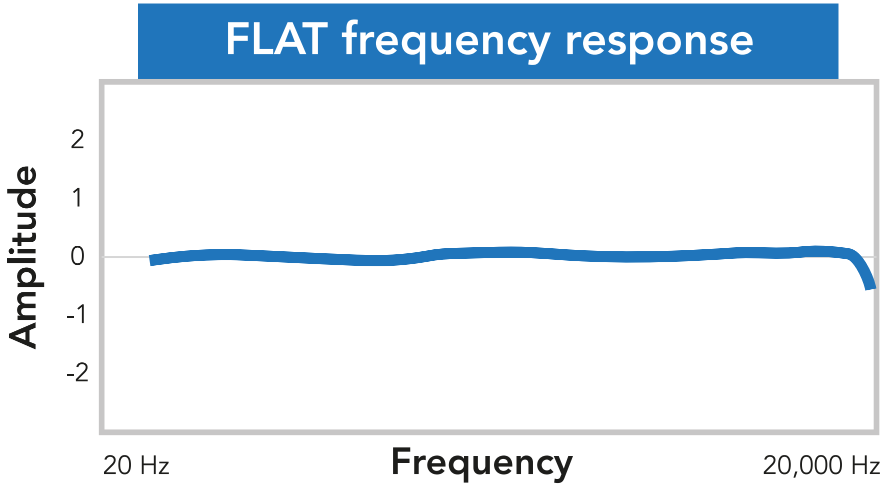
Hydrophones are used to pick up sound underwater and are often used for scientific research and musical or sound design effects.

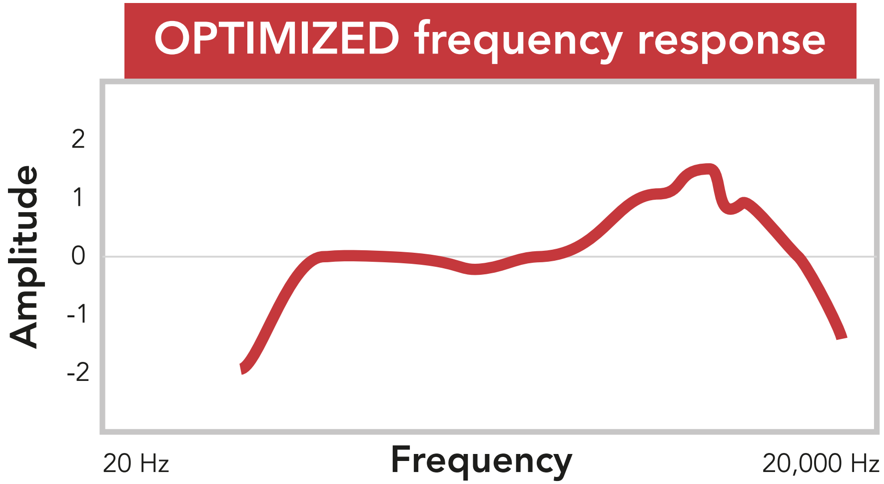


Microphones

Frequency response

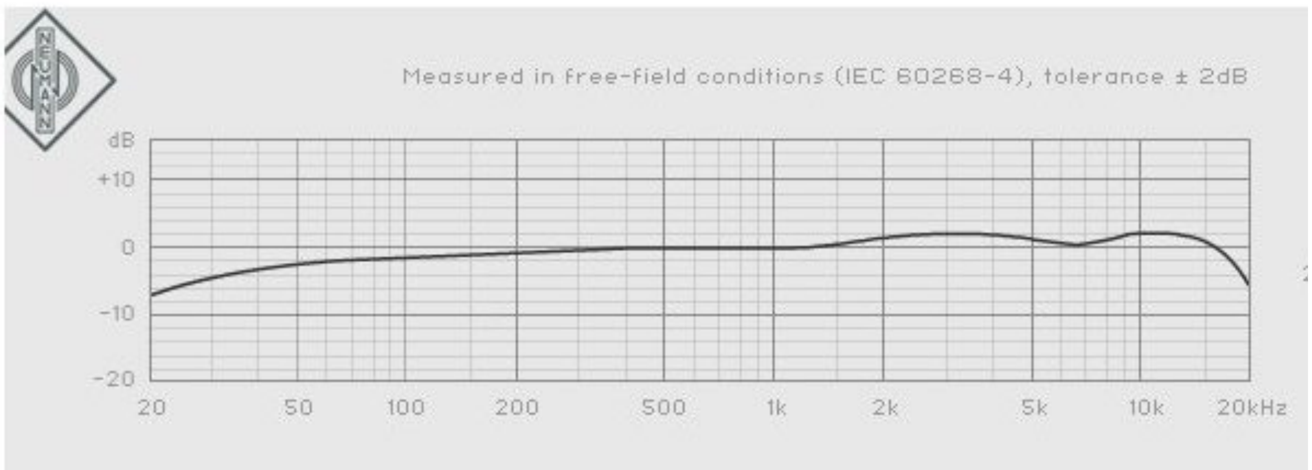
The **frequency response** of a microphone is defined as its sensitivity to different frequencies. We can plot the microphone's frequency response on an X-Y axis graph.





Microphones

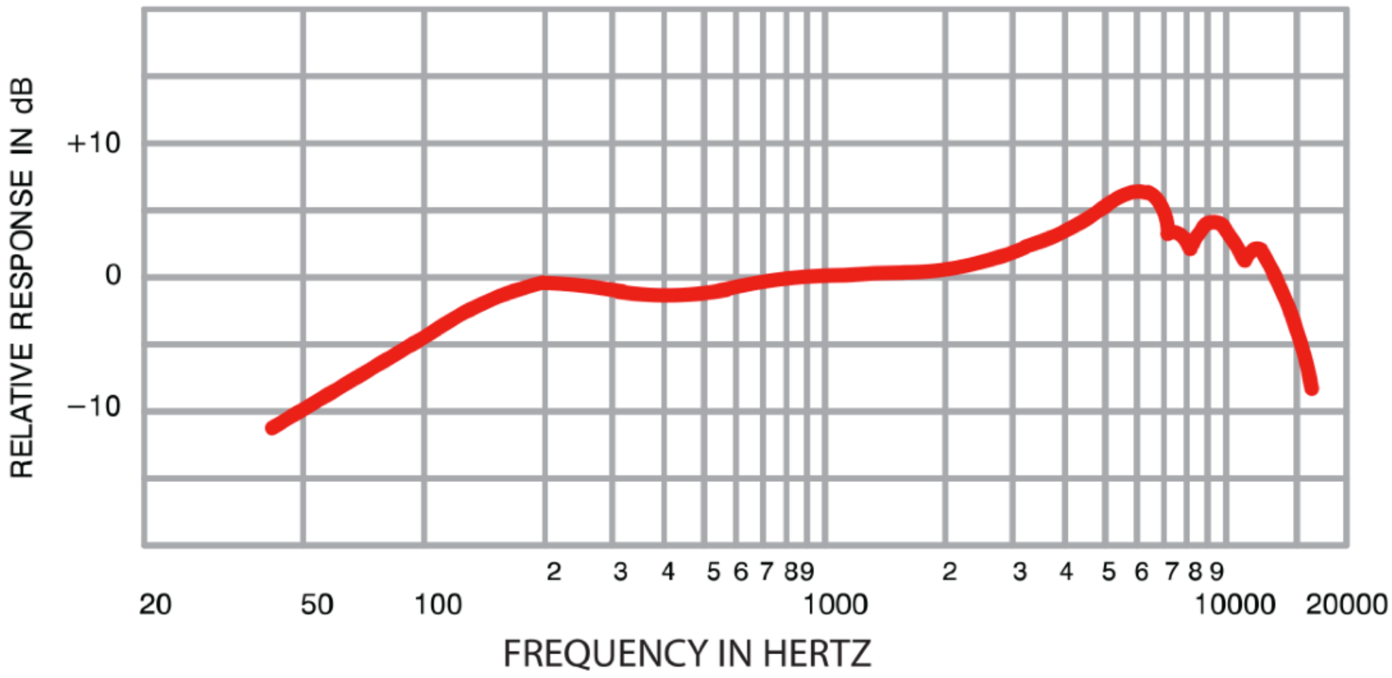
Frequency response



Frequency response - Neumann M 149

Microphones

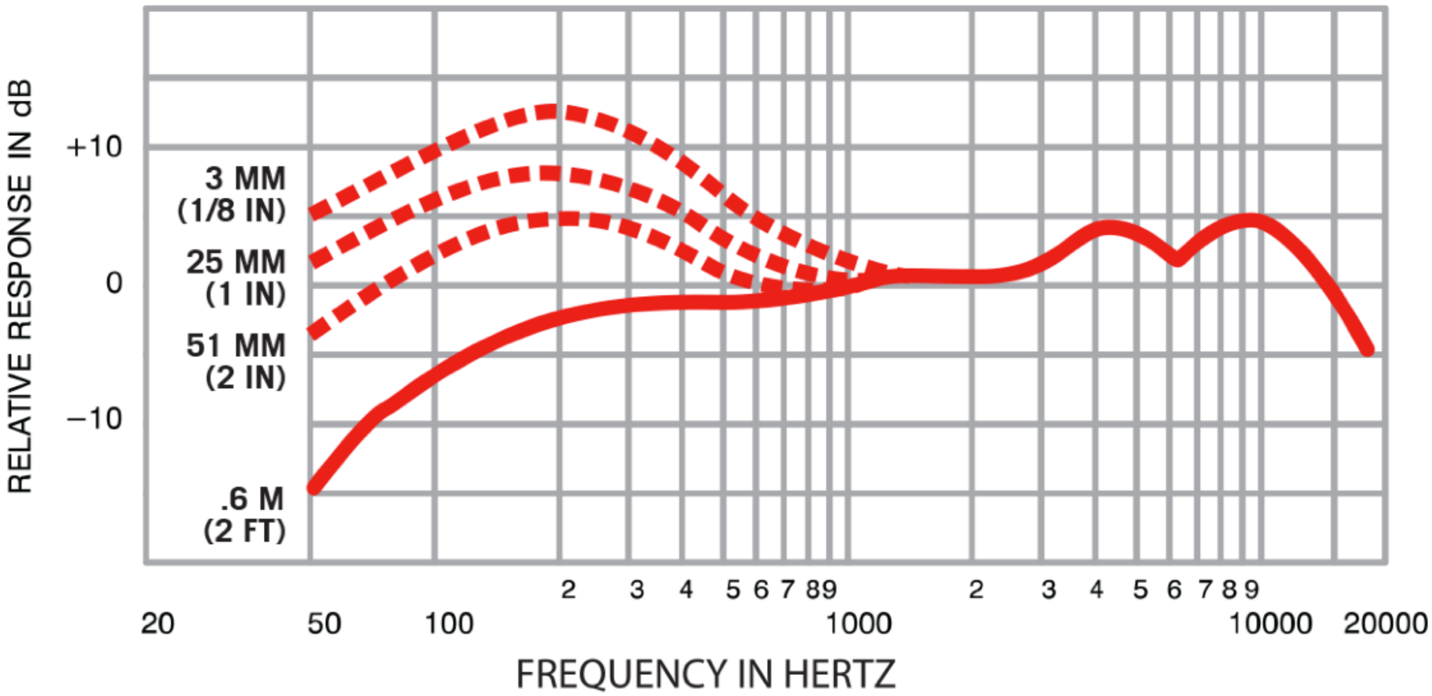
Frequency response



Frequency response - Beta SM57

Microphones

Frequency response

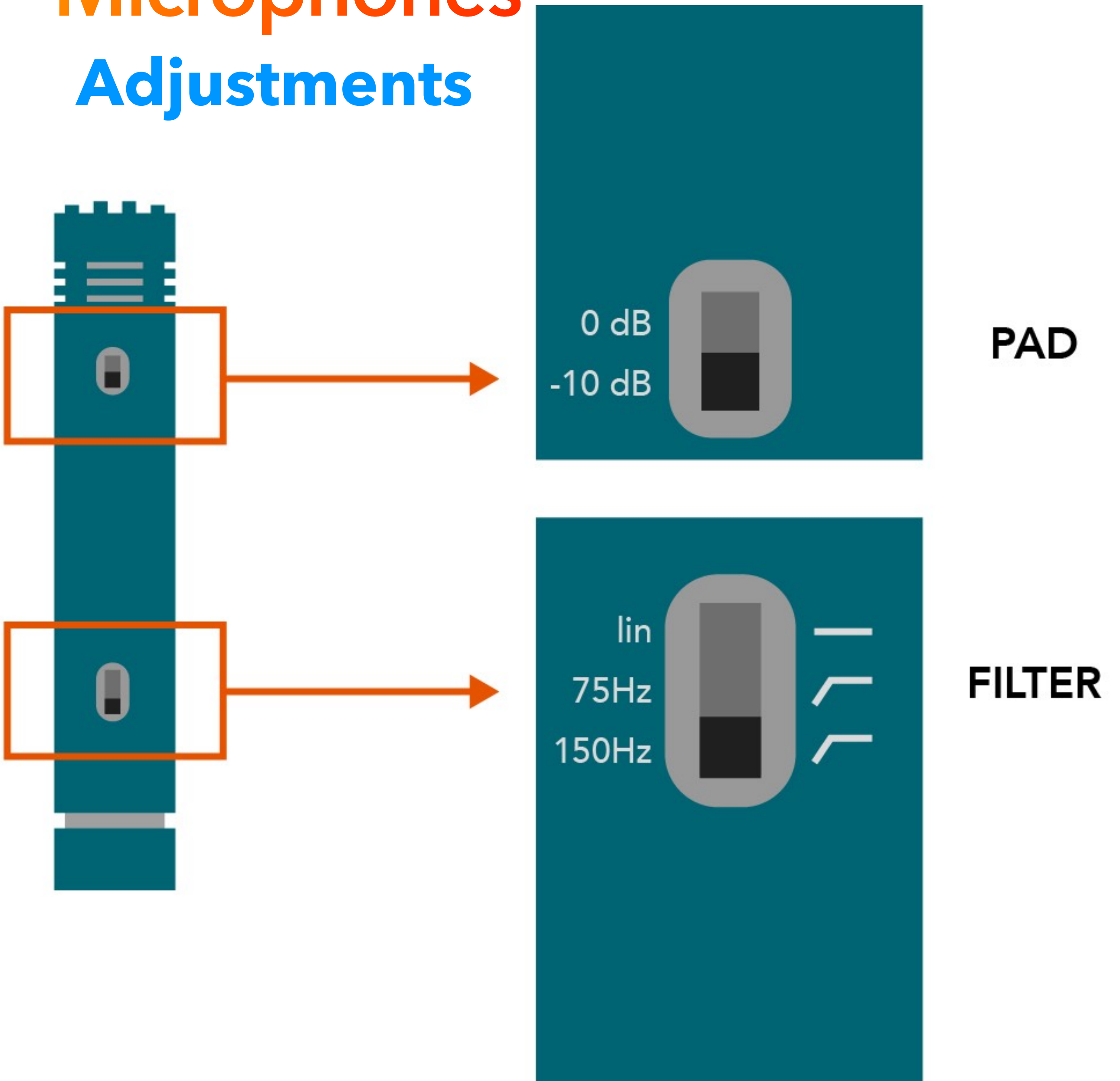


Frequency response - Beta 58 A

Microphones

Adjustments

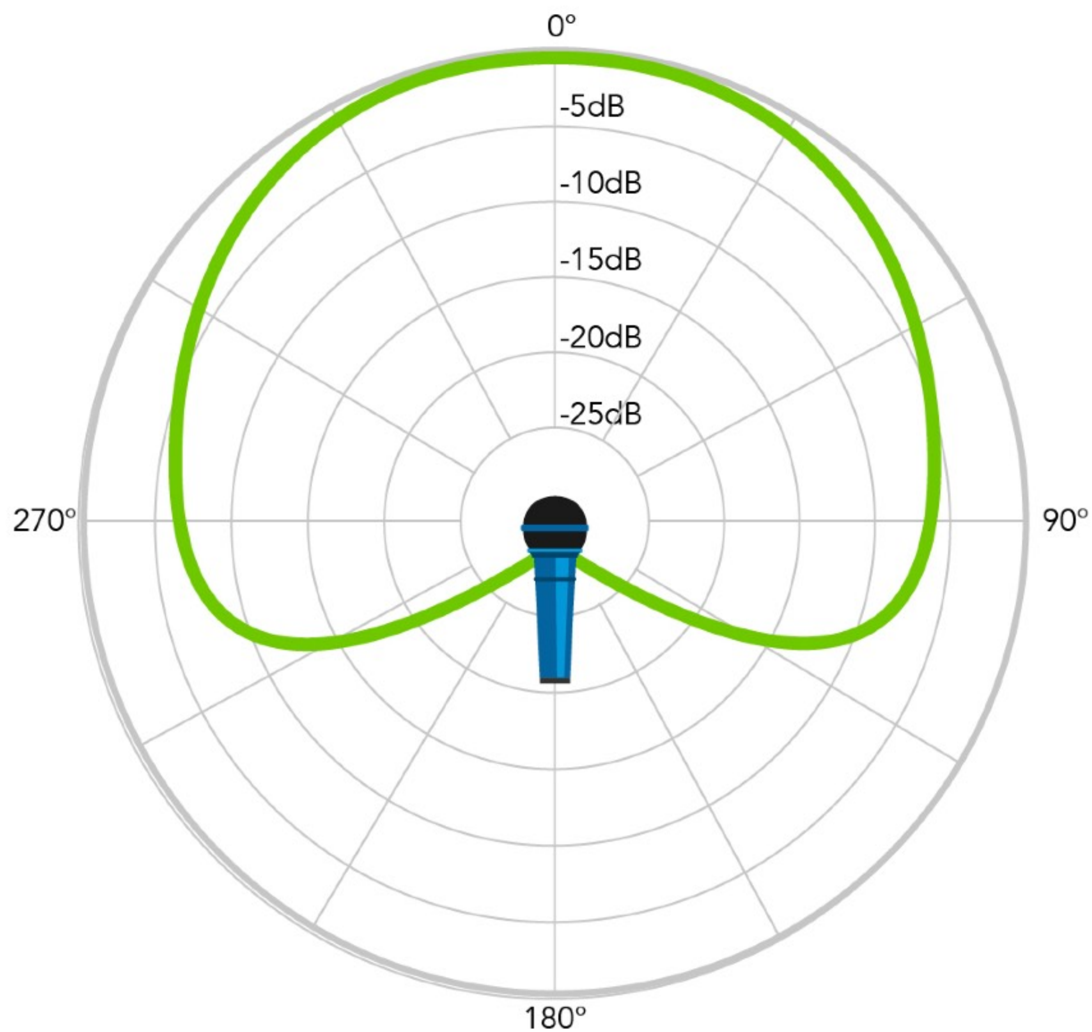
PAD
can be used on a microphone when the incoming sound wave is excessively loud and needs to be attenuated to prevent overloading the microphone and causing distortion.



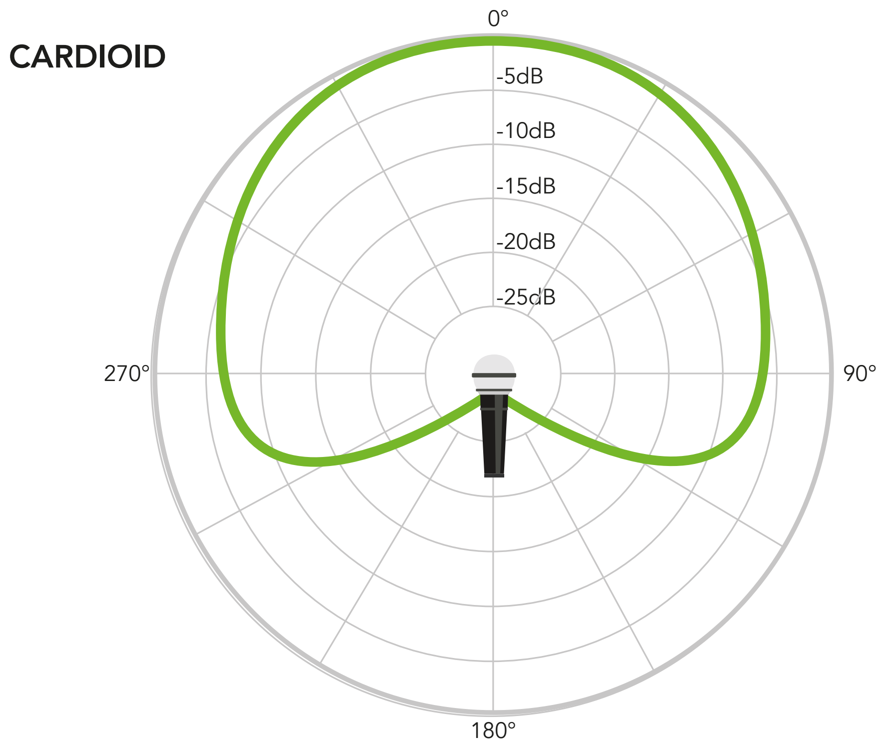
LOW-CUT filter
This filter can attenuate low frequencies by activating a high-pass filter, with some microphones offering multiple cutoff options. Low-cut filters are used to reduce wind noise, building vibrations, and plosive sounds in vocal recordings.

Microphones
Polar pattern

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

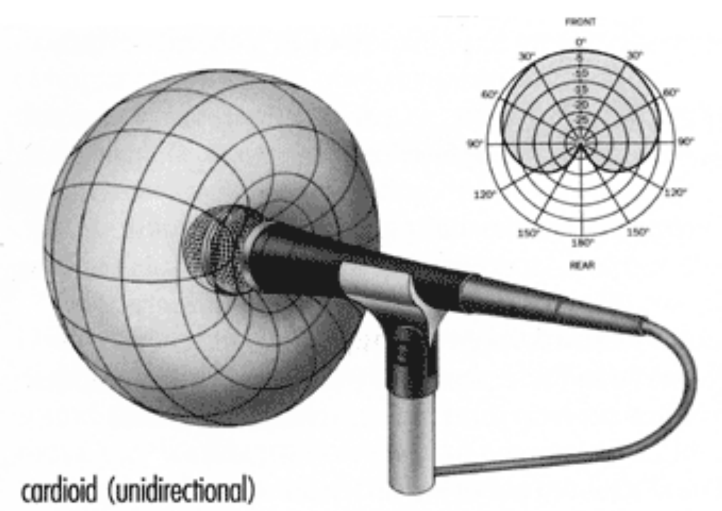


Microphones
Polar pattern



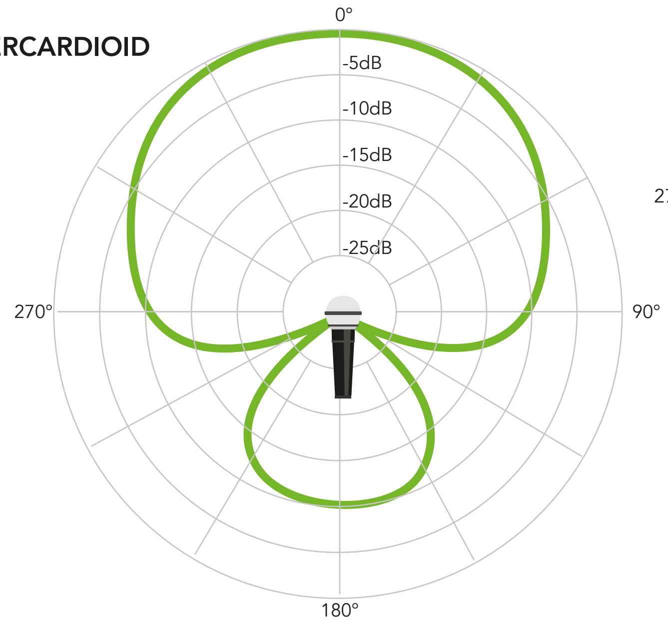
Cardioid

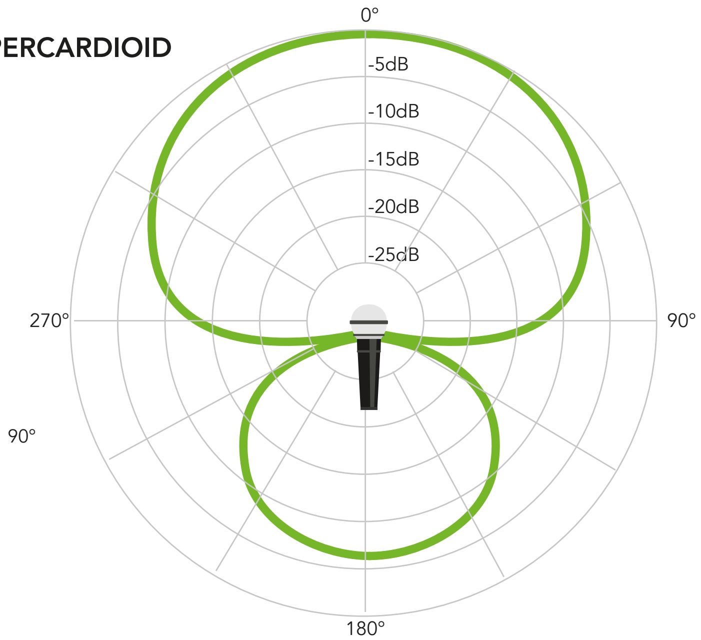
It has the highest sensitivity directly on-axis in front of the capsule (0°) and the lowest sensitivity at 180°, behind the capsule.



Microphones

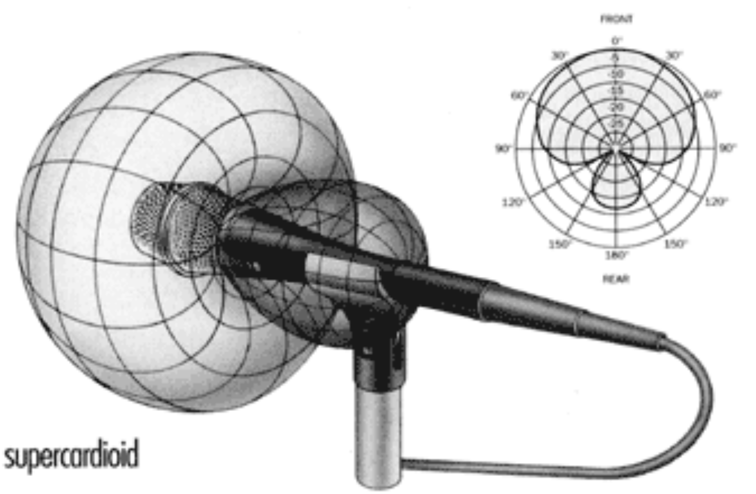
Polar pattern





Supercardioid and Hypercardioid

These 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°.

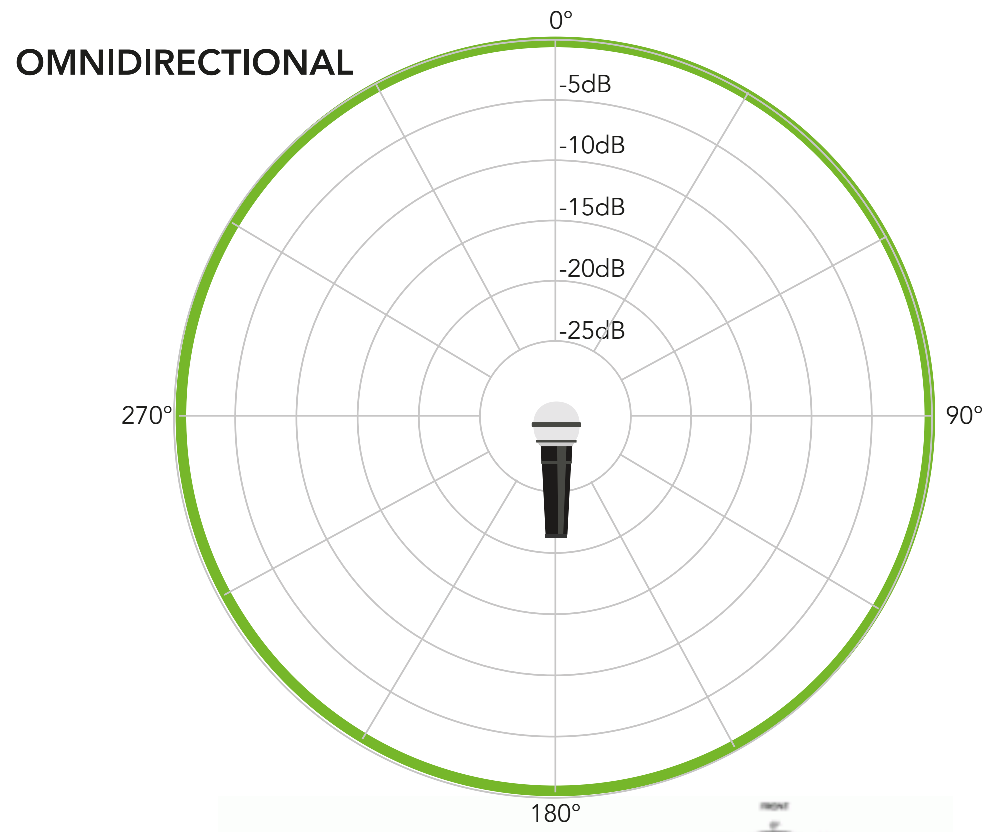


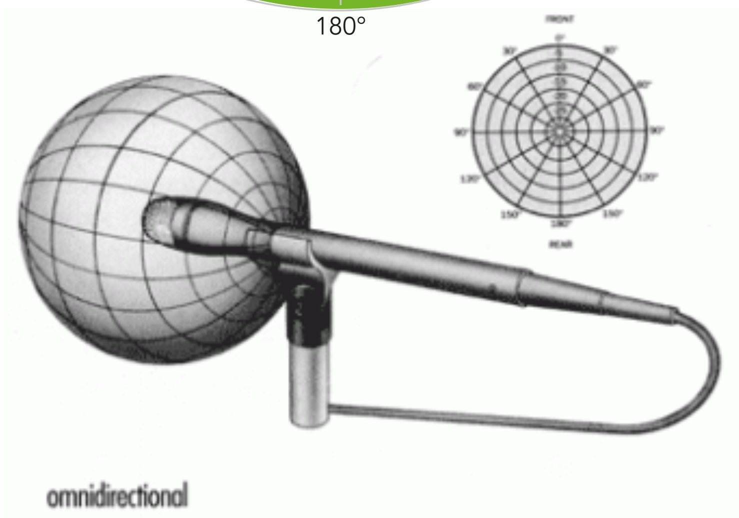
Microphones

Polar pattern

Omnidirectional

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



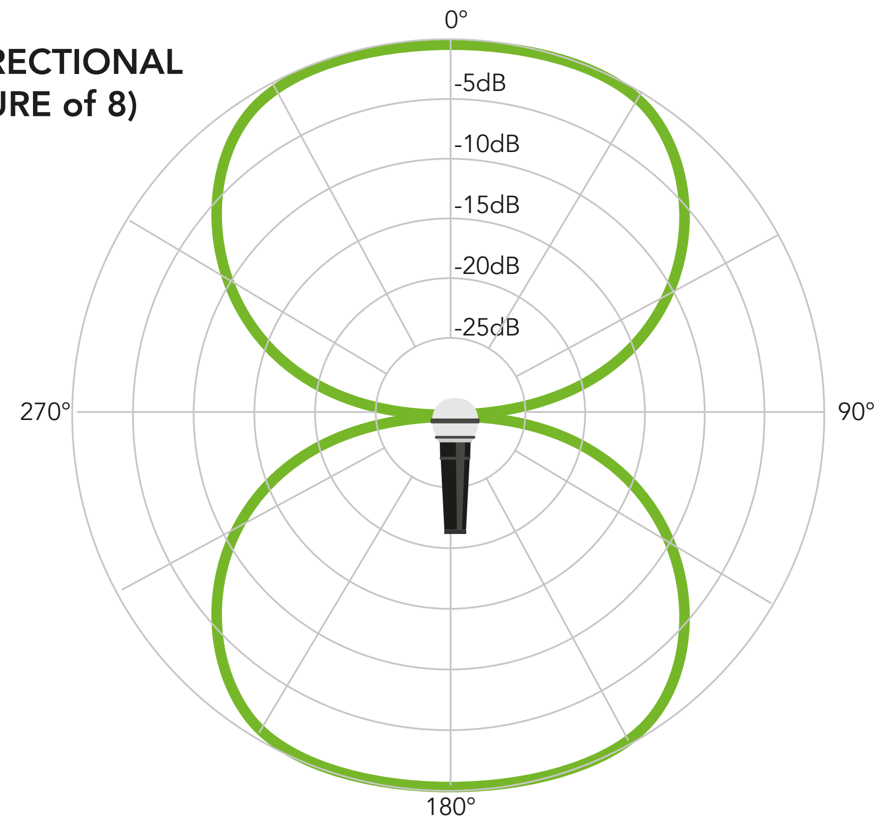


Microphones
Polar pattern

Bidirectional (Figure of 8)

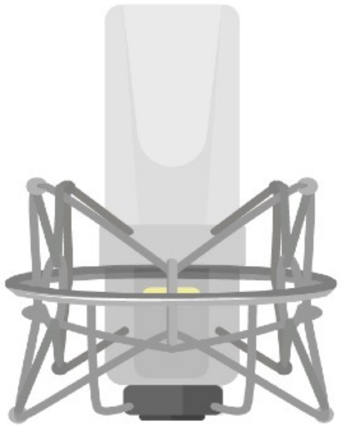
This polar pattern indicates that the microphone receives sound equally from the front and the back. The exciting feature of these microphones is that the two main lobes, or pick-up angles, are quite narrow.

BIDIRECTIONAL (FIGURE of 8)



Microphones

Accessories



Shockmount

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.

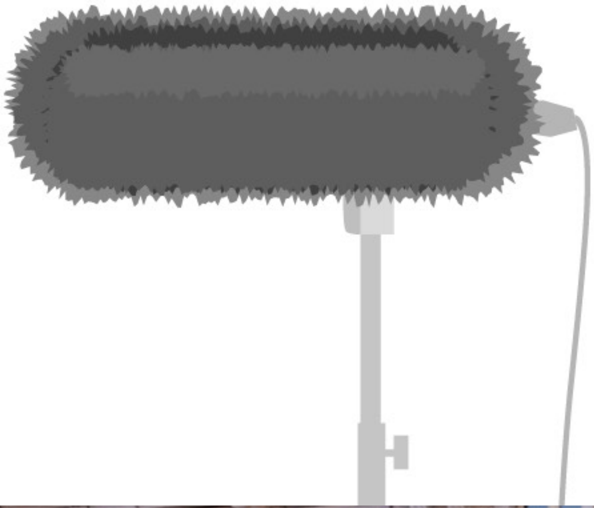
Microphones

Accessories

Pop filter

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

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.

Microphones

Accessories

Parabolic reflector

It 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 interpret the sound.

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 are in sync with respect to phase.

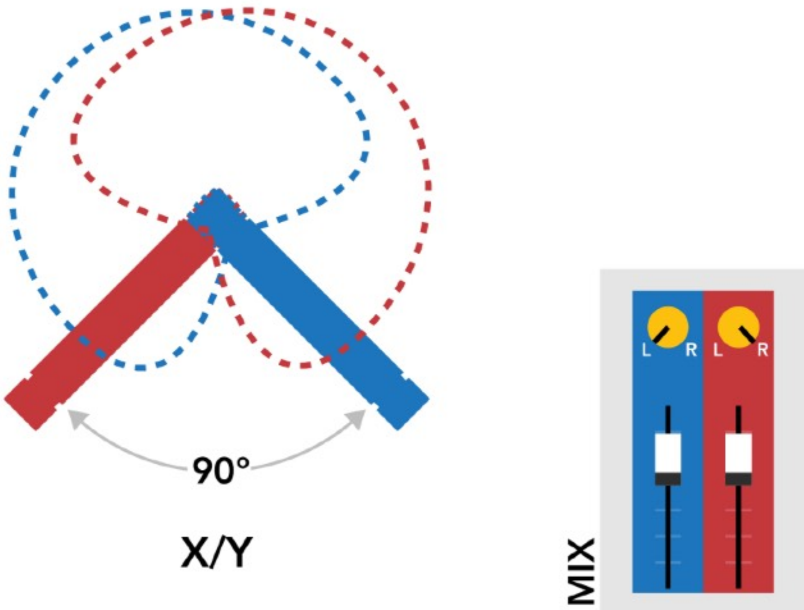
This characteristic is called **mono-compatibility** and stereo recordings made with coincident pairs excel at this characteristic.

Stereo microphone techniques

Microphones:
two cardioids, usually condenser

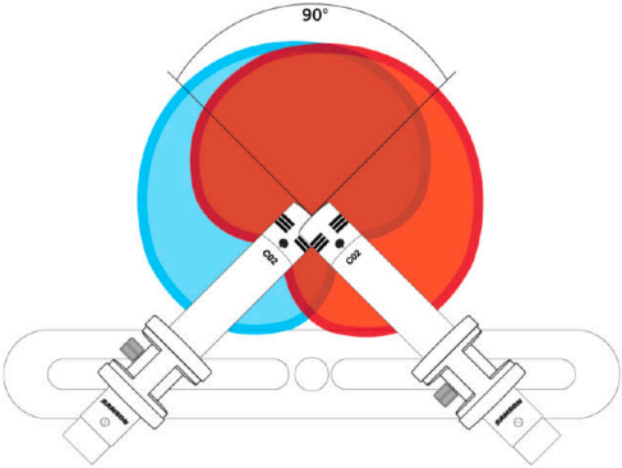
X/Y technique

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.

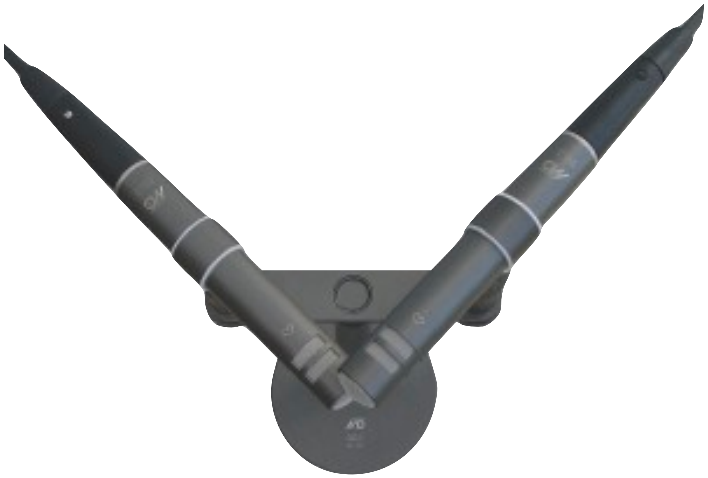


Because of the proximity of the two microphones, the sound arrives at the two capsules at the same time, reducing phase-shifting problems.

X/Y technique



X/Y technique

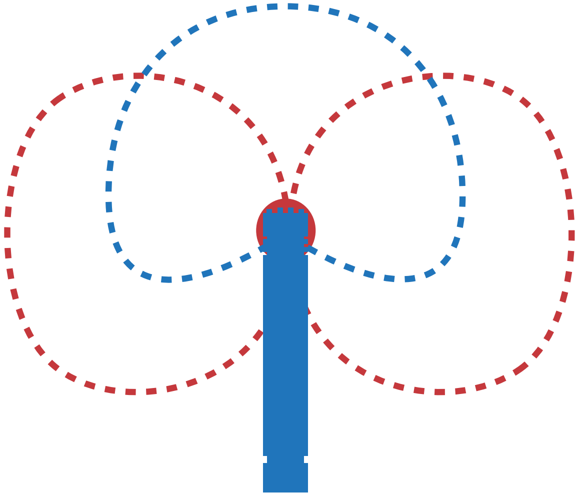


Stereo microphone techniques

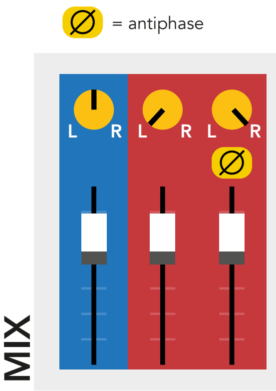
Microphones:
one cardioid and one bidirectional, usually both condensers

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.

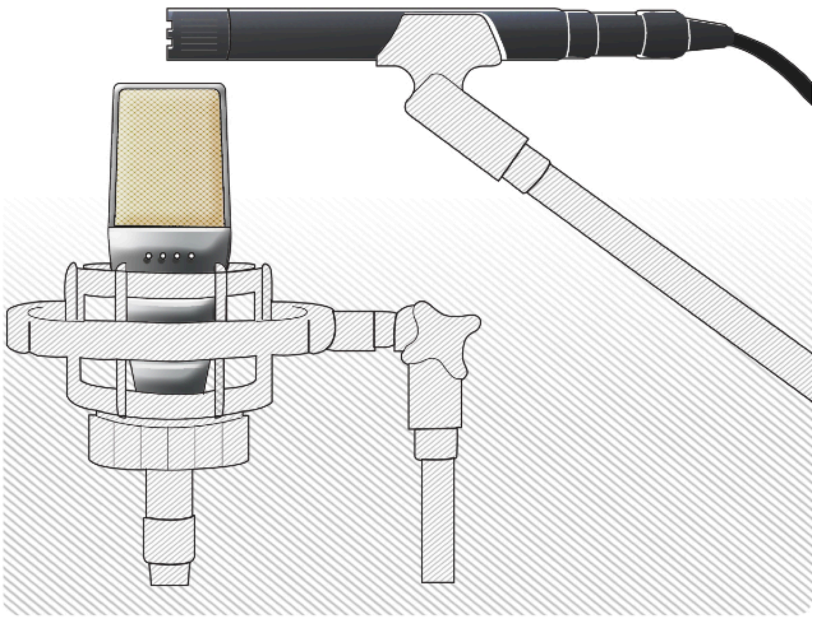


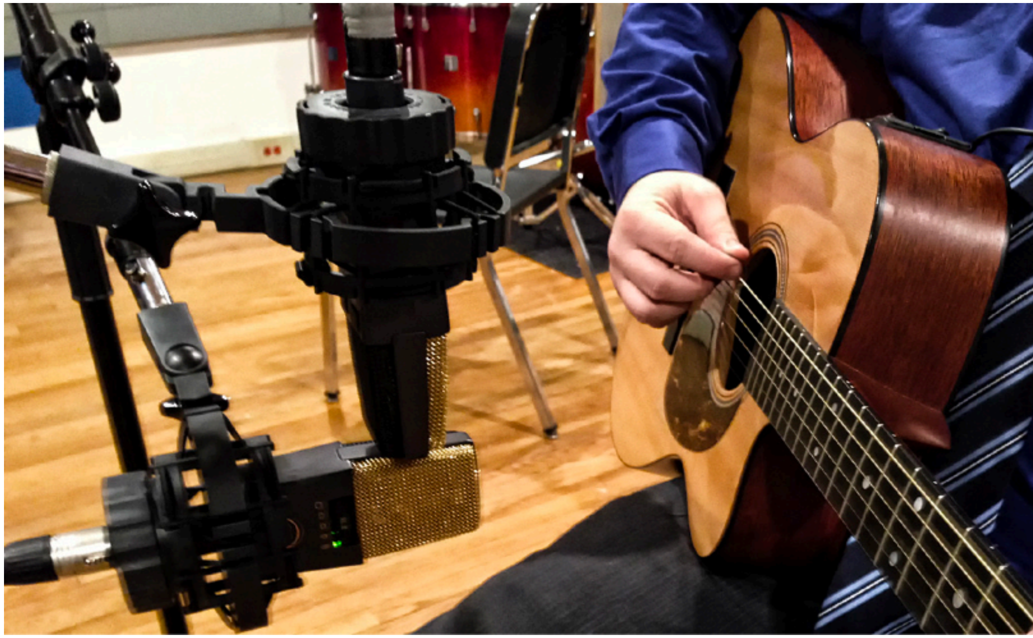
M/S



Mid/Side (M/S) technique

Mid/Side (M/S) technique





Microphones

Stereo microphone techniques

NEAR-COINCIDENT PAIR

These techniques involve using two microphones placed 15-30 cm apart.

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.

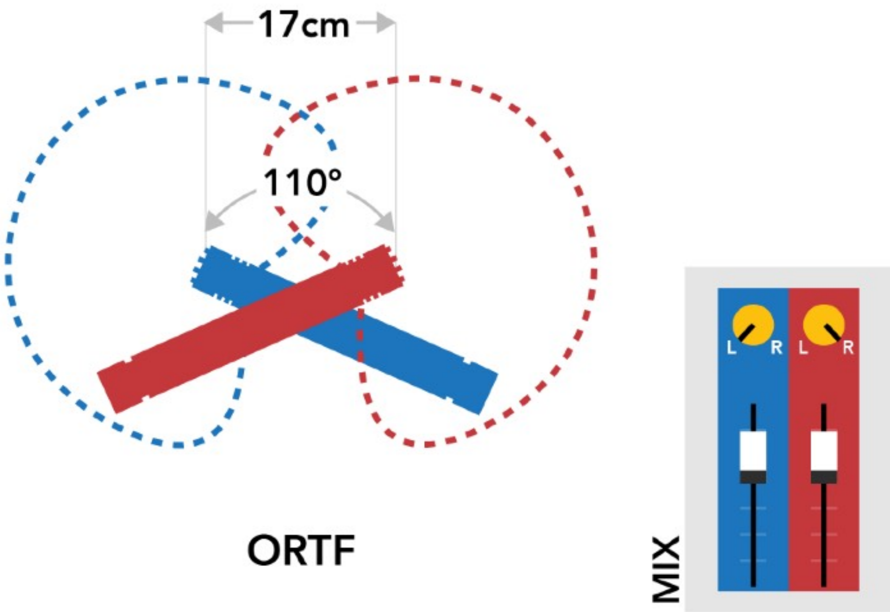
This, on the one hand, improves the width and quality of the stereo effect, but affects this technique’s mono-compatibility.

Stereo microphone techniques

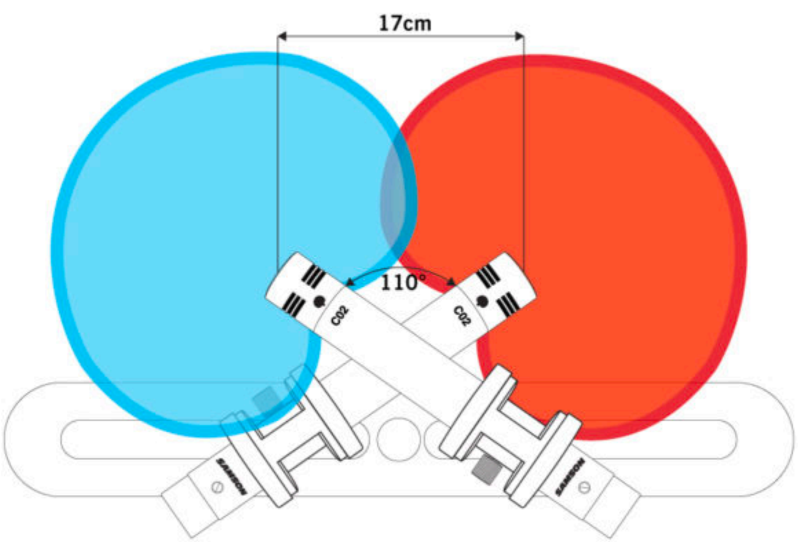
Microphones:
two cardioids, usually condenser

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 technique

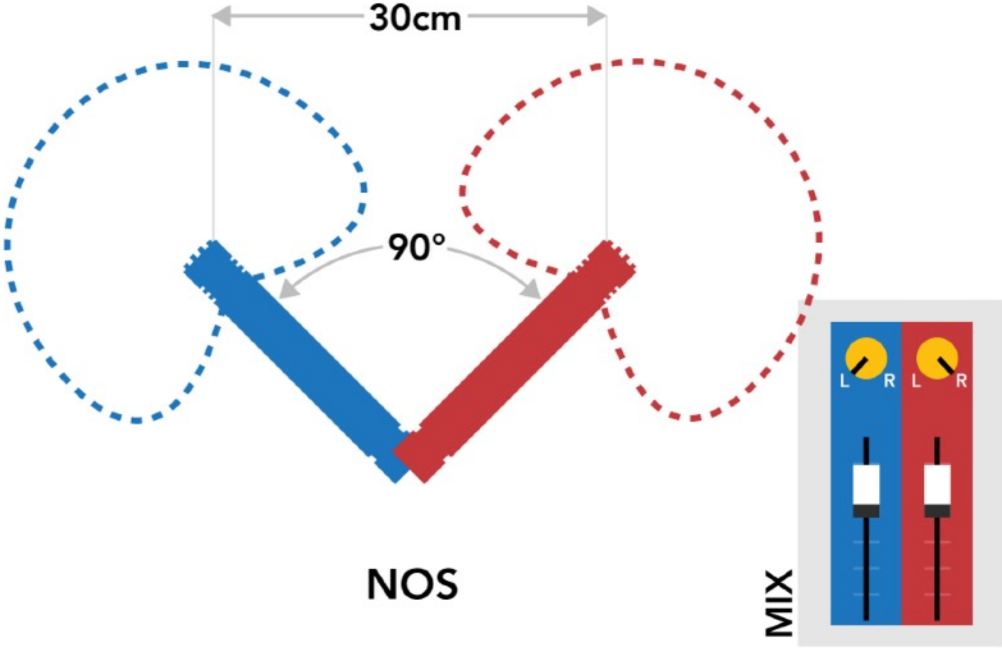


Stereo microphone techniques

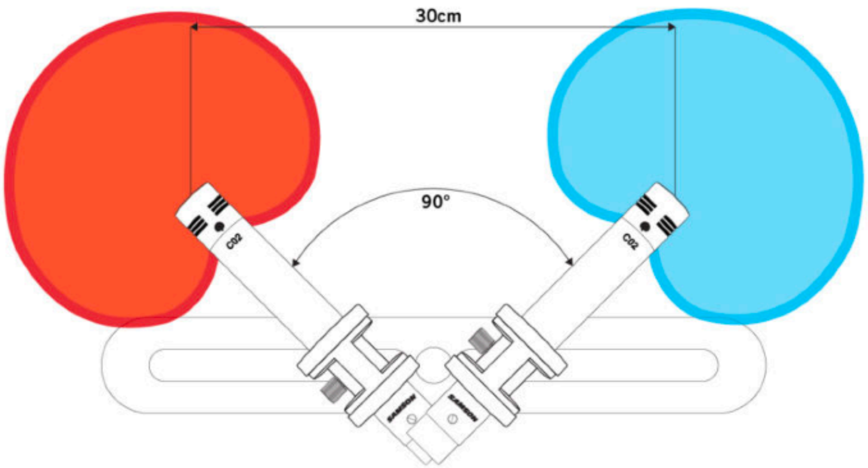
Microphones:
two cardioids, usually condenser

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. It's suitable for mid to large ensemble recordings.



NOS technique



Microphones

Stereo microphone techniques

SPACED PAIR

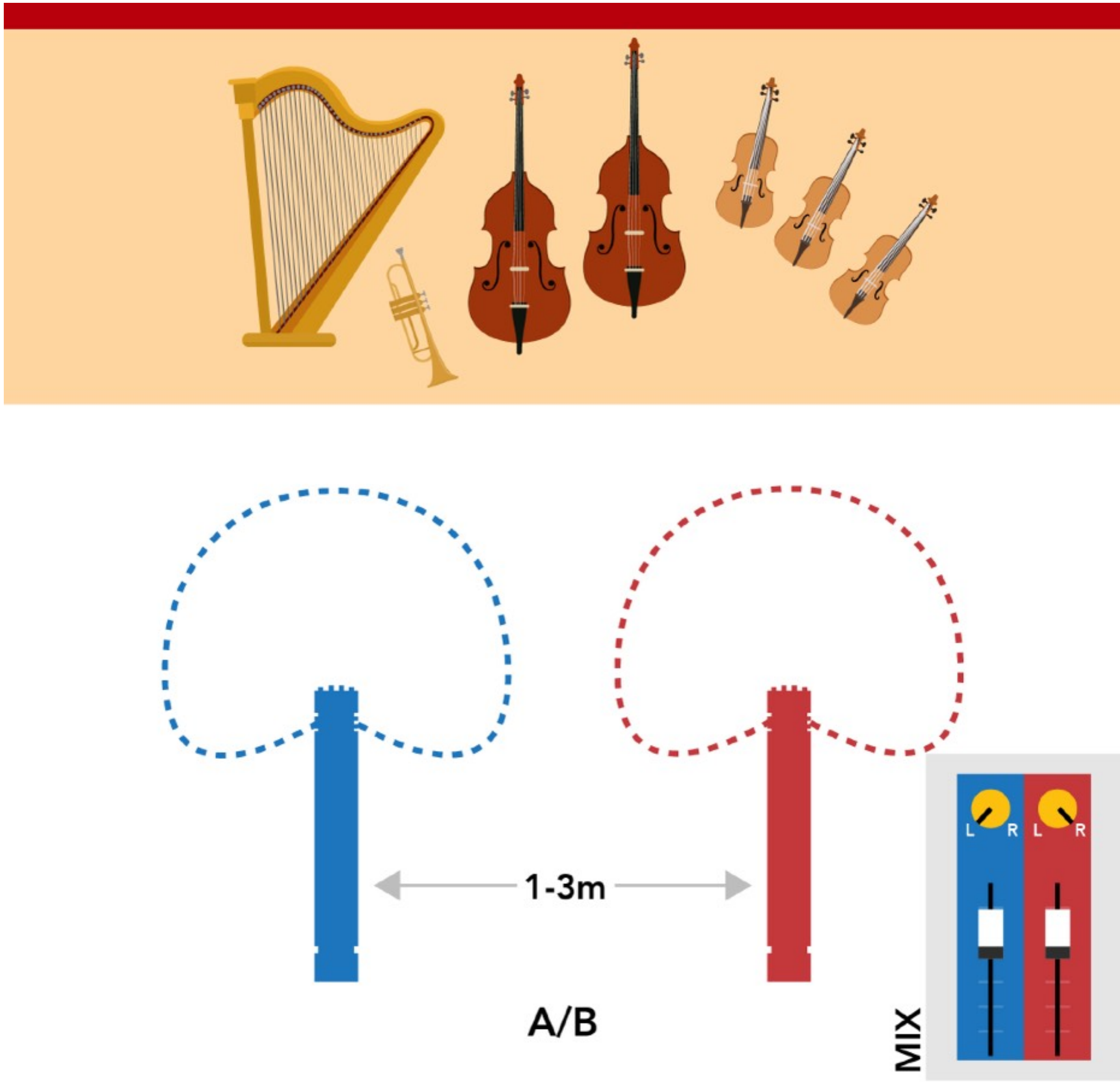
To avoid phase cancellation, the 3:1 ratio rule is applied, requiring the second microphone to be at least three times farther from the first than the distance to the sound source. For instance, if microphones are 6 feet from musicians, they should be 18 feet apart. Due to significant phase differences, these techniques are generally not mono-compatible and are used mainly in non-broadcast contexts.

Stereo microphone techniques

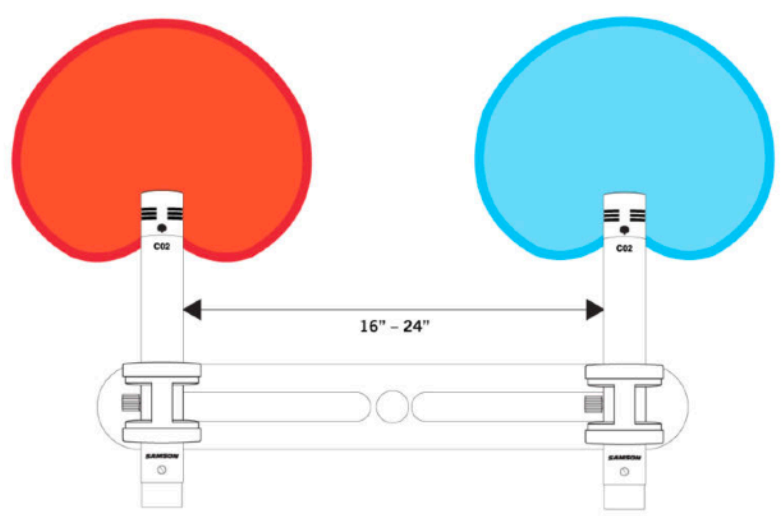
Microphones:
two cardioids, usually condenser

A/B and spaced pair technique

In the A/B technique, microphones are spaced 12″-48″ apart or 1-3 meters (3-10 ft) for a spaced pair, panned hard left and right. With no angle difference between them, large distances can cause phase interference, leading to poor mono-compatibility.



A/B and spaced pair technique



Microphones
Positioning examples

Microphones
Positioning examples

Microphones
Positioning examples

Microphones

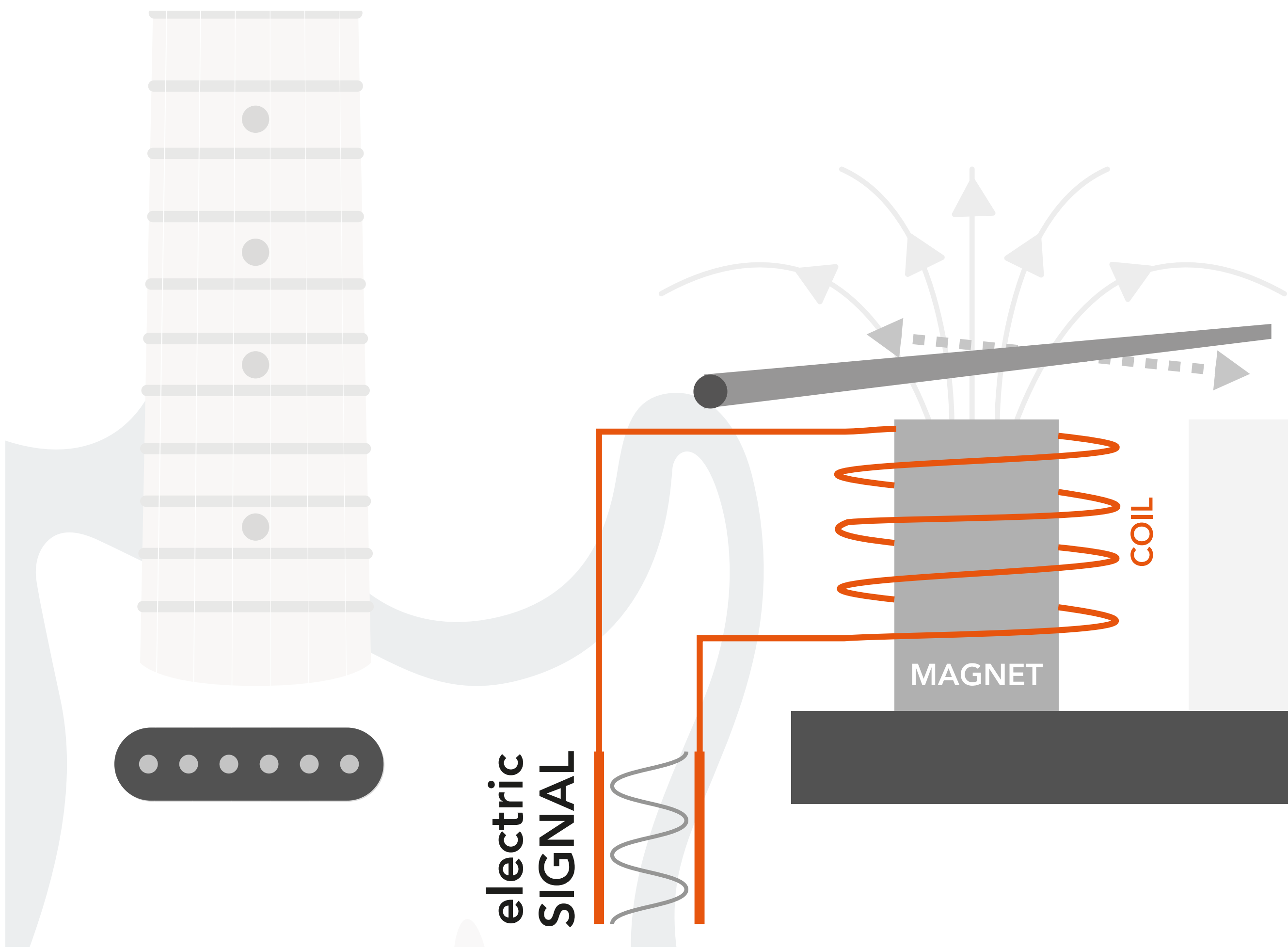
Positioning examples

Microphones
Positioning examples

Magnetic pickups

operation: Using the Faraday effect, vibrations of a metal string or cylinder change the electromagnetic field around a magnetic pole, generating an alternating current in the coils. This current, resulting from the string's motion, is the analog electric signal produced by the instrument.

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.

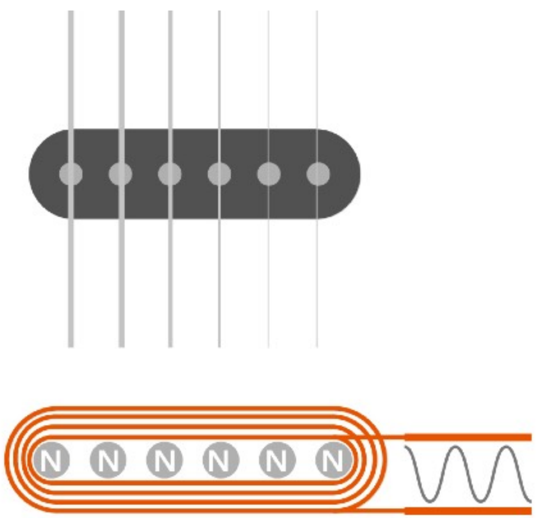


Magnetic pickups

GUITARS and ELECTRIC BASS

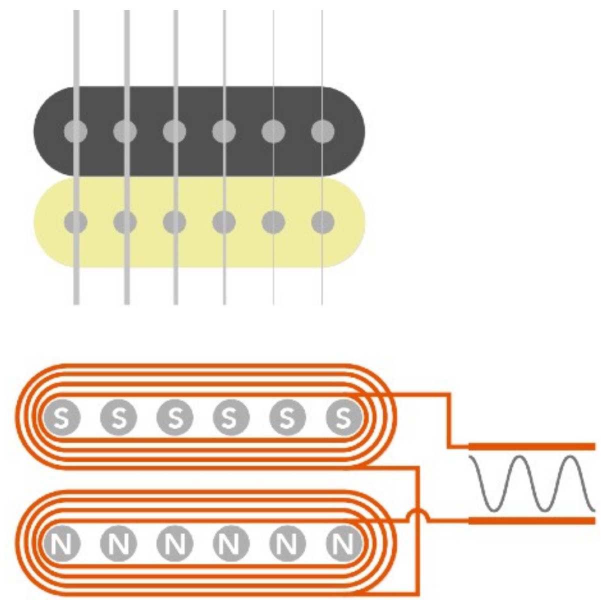
single coil

This pickup uses a single coil of thin wire around magnetic poles. The vibrating string creates a weak signal 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 have dual coils wound and oriented in opposite directions, reducing noise and producing a stronger signal. They offer a fuller sound with richer sustain and more midrange presence compared to single coil pickups.



Magnetic pickups

GUITARS and ELECTRIC BASS

Magnetic pickups

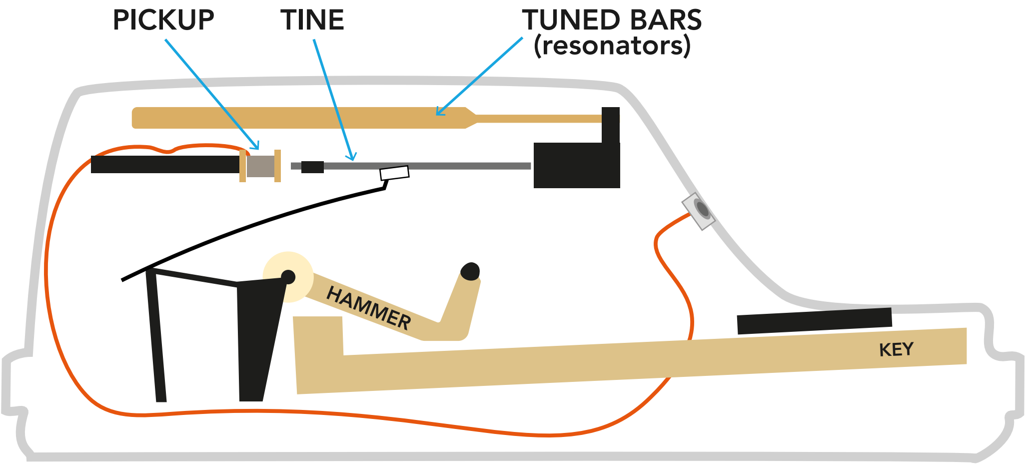
GUITARS and ELECTRIC BASS

The **pickup's distance** from the strings and its position on the instrument affect the tone. Closer pickups provide more volume and high frequencies but less sustain, while pickups further away offer more midrange, less high end, and more sustain

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.

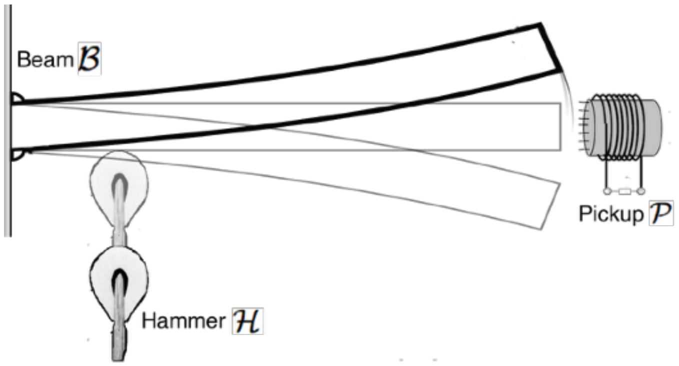
The **amplifier** adjusts the volume and can add distortion, enriching the sound with additional harmonics.



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.