

1 MICROPHONES – ADVANCED USAGE

1.1 PURPOSE AND FUNCTIONS OF MICROPHONES

Microphones are essential transducers in the field of audio engineering. Their primary purpose is to convert sound waves—vibrations in the air—into electrical signals that can be amplified, recorded, or transmitted. They are the first point of contact in the audio signal chain and are used in a wide range of settings including live performances, studio recordings, film productions, broadcasting, and everyday communication devices.

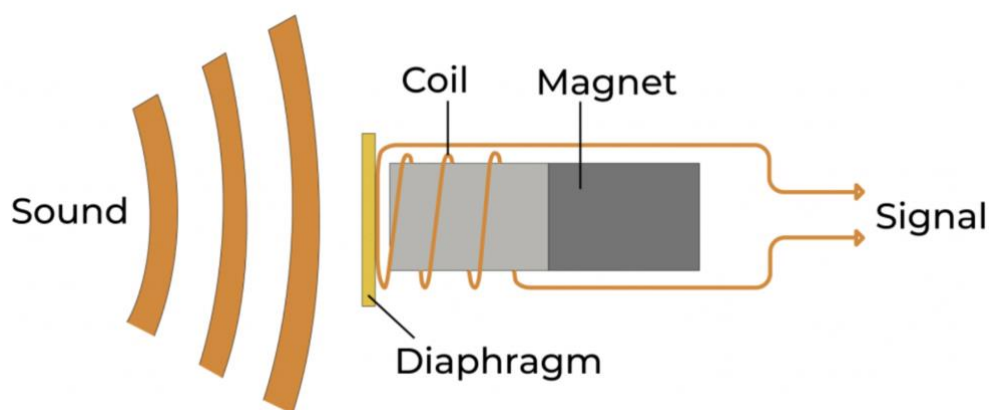
By capturing acoustic energy and translating it into a manageable signal, microphones enable the accurate reproduction, manipulation, and storage of sound. Without microphones, modern audio production would not be possible.

1.2 TYPES OF MICROPHONES: DYNAMIC, CONDENSER, AND RIBBON

1.2.1 Dynamic Microphones



Internal structure of a dynamic microphone.



Dynamic mics have small diaphragms made from a type of polyester (called BoPET).

A copper coil is attached to the diaphragm, and inside that coil is a stationary magnet.

When the diaphragm vibrates in response to a sound wave, it causes the coil to move. That's why it's also sometimes referred to as a 'moving coil' microphone.

And as the coil moves back and forth (oscillates) across the magnet, it builds up an electrical charge. This charge gets sent via the cable, to the audio interface for amplification.

When to use dynamic mics

Dynamic microphones are the least sensitive of the 4 types of microphones. This makes them particularly suitable for:

For loud sounds

Dynamic mics respond well to a reasonably loud and close sound source. In fact recording loud instruments are one of its strengths.

Use a dynamic microphone for high SPL (sound pressure level) instruments such as:

- drums
- guitar amps
- brass instruments

For vocals

Dynamic microphones are versatile, favoured by many vocalists for performing live. And their low sensitivity means these types of microphones are less prone to feedback on stage.

Some singers, particularly from the rock and pop world, love dynamic microphones in the studio too. They can impart a dark gritty character which you'll get from a dynamic mic.

Dark overtones

The frequency range of dynamic mics is well suited to instruments with a strong low to mid presence. They're not so good for trying to capture a delicate top end.

But very bright instruments can respond well to these types of microphones, as they're good at toning down any harshness.

Room acoustics

Dynamic mics are perfect for recording in a room with sub-optimal acoustics. This is because of their low sensitivity, combined with a cardioid pattern.

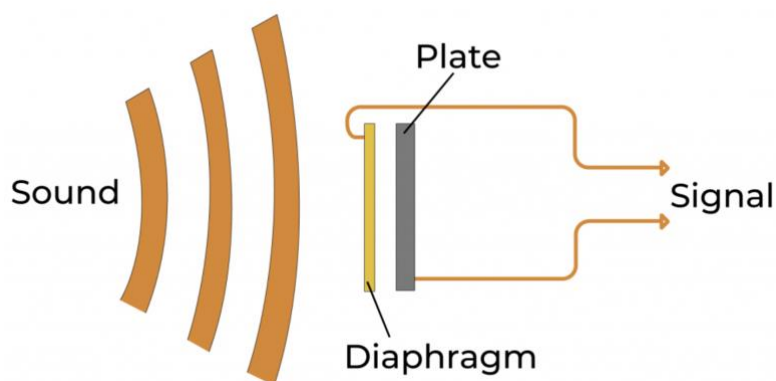
These types of microphones are less likely to pick up the sound of the room, than a condenser, which is much more sensitive.

Dynamic microphones also the best types of mic for a room with background noise, like the hum of traffic, or an AC unit.

1.2.2 Condenser Microphones



Internal structure of a condenser microphone



Similar to dynamic mics, the diaphragm of most condenser microphones are made from the polyester (called BoPET). But in condenser mics, they're lighter, and coated with gold.

Next to the diaphragm is an electrically charged metal plate. Together, they form a 'capacitor'. That's why these types of microphones are sometimes called capacitor mics.

The sound waves cause the diaphragm to vibrate. And the vibration makes it move back and forth from the stationary plate. This creates an electric charge called a 'capacitance'.

The charge enters some circuitry before exiting as an audio signal. This stage requires 48v power, called 'phantom power'. It's normally delivered through the cable, from the audio interface.

When to use a condenser microphone

Condenser mics are the natural choice for the recording studio.

They have very light diaphragms, and respond to the pressure of sound waves with sensitivity and precision. These types of mics can capture everything across the frequency spectrum, including the subtlest details.

This makes them ideal for recording vocals, acoustic guitar and any instrument with detail in the high end. Recordings with condenser microphones have a sense of air and transparency.

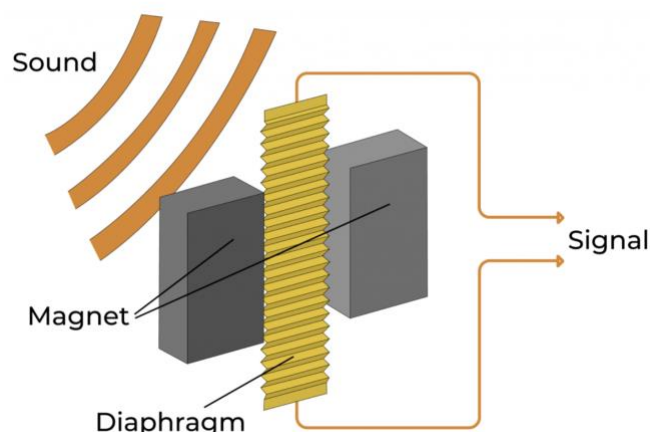
Room acoustics

Condenser microphones pick up every detail, including the size and shape of the room. This could pose a problem if your room hasn't been acoustically treated.

If this is the case, it might be better to go for a high quality dynamic mic instead. These types of microphones are less sensitive. They're also less likely to pick up any extraneous noises.

1.2.3 Ribbon Microphones

Internal structure of a ribbon microphone



The ribbon mic works on the same electromagnetic principle as a dynamic mic. But it uses a very delicate strip of corrugated aluminium (or film), instead of a moving coil.

This 'ribbon' is extremely sensitive to the velocity of air particles. Its subtle movements create a minute electrical signal, which is fed to a transformer for bolstering.

The output from ribbon mics is generally very low. But some modern ribbon mics also include a preamp stage to amplify the output. They're called active ribbon mics, and need phantom power.

They generally exhibit a bidirectional (figure-8) polar pattern and are best used in controlled studio environments. Due to their fragile nature, they must be handled with care and are not typically suited for high-SPL sources without proper precautions.

1.3 Microphone polar patterns

The polar pattern of a microphone describes how the mic picks up sound. Some mics pick up sound from the front, some from the sides. And others pick up sound from everywhere, no matter where you place the mic.

Each microphone polar pattern has its pros and cons, depending on what you're recording, where you're recording it, and the sound you're after.

1.3.1 Cardioid

This is the heart shaped polar pattern you'll find on most microphones.



Most live vocal mics are cardioids, or variations of cardioids. This is because a cardioid mic only records what it's pointing at. It will leave out anything coming from the sides and the back.

For live use, a cardioid mic will minimise sound from the stage monitors and nearby instruments. It's also pretty good at stopping feedback.

In the recording studio, cardioid mics also have their uses. Because the mic only picks up sound from the front of the mic, it's less likely to pick up the sound of the room.

Cardioid polar patterns are suitable for:

- Recording whatever you point your mic at
- Noisy environments, fan noise, traffic noise
- Rooms without acoustic treatment
- Isolating from other instruments while recording live
- Reducing feedback from stage monitors during performance

Some examples of cardioid mics:

- Shure SM58: Possibly the most famous mic of all time, the SM58 is a dynamic mic with a cardioid pattern.
- AKG C451 B: A bright small diaphragm condenser mic which creates larger than life, sparkling guitar recordings
- Sennheiser E935

- This is a popular cardioid mic for live singers. It has a brighter sound than the SM58.
- Rode NT1 :A good value, entry level large diaphragm condenser mic
- Shure KSM9: A great sounding condenser mic for both studio and live use. It also switches to supercardioid pattern when needed.

1.3.2 Supercardioid

The super-cardioid is a more focused version of the cardioid mic.

The supercardioid polar pattern rejects even more of the sides, leaving a narrower recording area at the front. But watch out – it also picks up a tiny amount from behind the mic.



A supercardioid mic is a popular choice for live vocals, because it does a great job of isolating whatever's in front of the mic – even more so than a cardioid. But be careful if you're more used to a cardioid.

Your sound can suddenly vanish while using a supercardioid if you don't stay right on the mic. Whereas a cardioid is more forgiving when you move to the side of the mic, or stray from the on-axis position.

Supercardioid polar patterns are suitable for:

- Hyper targeting the sound in front of the mic
- Noisy environments, fan noise, traffic noise
- Rooms with poor acoustic treatment
- Pronounced isolation from other instruments while recording live
- Eliminating feedback from stage monitors during performance

Some examples of super-cardioid mics:

- Shure Beta 58A: The upgrade to Shure's SM58 with an extended frequency range and brighter sound.
- Sennheiser E945: A dynamic mic, well suited to stage use.
- Telefunken M80: A classic looking retro dynamic mic with a supercardioid polar pattern. Great for vocals and snare drums.

1.3.3 Bidirectional (figure of 8)

The Figure of 8 polar pattern is also called bidirectional, as it picks up sound from two directions.



It will record sound equally from the front and back of the microphone, and reject sound from the sides.

This is the classic polar pattern for recording 2 singers – one behind the mic, and one in front. Both singers can then face each other to keep in perfect sync.

The bidirectional polar pattern works well for recording a vocalist who plays their own guitar. One end of the mic points towards the singer's mouth area, the other end towards the guitar.

Figure of 8 is the natural and standard polar pattern for traditional ribbon mics. If you do want to invest in a ribbon mic, bear in mind they have low output signals, and it's often a good idea to find a matched amplifier to go with it.

Figure 8 mics can be used for some pretty advanced stereo techniques too, such as mid/side and Blumlein.

They're also natural choices for many radio presenters because they respond so well to the proximity effect. That is, the closer you speak into the mic, the more the bass is boosted. It's how male presenters get that really deep and rich, 'larger than life' sound.

Bidirectional polar patterns are suitable for:

- backing singers, face to face
- Recording a vocalist with their own acoustic guitar
- Combining with other mics for stereo recording
- Boosting the bass in close proximity

Some examples of figure 8/bidirectional mics:

Royer Labs R-121 ribbon mic: A classy modern designed ribbon mic with a lot of uses in the studio. Used for recording brass, wind instruments and string instruments, as well as vocals and guitar. It's often paired with a Shure SM57 for recording electric guitars.

Coles 4038 ribbon mic: A classic ribbon mic with a long history and pedigree at the BBC. It has a distinctive dark sound, great for warming up brass instruments, guitars and drums.

AKG C411 condenser mic: This is a tiny contact mic with a bidirectional polar pattern. You can fix it to a guitar or violin for amplifying on stage.

1.3.4 Hypercardioid

The hyper-cardioid lies somewhere in between the cardioid and the figure of 8 polar patterns.



It's an extremely directional polar pattern, picking up sound from the front, but also partly from the back. Sound is effectively rejected from both sides.

The hypercardioid isn't the ideal polar pattern for use on stage because of that rear lobe, which could pick up sound from stage monitors, or other performers. But if you're using one in the studio, you could position some sound absorption behind the mic to effectively reduce sound getting in.

It's not the first choice for singers either, as it's quite sensitive to picking up plosives – those little bursts of air from the voice which can ruin a recording.

You'd use a hypercardioid polar pattern where you need extreme isolation. An engineer will use it to hone in on a particular sound source, or in a creative placement, such as inside a drum kit.

Hypercardioid polar patterns are good for:

- Extreme isolation from other instruments while recording live
- Exact targeting of sound sources
- Very effective rejection of unwanted noise from the sides
- Placed on a boom for location and TV recording
- Placed on a camera or DSLR to pick up sound from the subject as well as the camera operator's voice

Some examples of hypercardioid mics:

- Neumann KM185 condenser mic
A very accurate and transparent small diaphragm condenser mic, used for recording a wide range of acoustic instruments, such as piano, acoustic guitar, drums and orchestral.
- Audix D4 dynamic mic
A specialised mic, just for floor toms and kick drums.
- Audio-Technica AT4053B condenser
A high quality small diaphragm condenser mic, which sounds great with spoken word and indoor film dialogue.

1.3.5 Lobar (shotgun)

Lobar is the polar pattern for shotgun microphones. The lobar microphone can pinpoint a sound source with laser like clarity.



It's a great polar pattern for recording from a distance too.

Technically, the lobar is similar in construction to a hyper-cardioid mic, but with the addition of an interference tube, to really narrow down the focus to a pinpoint.

Lobar mics, or shotgun mics are used extensively in film studios. They can be kept just out of shot, attached to a handheld boom pole. Boom operators get really skilled at keeping the mic pointing directly at the actor as they move around.

With a highly directional pattern, you have to make sure to point the mic exactly at the sound source. If it's just slightly off axis, the sound quality can be noticeably quieter and of poorer quality.

Lobar/shotgun mics can also be used on top of cameras and DSLRS, to pick up dialogue from the talent. This is the type of polar pattern to use to get great sound on your YouTube videos.

Most lobar or shotguns are condenser mics, so they'll need power – either from an internal battery, or from external phantom power.

The lobar polar patterns are suitable for:

- Recording in a noisy, crowded environment
- Recording dialogue for film and TV
- Mounted on a camera or DSLR for self-filming

Some examples of shotgun mics:

Rode NTG2

Use this short shotgun mic with your DSLR camera for a huge improvement on the camera's internal microphone.

Rode NTG3 condenser mic

If you have the budget, stretch to one of these for your camera for superb full range sound. It's also great for film work, overdubs and foley.

Rode VideoMic NTG condenser mic

This is a mini shotgun in its own cradle. It's the perfect size for a DSLR, and mounts in the camera's cold shoe attachment. A great option if you need a compact filming setup with good sound.

Sennheiser MKH 416

A premium shotgun microphone which you can use in a variety of situations. It delivers top quality sound, and is also very effective as a voiceover mic.

1.3.6 Omnidirectional

An omnidirectional polar pattern receives sound from all directions. It doesn't matter where you point the microphone.



These types of microphones are great for producing an open, natural sound.

But watch out – an omnidirectional polar pattern will also pick up the full acoustics of the room. This is perfect if you're recording in an old chapel, or a beautifully treated studio, like Abby Roads.

It's the same for live and stage use. An 'omni' mic will pick up all of the surrounding instruments, the stage monitors, even the audience. And it will be prone to feedback.

The omnidirectional polar pattern is used in a broad range of microphone types, for many different uses. Clip-on lavaliers, mics for PCs and laptops, reporting, podcasts, field and ambient recordings.

Omnidirectional polar patterns are good for:

- Acoustically treated environments
- Acoustically beautiful environments
- An open, natural sound
- Outdoor field recording

Some examples of omnidirectional mics:

Sennheiser MD42

A dynamic mic with high quality sound, used mainly for reporting in radio and TV. It's well suited to outdoor use, handling wind noise well.

Audio-Technica AT 4022

A high quality studio mic for recording instruments with natural and clear sound. Sounds fantastic on an acoustic guitar.

Blue Yeti USB mic

A very popular omni mic for using with a PC. Great for voiceovers, gaming and recording podcasts.

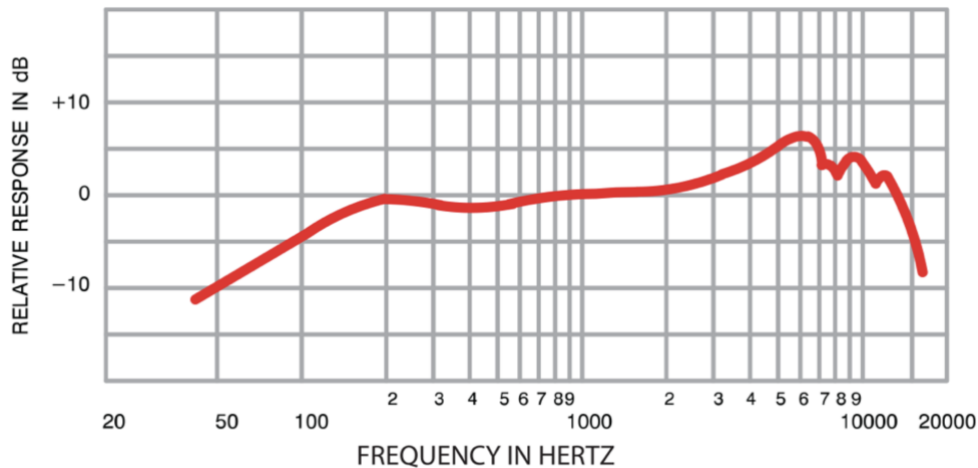
Rode Lavalier Go

A popular budget clip-on mic with a miniature condenser capsule. Keep one of these around to use with your DSLR camera or notebook. You can also turn it into a wireless system.

1.4 MICROPHONE FREQUENCY RESPONSE

Frequency response refers to the way a microphone responds to different frequencies. It is a characteristic of all microphones that some frequencies are exaggerated and others are attenuated (reduced). For example, a frequency response which favors high frequencies means that the resulting audio output will sound more trebly than the original sound.

A microphone's frequency response pattern is shown using a chart like the one below and referred to as a frequency response curve. The x axis shows frequency in Hertz, the y axis shows response in decibels. A higher value means that frequency will be exaggerated, a lower value means the frequency is attenuated

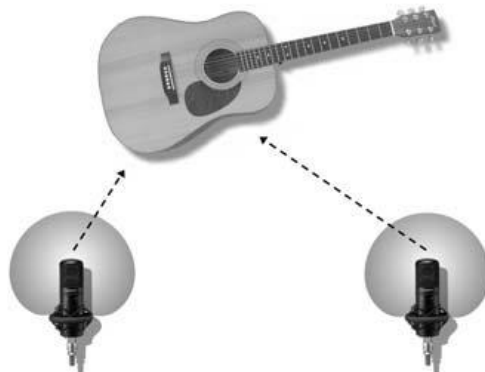


1.5 STEREO MICROPHONE PLACEMENT

Microphone placement is crucial, as is the way that multiple mics will be placed together in order to create an overall sonic image. Individual microphones may be placed where they will pick up the strongest sound of the instrument being captured, but multiple microphones (usually two for a stereo image) must be positioned while taking into consideration phase and contribution to the overall image.

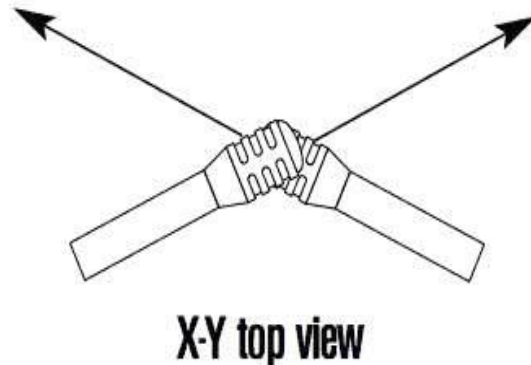
1.5.1 Spaced Pair

Spaced microphones (Figure below) can be placed in front of an instrument or ensemble (in a left/right fashion) to obtain an overall stereo image. This technique places the two mics (of the same type, manufacturer, and model) anywhere from only a few feet to more than 30 feet apart



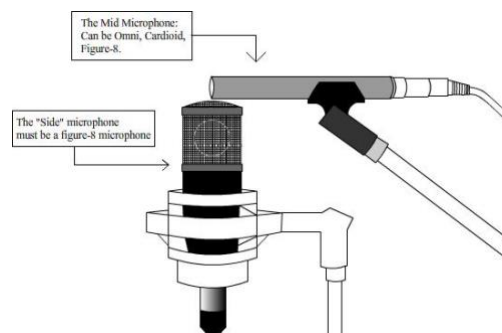
1.5.2 X/Y positioning

It involves placing two matched microphones across each other at 90 degree angles, with their capsules kept close to avoid “holes” in the sound. Stereo microphones actually consist of two mics that are already connected.



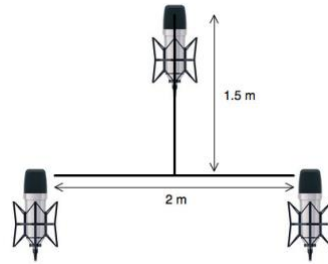
1.5.3 MS Stereo

Using a combination of a cardioid and figure-8 pattern, it is possible to create a very nice stereo image using a technique called “MS” (middle, side).



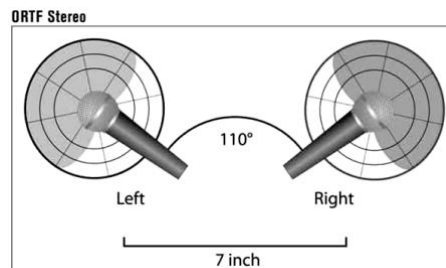
You basically set up the mics in the same vertical axis (close together). Aim the figure 8 so that it captures the sides, and the cardioid so it captures the front. Then send the cardioid to both tracks, the figure-8 to the left track, and the figure-8 (out of phase) to the right track. The stereo field will vary with the proportion between the two mics.

Decca tree



A variation of the spaced pair is the Decca Tree, which is essentially a spaced pair with a center mic connected to a custom stand and suspended over the conductor. It is still in used in film scoring/classical orchestral and opera recording as it produces a very spacious stereo image with good localization.

1.5.4 Near-coincident pair



The most common example of the near-coincident method is the ORTF system, which uses two cardioids angled 110 degrees apart and spaced seven inches (17 cm) apart horizontally.

This method tends to provide accurate localization; that is, instruments at the sides of the orchestra are reproduced at or very near the speakers, and instruments halfway to one side tend to be reproduced halfway to one side.

ORTF provides a much greater sense of space, due to time/phase differences, because the capsules are as far apart as your ears