

How Do Microphones Work?

The Basics

Microphones are a type of *transducer* - a device which converts energy from one form to another. Microphones convert acoustical energy (sound waves) into electrical energy (the audio signal).

Different types of microphone have different ways of converting energy but they all share one thing in common: The *diaphragm*. This is a thin piece of material (such as paper, plastic or aluminium) which vibrates when it is struck by sound waves. In a typical hand-held mic like the one below, the diaphragm is located in the head of the microphone.



When the diaphragm vibrates, it causes other components in the microphone to vibrate. These vibrations are converted into an electrical current which becomes the audio signal.

Note: At the other end of the audio chain, the loudspeaker is also a transducer - it converts the electrical energy back into acoustical energy.

Types of Microphone

There are a number of different types of microphone in common use. The differences can be divided into two areas:

(1) The type of conversion technology they use

This refers to the technical method the mic uses to convert sound into electricity. The most common technologies are *dynamic*, *condenser*, *ribbon* and *crystal*. Each has advantages and disadvantages, and each is generally more suited to certain types of application. The following pages will provide details.

(2) The type of application they are designed for

Some mics are designed for general use and can be used effectively in many different situations. Others are very specialised and are only really useful for their intended purpose. Characteristics to look for include directional properties, frequency response and impedance (more on these later).

Mic Level & Line Level

The electrical current generated by a microphone is very small. Referred to as *mic level*, this signal is typically measured in millivolts. Before it can be used for anything serious the signal needs to be amplified, usually to *line level* (typically 0.5 -2V). Being a stronger and more robust signal, line level is the standard signal strength used by audio processing equipment and common domestic equipment such as CD players, tape machines, VCRs, etc.

This amplification is achieved in one or more of the following ways:

- Some microphones have tiny built-in amplifiers which boost the signal to a high mic level or line level.
- The mic can be fed through a small boosting amplifier, often called a *line amp*.
- Sound mixers have small amplifiers in each channel. Attenuators can accommodate mics of varying levels and adjust them all to an even line level.
- The audio signal is fed to a power amplifier - a specialised amp which boosts the signal enough to be fed to loudspeakers.

Directional Properties

Every microphone has a property known as *directionality*. This describes the microphone's sensitivity to sound from various directions. Some microphones pick up sound equally from all directions, others pick up sound only from one direction or a particular combination of directions. The types of directionality are divided into three main categories:

1. Omnidirectional

Picks up sound evenly from all directions (omni means "all" or "every").

2. Unidirectional

Picks up sound predominantly from one direction. This includes cardioid and hypercardioid microphones (see below).

3. Bidirectional

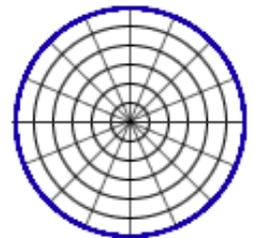
Picks up sound from two opposite directions.

To help understand a the directional properties of a particular microphone, user manuals and promotional material often include a graphical representation of the microphone's directionality. This graph is called a *polar pattern*. Some typical examples are shown below.

Omnidirectional

Captures sound equally from all directions.

Uses: Capturing ambient noise; Situations where sound is coming from many directions; Situations where the mic position must remain fixed while the sound source is moving.



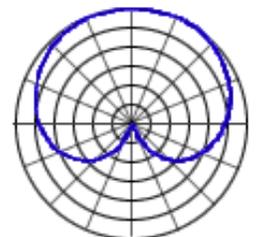
Notes:

- Although omnidirectional mics are very useful in the right situation, picking up sound from every direction is not usually what you need. Omni sound is very general and unfocused - if you are trying to capture sound from a particular subject or area it is likely to be overwhelmed by other noise.

Cardioid

Cardioid means "heart-shaped", which is the type of pick-up pattern these mics use. Sound is picked up mostly from the front, but to a lesser extent the sides as well.

Uses: Emphasising sound from the direction the mic is pointed whilst leaving some latitude for mic movement and ambient noise.



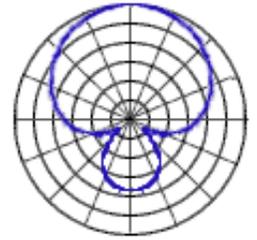
Notes:

- The cardioid is a very versatile microphone, ideal for general use. Handheld mics are usually cardioid.

- There are many variations of the cardioid pattern (such as the hypercardioid below).

Hypercardioid

This is exaggerated version of the cardioid pattern. It is very directional and eliminates most sound from the sides and rear. Due to the long thin design of hypercardioids, they are often referred to as shotgun microphones.



Uses: Isolating the sound from a subject or direction when there is a lot of ambient noise; Picking up sound from a subject at a distance.

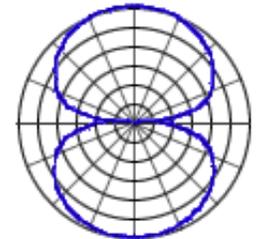
Notes:

- By removing all the ambient noise, unidirectional sound can sometimes be a little unnatural. It may help to add a discreet audio bed from another mic (i.e. constant background noise at a low level).
- You need to be careful to keep the sound consistent. If the mic doesn't stay pointed at the subject you will lose the audio.
- Shotguns can have an area of increased sensitivity directly to the rear.

Bidirectional

Uses a figure-of-eight pattern and picks up sound equally from two opposite directions.

Uses: As you can imagine, there aren't a lot of situations which require this polar pattern. One possibility would be an interview with two people facing each other (with the mic between them).



Variable Directionality

Some microphones allow you to vary the directional characteristics by selecting omni, cardioid or shotgun patterns.

This feature is sometimes found on video camera microphones, with the idea that you can adjust the directionality to suit the angle of zoom, e.g. have a shotgun mic for long zooms. Some models can even automatically follow the lens zoom angle so the directionality changes from cardioid to shotgun as you zoom in.

Although this seems like a good idea (and can sometimes be handy), variable zoom microphones don't perform particularly well and they often make a noise while zooming. Using different mics will usually produce better results.

How to Position a Microphone

Distance

The golden rule of microphone placement is **get the distance right**. In general, place the microphone as close as practical to the sound source without getting so close that you introduce unwanted effects (see below).

The aim is to achieve a good balance between the subject sound and the ambient noise. In most cases you want the subject sound to be the clear focus, filled out with a moderate or low level of ambient noise. The desired balance will vary depending on the situation and the required effect. For example, interviews usually work best with very low ambient noise. However if you want to point out to your audience that the surroundings are very noisy you could hold the mic slightly further away from the subject.

It is possible to get *too* close. Some examples:

- If a vocal mic is too close to the speaker's mouth, the audio may be unnaturally bassy (boomy, excessive low frequencies). You are also likely to experience popping and other unpleasant noises.
- A microphone too close to a very loud sound source is likely to cause distortion.
- Placing a mic too close to moving parts or other obstacles may be dangerous. For example, be careful when micing drums that the drummer isn't going to hit the mic.

Phase Problems

When using more than one microphone you need to be wary of *phasing*, or *cancellation*. Due to the way sound waves interfere with each other, problems can occur when the same sound source is picked up from different mics placed at slightly different distances. A common example is an interview situation in which two people each have a hand-held mic - when one person talks they are picked up by both mics and the resulting interference creates a phasing effect.

Think Laterally

You don't always have to conform to standard ways of doing things. As long as you're not placing a microphone in danger there's no reason not to use them in unusual positions. For example, lavalier mics can be very versatile due to their small size - they can be placed in positions which would be unrealistic for larger mics.

Examples



Guitar amps are miced very closely. This helps keep the sound isolated from the rest of the stage noise. Theoretically the amp will not create any level burst strong enough to distort the microphone.



Snare drum mics need to be close to the skin without getting in the way of the drummer or risking damage.

Boom Microphone

The boom microphone is very popular in film and television production. A directional mic is mounted on a boom arm and positioned just out of camera frame, as shown on the right. The cable is wrapped once or twice around the boom arm.

Booms have the advantage of freeing up subjects from having to worry about microphones. They can move freely without disturbing the sound, and concerns about microphone technique are eliminated.

You can make a simple boom from just about anything which is the right shape. A microphone stand with its legs removed is a good option, or even a broomstick or fishing pole.

A good boom will have some sort of isolating mechanism for the microphone to prevent vibrations being transferred to the mic. This may involve elastic suspensions, foam padding, etc.



The distance between the microphone and subject must be carefully controlled. The mic must be as close as possible without any chance of getting in frame (you might want to allow a safety margin in case the framing changes unexpectedly). It must also maintain a reasonably consistent distance to avoid fluctuating audio levels.

Make sure the boom doesn't cast a shadow on the scene.

In the example on the right, the sound operator is also acting as a guide for the camera operator as they walk backwards, keeping a constant distance from the walking subjects.

Hand-held Microphones



The term "hand-mic" generally means any microphone held in the hand and used to pick up human speech. Hand-mics are used in a huge variety of settings, from musical performances to television interviews. When you say "microphone", most people picture a hand-mic. Everyone knows what they are and what they do, and everyone thinks they know how to use them. Sadly, this is not the case.

Although there is a knack to using the hand-mic properly, it's really not difficult to learn. Perhaps that's why it's so frustrating to see people get it wrong - because it's so easy to get it right.

Listed below are some general rules of microphone technique. We've used the example of a television presenter conducting an interview, but these rules can be applied to most situations.

- Be aware of what type of mic you're using. In particular, you should know about its **directional characteristics**.
- Make sure you do a sound check yourself, well before the interview. Position yourself and the microphone, and speak exactly as you intend to during the interview.
- If the mic has an on/off switch, keep an eye on it. If the mic is battery-powered, make sure you turn it off when you've finished.
- Hold the microphone firmly. Remember that the mic will pick up any handling noise so be careful not to move your hand around on the mic casing, or bump the mic into anything.
- If you're exposed to the wind, try and give the mic some shelter.
- Hold the mic at a constant distance and angle from your mouth (or your subject's mouth). Around 15-20cm from the mouth should be fine.

Any more than this, and not only will the voice become weak, but other noises will become more prominent.

Any closer than this, and you'll get various unpleasant sound effects (such as "popping"). (Note that musicians have a special set of rules for mic distance. Most vocalists hold their mics fairly close to their mouths.)

- Always direct the mic towards the person who's talking. You can also use mic-pointing to direct your subjects. When you point it at yourself, you're talking. When you point it at the subject, you're saying "Now it's your turn to talk". If you have more than one subject, you can use the mic to point toward the person you want to speak.
- Never give the mic away during an interview. It's not uncommon for a subject to want to hold the mic, but don't let them. It creates all sort of problems and it's just not worth it.

If you want to see some good examples of microphone technique, watch television talk-show hosts moving around their audiences. These people know how to use their microphones - not just as technical instruments, but as a means of maintaining control.

Microphone Stands, Mounts & Clamps

An important consideration is the way the microphone is held or mounted. A poorly mounted mic can lead to all sorts of problems, whereas a well-mounted mic can lift the audio quality significantly. Things to consider when mounting a mic include:

- The mic obviously needs to be correctly positioned, facing the required direction. You should be able to reposition the mic if necessary.
- The mic must be safe, i.e. Won't fall over, get knocked, get wet, etc.
- The mic must be shielded from unwanted noise such as handling noise, vibrations, wind, etc.
- Cables must be secure and safe. In particular, make sure no one can trip over them.

There are many ways to mount microphones. Let's look at the most common methods...

Microphone Stands

The most obvious mount is the microphone stand. There are three main variations: The straight vertical stand, the boom stand and the small table-top stand.

Boom stands are very useful and versatile. If you are considering buying a general-purpose stand, a boom stand is the logical choice.

Some things to watch out for when setting up a microphone stand:

- Always position the boom to extend directly above one of the stand legs. This prevents the stand from tipping over.
- Don't wrap the lead a hundred times around the stand. This serves no purpose except make your life difficult and possibly increase twisting pressure on the lead. One turn around the vertical part of the stand and another turn around the boom is all you need.
- Never stand on the legs. You will wreck them.
- Never over-tighten clamps. Do them up until until they are firm - no more. Don't try to adjust clamps while they are tightened - undo them first.

Note: Boom arms controlled by sound operators will be covered on the [next page](#).

Clamps

Instead of using a dedicated mic stand, you can use a specialised clamp to piggyback on another stand (or any other object).



Boom Stand



Tabletop Stand

Advantages:

- Less floor space is used, more mics can be squeezed into the same area.
- Less equipment to carry (clamps are smaller and lighter than stands).
- Can sometimes be useful reaching difficult positions.

Disadvantages:

- Can sometimes be tricky to set up and more difficult to get exactly the right positioning. Also more difficult to move or adjust once set up.
- More likelihood of unwanted vibration noise creeping into the mix.

Clamps are often used in musical situations where there are many stands and many microphones. The classic example is the drum kit which is surrounded by cymbal stands - clamps are well suited to this application.

Clothing Clip

Lavalier (lapel or lap) mics are usually attached to the subject's clothing using a specialised clip. Obviously the preferred position is on the lapel or thereabouts. This provides consistent close-range sound pickup and is ideal for interview situations in which each participant has their own mic. It also means the subject doesn't have to worry about mic technique.



If you have time, discreetly hide the cable in the clothing. If there is nowhere to place the mic on the subject's chest, try the collar.

Headset

A headset with its own mic works well in situations such as:

- When the person talking needs to listen as well as speak.
- When the person talking must be able to move around with their hands free.
- When there is a lot of background noise, likely to be distracting the the subject.

Headsets are ideal for stage performers, as well as sports commentators, radio announcers, etc. Like lav mics, they provide very consistent audio.

Shock Absorption

In order to minimise unwanted noise caused by vibration of the stand or mount, a shock absorption system may be used. This isolates the mic from the vibrations, usually with foam padding or elastic suspension.