

# Microphones and Speakers

After completing this lesson, the student should be familiar with the following concepts:

- Sound waves can be represented by voltage fluctuations.
- Microphones can be used to convert sound waves into a representative voltage.
- A microphone's output must be preamplified before it can be used with other studio equipment.
- Speakers can change electrically represented sounds back into sound waves.
- Signals must be amplified by an amplifier before being sent to speakers so that there is enough energy in the signal to make the speakers work.
- A PA system is comprised of four basic components: a microphone, a preamplifier, an amplifier, and a speaker.

## Glossary for this Lesson:

**Amplifier** - A device which increases the amplitude of a signal by adding energy to it. In acoustic terms, this means increasing the volume of the sound. Signals must be amplified so that they will have enough energy to move a speaker cone back and forth, creating sound waves from sounds represented varying voltage. Amplifiers can be built into speakers or can be discreet components. A simple example of an amplifier is the tuner unit of most home stereo systems.

**Diaphragm** - A thin, internal part of a microphone which is moved slightly when sound waves impact it. This is the part of a microphone which actually gathers sound waves from the air. Diaphragms are usually made of a metal alloy such as neodymium in cheaper microphones, while more expensive models use foils made from precious metals such as gold.

**Line Level** - A signal is said to be line level when it is put out at a level of -10 dBu. The outputs you find on the back of your CD player operate at this level, as do most professional synthesizers. Some higher-level pro equipment operates at +4 dBu. Examples of signals which are not line level include the raw output of microphones, electric guitars with passive circuitry, and the outputs of amplifiers. (Amplifiers add so much energy to a signal that their output is typically far above line level.)

**Mic Cable** - A cord with 3 conductors which has a male XLR connector on one end, and a female XLR connector on the other end. Mic cables are typically used to connect mics to mic preamps, but can be in other places as well.

**Microphone** - (mic) A transducer which is capable of producing a tiny voltage which changes constantly in response to sound waves which impact its diaphragm. The simplest microphones accomplish this through the use of an inductance coil attached to the diaphragm, while other, more expensive (and sensitive) designs utilize a metal diaphragm as a charged capacitance plate. The later design actually requires power from the mixer called phantom power. Phantom power is typically +48 VDC, but many mics can operate from a standard 9 volt battery.

**PA System** - (Public Address System) A system which includes a microphone, a mic preamp, an amplifier and one or more speakers used to amplify the sound of someone's voice. PA systems are common at large sporting events, churches, and larger stores.

**Preamplifier** - (preamp, mic preamp, mic pre) A device used to add energy to the output of a microphone. (Preamps can be used on other devices such as guitars, phonographs, etc., but this chapter deals exclusively with their use with microphones.) Preamplifiers are commonly found integrated into mixers, where their presence can be easily detected by looking for XLR connectors and gain knobs on the mixer's channels. Preamps are also made as discreet units, usually packaged in rack mountable boxes. While most fall into the \$100-500 price range per channel, specialized or esoteric mic pres can easily run into several thousand dollars per channel.

**Speaker** - A transducer used to convert electronic representations of sound waves into sound waves moving through the air. Simple designs incorporate an electromagnet which moves a paper cone housed in a tuned wooden enclosure to disturb air molecules, thus creating sound waves. Some more sophisticated designs utilize both a moving coil design with a piezo driver element. The moving coil produces lower frequency sounds while the piezo 'driver' produces higher frequencies.

**XLR Connector** - (Exchanging Line Receptacle Connector.) A circular 3-pin connector which carries two copies of a signal, each 180 degrees out of phase. At the receiving end of a cable, a summing stage cancels any noise the cable might have picked up. This balanced system allows much longer cable runs without fear of induced hum or other noise. Almost all microphones have XLR connectors, and many high-end audio devices use them as well.

### **HELP YOUR STUDENT REVIEW**

Time for a field trip. Visit a local music store which deals pro gear. Spend a little time looking at some real microphones, speakers, and mixers. Although salespeople can sometimes be impatient with children, some of them are kind enough to realize that if they can hook kids on music technology, they will continue to have a customer base in the future. (Music technology can be horribly addictive!)

Try to pick an 'off' time of the day to visit your music store. Salespeople are more likely to answer your questions if there aren't 40 other customers waiting for them. Avoid weekends, and afternoons. Mid week mornings seem to be a great time for these visits!

# Microphones and Speakers

## MEET MR. MICROPHONE

In a recording studio, we work with sound. Almost all of the devices in a modern studio can only work with sounds that are represented in electrical form. One of the most important devices in a studio is a **microphone**. Think of a microphone as a device which takes sound waves traveling through the air and converts them into a tiny electrical signal.

Our ears cannot hear sounds when they are represented by electricity, so we need a device that can turn electrical signals back into sound waves. This device is called a **speaker**. In this lesson, we will learn a little bit about speakers and microphones.

Microphones or **mics** come in all shapes and sizes, but the most common microphones are called **hand-held microphones**. A hand-held microphone is just a microphone that was designed for you to hold it in your hand while talking or singing into it. You can see a hand-held microphone in the center of this page.



Of course, we have to connect the microphone to something if we want it to do anything. A cable with XLR connectors must be used to connect the microphone to another device. This cable is called a **mic cable**. When you plug a mic cable into a

microphone, it clicks and

locks in place. This is so that no one will accidentally pull the cable out of the microphone while someone is trying

to sing. This can happen sometimes when a singer is walking around with a microphone on stage. To unplug an XLR cable, you have to first push and hold the tiny button on the cable, then pull the connector out. Otherwise, the connector will not come out of the jack on the microphone.

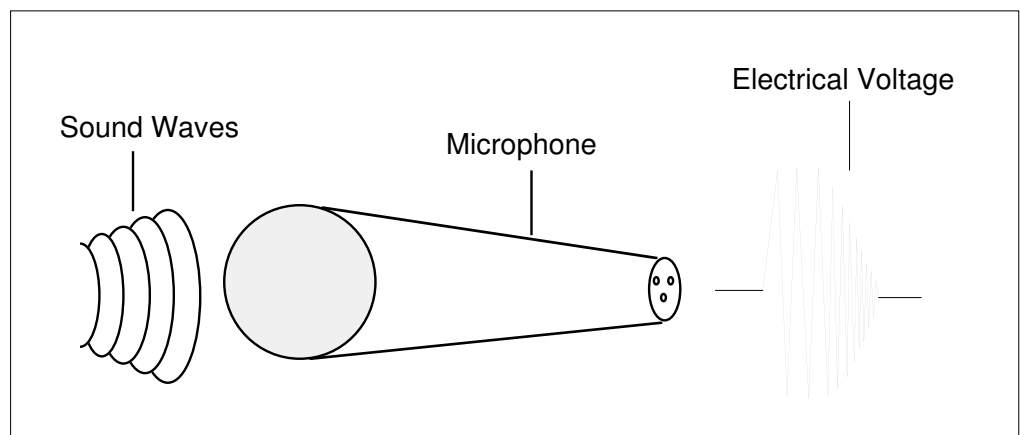


## USING PREAMPS

The voltage that a microphone produces is so small that it cannot be connected to the kind of mixer we learned about in the last lesson. It has to go to a different device called a **preamplifier** first. The preamplifier performs a simple job: it raises the level of the mic's output to **line level**. (This is basically like turning up the volume.) Line level is the level of voltages a mixer can deal with. A microphone preamplifier can look like a box with some knobs, or it can be part of a mixer. Many mixers

## HOW DOES A MICROPHONE WORK?

The way a microphone works is a little too complex for these lessons, but what you really need to know is that when sound waves hit the top of the microphone (called the **diaphragm**), a tiny amount of electrical voltage comes out a special 3-pin connector at the back of the microphone. This connector is called an **XLR connector**, and most microphones use them. (You can see one near the right side of this page.) When sound waves hit the diaphragm of a microphone, the microphone puts out a tiny amount of voltage which represents the sound that came in.



have mic preamplifiers on some or all of their channels. You can usually tell if a mixer has mic preamps on it if it has XLR jacks as inputs on some of its channels. Because some mics need more preamplification than others, mic preamps usually have a knob that allows you to set how much gain you want to add to the mic's signal.

## SPEAK TO ME

At some point, we need to convert these electronic signals back into sound waves so that we can actually hear them. **Speakers** are the devices used to change sounds from an electrical form back into sound waves we can hear. You might think of speakers as the opposite of microphones. Mics change sound waves into an electrical form (which we can't hear), while speakers change sounds in electrical form back into sound waves.

The electrical signal coming out of the left and right output jacks on a mixer aren't strong enough to make a speaker work. We need to use a device which adds energy to the signals coming from the mixer. An **amplifier** or **amp** is the device which adds the energy to the signals to make them strong enough to make the speakers work. We need one amplifier for each speaker.

Amplifiers can be a separate black box with a gain knob to set the volume of the speakers, or they can actually be built right into the speakers. Most amplifiers which are separate units actually have two amplifiers in them: one for the right speaker, and one for the left speaker. There are several ways you can tell if a speaker has an amplifier built into it. Speakers by themselves are pretty light (they are filled only with air). Speakers that have amps built into them are heavier. Speakers that have amplifiers built into them usually also have small lights on them that turn on when they are plugged into the wall. (Speakers without amplifiers

don't have to be plugged in to the wall. You just have to connect them to an amplifier.)

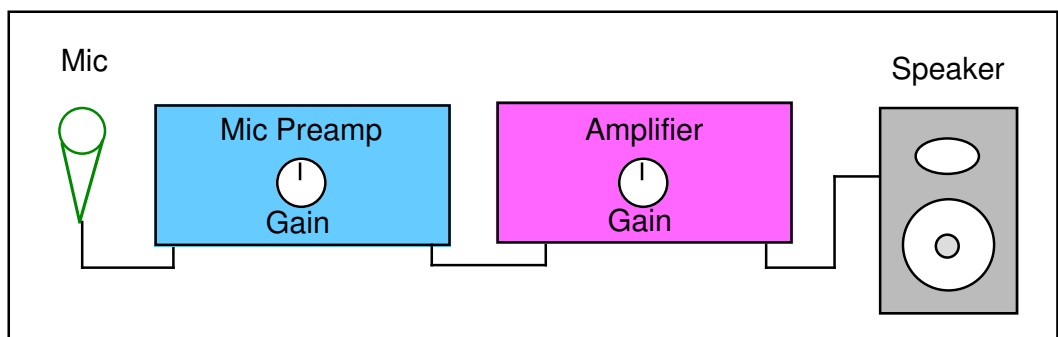
## PUTTING IT ALL TOGETHER

In this lesson, we have learned about microphones, mic preamps, amplifiers, and speakers. These are the four main ingredients in a **PA System**. PA stands for public address. A PA system is equipment set up so that a large audience can hear someone's voice. When you go to a concert in a large arena, everyone can hear the singer's voice because it is going through a PA system.

To create a simple PA system, we have to connect a microphone to a mic preamp using a mic cable. The preamp is connected to the amplifier, which is connected to a speaker. You can see the whole setup at the bottom of this page.

The output of the microphone is connected to the input of the mic preamp. The output of the mic preamp is connected to the input of the amplifier, and the output of the amplifier is connected to the input on the speaker. When someone speaks or sings into the microphone, their voice is preamplified to line level, then amplified to a level high enough to move the speaker. The audience can then hear their voice.

In a musical situation, several people need to use the PA system at the same time. A band might have a guitar player who sings, a bass player, and a drummer. Just three musicians can use ten or eleven mics! To get all of these sounds through the PA system, we can connect the microphones to a mixer which has mic preamps built into it. We can then connect the mixer's output to an amplifier, and then to a speaker system.



## Experiments:

1. Connect the mic to a mic cable. What do you have to do to disconnect the mic cable?
2. Connect a mic to the preamp on a mixer. Can you find the gain control? Listen to the microphone's mixer channel in headphones. What happens when the gain is too low? Too high?
3. Look at some different speakers. Can you tell if they have amplifiers built in? Where you you connect cables to these speakers?
4. Listen to the sound of a synthesizer through speakers. If you look closely at the speaker.
5. Make a basic PA system. Be careful not to create feedback (sound from the speaker going back into the microphone).

## On the Web:

If you would like to see more pictures of some real mics, preamps, amplifiers, and speakers or read more about them, check out the following sites online:

<a href="http://www.AKG.com">http://www.AKG.com</a>	<a href="http://www.tannoy.com">http://www.tannoy.com</a>
<a href="http://www.shure.com">http://www.shure.com</a>	<a href="http://www.mackie.com">http://www.mackie.com</a>
<a href="http://www.neuman.com">http://www.neuman.com</a>	<a href="http://www.summitaudio.com">http://www.summitaudio.com</a>
<a href="http://www.roland.com">http://www.roland.com</a>	<a href="http://www.neve.com">http://www.neve.com</a>
<a href="http://www.focusrite.com">http://www.focusrite.com</a>	<a href="http://www.earthworks.com">http://www.earthworks.com</a>
<a href="http://www.event.com">http://www.event.com</a>	<a href="http://www.beyerdynamic.com">http://www.beyerdynamic.com</a>
<a href="http://www.audio-technica.com">http://www.audio-technica.com</a>	<a href="http://www.sennheiser.com">http://www.sennheiser.com</a>
<a href="http://www.electrovoice.com">http://www.electrovoice.com</a>	<a href="http://www.crown.com">http://www.crown.com</a>
<a href="http://www.harmonkardon.com">http://www.harmonkardon.com</a>	<a href="http://www.alesis.com">http://www.alesis.com</a>

## Student Tips!

The students who are best at music technology are also good teachers! Teach someone at home the things that you learned in your lesson, and you will have a much easier time remembering what you learned. Teaching is a fun way to review!

## Words to Know:

Can you tell your parents what each of these words means?

Amplifier	Mic Cable
Amp	Microphone
Diaphragm	PA System
Line Level	Preamplifier
Mic	Speaker
XLR Connector	

## Let's Review

1. What is the amplifier's job and how do you connect it?
2. What does a microphone do? What does a speaker do?
3. What does a mic do to sound waves?
4. What does a preamplifier do?
5. What are the parts of a PA system, and how do you connect them?