A Sound Look at Sound

By Ulf Olofsson

The word *sound* has many meanings, several having nothing at all to do with music or movies, but if we isolate the applicable definitions we find that *sound* embraces all of the following:

1. The act of making or emitting a sound
2. The physical event of sound waves propagating [to travel through space or a physical medium] in a medium, air being but one of many media through which sound can pass
3. The perceptions arising from sound waves that cause the eardrums to vibrate, which can be (a) meaningless noise, (b) recorded material, or (c) the particular musical style characteristic of an individual, a group, or an area—for example, the "Canto-pop" sound

Sound travels because vibrating molecules make the surrounding molecules vibrate at a similar rate. When you graph different pitches—vibrations per second—of sound, you get something which looks like a wave. But it isn't a wave, it's just an energy force which sets atmosphere molecules into vibration which then causes agitation of nearby molecules which in turn transfer the vibration to other molecules and you get a traveling vibration.

Audio is a term used in relation to the transmission, reception, or reproduction of sound.

Sound is an atmospheric phenomenon.

Audio is sound represented as an electronic *signal*.

Signal is an electrical quantity or effect, as current, voltage, or electromagnetic waves that can be varied in such a way as to convey information.

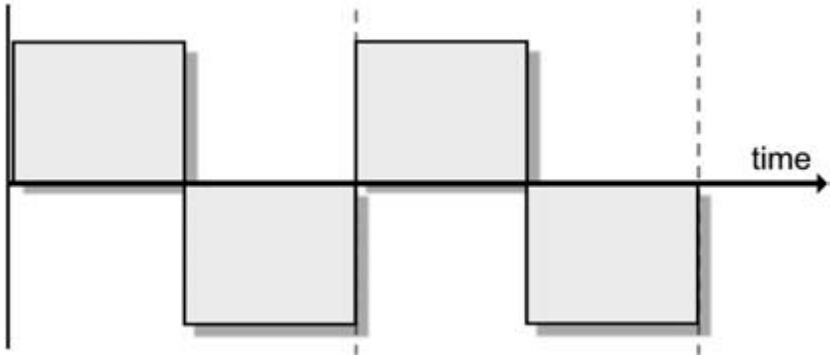
Categories:

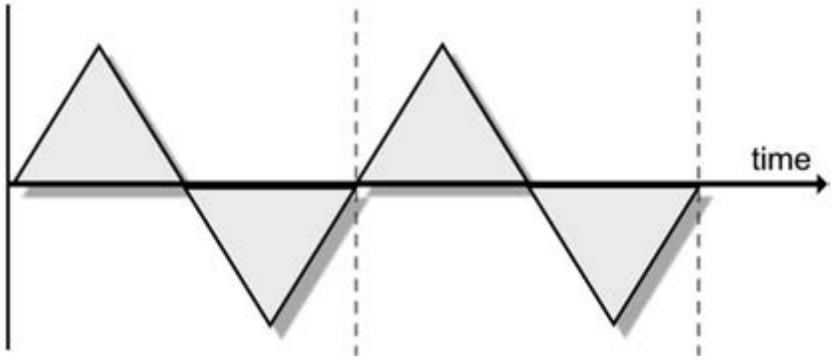
When dealing with sound as a subject there are many different ways of classifying categories as well as technically grouping sub divisions. For the non-technician who is interested in sound for application purposes there are 6 categories which comprise the entire subject of sound and all of its techniques and application. Any and all sound/audio equipment is designed to handle one or several of these 6 categories – no exceptions. The categories are:

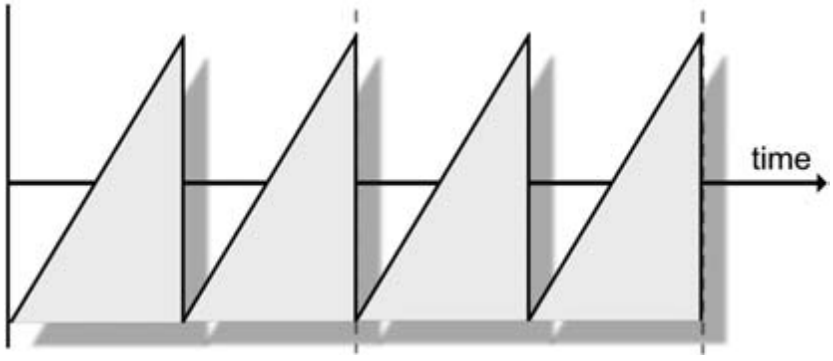
1. **Volume**
2. **Pitch** (frequency – number of vibrations per second)
3. **Timbre** (the characteristic or quality of sound)
4. **Echo** (reverberation and reflections)
5. **Ambient sound** (surrounding noise)
6. **Equipment interference** (hum, buzz – generally electronically, unwanted added sounds)

Below you can see 3 types of audio signals. The first is technically called a *square wave*. The second is called a *triangular wave*. The third is called a *saw tooth wave*. They have the same *volume* and *pitch* but different timbre, just like a flute, a harp and a violin can play the same note or pitch at the same volume, but they sound drastically different – they have different timbres or sound qualities.

The same is applicable for human voices. 3 women can sing the same note at the same volume but they have different voice qualities – different timbres – and if you graphically represented their voice characteristics they would look different.





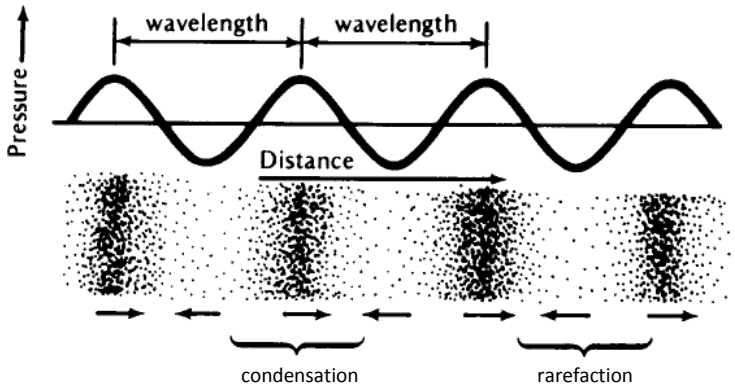


Physics of Sound

Sound is produced when an object (the source) vibrates and causes the air around it to move. A sound source *oscillates* between being slightly larger than normal and then slightly smaller than normal.

[To *oscillate* means to produce an *oscillation* - the repetitive variation, typically in time, produced and measured with values that repeatedly and regularly fluctuates above and below some average or unchanging value, as the pressure of a sound wave or the voltage of an alternating current.]

As a sound source pulsates it will alternately compress [make more dense] and then rarefy [make less dense] the surrounding air (see below) resulting in a series of compressions and rarefactions traveling away from the sphere, almost like a 3D version of the ripples which travel away from a stone dropped into a pond.



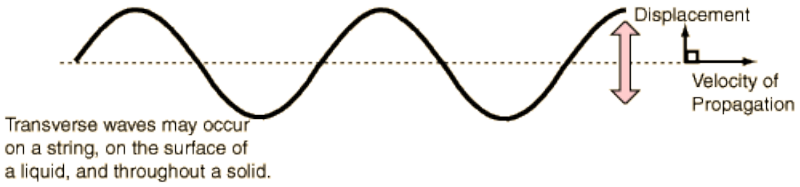
Acoustics is the study of sound and is concerned with the generation, transmission, and reception of sound waves. These three phenomena are created when energy causes a disturbance in a medium [an intervening substance, as air, through which a force acts or an effect is produced.]

For example, when a drum is struck, its drumhead disturbs the surrounding air (the medium). The outcome of that disturbance is the sound of a drum. The mechanism is fairly simple: the drumhead is activated and it vibrates back and forth.

When the drumhead pushes forward, air molecules in front of it are compressed. When it pulls back, that area is rarefied. The disturbance consists of regions of pressure above and below the equilibrium atmospheric pressure. The displacement is quite small; in normal conversation, particle displacement is about one millionth of an inch. A louder crowd's acoustic outpouring might cause displacement of one thousandth of an inch.

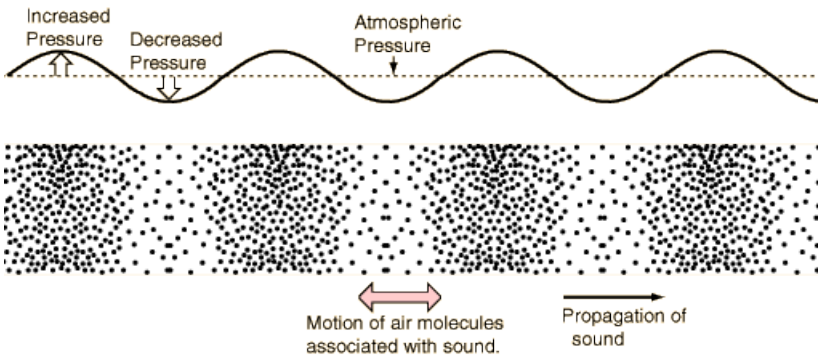
Sound is propagated [to cause a wave to move in some direction or through a medium; transmitted] by air molecules through successive displacements that correspond to the original disturbance. In other words, air molecules colliding one against the next propagate the energy disturbance away from the source. Sound transmission thus consists of disturbances propagating from one region to the next. The displacement of air molecules occurs in the direction in which the disturbance is traveling; thus sound undergoes a *longitudinal* [running lengthwise] form of transmission, as compared to *transverse* waves as in audio signals.

For transverse waves the displacement of the medium is perpendicular to the direction of propagation of the wave. A ripple on a pond and a wave on a string are easily visualized transverse waves.

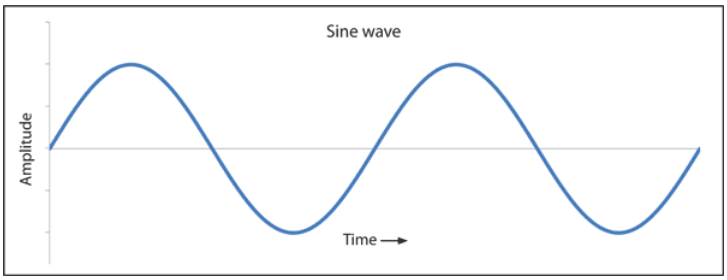


Transverse waves cannot propagate in a gas or a liquid because there is no mechanism for driving motion perpendicular to the propagation of the wave. In longitudinal waves the displacement of the medium is parallel to the propagation of the wave. A wave in a "slinky" is a good visualization. Sound waves in air are longitudinal waves.

A single-frequency sound wave traveling through air will cause a sinusoidal [like that of a *sine wave*] pressure variation in the air. The air motion which accompanies the passage of the sound wave will be back and forth in the direction of the propagation of the sound, a characteristic of longitudinal waves.



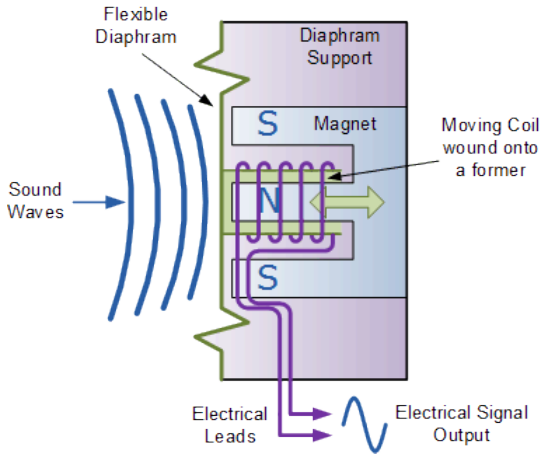
It is worth briefly mentioning a bit about the *sine wave* as it is the most fundamental type of wave form in physics and audio alike. The sine wave pattern occurs often in nature, including ocean waves, sound waves, and light waves. It is also a fundamental building block in processing and creating synthesized sounds.



Turning longitudinal sound waves into transverse audio signals

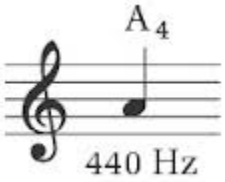
A receptor [receiving point or any of various devices that receive information, signals, etc], like a microphone diaphragm [a thin disk inside a microphone that vibrates when receiving sound pressure], placed in the sound field will similarly move according to the pressure acting on it. When recording sound into audio signals or reproducing audio back into sound using loudspeakers we have to use a component called a transducer. A transducer is a device that receives a signal in the form of one type of energy and converts it to a signal in another form.

In a microphone the diaphragm is the transducer – it converts sound vibrations to electrical vibrations. A loudspeaker is the opposite type of transducer which converts an audio signal in the form of a vibrating electronic signal to vibrations in the air which we hear as sound. For example, a drum changes the mechanical energy produced by the mallet to acoustical energy. A microphone responds to the acoustical energy by producing electrical energy. A loudspeaker reverses that process to again create acoustical energy from the electrical energy. Here's an example of sound converting to an electronic signal in a microphone.



The pressure changes of sound vibrations can be produced either periodically or aperiodically. A musical note played on a violin moves the air back and forth periodically at a fixed rate. However, a cymbal crash has no fixed period; it is aperiodic.

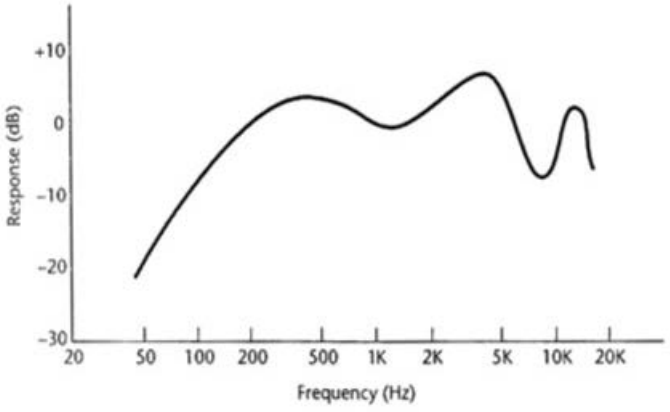
One sequence of a periodic vibration, from pressure rarefaction to compression and back again, determines one cycle. The number of vibration cycles that pass a given point each second is the frequency of the sound wave, measured in Hz (Hertz). A violin playing concert A, for example, generates a sound vibration that repeats about 440 times per second; its frequency is 440 Hz.



The sound frequency range can loosely be defined as the frequency band from 20 Hz to 20 kHz (20 – 20,000 Hz) which is roughly the range of human hearing. Audio devices are generally designed to respond to frequencies in that range.

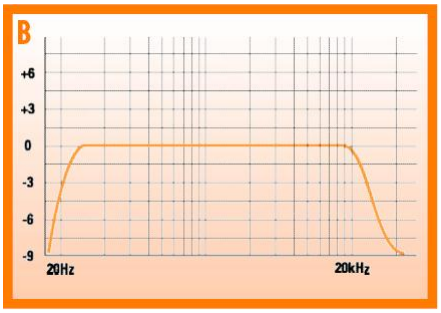
A *wavelength* is the distance sound travels through one complete cycle of pressure change and is the physical measurement of the length of one cycle. Because the speed of sound is relatively constant at about 1130 ft/s (feet per second) we can calculate the wavelength of a sound wave by dividing the speed of sound by its frequency.

Quick calculations demonstrate large differences in the wavelength of sounds. For example, a 20,000-Hz wavelength is about 0.7 inch long, and a 20-Hz wavelength is about 56 feet long. No transducers (including our ears) are able to linearly [all frequencies at the same level] receive or produce that range of wavelengths. Their frequency response is not “flat” or equally responsive to all frequencies and their frequency range is limited. The following graph shows how our ears have a different sensitivity to various frequencies depending on what volume they are at.

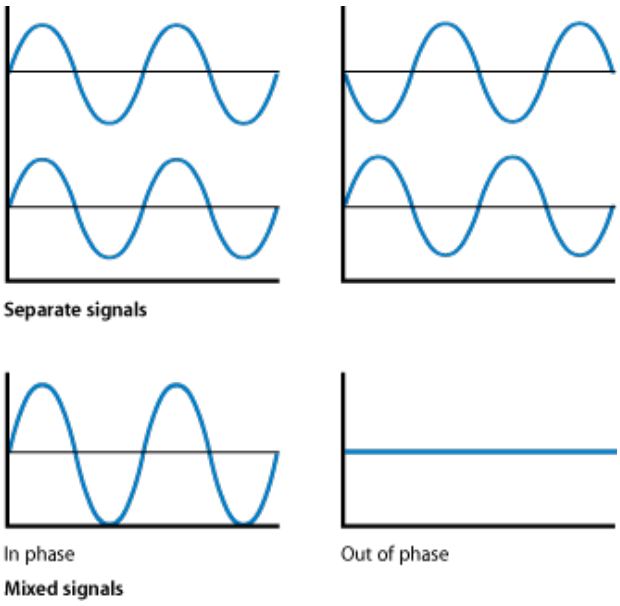


The range between the lowest and highest frequencies a system can accommodate defines a system's *bandwidth*. The ear's bandwidth for a younger person is roughly 20Hz – 20,000Hz. The bandwidth of a better Hi-Fi system or a theatre loudspeaker system is also roughly 20Hz – 20,000Hz.

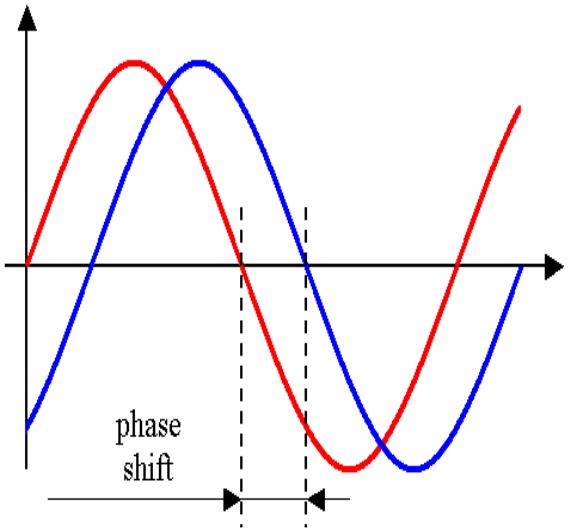
A "flat" frequency response of a piece of audio equipment could be graphed like this:



If two waveforms are coincident in time with their positive and negative variations together, they are "in phase". When the variations exactly oppose one another, the waveforms are "out of phase". Any relative time difference between waveforms is called a "phase shift". If two waveforms are relatively phase shifted and combined, a new waveform results from constructive and destructive interference.



Example of "out of phase"



Example of *phase shift*

The subject of phase becomes very important in post production and sound design as phase is a major factor in recording when using multiple microphones as well as the mixing process and sound design - for both music and film.

Digital Basics

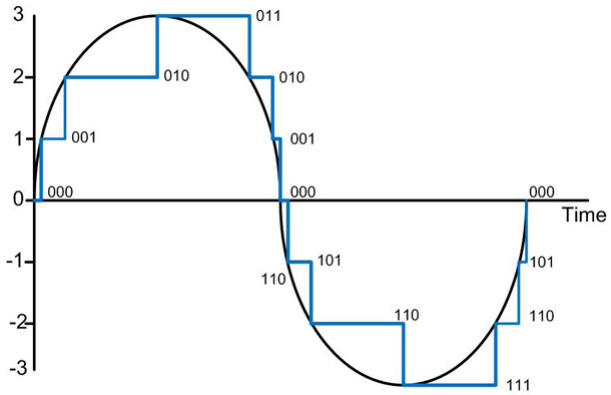
Analog means a representation of a signal with another continuously varying medium.

For example, in audio voltage changes are used to represent changes in sound pressure. Other analog examples include the grooves in a vinyl record and the changes in magnetism on a magnetic tape. The mercury in an old-fashion thermometer is another analog example. The expansion or contraction of the mercury liquid corresponds to the temperature changes and can be interpreted using a scaled numbering system printed on the thermometer glass. Analog is a short form of analogous which means “having analogy” or a similarity between like features of two things, on which a comparison may be based.

Digital in the field of audio could be said to be signals or information stored and transmitted as series of individual, non-continuous electrical impulses representing digits (numbers) rather than as a continuous analog voltage. In audio, a waveform's amplitude is represented digitally as a series of numbers. Thus, digital audio is primarily a numerical technology. The word digital comes from the word digit which literally means finger or toe, from the idea of using these to count. In digital audio it takes on the meaning of using either of the symbols of 0 or 1 in the binary system.

There are many different numbering systems that could have been used but digital scientists settled for the binary system. This is a base-2 system. The metric system is a base-10 system. The binary system is better suited for storing and processing numerical information. With digital we deal with numbers, as opposed to analog with constantly varying electrical signals.

Here’s a crude representation of analog verses digital. The smoothly curved line represents the analog signal as a continuous sine wave. The blue or squared line represents a sampled digital signal where each level is equally spaced from each other. In fact, the blue signal would be considered a 3 bit signal. Note that the levels change from 000 to 111, the first bit represents positive or negative and the last two bits represent the level.



Numbers offer a way to encode, process, and decode information. In digital audio, numbers entirely represent audio information. We usually think of numbers as symbols. For example, consider a classic 1962 BMW R50/2 motorcycle as can be seen in figure 1 below, 500 cubic centimeters, registered as 129907. Several numbers describe this machine; not so obvious is the important context of each. “R50/2” represents the motorcycle's model number, “1962” is the year of manufacture, and “500” represents the quantity of cubic centimeters of engine capacity. The license number “129907” represents specifically coded information that allows a speeding ticket to be properly credited to one’s account.

These various numbers are useful only by virtue of their arbitrarily assigned contexts. If that context is confused, then information encoded by the numbers goes awry. One could end up with a motorcycle with license number 1962, manufactured in the year 500, with an engine capacity of 129907 cubic centimeters…

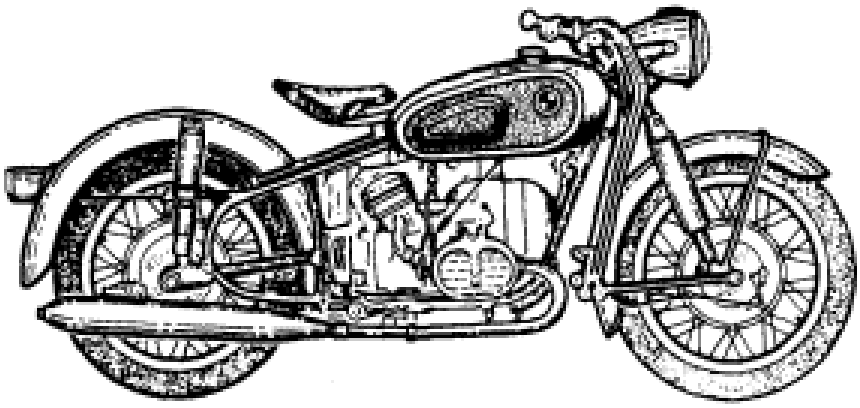


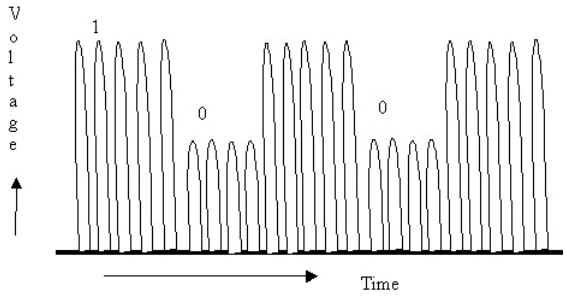
Figure 1
A classic 1962 BMW R50/2 motorcycle.

Similarly, the numerical operations performed on numbers are matters of interpretation. Numbers, if properly defined, provide a good method for storing and processing data. The negative implication is that numbers and their meanings have to be used carefully.

For most people, the most familiar numbers are those of the base 10 system, apparently devised in the ninth century by Hindu astronomers who conceived of the 0 numeral to represent nothing and appended it to the nine other numerals already in use. Earlier societies were stuck with the unitary system, which used one symbol in a series of marks to answer the essential question: how many? That is an unwieldy system for large numbers; thus, higher-base systems were devised.

Babylonian mathematicians invented a number system that used 60 symbols. It was a little cumbersome, but even today, 3700 years later; the essence of their system is still used to divide an hour into 60 minutes, a minute into 60 seconds, and a circle into 360 degrees.

Choosing a number system simply questions how many different symbols we think are most convenient. The base 10 system uses 10 numerals. The position of the numerals shows the quantities of ones, tens, hundreds, thousands, etc. In other words, the number in each successive position is multiplied by the next higher power of the base. A base 10 system is convenient for 10-fingered organisms, such as humans, but other number bases might be more appropriate for other applications. This picture shows 0 and 1 represented as two voltages.



Sound "Hats"

Before getting into specifics about microphones and sound recording techniques I want to lay out a few basics regarding being a "sound man". No matter if one has a hired professional(s) on his team or due to budget constraints the camera man is forced to take sound, there are certain **functions** that have to be in place for the shoot production as well as post production. These functions have to be covered whether or not they are done by 10 people or one person.

For simplicity in explaining those functions I'm going to use an old term – "hat" – which is an informal way of saying someone's role at a workplace, as in the old days various professions were differentiated by the hats they wore, like the train conductor, the post man, the baker, etc.

So, during any film or video shooting – location or on set – there are a number of sound functions that have to be covered no matter how slim the shoot crew is. These sound hats are most commonly referred to as:

- Sound Mixer
- Boom Operator
- Cable Man

The *Sound Mixer* could better have been described as the "Recordist" but the official Oxford English Dictionary doesn't yet approve of this term, but it would better describe what this hat does. The *Sound Mixer* is the person that sets and monitors sound levels during recording as well as mixing down (combining) the various microphones present during each shot to, usually, a 2-track or 4-track recording. Often the *Sound Mixer* has a portable recording device he is also operating, but if he is recording straight to camera his function is still the same.

The *Boom Operator* is the person who carries the mic pole or boom which the microphone is attached to. He directs or operates the boom during a shoot so as to point the microphone at the actor(s) as close to the actor's face as possible without being in the camera frame.

The *Cable Man* (could be a women but would still be called a *Cable Man*) is the person that runs the cables and tends the cables for the boom operator (when he/she needs to move around during a shot) and is generally the sound assistant for either the *Boom Operator* or the *Sound Mixer*. For extensive shoots the *Cable Man* can also "double hat", meaning taking on the role as a second boom operator for a multiple microphone recording.

Though Post Production will be gone over in detail at a later stage it is worth mentioning here what the sound hats required in post production are. The below list doesn't include anything having to do with the music score which requires its own team of composers, arrangers, orchestrators, recording engineers, musicians, mixers and music editors, but the below list covers all the hats required to produce a soundtrack, even if they are all covered by one person.

- Supervising Sound Editor
- Sound Designer
- FX Recordist
- Dialogue Editor(s)
- ADR Supervisor (Director)
- ADR Editor(s)
- Sound Effects Editor(s)
- Foley Artist(s) [also called "Foley Walker]
- Foley Supervisor (Director and Recording Engineer)
- Foley Editor(s)
- Assistant Editor(s) for audio syncing, mixing production requests, etc
- Re-recording Mixer(s) [also called "Dubbing Mixer"]
- Machine Operator(s) for transfers, copies and run-offs

[Definitions]

ADR: *Dubbing*. **Dubbing**, also known as **rerecording**, is the post-production process, used in filmmaking and video production, in which vocal recording (usually dialogue) occurs subsequent to the original recording stage. The term most commonly refers to the substitution of the voices of the actors shown on the screen by those of different performers speaking a different language; however the practice also involves the rerecording of poorly recorded original audio segments and then synchronizing the new recording with the existing footage. The procedure was sometimes practiced in musicals when the actor had an unsatisfactory singing voice, and remains in use to enable the screening of films, videos and sometimes video games to a mass audience in countries where viewers do not speak the same language as the original performers.

This process whereby an actor rerecords lines spoken during filming in order to improve audio quality or reflect dialogue changes is called **Automated Dialog Replacement** (**ADR**), also known as **Additional Dialog Recording**.

Foley: *Foley* is the reproduction of everyday sound effects which are added in post production to enhance the quality of audio for films, television, video, video games and radio. The term *foley* is named after Jack Donovan Foley (1891-1967) who began what is now known as Foley art in 1927. He had started working with Universal Studios in 1914 during the silent movie era. When Warner studios released its first film to include sound, *The Jazz Singer*, Universal knew it needed to get on the bandwagon and called for any employees who had radio experience to come forward. Foley became part of the sound crew that would turn Universal's then upcoming "silent" musical *Show Boat* into the musical that it is known as today. Because the microphones used for filming could not pick up more than Dialog, other sounds had to be added in after the film was shot. Foley and his small crew would project the film on a screen while recording a single track of audio that would capture their live sound effects in real time. Their timing had to be perfect so that footsteps and closing doors would sync with the actors' motions in the film. Jack Foley created sounds for films until his death in 1967. His methods are still employed today.

The aforementioned hats would all be part of a major movie production as individually posted people, but even for a low-budget Indie film all those hats have to be worn, even if by two people. For just a video interview you may not need a boom operator (if you're only using a clip-on lapel mic) and any cable hook-ups and tending can be done by the camera operator. For post production maybe only one person will take care of all the audio as well as music, but the above functions would still have to be applied among the involved production crew for the final product to be professional.

Professionalism

For a product to be professional it requires that it is produced by professionals. Long years of education and decades of experience don't necessarily equal to being a professional, nor are they required to become a professional. "Professional" has been defined in many ways by many people. To me being "professional" is more of an attitude rather than something you gain by study, merit or experience, though these definitely contribute.

With "attitude" I don't mean a social façade you decide to put on, but rather a state of mind you adopt towards the actions you set out to do – on your job, in the arts or in life.

In my view you should never do anything as though you were an amateur. Anything you do, do it as a professional to professional standards. If you have the idea about anything you do that you just dabble in it, or "trying it" or just "helping out" or "I guess I have to learn this too", you will wind up with a dabble life. There'll be no satisfaction in it because there will be no real production you can be proud of.

Develop the frame of mind that whatever you do, you are doing it as a professional. With a set frame of mind, a good study and understanding of the basics of your field and **practice** you WILL move up to a professional standard in your field.

The only successful persons in any field, including living itself, are those who have a professional viewpoint and insist on making themselves being professional.

Being a professional doesn't mean you won't make mistakes. The greatest mistake you can make in life is continually fearing that you'll make one. The times you fall down don't count. What counts are those times you pick yourself up again and keep going. It is a very true axiom indeed that only those who will risk going too far can possibly find out how far they can go!

To put that into practical application, the following short article was written in the 70's by Alfred Barrious which I find very truthful by my own experience and observation:

"The world's greatest geniuses have all had 24 personality characteristics in common and you can develop the same traits yourself, says an expert. Most people have the mistaken idea that geniuses are born, not made. But if you look at the lives of the world's greatest geniuses like Edison, Socrates, DaVinci, Shakespeare, Einstein, you will discover they all had 24 personality characteristics in common.

These are traits that anyone can develop. It makes no difference how old you are, how much education you have, or what you have accomplished to date. Adopting these personality characteristics enables you to operate on a genius level.

1. ***DRIVE***. *Geniuses have a strong desire to work hard and long. They're willing to give all they've got to a project. Develop your drive by focusing on your future success, and keep going.*
2. ***COURAGE***. *It takes courage to do things others consider impossible. Stop worrying about what people will think if you're different.*
3. ***DEVOTION TO GOALS***. *Geniuses know what they want and go after it. Get control of your life and schedule. Have something specific to accomplish each day.*
4. ***KNOWLEDGE***. *Geniuses continually accumulate information. Never go to sleep at night without having learned at least one new thing each day. Read. And question people who know.*
5. ***HONESTY***. *Geniuses are frank, forthright and honest. Take the responsibility for things that go wrong. Be willing to admit, 'I goofed', and learn from your mistakes.*
6. ***OPTIMISM***. *Geniuses never doubt they will succeed. Deliberately focus your mind on something good coming up.*
7. ***ABILITY TO JUDGE***. *Try to understand the facts of a situation before you judge. Evaluate things on an opened minded, unprejudiced basis and be willing to change your mind.*
8. ***ENTHUSIASM***. *Geniuses are so excited about what they are doing, it encourages others to cooperate with them. Really believe that things will turn out well. Don't hold back.*
9. ***WILLINGNESS TO TAKE CHANCES***. *Overcome your fear of failure. You won't be afraid to take chances once you realize you can learn from your mistakes.*
10. ***DYNAMIC ENERGY***. *Don't sit on your butt waiting for something good to happen. Be determined to make it happen.*
11. ***ENTERPRISE***. *Geniuses are opportunity seekers. Be willing to take on jobs others won't touch. Never be afraid to try the unknown.*
12. ***PERSUASION***. *Geniuses know how to motivate people to help them get ahead. You'll find it easy to be persuasive if you believe in what you're doing.*
13. ***OUTGOINGNESS***. *I've found geniuses able to make friends easily and be easy on their friends. Be a 'booster' not somebody who puts others down. That attitude will win you many valuable friends.*
14. ***ABILITY TO COMMUNICATE***. *Geniuses are able to effectively get their ideas across to others. Take every opportunity to explain your ideas to others.*
15. ***PATIENCE***. *Be patient with others most of the time, but always be impatient with yourself. Expect far more of yourself than others.*
16. ***PERCEPTION***. *Geniuses have their mental radar working full time. Think more of others' needs and wants than you do of your own.*
17. ***PERFECTIONISM***. *Geniuses cannot tolerate mediocrity, particularly in themselves. Never be easily satisfied with yourself. Always strive to do better.*
18. ***SENSE OF HUMOR***. *Be willing to laugh at your own expense. Don't take offense when the joke is on you.*
19. ***VERSATILITY***. *The more things you learn to accomplish, the more confidence you will develop. Don't shy away from new endeavors.*
20. ***ADAPTABILITY***. *Being flexible enables you to adapt to changing circumstances readily. Resist doing things the same old way. Be willing to consider new options.*
21. ***CURIOSITY***. *An inquisitive, curious mind will help you seek out new information. Don't be afraid to admit you don't know it all. Always ask questions about things you don't understand.*
22. ***INDIVIDUALISM***. *Do things the way you think they should be done, without fearing somebody's disapproval.*
23. ***IDEALISM***. *Keep your feet on the ground – but have your head in the clouds. Strive to achieve great things, not just for yourself, but for the better of mankind.*
24. ***IMAGINATION***. *Geniuses know how to think in new combinations, see things from a different perspective, than anyone else. Unclutter your mental environment to develop this type of imagination. Give yourself time each day to daydream, to fantasize, to drift into a dreamy inner life the way you did as a child."*

Be passionate about your field

Before going into the subject of passion there is one thing I want to stress again. You must understand your basics and fundamentals! The basics of a field will never change. Technical applications and tools will, but not the basics. The principles of sound has been are and forevermore will be the same.

Whether you record with an analog tape recorder or a digital hard disk recorder or some future liquid-helium gas; whether you're cutting magnetic film or tape manually or spinning a mouse ball with a nonlinear computer platform – the techniques, procedures, technical disciplines [systematic instruction given to disciples to train them as students in a craft or trade], and creative craftsmanship of creating an acoustical event are the same. Only the tools change; the artistic and scientific principles remain the same.

Some of the better books on the subject of film making and the subject of sound for film were written between 30 – 50 years ago. They cover the basic principles better than modern books and they certainly still apply. Modern books have a tendency to focus less on actual usage and they focus more on highly technical jargon and explanations which isn't very useful for someone who is just trying to learn how to do something.

So, back to passion… Many newcomers to the industry confuse the concept of loving the idea of doing something with being passionate about actually doing it. It reflects in their work; it reflects in the attitude of how they work. Many lose their way spending untold fruitless hours trying to develop shortcuts rather than rolling up their sleeves and simply doing the work. This is even more applicable today in this modern world where an "app" will supposedly do everything for you. This advancement in technology has also developed an apparent lesser need to learn and apply the basics. But to be able to apply basics in full, one has to have a passion for what one does. For those of us lucky enough to be endowed with love and passion for our work, there is only the craftsmanship and the yearning to achieve a greater levels of quality and meaning. The secret to real success and personal satisfaction, in my view, is knowing you must have passion for everything you do, even for jobs for which you have disdain.

To obtain a great product you must imbue it with life!

You cannot work in the film industry by doing only what you want to do, and you probably cannot start right away working at the job of your dreams. The quickest way to achieve promotion or advancement toward a dream career is to approach each job assignment and task with a professional attitude and with as much passion and enthusiasm as if it were your dream job.

I remember working at an audio post production place here in Hong Kong and I was apparently being too picky about getting a soundtrack just right. My superior at that time told me, “Hong Kong is just cheap, cheap, quick, quick. Nobody here cares about the sound as long as you can hear the dialog. I like your style but you care too much and it’s not going to make a difference!”

I nodded. “You’re right that I care about what I do and I know it makes a difference!”

Preparation

By actual observation and experience, the success or disappointment of your final soundtrack is decided before the camera even rools, even before you commence preproduction.

Planning, and I mean FULL planning and knowing your various departments and what they all need and want and intelligent budgetting comes first, no matter the size or type of project.

For a film production you must obtain a good sound mixer along with an excellent boom operator. You must know the pitfalls and the traditional clashes of production form and function to get a shot “in the can” and to the edit bay. You must know how to convey the parameters and needs to the non-sound departments, departments which have a major impact on the ability of the sound-recording team to capture a great production dialogue track.

If you do not allow enough money in the lighting budget to rent enough cable for that location shoot; if you do not get the generators far enough away from the set, the result is a continous intrusion of background generator noise. This isn’t so bad if you’re filming in bustling city streets, but it certainly doesn’t bode well if you are filming an intimate love scene in an otherwise relatively silent park. Regardless of the period or setting of the film, unwanted ambient noises only intrude on the magic of production performances.

In addition there are the annoying intrusions of cellular phones, walkie talkies and other radio-controlled equipment and these wreak havoc with wireless microphones. You must know how to budget a multiple microphone setup using multiple boom operators and multiple cameras. You must understand the ramafications of weather conditions and the climate so as to predict rainy or very humid or very windy conditions during an exterior shoot.

Excellent equipment exist for all applications including heavy rain or wind, but one must know about them and account for them in budgeting and logistics. Whether or not the basic equipment comes from the sound person(s) or is a rental package, you still have to make sure they do have all the items required for a shoot and if not get it included if you want a good, predictable result in the end.

Another important factor is to always consult with your director of photography for each shot. After careful consideration of the photographic challenges you must overcome, you will soon know what kind of equipment will be necessary to pull off the shoot in a satiesfying manner for both you and the D of P. If you don't you may end up with production sound that is utterly unuseable. You can always throw up your hands and tell the sound mixer you'll have to ADR it later in post production. You can do that but why should you?

In addition to simple logistical planning and preparation you also have to know the techniques available to you. Often individual crew are only aware of their specific discipline but lack partially or fully the knowledge and techniques of the other departments. Many filmmakers today do *not* know their techniques. They don't have a background in the technical disciplines; hence they have no knowledge of what is possible or how to technically realize the vision trapped inside their heads.

One can go one step further and analyze all those calling themselves "Director" and "Producer" or "Filmmaker" just because they downloaded a crack version of FCP and own a DSLR camera. Knowing a software doesn't equate to knowing the basics and technical disciplines of a subject, especially one that is as diverse as film making. Executives and producers often may be very interested in film production, or at least its potential profit, but that doesn't make them knowledgeable in the technical disciplines of film making.

However, very often non-technical executives, producers and other administrative personnel make operative decisions that should be coming, if not directly, at least by the advice of the craftspeople.

Often the decisions and orders and instructions are forwarded in a suffocating way with abstract terminology that makes for so much artsy-sounding double-talk. When production then doesn't go like they "planned" you will get "qualified" excuses like, "Oh, we'll ADR it later!" or, "We'll fix it in post!" or, something I personally as a mixer hate hearing, "We'll fix it in the mix!".

These are, more often than not, lazy excuses that really say, "I actually don't know how to technically handle this." or, "Oops, we didn't consider that…" or, "This isn't the important thing on my mind right now!"

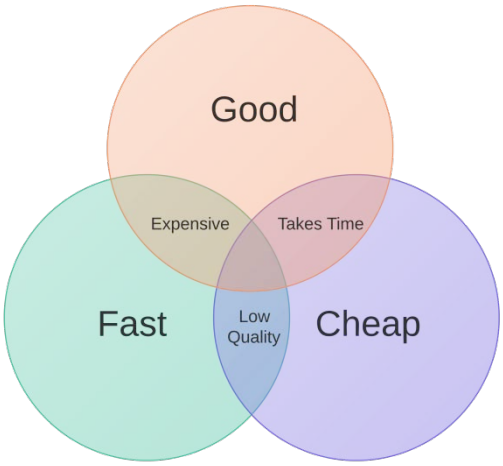
Sometimes you simply must step back, take a moment, and do everything you can do to capture a pristine dialog recording. The vast majority of filmmakers will tell you they demand as much of the original recording as possible; they want the magic of the moment. They should want that, and so should you and you should get it.

But sometimes because of your technical know-how and experience you also realize that post production sound can and will handle the moment as well if not better than a live on-location recording, so you either shoot MOS or you stick a microphone in their to at least get a guide track for the editor. You must know your options!

MOS: without sound. In The Screenwriter's Bible, David Trottier credits the term to Austrian director Erich von Stroheim, who allegedly would tell his crew with his heavy Austrian accent, "Ve'll shoot dis **M**id **O**ut **S**ound." Hence the term *MOS* for "without sound".

Quality versus speed versus budget

An old and tired cliché still holds true today: the classic triangle of structuring production quality, schedule issues and budget concerns – The Great Triangle Formula. (1) You can have **good quality**. (2) You can have it **fast**. (3) You can have it **cheap**.



Now axiomatically you can only pick **two** of the three! When potential clients tell you they want all three options, well, at least you know what person you are dealing with, so I recommend another sound person/team to them. No genuine collaboration can happen with people who expect and demand all three.

In addition to the time allocated for the production sound mixer, the smart producer budgets time for the mixer to come on a location field trip to see and hear the natural ambience, to walk the practical location and hear the potential for echo; to note nearby factories and highways; to detect the presence of aircraft flight paths, and so on.

Also, the mixer takes a quick overview of where power generators might be parked and if natural sound blinds exist to help block noise or if acoustic gear should be brought to knock down potential problems.

With regard to a pristine dialog track, the boom operator is the key position. The production mixer is the head of the production sound crew, but even the mixer will tell you the boom operator is more important. If the microphone is not in the right position, what good is the subsequent recording? More often than not, the producer or budget responsible executive always under-budgets the boom operator slot. I have seen production mixers take their own salary and pay a boom operator just to be able to get decent sound. Smaller productions and Indie films can't afford the cable man. But the function still has to be covered by the other sound crew but is usually not demanding for smaller film shoots.

Sometimes it is not convenient to get the "best sound" while shoot production is occurring. For example if a film requires a fancy sports car to be part of a larger scene which includes dialog, but, the director also wants that "big sound" for the car, then the specific car sounds will not be attempted to be recorded during shoot production, but instead the sound crew will focus on the dialog.

Then during off-hours when the shoot unit is in no need of any props, the car and the location in question, the sound team and a stunt driver can team up to get the proper car sound recorded.

Occasions do arise however when an FX Recordist will have to record during actual shooting, such as recording cattle stampeding through a location set. It may be financial hardship to field the cattle and wranglers after the actual shoot just to record the cattle stampeding. Recordings like these are best orchestrated in a collaborative manner with the camera crew and director. Each situation requires a different problem-solving approach.

The key is to come up with a coordinated solution that works for both sound and the rest of the crew while not causing delays or straining budget concerns. To do so one needs the knowledge and experience.

The FX recordist is usually not part of the production sound crew but comes in for special shooting scenes demanding both production sound dialog and background effects and/or ambience to be recorded. Recording production sound effects during principal filming is very demanding and seldom to the satisfaction of the FX recordist. But a project may require specific wild track to be recorded of a scene to be authentic. This task needs to be entrusted to a recordist who understands the various techniques of recording sound effects rather than production dialog which requires very different techniques.

Microphone basics

Though it is known in the recording industry that the principle of crap in equals crap out, as far as quality of microphones goes, it is equally true that a well-positioned cheap and cheerful mic can often outperform a poorly-positioned, thousand-dollar microphone! The microphone jargon has a tendency to be slightly confusing as types of microphones are often incorrectly categorized. To sort this out I will categorize type of microphone designs as well as microphone applications.

Microphone design types:

There are four very basic types of microphone designs. They are:

- Dynamic microphones
- Condenser microphones
- Ribbon microphones
- Electret microphones

For the simplicity of giving a general idea I won't go into all the nuances of designs that exist of the four above categories. They mainly differ in the way electricity is used to convert sound vibrations to an audio signal.

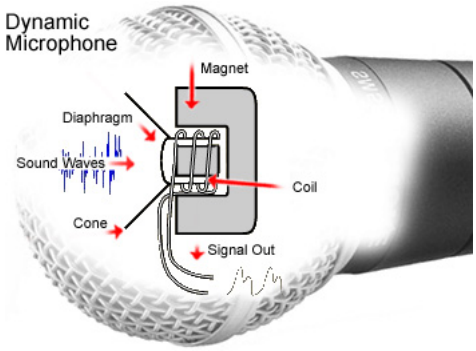
There are some older as well as very rare types of microphones which are based on different designs, but none of those usually apply to the field of recording sound for film production.

One word needs defining first: *Phantom power* is a DC voltage sent through a microphone cable to power condenser microphones. In the old days condenser microphones required a separate power supply and power cable. Famous vintage microphones for music applications with power supplies are still in use. The word *phantom* is used as the power travels through the same cable as the audio signal. As no power cable is used the power is “phantom”. That is about as much of an electronic clarification as I will do here. There are plenty of texts which describe the electrical engineering of microphones.

Dynamic microphones

Why a *dynamic microphone* is called “dynamic” is somewhat lost in history. This microphone design doesn’t need *phantom power*. Think of a *dynamic microphone* as a manual typewriter. The harder your finger hits the key, the stronger the imprint.

With a dynamic mic, the pressure of the sound waves moving the diaphragm actually generates electrical current (which is what the sound signal is) through the principles of electro-magnetism.



Dynamic mics are extremely rugged and do not require any form of battery powering. They are relatively insensitive to background noise and are commonly used as handheld performance mics and reporter’s mics. A dynamic mic used close to the mouth will reject all but the loudest background noise, making them ideal for stand-up reporting (mic can be seen on camera) or on-stage performance (to eliminate background sounds as well as eliminating feedback).

Dynamic mics tend to naturally compress loud noises, making them a good choice for recording explosive and crashing sound effects. A loud sound effect, unless carefully recorded, will tend to be "blown" right off of the recording tape and not come out as much more than distortion, which is why real gunshots that leave your ears ringing only sound like dull pops on a videotape.

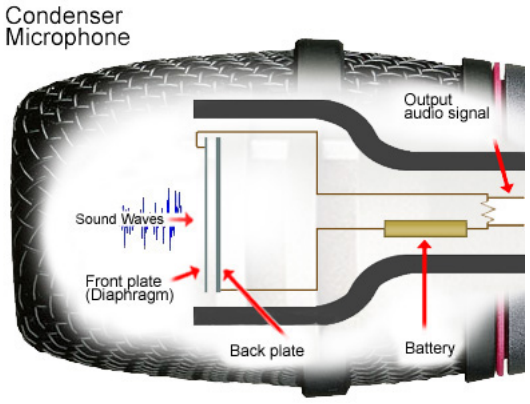
The downside to dynamic microphones is that they have very poor reach in terms of distance when it comes to dialog. They are pretty much useless on a boom or fish pole.

Machine gun recording with different dynamic microphones

Here's a tip: When filming an actor who is pretending to be a performer and will be seen using a handheld mic, it is much safer to consider the hand mic as merely a stage prop and to mic the actor with a boom or lavalier. Actors in those situations tend to gesture wildly with the mic, making your chances of getting good dialog quite slim.

Condenser microphones

The *condenser microphone* is also called a **capacitor microphone** or **electrostatic microphone.** The word *condenser* is an older word for *capacitor* – an electrical component that has the ability to hold electrical charge. Like an electronic word processor, a condenser mic requires external powering such as 48-volt phantom or 12-volts phantom, which can be supplied by an accessory battery power supply, plugged in line between the microphone and the mixer/recorder. Some mixers and video recorders offer built-in mic phantom powering.



As stated before, dynamic mics do not require any external powering, and plug directly into the MIC INPUT of a mixer/recorder. Condenser mics require external powering, which can be a battery supply located anywhere along the mic cable path. For instance, the mic connects to a regular XLR cable, that cable plugs into the power supply, and then another short cable connects the power supply to the MIC INPUT.

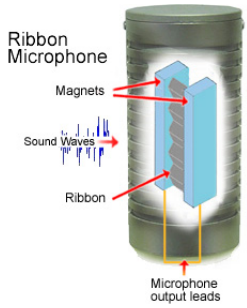
In the case of using a battery power supply, and, if the mixer/recorder offers the option of mic powering, that option IS NOT USED. Ensure the mixer/recorder phantom power indicator is off.

Sometimes, we can power a CONDENSER mic directly from the mixer or recorder. In that case, the external battery supply is not used at all, and the mic plugs directly in. A switch near the MIC INPUT should be switched to "48 Phantom" or whatever the device is labeled as.

Condenser mics are generally much more sensitive than dynamic mics and have a higher sound fidelity. Therefore they are the most common types of mic design used for film production sound recordings.

Ribbon microphones

The *ribbon microphone* is briefly mentioned here though it doesn't have much use in film sound typically. A ribbon microphone uses a thin, usually corrugated metal ribbon suspended in a magnetic field. The ribbon is electrically connected to the microphone's output, and its vibration within the magnetic field generates the electrical signal. Ribbon microphones are similar to moving coil microphones (dynamic microphones) in the sense that both produce sound by means of magnetic induction. Due to this the ribbon microphone is not very sensitive, though modern versions exist which are also powered to become more sensitive and these are sometimes used for vocal and instrument recordings.

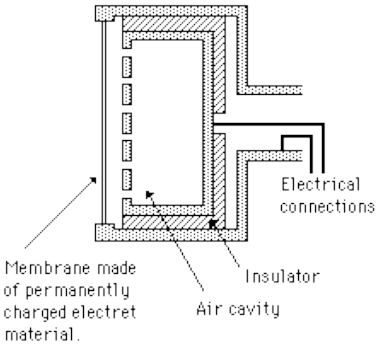


Electret Microphones

After the dynamic microphone the next most sensitive group of microphones is the ***electret condensers*.** Electret condenser microphones have a permanently charged magnetic element as compared to regular condensers which require an external charge.

These microphones operate off of a nominal voltage (usually 1.5 volts) which is derived from an internal battery such as an AA battery. The voltage that creates the audio signal comes from the battery (as opposed to being generated magnetically as in the case of dynamics); the relative sound levels control how the capacitors release voltage charge according to what the mic “hears”. Almost think of it like a meter that measures the sound, and releases a signal accordingly.

Electret Microphone



Electret condenser mics offer much more sensitivity (range) than dynamics but less than a regular condenser mic, and include what is commonly referred to as "ENG" grade shotgun mics as well as most lavaliers.

Examples used in film sound production of electret condenser shotgun mics include the Sennheiser ME80 & K66; and the Audio Technica AT835b, 815b. Lavaliers include the Sony ECM44/55/66/77, the Tram, the Sennheiser MKE2, and the Audio Technica 830.

Microphone care

Condenser (and all types of electrically charged or powered microphones) don't like dust, smoke or humidity, all of which will affect the sound quality whilst in that environment and, in the case of dust and smoke, progressively and permanently degrade the microphone diaphragm. Decent microphones are relatively expensive so it pays to look after your investments. If you suspect the performance of your microphone is not as good as it once was, consider returning the microphone to the manufacturer or a specialist company for servicing and to have the diaphragm cleaned.

Always handle microphones with care! Put them away when not in use, don't drop them, and never slam the lid on their boxes or you could split the diaphragm. Ideally, keep your microphones in a closed foam-lined box after use and store them somewhere warm and dry.

If you don't want to keep packing and unpacking your microphones, leave your microphones on stands at the side of the set with appropriately-sized freezer bags over them to keep the dust out.

Microphone level attenuation

For any condenser microphones, they are generally designed to cope with a “normal” range of sound pressure levels. If you place the microphone very close to a loud sound source, their internal circuitry can easily be overloaded, producing distorted sound. Many condenser microphones either have switchable attenuators or special attenuating modules which can be inserted between the capsule and preamp body. If in doubt, use the attenuator function. Usually this lowers the sensitivity level by 20 decibels. To be safe when using louder sound sources (like actors yelling or screaming) you would be better off using the attenuators and get a lower level output from the mic, which can be corrected with the recorder level knob or the camera level knob, rather than a distorted sound, which cannot be easily corrected!

Microphone polar patterns

A microphone's directionality or polar pattern indicates how sensitive it is to sounds arriving at different angles about its central axis. The polar patterns illustrated below represent a collection of points which produce the same signal level output in the microphone if a given sound pressure level (SPL) is generated equally from all around the microphone. How the physical body of the microphone is oriented relative to the diagrams depends on the microphone design.

Omni- directional | Bi-directional or figure-8 | Subcardioid | Cardioid | Hypercardioid | Supercardioid | Shotgun or Rifle mic

Omni-directional refers to hearing equally well in all directions. Omni mics are also preferred for handheld interviews, since this allows for the unexpected overlapping of dialogue between interviewer and subject. When you go off-axis with any other type of polar patterns the sound quality drastically changes.

“Cardioid” literally means heart shaped, and refers to microphones that are more directional from the front.

The hypercardioid or supercardioid is considerably directional. This group includes what are known as "short shotguns" such as the Sennheiser 416 and Audio Technica 4073.

Ultra-directional means extremely directional, such as long shotgun mics. Examples include the Sennheiser 816 and the Audio Technica 4071.

These last 4 mics are some of the most used mics in TV and film sound productions though the best shotgun mic I’ve ever tested was the Schoeps CMIT 5 U, but it is expensive…

Based on the polar pattern the areas within the circular figures above represent the directions from which the microphone is sensitive to sound. As can be seen the omni-directional microphone picks up sound from all around (omni) while the figure-8 microphone doesn’t pick up sounds from the side. The cardioids categories don’t pick up sound from the back which makes it somewhat more useful in live application where feedback needs to be prevented, though dynamic microphones are even more effective at this, though not as full and “natural” sounding as condenser microphones.

You can also see that the shotgun microphone polar pattern is very narrow and mainly pick up the sounds from exactly what it is pointed to. That’s why it is so important that the boom operator always aims the shotgun mic directly at the actor’s face or the mic won’t be picking up much sound at all.

An omni-directional microphone often has a more neutral sound and a more extended bass response than a directional one. However, because it has no ability to discriminate against unwanted sound sources, it must be positioned at less than around half the distance of any directional microphone for the same amount of “spill” or room sound. So if you are happy to close-mic a source, don't discount using an omni, which will often sound less colored than a cardioid, for the spill penalty will probably be negligible.

Don't forget that many (cheaper) omnis tend to become quite directional at high frequencies, so try to keep the main sound source on-axis when using these for best tonality.

All directional microphones exhibit some degree of proximity effect (bass boosting, which becomes stronger the closer the microphone is to the source). This can be used to advantage if you want to warm up a sound in a more natural way than with EQ (equalization), but beware of putting microphones close to a moving source, because the character of the sound will vary as they move. Dancing vocalists and swinging guitarists are often uncontrollable!

Microphone application types

Earlier we spoke of different types of microphone designs. I want to briefly mention another category of microphones which is directly related to the application or uses of the microphones.

Shotgun microphone

The most common microphone used for set and location sound recording is the *shotgun microphone*. It is also referred to as a rifle microphone as it resembles a rifle when held by the hand in a mic holster. See below picture.

The shotgun microphone is really a type of condenser mic with one design addition. Shotgun microphones are the most highly directional. They have small lobes of sensitivity to the left, right, and rear but are significantly less sensitive to the side and rear than other directional microphones. This results from placing the element at the back end of a tube with slots cut along the side; wave cancellation eliminates much of the non-aimed-at sound. Due to the narrowness of their sensitivity area, shotgun microphones are commonly used on television and film sets, in stadiums, and for field recording of wildlife.

Because of the additional wave cancelling circuitry the sound quality is not as good as a regular condenser microphone, but way less prone to pick up ambient sound and therefore has a much better use for ambient location recordings. It is normally more convenient to use indoors as well, but if you want to get absolutely ideal production dialogue sound you can use a regular, small-capsule condenser microphones mounted on a boom, but it requires good ambient noise control.

The Schoeps CMC5/MK4 (cardioids) and MK41 (hypercardiod) condenser microphones are commonly used and make very high quality sound recordings. The MK41 microphone is also the choice microphone at major awards presentations such as the Academy Awards.

They require more attention to acoustic handlings and wind protection, but they are not as sensitive as the shotgun microphones and are a better choice when trying to capture multiple people with one microphone.

Examples of condenser shotguns commonly used for film production include the Sennheiser MKH416/816, the Schoeps CMIT5U Shotgun Microphone, and the Audio Technica 4073/4071.

Boom microphone

This is not a specific mic but simply refers to an application whereby a microphone has been attached to a specific mount (which either comes with the microphone when purchased or can be obtained as an accessory to that microphone) on a boom or fish pole. Usually shotgun microphones are mounted on booms but also small-capsule condensers like the Schoeps MK41 are mounted on booms for high quality set and location recordings.

Boom operator with boom
and a Sennheiser shotgun mic

Schoeps CMC5 with MK41 capsule
with mount to attach to a boom

Lavalier (or Lapel) microphone

This is not a “type” of microphone but is rather an application. It is called a lavalier or lapel microphone as it is of a smaller design usually fitted with a clip that attaches onto a lapel, or tie, or pocket or some piece of clothing. For interviews, live TV and news broadcasts it is very common to use lapel mics. Most lavaliers are omni, which is good since they could end up being worn in different places and at different angles in order to accommodate clothing styles. But lapel mics can have different polar patterns for specific usages. There are even dynamic lapels.

Using lapel mics for film production can be very “convenient” as it doesn’t require a boom operator. However it is very hard to get and keep a clean sound using lapel mics on moving actors/actresses. For a static news caster it’s not a situation, especially as the lapel mic is usually right out in the open. Hence there is no “rustle” sound from clothing covering the mic, or movement-sounds as the person is somewhat in a static position. This type of mic is great for this use.

For film sound it can be quite problematic however. Firstly you are not supposed to see the microphone so you have to hide it inside the actors clothing or attire. This means the mic will be covered by fabric. Fabric moving against the mic causes a rustling sound. If the actor is moving this causes extraneous noises. They are also not wired but are using radio transmission and this is very prone to interference when moving around with clothing constantly touching or rubbing against the mic.

Sometimes due to having actors in a long shot, a boom mic just isn’t an option. Then it comes down to the quality of the mic, radio frequency equipment and the innovative ability of the sound men to properly secure the microphone on the actor with minimum to no rustle. Some professional sound men have even designed their own cages to hold the mic suspended under clothing for no extraneous noises. These are not obtainable in the store however and have to be hand-made.

Radio (wireless) microphones

These are not a specific type of microphone but simply describe an application where the mics are connected to the recording device with wireless (radio frequency - RF) transmission instead of audio cables. Obviously many situations occur where the boom operator cannot take the microphone boom where traditional microphones may go. The obvious answer is to break out the RF mics. A small microphone capsule can be either clipped or taped in a position somewhere on the upper part of the body, usually against the chest just above the heart.

The capsule has a small wire that runs under the clothing to where the transmitter pack is attached. The transmitter pack is belted, taped, or otherwise affixed to the actor's body and has a short transmission wire (antenna) taped in place to broadcast the signal to the mixer.

Batteries are consumed rapidly when using a radio microphone, so the boom operator should be prepared to change the batteries every couple of hours. It is not practical to turn the transmitter pack on and off between takes, so leave it turned on from the time you mic the actor to when you either wrap the actor or reach a point where the batteries, starting to show signal degradation, must be changed.

Before the boom operator approaches the actor, he or she should go to the wardrobe department to coordinate fabrics and textures as well as any special requirements, such as cutting holes inside the costume to allow wires of radio microphones to be connected to the transmitter worn somewhere on the talent's body. Some fabrics such as silk, wreak havoc with radio mics, as they cause much noise. Another consideration may be whether an actress is wearing a bra. If so, the microphone wires can be hidden easily in the bra material, circling around the chest to the back. The wire can be taped as it descends down to the transmitter, which is often hidden in the small of the back. The absence of a bra necessitates carefully taping the wire to the body so that it does not move and show up as it pushes out against the fabric of the costume. On a woman this can of course be a sensitive issue if the operator is a male, so simply have decent sense in approaching this.

Which microphone do you use?

The rule of thumb is that the more directional the microphone, the more it will emphasize echo in a small room. Therefore, work towards the best compromise between the reach you need (distance to the actor or object you're recording) and the sound quality you would like to hear.

Long shotguns work the best for most exterior shots, since these mics are characterized by a long reach and very narrow pick-up. The narrow field of view helps to control background noise if the mic is deployed overhead. The greater range helps because exterior shots are very often much wider than interior frames, since there is more interesting stuff to look at or action to cover.

Always use a blimp windscreen on your long shotguns to guard against wind noise. I find that using a foam windscreen inside of the blimp gives almost twice the protection. For most condenser mics, a furry windsock will help to disperse the wind and diffuse it upon impact.

Blimp windscreen

Furry windscreen

Foam windscreen

To guard against rain, use lots of ScotchGuard spray. Extreme rain (or fire fighting) would call for a thin condom over the mic itself (no kidding), as well as a rain-hat over the blimp made from what we call "hogs hair" or "rubberized hair". A mic covered by a condom can also serve at a pinch to do underwater recordings or in otherwise wet conditions. Hogs hair is a thicket type material that will break up the raindrops and prevent the pitter patter sound of them striking the windscreen, roof of a vehicle, or roof of a recording stage.

Long shotguns may also be used on some interiors, providing that the room or sound stage is very large and free of excess echo. They offer the advantage of increased overhead range and headroom on wide shots. Their disadvantage on interiors is: 1) they are physically longer and may bump a low ceiling; 2) they must be precisely cued or aimed because of their narrow pattern (to cover two actors requires a very good boom operator); and 3) long shotguns will exaggerate room echo.

Prime examples of long shotguns include the Sennheiser MKH816 (condenser, 12 volt T versions & rarer 48 phantom versions); and the Audio Technica AT4071 (48 phantom). Audio Technica also offers the AT815a/XLR, which is an Electret condenser (AA battery) ENG type of shotgun which is good for smaller budgets.

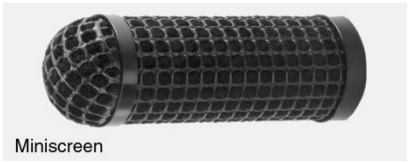
Interior locations are usually better off being miked (balanced) with a short shotgun. The short shotgun features a slightly wider pattern and slightly less range, but does not exaggerate the room echo as much. The wider pattern and physically shorter length of theses mics facilitates use with lower ceilings, especially when it comes to covering multiple actors.

Short shotguns come in a variety of "focal lengths", so to speak. The Sennheiser 416 has a fairly tight pattern, and can double for exterior work. The extinct Sennheiser 435 offered a wider pattern than the 416, less range but also less echo. The extinct Sennheiser 406, and the Schoeps CMIT 5 U, offer fairly wide patterns, short range (a foot or two), but excellent defense against room echo.

The Audio Technica AT4073a has greater range than a 416, but a slightly wider pattern and more even off-axis response that makes it one of the best sounding (very echo resistant) all-purpose interior condenser mics on the market today.

In the choices of electret condenser short shotguns, there are the Sennheiser K3U/ME80 and the Audio Technica AT835. Neither mic offers the range (4 to 5 feet) of their big brother condensers (the 416 and the 4073a), but at shorter distances (up to 2-3 feet) they sound equally good on the track. The main advantages of these ENG shotguns are price and ruggedness. Both mics are the standards of the news gathering industry.

All short shotgun mics should always be used with a foam windscreen, even indoors. Outdoors, a blimp windscreen or half-blimp such as the Light Wave Mini Screen or Rycote Softie should be used.


Miniscreen

In a pinch, simply wrap a few layers of cheesecloth over the foam windscreen, and then cover in a tube-style sweat sock. It works.

A rule of thumb is that natural material such as animal hair or fur or even natural fibers such as cotton passes sound through better while being protective (to a degree) against wind force. Synthetic and plastic material have a tendency to remove all high frequencies so the recordings end up sounding dead, dull and muffled with windscreens or coverings made of non sound-friendly material. A simple with-and-without test on the spot will tell you the difference using a human voice as a test. Same rule goes for clothing and covering lapel mics in clothing. Types of clothing material make a big difference regarding its ability to pass full-range sound through. All fabrics deaden in part the high frequencies, but the better material only makes a negligible difference.

Any shotgun mic should always be used in a good shock mount to eliminate handling noise and vibration. One industry standards for short shotguns is the Audio Technica AT8415 universal shock mount (the tic tac toe rubber band mount).

Blimp windscreens require their own brand of pistol grip shock mounts, which are usually purchased in conjunction with the windscreen system. These mounts are intended to be used with or without the windscreen, so there is no need to purchase a separate shock mount if you have a blimp system.

Microphone positioning or “balancing”

When evaluating how to approach a scene there is a “Hierarchy of Microphone Techniques" which can be employed which consists of the following:

1. Overhead boom
2. Boom from underneath
3. Boom mics as plant mics
4. Lavalier mics as plant mics
5. Lavalier mics as body mics
6. Lavalier mics, wireless

The overhead miking from a fish pole (or studio boom) is the most favored technique for film/video production and is the best choice most of the time.

The operational word here is "overhead". Why?

There is a tendency for filmmakers to rely too heavily on their camera mounted shotgun mics rather than separately mounted boom mics. Obviously, having a microphone on the camera is more convenient. But our objective in the field is not convenience, but obtaining the highest quality sound possible!

Think of your shotgun microphone as a telephoto camera lens. A long lens will isolate and magnify a distant subject, but at the same time it will compress the perceived distance between subject and background. Everything appears to be closer together than they physically are.

The same sort of spatial compression takes place with microphones. The voice of the subject will sound closer, but any noise in the background will also be magnified.

Therefore, the key to isolating voice without background noise is to create a line of sight with the microphone that sees the voice but does not see the background!

To put this simply, aim the mic from ABOVE the subject so that the mic points DOWNWARD. The line of sight reaches from the front of the mic, to the mouth, and then towards the ground. Background noise and ambiance will strike the sides of the microphone (which is the maximum rejection angle) rather than striking the mic along its most sensitive front axis.

In the event that it is impossible to mic from above, the next best option is to mic from below, so that the line of sight terminates with sky. Personally, I find that miking up tends to emphasize bass a bit more, since the mic is seeing more of the chest cavity.

Also, camera operators are not as accustomed to maintaining a strict lower frame line as they are at watching their headroom, so the mic tends to pop into the shot more frequently.

Another important consideration when booming is not just the angle of the mic but the distance. Shotgun mics are not designed to be used (for broadcast quality sound) at much more than a few feet. One of the great advantages of using the mic on a fish pole, as opposed to being attached atop a camera, is that the mic can be brought close to the subject even when the camera isn't.

For clear and clean dialog for documentaries, interviews, etc., the optimum distance to the mouth is only 6-8", or the width of your fingers as in the below picture. You'll still get good sound up till about 16" or even 2 feet with higher quality mics, but beyond that even the best rifle mic will pick up quite a bit of ambient sound and requires much more attention on ambient sound control. The mic for interviews should be angled around 45 degrees.

I often tell novice boom operators that they aren't doing their job properly if the camera operator fails to complain that the mic is in the frame (during rehearsal). Every inch closer that the mic can be to the subject will improve the quality of the sound. Never fly the mic higher than it absolutely needs to be if you want to control echo and background noise. Several inches to a foot over the top of talent's head is ideal; up to a few feet overhead is okay depending on the situation.

Some camera operators confuse width with height. A wide-angle lens means wide from left to right; it doesn't mean that they have to reveal several feet of air above the talent's head. A simple tilt-down of the lens will correct excessive headroom in the composition when using a wide angle lens!

Learn to recognize and take advantage of the on-axis (live) and off-axis (deader) angles of your mics. Most shotgun mics are very much on-axis at the front (say, twelve o'clock), and taper off towards the back (six o'clock). But at exactly six o'clock, there is an increase of sensitivity! In other words, the back of the mic does not offer the most rejection to background noise. The most rejection occurs around four o'clock and eight o'clock respectively.

So to decrease a source of noise, you would not want the mic facing directly away from it, as that would only serve to put the noise at the live spot in the back. Instead, angle the mic so that the noise source strikes slightly to the side and rear.

When deploying your mic overhead, keep these angles in mind. Often it is better to compromise the angle of the voice (slightly) in order to keep heavy background noise to a minimum. Any angle of the mic should be consistent with the source of the worst noise. For instance, a person talking on the sidewalk would put the mic overhead, but cheated towards the buildings and away from traffic — even if the camera changes shot angles. Similarly, a subject walking along the edge of the surf on a beach should have the mic facing along the beach or at least away from the surf, not out towards the noisy surf.

Another important factor to pay attention to is "perspective". The distance between microphone and subject should agree with the distance to the screen or camera. In a long shot, it is natural for the voice to sound more distant and for there to be a greater presence of ambiance. Close-up angles should consist of more voice and less background. What you see is what you should hear – seeing is believing and in this case hearing is also believing.

However, angle of motion is very important. A person walking away from the camera should not be walking towards the microphone, or vice versa!

Novice boom operators are notorious for perching themselves in a safe spot out of the frame that places the mic in a position not consistent with the direction of travel relative to the lens.

A person with their back to camera should not be facing the mic. A person walking up to the camera should not be walking away from the mic.

To balance a strong voice against a weak voice, use your mic angle and placement rather than riding the level (volume/gain) on your mixer/recorder. Let the strong voice strike the mic slightly off-axis and/or from a little more distance than the softer speaking actor. This will balance the relative volume of both people without having the background noise continually changing during the shot, which it will if the sound mixer is constantly changing recording levels.

Audio Levels

The term “level” can mean many things. In sound applications the term basically refers to one of two things:

1. The exact audio volume at any given instance
2. The range (*dynamic range*) of the audio signal, measured as an average figure between the lowest audio level to the highest audio level

Level simply means the volume or strength of a signal. The louder a sound, the more energy it has. Loud sounds have a large volume, or *amplitude* as it is more commonly referred to. Think about what an amplifier does: it makes sounds louder. It is the amplitude that relates to how loud sound is.

Dynamic range

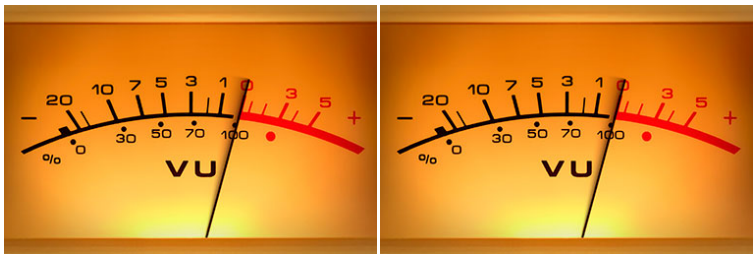
When speaking of a system’s or a piece of equipment’s *Dynamic range* it means the ratio of the loudest to the softest signals that system can handle without distortion. In other words, the range of level a piece of gear is capable of reproducing without distortion.

In practice this is the difference between the lowest audio level the system can reproduce before its own self-generated noise and the onset of distortion due to the level being more than the system components are designed to handle.

When speaking of the dynamic range of a recorded signal we’re referring to an average range – not the difference between the ambience level and the loudest cry. The dynamic range of a voice is **the level between the average lower levels of the voice and the average louder levels of the voice**.

Most audio texts will define this in terms of dB, or decibels. This is like many other things such as meters, volts, liters, gallons, etc. – an arbitrary term that someone (in this case the Bell Laboratories in honor of Alexander Graham Bell) invented with a bunch of mathematical formulas. For all intents and purposes we will just say that a decibel indicates a unit of level. Electronic audio is measured in dB (decibel) and acoustic sound is measured is dB SPL (Sound Pressure Level).

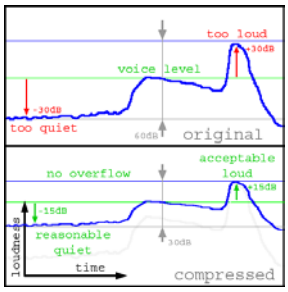
On modern digital recorders and cameras they usually have some form of audio meters. These uniformly have 0 dB as the maximum level before distortion. In the analog days they used to have 0 VU (Volume Units) as the maximum level. VU and dB are basically synonymous and their difference is based on the mathematical standards used, of which there are many pending on what country you are in – very confusing subject…



For decent magnetic audio tape one can say that an acceptable dynamic range of a recorded signal is between -16 VU and 0 VU. If the average “lows” of the audio recording is below -16 it became too noisy (because of the analog tape) and if your average “highs” were above 0 dB you would get distortion. However, there was a margin so that an occasional loud word over 0 VU and an occasional low word below -16 VU would still be acceptable as long as the average range stayed between -16 to 0.

For digital audio 0 dB is the ABOSLUTE maximum – you can’t go over that. In digital audio 0 dB is most commonly referred to as 0 dBFS – 0 **d**eci**B**els at **F**ull **S**cale. This simply means that if you have 16 combinations of 1’s and 0’s (like on a CD) to define the audio, 0 dBFS equals 1111111111111111. Above that you have no more bits to define the sound and you get distortion.

The more bits you have available to you, also called digital resolution, the bigger the acceptable dynamic range is. For digital audio or video, the more samples you take per second, the higher the definition of the audio (or video) is. Most cameras record at 16 bit resolution and 48,000 Hz sampling rate (definition). This is good enough for dialog, but for music production the original recordings are most often at a much higher bit resolution and sampling rate.



Dynamic range expressed as before and after compression is applied in mixing

Reading volume or level meters

There are two types of basic meters:

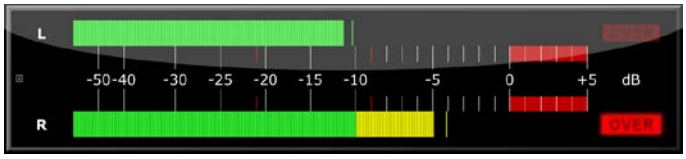
- Peak meters (which most digital displays on cameras and digital audio recorders have)
- VU meters (Volume Unit) which show the average energy of the audio signal

VU meters were very common in the analog days and were found on most mixing consoles. Modern mixing consoles sometimes have only peak meters and some a combination of both.

For analog audio VU meters are more useful but for digital audio, peak meters are better to ensure your levels are correct.

Peak meters

A peak meter always and only show the maximum (or peak) electronic amplitude of an audio signal. As stated above for digital audio "0" (or 0 dBFS) is the maximum level. That means that ANY audio signal louder than "0" will cause distortion – always.



Peak meter

VU meters

A VU meter always shows the average electronic energy of an audio signal. It is calculated with an RMS mathematical equation. RMS means Root Mean Square which is a fancy term to calculate the average of something that fluctuates. The more high frequency content the audio signal has, the more peak information and less average level the signal will have. On the contrary, bass information has a lot of average energy but not so much peak information. Therefore using both types of meters is ideal for recording and mixing, especially when dealing with music.

VU Meters

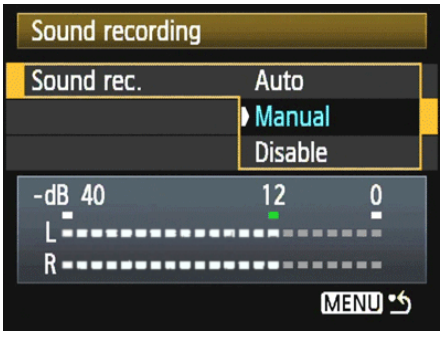
The human voice contains both high and low frequencies. Dialog has much less peak information than sounds of objects hitting each other. To illustrate this when recording two people eating dinner, it is quite possible that the higher peaks of the dialog is 6-12 dB lower than the peaks of sounds like putting a cup or a plate on a table. As the dialog is the meaningful signal, the levels would be adjusted to the dialog ONLY, not the peaks of cups, plates or other sounds of objects.

On a camera or handheld recorder, levels can usually only be monitored on a digital peak meter. Many cheaper versions of video cameras and audio recorders have a very limited set of steps indicating the audio peak level – maybe as few as 4. When this is the case one has to really test his audio levels to ensure a proper level has been established.

Setting the audio levels during a set or location shoot

As a general rule with digital recordings, you try to keep the level of the dialog as high as possible without the risk of distorting the audio because the levels are too high. The higher the skill and attention of the recordist to the audio levels, the higher the level can be set and adjusted, sometimes in real-time by the very skilled ones.

If the crew or shooting situation demands that a basic level is set and left that way, you should err on the lower side by testing the levels during a rehearsal. Give yourself a 6-dB margin of headroom (amount of decibels left until distortion) based on the louder parts of dialog expressed during the rehearsals. This should amount to the average dialog peaks hitting around -18 dB to -12 dB with occasional peaks at -6 dB. This will give you a safe level that is a bit low, but not low enough to cause audio degradation, additional noise, etc, and, you will be safe at running the risk of distortion.



For consistency of the entire scene, it is better to keep the level roughly the same between takes rather than constantly adjusting the level. If the ambience level of each shot/take is consistent that makes the dialog editor's and mixer's job very easy. It is simple to mix different shots with the same ambience level but varying dialog levels (to a degree).

However, if you run the risk of distortion it is better to adjust (lower) the level temporarily for an extra loud dialog shot, like a cry or scream. The mixer has more tools to handle a jump in levels or background noise than handling distorted dialog, which can be improved, but never made “un-distorted”.

It is a fine balance between proper levels and consistent levels but if you can achieve this it makes audio post production a breeze. For most shooting situations you should be able to set the levels as indicated above and pretty much leave it like that with only minor adjustments. It has to be monitored though to ensure your margins are still what you think it is.

A much better means to handle the “level” which you can do if you’re using a boom mic, is for the boom operator to move away from a source that is speaking suddenly louder. Then move the mic back when the dialog is normal. The same goes for quieter or whisper-type dialog shots. Just move the mic closer as usually the DofP likes to go closer too for intimate scenes and therefore should be able to shorten the distance to the mic and still stay out of the camera frame. This does require an experienced and dexterous boom operator however.

With stationary mics and lapel mics, this can’t be accomplished and level differences are entirely up to the recording engineer and he must adjust the levels according to the situation.

The louder the background noise or ambience level is (that can’t be removed such as turning off the A/C) the more important it is to be consistent in ambience level during shooting.

It goes without saying that it makes life a lot easier for both the recording guys and the post guys if extraneous noises are shut off or otherwise handled during the shoot. This includes turning off A/C units, fans, buzzing electrical components (like fridges), or simply closing a door or window. 10 seconds of time taken on the shoot can save 2 hours of work in post!

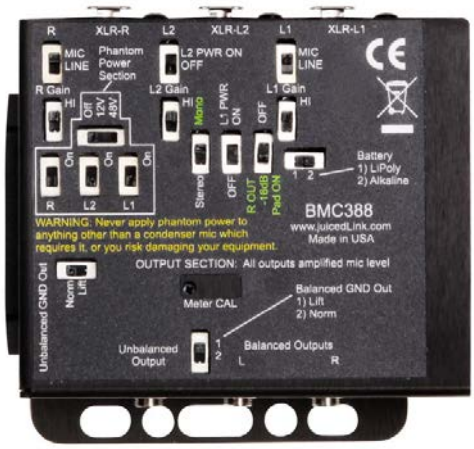
It is also smart to appoint a specific person, even as a second hat or function, to turn things like the A/C on and off – off for the shoot and on for in-between so the crew members don’t get heat strokes! But don’t forget – there is nothing harder to cope with in post (outside of distortion or no sound at all) than some shots having A/C noise and others having none.

NEVER use Auto-Gain or Automatic Gain Adjustments on a camera or recording device! On some cameras and devices you’ll see a switch that says “REC LEVEL” and has the option of “A” or “M”, meaning Automatic or Manual. **Always** set this to **Manual**. If set to automatic the ambience level will constantly fluctuate and it will be impossible for the mixer to later make this sound consistent. Maybe this setting can be used for some quick news footage where you don’t have time to properly set things up, but **NEVER** for a film soundtrack.

The audience is naturally distracted by **CHANGE**. Any change visually or audibly can become a distraction, unless this is a technique specifically employed by the film maker. For sound it is then important to keep levels and background noise consistent from shot to shot in any given scene to ultimately keep the audience from being distracted by audio changes. The audio editors and mixers can fix some degrees of change, but not only does this add a lot of time, but large changes cannot be coped with and will not sound transparent to the eventual audience. Some "solve" this by just putting music on top of the dialog (like many Cantonese movies I have worked on) and doing so is a tool, but music shouldn't be used to "cover up" but should only be used to enhance the soundtrack where needed.

Mic/Line connections

One last thing to mention and clarify is the difference between ***line*** and ***mic*** inputs, outputs and switches.



Line as a word in audio or video applications means either 1) short for line level, or 2) a cable.

There are basically three types of "strengths" of audio signals. They are:

- Mic level
- Line level
- Speaker amplifier level

The mic level is the weakest of the signals and requires the most amount of amplification. Therefore the audio circuitry must be designed to handle this type of signal. The signal is generated from microphones before they are amplified by a pre-amplifier. Dynamic mics output the lowest signal and require the most amount of level boosting. Therefore a dynamic mic recording is usually noisier than a condenser mic as it requires more amplification which also carries with it a certain bit of self-noise.

The line level is stronger than the mic level but not strong enough to be sent to a speaker. Examples of line level signals are the output of a CD player or inserting mixing equipment on a mixing console. A line level signal requires an amplifier to be sent to speakers.

The speaker amplifier level is what is sent to speakers. It is a much stronger signal than mic and line levels. If a speaker signal is plugged in by mistake to a mic or line level device you can blow up its circuitry.

On a video camera recorder, audio recorder or mixing console you usually have a choice of plugging into the ***line*** inputs or the ***mic*** inputs. Sometimes the plug is the same but there is a switch which selects ***mic in*** or ***line in***.

For a microphone which requires phantom power it can only be obtained by plugging into the ***mic in*** connection. The ***mic in*** and ***line in*** inputs have different electronic designs to fit each application. Equipment designed for the ***line in*** inputs are referred to as using ***line level*** signals – as compared to ***mic level*** signals for microphones as well as certain other devices such as turn tables.

When referring to ***line level*** one is usually either talking about 1) an amplified signal level put out by an preamplifier and used as the normal level that runs through the interconnecting cables in a control room, such as a microphone signal which has been boosted to ***line level*** by a microphone pre-amplifier or “mic-pre”, or, 2) a low level signal such as the signal in a guitar cord or from some types of keyboards. If a Sound Mixer also sends the recorded microphones as a feed to a camera, with the audio levels already set on his recording device, the camera should be set to ***Line*** as the signal has already been pre-amplified by the Sound Mixer.

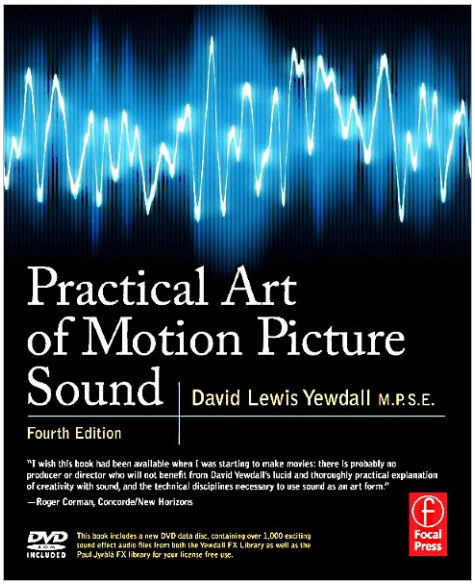
Most parts of a public address (PA) system require a line level signal. Remember, however, that speaker amplifier outputs are not line level. Plugging speaker outputs into line inputs will result in damage to the equipment.

As a rule of thumb microphones are plugged into the ***mic in*** (or the device switched to ***mic in***) and audio devices such as DVD players, CD players, iPods, etc. are connected through the ***line in*** inputs.

Summary

Much can be said and explained about the basic sound discipline for film production but the above covers the basics for practical applications. No matter the theory, the principles laid out above have to be tested and experienced directly by any operator to fully make sense. With that experience and some trial and error, the expertise as well as full understanding of the theory will come about as a natural progression.

Much has been written about the subject already, but in particular for those who want to dig in, roll up their sleeves and get serious about the subject of sound for film, they should get and read the book *Practical Art of Motion Picture Sound* (4th Edition) by David Lewis Yewdall. It is very comprehensive, not too technical and a very informative sound instruction book with exact ways and tools to handle practically all situations that can arise during the full production of a film.



Sound is an important element of film production. Some say it is 50% of the film. It is factually quite a simple field if you know and apply the basics. With a little bit of understanding, sense and practice, sound can be turned into an easily managed operation yielding satisfying results for the eventual completed product.

Good luck!