Microphones and Transducers

Microphones and transducers? Really is the same thing. A transducer is a tool which creates electrical waves out of an analog input, which is basically the function of a microphone.

A microphone, in the standard sense as we know it, records audio being received by it, it does so by having a system which translates the analog input of the sound which was driven by the air to it. Meaning that it converts the small changes in air pressure, which we call sound, into a signal which can then be enhanced, recorded, played back etc.

There are many kinds of microphones, but among the most used ones are dynamic and condenser microphones. There are many other kinds, which we will get to shortly.
A dynamic microphone works through very basic electro magnetic theories, that when having a spunned wire around a metal core, you can create electro magnetism and move the core if you add voltage to the spunned wire, but if you move the metal core, the system works the other way around, instead of adding voltage to the system and moving the metal core, you move the metal core and create voltage which can then be sent to any system of preference.

A good example is that a dynamic microphone can actually be used as a speaker, and a passive speaker can be used as a microphone.
Setting a speaker in front of your kick drum to record the sound of the drum, is actually not such a bad idea.

A device which then controls the amount of movement in the metal core, like a small piece of paper which you yell at, will be able to pick up the slightest changes in air pressure and minimally move the metal core.
Here is is already given why such a signal must be amplified quite a bit before it can be played back and heard at a useful level again. The amount of voltage generated by the metal core is so little that it takes a lot of power to make it count, the basic difference between volts and amps.

This also means that any system which can generate a slight voltage, can be used as a microphone and this can be spoken of as a transducer.

A condenser microphone works slightly differently and requires a small amount of power to work, better known as phantom power. The power creates a small electrical field inside it's capsules, which when picks up changes in air pressure, will send a small signal back, which we then can use.
A general rule on condenser vs. Dynamic microphones, is that dynamic microphones are more prepared for a heavy load, but takes a lot more physical power to respond to sound and a condenser microphone needs very little power to reproduce it's electrical signal, this making dynamic microphones useful when you know the signal is of a certain power and perhaps if you already know that the noise from the source will be quite loud, condenser microphones on the other hand are much more sensitive the loudness, but pick up much more detail in the sound than the dynamic microphone – when close mic'ing and picking up signals from a kick drum and a hihat, the kick drum containing much more energy and that "omph" as we know it, not needing much help in getting loud. The hi-hat on the other hand has a lot of frequencies at once and we can benefit from the condenser microphones system to pick up more detail on these frequencies, than we would with a dynamic microphone.
Yet, it's always a matter of taste and there is no right from wrong when recording something, as

long as it sounds the way you want and can justify the recording quality.

Any device, which can create currant can be used to create an electrical signal which can then be recorded
Taking a 9 volt battery and connecting it directly to a speaker, will result in the speaker being full blown out. Not destroyed or not working, but a firm click will sound and the speaker will be fully in it's maximum position. Change the poles and it will be in it's minimum position and you shouldn't be able to tell the difference between the two clicks.

This is also where accellerometers and piezo discs become very interesting.
Piezo discs work by being a disc of cobber with a bit of quartz crystal attached to it – quarts crystal is a very strong material and is often used in clocks, where a tiny bit of voltage is added and the crystal will resonate in a very precise clock, which in the clock is of course used to keep track of the seconds passed.
The keyword here is resonate, and if power is added enough to a piezo disc, the quartz and cobber disc will resonate back at the frequency mathing the size of the disc, creating a very loud almost unbearable square wave like sound. They are mostly used in your average home devices needing the make small beeps and bleeps whenever it needs your attention, like bed room alarm clocks, microwaves, smoke detectors and so on.

The other way around, just as the dynamic microphone, is much more fun, from a microphone perspective of course. Sodding a hot wire to the quartz and the ground to the cobber disc and connecting it to your amplifiers microphone input, will allow you to hear any vibration added to the disc. You can't talk into the disc and hear it – but you can place it on a table or window, and touch the surface of the table or window and listen to that.
By doing so, we have just created a contact microphone, which can now be attached to any surface and listen to it's vibrations, like the sound of a fence. The sound of a car, inside the metal parts, an insect walking on your table, put it inside a bag filled with water and drop it in your freezer and listen to the sound of water freezing. Or melting again, if you want to try a different approach, use some temperature resitant cables, and stuck it inside your favorite chocolate cake and you can hear it become crisp, stick it into the ant farm in the garden and hear it come alive.

Accellerometers are much more sensitive and doesn't require any prepping before ready to be used, and will give much higher quality recordings than the piezo disc, but a piezo disc, with cables and some electrical tape to protect it should cost no more than 10€ or 10$ for 10 or even more of them. So taking the price into consideration, you get pretty far with piezo discs and home sodding, besides sodding is fun and a learning experience in itself.

Characteristics

Microphones have many different characteristics, and the best way to explain it is that all microphones record differently and some may even be altered in their area of recording.
Most microphones record straight forward what's in front of them, but what about what is behind the microphone?. Some microphones, techniques and characteristics record more and / or less what's behind them or to their sides, this is called the microphone characteristic – the the microphone itself and the technique you decide to use, greatly expands the world of what is possible within recording.

A so called Omni characteristic, records everything around the microphone, no matter if it's coming from either side, front, behind or above the microphone.

A cardiod microphone, or as some call it, a kidney characteristic microphone, given it's name because it's recording pattern is in the shape of a kidney. A Cardiod microphone is what you would usually see on a vocalist or during an interview, where you do not care about the behind the persons involved or to the sides of them, for that matter. It records most of what is straight in front of it, but almost nothing of what is behind it and only slightly from the sides.

If you want even less from the sides and behind, you can use super cardiod or even club characterized microphones, recording only what's in front of you, basically leaving out all noise coming from behind the microphone. Easy to use on boom poles where you cannot get too close to the object or person you want to record, but still can just point straight at their face and record their voice. Quality on such a microphone differs a lot and distance to the source is crucial.

Another key element is that microphones where characteristics are very directional, like club, super cardiod and so on, are much more sensitive to touch, giving that "useless" muffled noisy sound when handled.
Very directionally characterized microphones are often easily recognised by their amount of holes, and many wonder why holes make less sound.

This is simple because of the way you physically direct the microphone, it is done by phasing out the sound coming from the directions that you don't want, and by adding holes behind the actual wanted direction, you can phase out the input from that direction, from the wanted signal.
A very simple depiction of how it works can be seen here:

Figure eight microphones, work just as the name says. It records to both sides, but nothing from the front and back. Can be used if only one microphone is avail able and you need to record equally from both people talking, or between two drums where either is important.
Figure eight microphone, is always an important part of the MS microphone setup, which will be described in the section on stereo setups.

Inside the mic

Now we have described many of the different types of characteristics, but characteristics is one thing, another is how and why they actually behave as they do.
Already here some explaining can cause confusion, because as audiowaves are usually shown, as sine waves and therefore only moves from left to right on a horizontal line and shows the changes in air pressure, this way of imagining sounds can be confusing as to, how an omni microphone works.

An omni microphone has a single layer, which may be manipulated by the air pressure. This layer moves the coil or changes the electrical currant within the capsule of the microphone, and if displayed as just a small membrane which is hit by the horizontally moving sine wave, as mentioned before, then making sense is kind of easy to do.
If the sine wave is up, then the pressure is high and the membrane, coil and everything else is pushed slightly in, if the airpressure is low and the sine wave at it's lowest point, then the membrane, coil, etc. Will be able to move out of it's position.
All this transformed into an electrical signal which we can then translate into sine waves again to record, amplify or whatever we want to do with it.

But what if you membrane is pointing left, and your sound is coming from the right, so the sine wave which is read from left to right, needs to move left and hit the back of the microphone first? Then it can make it quite difficult to understand, from the imagery at least, how the microphone works.

Air pressure isn't excactly sine waves moving in the air, yes it can be depicted as the mathematical function sine, but only if we looked at air as going from left to right and at a very tiny space, which is never the case.
When looking at a recorded sinewave, you are basically just looking at a graph, interpretted from the input of a scientific measuring device, which tell your tiny differences in air pressure.
But air pressure is all around us and could also be understood as water or any other material for that matter and it's only at one excact spot, the one of the membrane and coil, which is read by our microphone and knowing the sound does not only move from left to right – we can then better understand that a pressure change, even if coming from behind, will still cause our omni microphone to respond.

It can also be named a pressure microphone. Meaning that any change in airpressure, no matter from which direction it comes, the membrane will be affected by it.
The pressure at that excact spot, is "always" the same, no matter which way you turn the membrane.

Now another type of microphone characteristic and membrane setup is pressure gradient. A pressure gradient microphone allows the membrane to be manipulated by airpressure not only from it's front, but also from it's back.
Doing so will cause some weird, but nice and usable effects. Pressure gradient basically gives you a figure eight microphone, because the electrical currant produced by the membrane and coil will be the sum of the values coming from the air pressure from the front and the back combined – and if a sound comes from the side of the membrane, the pressure will be equal on both the front and the back of the membrane, causing silence – in your recording at least.

Having a regular box, with a membrane, which works as our omni microphone, making a small hole in the back of the box causes sound to enter the system from behind.
But if we dampen the signal fron the back of the microphone a bit, we can combine the two pressure and pressure gradient techniques and use the signal coming from behind as a tool.
Which will result in a super cardioid characteristic, meaning that it will respond to sounds coming from the front and in the angles around here, but not from the side, yet still anything coming from directly behind the microphone is still picked up.

But what if we phase invert the signals coming from behind? Then we are able to record what is coming from the front, but phase out the past of the signal coming from behind, making it possible to record only what is coming right in front of the microphone and not from the sides or behind – you may have seen so called shotgun microphones or zoom microphones, long, with a high number of holes or slots along the way down the microphone away from the main membrane at the end.

Having more holes in the back of the microphone, as you may have seen on many zoom and shotgun microphones, they look as if they are "good" in the sense that they have many holes and are then able to pick up a lot of sound.
What all these holes basically do, is that they allow sound to enter from behind and will phase out this signal from the original one. Meaning that the signal actually picked up by the main membrane

is actually omni and everything around it, but by phasing out the signal from behind this then "disappears"

A common rule is that, the more directionally sensitive a microphone is, the more sensitive it is to your touch as well, so a directional microphone should always be used with gyro, elastic band, boom poles or steady mounting to objects, and not held in bare hand or touched too much during recording. And then again, don't touch your microphones during recording at all anyway.

Stereo Setups

When using two microphones, to record both left and right, we have a stereo setup.
It's not the same as recording two sources in mono, but it makes a great difference to your stereo perspective when listening to the playback or just monitoring the sound straight from the microphone in headphones.

An AB Setup, is a setup where two omni characterised microphones are spaced with about 18 cm aparts. This type of recording gives a very detailed and almost binaurally precise playback, it can be used to create a stereo perspective of a human listener, by being placed in front of a live band.

ORTF. L'office de radio est television France. As the name inclines, then this setup comes from France, and was used in their radio and tv productions. An ORTF setup is two cardiod microphones, put with their bottom closely together and their fronts with about 18 cm apart. Giving an angle op about 110 degrees at the bottom. This gives a wider stereo perspective than the AB setup, because of the different type of microphone and the way they point.

NOS. Nederlands Operation Setup. Is from Holland, and almost resembles the ORTF setup, but is wider setup, with more angle and further apart.

A question arises quickly when going through all these different, yet almost similar setups, of why?, why all these different setups when all they do is record and of course sound differently, by why so many different ones.?

In the past, when internet and other quickly distributable media wasn't around, in the pre-historic ancient days, almost back to the time of big bang, all media producing companies within the industry had to use a standard setup, this is to make it easier for everybody to use the same, so that when the radio and television company in France orders something recorded in stereo, the audio engineer won't have to wonder what type of setup they want, he just has to use the standard setup, which in this case would be ORTF.

Of course in these days, we can, as well as they could, use whatever we want. So try them all and get to know their results and use it to your advantage when making stereo recordings.

The XY setup, is almost a reversed ORTF. Where the front of the microphones are crossed, so that the right and left side are almost in the same location but right is turned slightly left and left is turned slightly right. Giving a very narrow but solid stereo perspective.

The MS setup, is quite different from the others. You will place a cardiod microphone pointing straight forward, and a figure eight behind it, for recording the sides. This results in two, not very stereo like signals.

But taking the figure eight recording, splitting it up into two signals one left and one right and phase inverting either one of them, will leave you with three signals. A cardiod which is dead center, and a new stereo / phase interved two channel mix of the figure eight microphone. Combining these two signals provides a huge stereo perspective. Turning up the center microphone and to your own desire adding the stereo figure eight recording works really well.

You can also make a dobbel MS setup, which is two cardiod microphones instead of a figure eight, but the microphones must of course be alike and should be matched, therefore a set of matches microphones is recommended and dobbel MS setups can be purchased from many microphone producing companies.
