## Microphone types.

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This workshop will briefly explain how different microphones work with a short comparison between types. It follows on to describe the polar or pickup patterns of different microphones and again why or when different microphones would be used.

Operation of microphones.
All microphones pickup sound and convert this signal into an electrical signal which can be amplified and fed to loudspeakers. The way this conversion is performed is one method of characterising a microphone. The first microphones worked in the opposite way to a loudspeaker. Whereas a loudspeaker is fed by an electrical signal which makes a coil of wire move in a magnetic field and hence make the speaker cone move and cause vibrations in the air which are heard as sound, in a microphone the airborne sound makes the diaphragm move. The diaphragm is attached to a coil of wire which is then made to move within a magnet field. This movement of the coil generates a voltage in the coil and this voltage is output from the microphone and fed to an amplifier etc. This type of microphone can be manufactured to be of excellent quality and many professional artists and broadcast companies use this type of microphone. One drawback is that of size; it is very difficult to make the magnet and coil system sufficiently small to allow discrete microphone positioning. It is also difficult to make this type of microphone extremely light weight as the microphone is built round a magnet which must have sufficient size and mass to produce a good output signal. This type of microphone is called a dynamic microphone.

Later microphones where based on a capacitor. This system is much lighter weight but has other problems. A small electronic circuit is required to be built very close to the microphone, usually within millimetres. This also means that this type of microphone requires some electrical power to make it work. The principle of operation is as follows:
A capacitor holds electrical charge; the amount of charge a capacitor holds is determined by the voltage applied to the capacitor and the size or value of the capacitor. In turn the value of the capacitance depends on its physical dimensions. A capacitor is made of two electrically conducting plates separated by some small distance usually a few micro-metres. To charge a capacitor a relatively high voltage is connected to the capacitor via a high value resistor, the voltage is generally about 48 volts and is called the polarising voltage; the resistor is generally over 1,000,000,000 ohms (1Gohm). The microphone is manufactured so that when sound hits the diaphragm one of the conducting plates moves or vibrates with this sound. When the plate moves the distance between the plates varies and as described above this causes the capacitance to change in sympathy with the sound. As the polarising voltage is kept constant and the charge on the capacitor cannot escape due to the high value resistor, the voltage on the capacitor must change; this change in voltage is then fed out of the microphone as the signal, usually via some more electronic circuitry. This type of microphone is called a capacitor or condenser microphone; a special variety of this type is an electret microphone. This variety differs in as much as the high polarising voltage has been replaced by a physical charge fixed into the capacitor during manufacture. Although early versions of the electret microphone were poor modern electrets can work as well as any capacitor microphone and now electrets probably represent the majority of microphone sold.

As mentioned in the previous paragraph, capacitor and electret microphones require a power source to drive the electronic circuitry and make the microphone work. This power source was originally a battery but more commonly this is supplied by phantom power. Phantom power is a powering system found in most mixer desks and an increasing number of other amplification systems which have a facility for microphone input. It is only available on microphone inputs which use balanced XLR connectors. These are three pin connectors which allow improved microphone connections and microphone circuits. The phantom power voltage was traditionally 48v but there is now a lower voltage standard of 12v which may be found, on occasions other voltages may be found, 9, 15 or 24v are quite common.

Another aspect of the microphone input associated with phantom power is being balanced. A balanced microphone is one which has three output connections, one earth and two signal wires. The two signal wires form the balanced signal. When a sound hits the diaphragm of a microphone the voltage on the one of the output wires rises whilst the other falls, making the two signals equal and opposite or balanced. This has an advantage in that if the cable connected to the microphone is subjected to interference this interference will affect both signal wires in the same way. When the microphone signal reaches an amplifier with a balanced input, the amplifier amplifies the difference between the signal wires. This means that the wanted signal, which is opposite on the two wires, is amplified but the interference signal, which is the same in the two wires, is not amplified and so the signal passing through the amplifier to the loudspeaker is interference free. This balanced system is used on dynamic, condenser and electret microphones.

<u>Pickup pattern or polar pattern.</u>

Microphones are designed to pickup different amounts of sound for different purposes. In general there are omni-directional and uni-directional microphones. This means microphones which pickup everything or all directions and those which pickup in one direction. Uni-directional microphones are yet further sub-divided in the narrowness of this one direction.

The omni-directional microphone probably produces the closest to perfect signal, all other factors being equal. There are however problems associated with this and these will be discussed later.

The directional microphone, as mentioned, is sub-divided still further, the most common sub-divisions being cardioid, hyper-cardioid and sub-cardioid. Producing directivity is always a compromise; when you have an advantage in the directionality you often have a disadvantage or a change in characteristic in another aspect. All directional microphones suffer from the proximity effect. This is an increased bass or low frequency response when the sound source is close to the microphone. The dimensions and construction of the microphone can change the distance where this comes into play but generally it is between 50 and 300mm. This effect can be used to great affect by singers; bringing the microphone close to the mouth can give the singer and deep and full-bodied sound. In instruments it can give a more mellow, rounded and bass rich sound.

The simplest directional polar pattern is the cardioid shape. This shape has a full pickup sensitivity at the front and a zero pickup at the back with the signal decreasing progressively as you move from front to back. When drawn this looks like a heart shape hence the name.

Between the cardioid and the omni-directional is sub-cardioid. This is similar to the cardioid but rather than a zero at the back, there is only a reduction, about 10dB or 1/3 of the signal.

The hyper-cardioid is a more directional pattern but this is not a simple heart shape like the cardioid. Instead the hyper-cardioid has two zero points towards the back at 30degrees either side of the back location. The back sensitivity is similar to the sub-cardioid at -10dB or 1/3 but the width of the front sensitivity is narrower. Where the cardioid front sensitivity is full and at 90 degrees this is reduced by 6dB or ½ signal the hyper-cardioid has full sensitivity at the front but the 90degree signal is reduced by 10dB or 1/3.

Each polar pattern has its own uses but perhaps one important use for the live artist is its susceptibility to feedback.

As describes in the workshop on feedback, feedback occurs when sound from the loudspeaker gets back to the microphone and is amplified even more so it arrives back at the microphone even louder than previously. This continues, in a very short time, to produce a loud howling sound. It is easily imagined that if using an omni-directional microphone this situation can exist very easily as the omni microphone will pickup sound from everywhere. It can also be imagined that a directional microphone could make this situation better but which polar pattern would actually be best. Unless the loudspeakers are at very specific locations and the microphones could be positioned so that the polar pattern zero point exactly coincided with this location then more information needs to be known about the microphones.

The characteristic which can give a measure of the microphone's susceptibility to feedback is the ratio of front to random sensitivity. This means the ratio of the output of the microphone if it was in a room where the signal was only coming from one direction, in front of the microphone compared to the output of the microphone if it was in a room where the same level of sound was coming form all directions.
Using this ratio the omni-directional microphone has a ratio, expressed in decibels, of 0dB the cardioid pattern microphone has a ratio of 6dB and the hyper-cardioid has a ratio of 12dB showing that the hyper-cardioid microphone can produce the greatest amount of amplification before feedback. This is the prime reason why Accusound provide a hyper-cardioid capsule for all their instrument microphones, omni-directional and cardioid capsule are also available to order.

When to use different polar pattern microphones.

From the discussion above it is generally better to use a directional microphone for live work or any work where the sound is replayed live through loudspeakers. This is not a 100% rule as it also depends on the level of the amplified sound. If the amplification is only very low level, feedback may not be a problem and therefore any polar pattern microphone may be used depending on your preference. Even in a recording studio where you might expect omni-directional microphones to be used as they generally produce the truest signal, many directional microphones are used. In addition to reducing the chance of feedback, a directional microphone will reduce the amount of room echo or reverberation, and also reduce the amount of sound pickup from other instruments in the same room. Generally a cardioid microphone is the most directional microphone used in a studio.
Directional microphones also suffer to a greater extent from wind noise and vibration compared to omni-directional microphones. For this reason it is a good idea to have a good quality windshield on any directional microphone and if possible mount it using a flexible or soft rubber mount to reduce handling or vibration noise.