Microphones and Ham Radio

In the first installment of a three-part series on the quality of transmitted audio, K6EB discusses common types of microphones and the characteristics that contribute to their sound and audio quality.

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Most hams attribute their sound quality over the air to the microphone they use. But in most cases, this isn't necessarily true. Using a $6,000 Neumann condenser microphone won't make your audio sound bad, but you most likely will not receive your money's worth in the improved audio quality that you were hoping for.

Understanding Audio Bandwidth

Almost all modern HF SSB transceivers have an audio bandwidth starting at 150 to 200 Hz and ending at 3 kHz. This is essentially the same bandwidth standard telephones have had for more than 100 years — Ma Bell chose this response characteristic as the necessary response bandwidth to convey speech intelligibility. It's far less than the response of most modern microphones. The human ear responds to sounds from approximately 30 Hz to as much as 20 kHz. The Neumann microphone mentioned earlier will give you a flat response over that entire bandwidth. Conversely, with a transceiver, the response from 3 to 20 kHz won't be transmitted.

There are good reasons for the limited bandwidth of ham transceivers, as well as telephones. The simple explanation is that the signal-to-noise ratio (SNR) is inversely proportional to bandwidth. Using only the most important portion of your speech response to convey information optimally will give you the most efficient transmission. The wider the audio bandwidth, the lower the SNR. There are many other concerns as well, such as spectrum availability. If everyone was transmitting a full 20 kHz wide signal, the band would only accommodate less than 20% of the number of signals. You can imagine the problem that this would present in a contest.

Important Microphone Characteristics

Proximity Effect: One of the factors to consider when choosing a microphone is that they all have a proximity effect. This means that when you speak relatively close to the microphone, it'll accentuate the lower frequencies of your voice (this can be as much as 10 dB). This is much more pronounced with cardioid-pattern microphones, as opposed to omnidirectional microphones. Because there's little intelligibility transferred in this portion of the speech bandwidth, it's less useful for ham radio. For some, this rich, full sound may be what you're striving to achieve. If you're looking to make contacts with a full, natural sound, then accentuating the low frequencies will give you what you want. But it won't improve the intelligibility of your transmission. If the ham listening to you hears your signal at 20 dB over S9, this won't be an issue. But if you're trying to be heard through a pileup, it's a big disadvantage. In SSB transmissions, the energy utilized in these low frequencies will concentrate much of the transmitted energy in a portion of the audio spectrum that conveys little, if any, intelligibility. Virtually all of my audio engineering textbooks point out that the portion of the human voice that conveys maximum intelligibility is between 1.5 and 5 kHz. Because you only have 3 kHz to begin with, it becomes even more important to concentrate on that 1.5 to 3 kHz.

Handling Plosives: Another microphone characteristic to pay attention to is how well it handles speech plosives, or the sounds made when you pronounce "p" and "t," and a few other consonants. Pronouncing words that utilize plosive sounds will cause an excessive compression of the air projected toward the microphone diaphragm, which causes it to move excessively, creating a popping sound. This is dealt with in most microphones by the use of pop filtering, which is typically a foam covering that keeps the excess popping to a minimum. Most modern microphones handle this reasonably well. If you're using compression, which many modern radios do, plosives can also cause the compressor's gain reduction to overreact and poke holes in your audio.

Frequency Response: Some microphones have been designed for specific purposes, like the Shure SM58, which was developed for very close miking and has been effectively utilized in live vocal performances. The Shure 562 was designed for paging and industrial communications. These microphones often have frequency responses focused where the maximum

intelligibility is transferred. Interestingly enough, this is also the same portion of the audio bandwidth that's most important to hams. Some microphone companies, such as Heil Sound, have capitalized on this by designing microphones with a healthy bump in the response from about 1.5 to over 5 kHz. This response extends beyond the 3 kHz bandwidth of most ham transceivers. It doesn't present a problem because the transceiver rolls off the information above 3 kHz.

Sensitivity: Another characteristic that affects microphone performance is its sensitivity. Condenser microphones are very sensitive to sounds and will pick up extraneous noises within your shack, whereas some other microphones, like those designed for live performance usage, were constructed in a way that limits background noise and accentuates sounds that are closest to the microphone. The diaphragms of these microphones are stiffer and only respond to close-proximity sound. This is important to consider if your shack has extraneous noise levels.

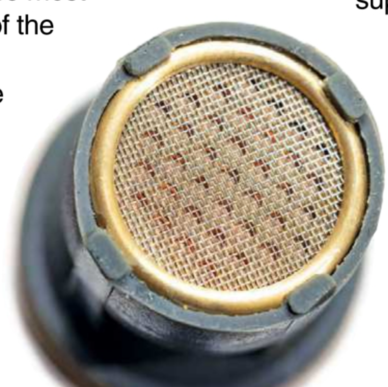
Balanced/Unbalanced Output: There's one other microphone characteristic that should be mentioned, and that's whether the microphone provides a balanced or unbalanced output. This is only a concern when using a lengthy cable between the microphone and the transceiver. If the cable is more than a few feet long and unbalanced, the capacity of the cable, caused by the center conductor and the outer shield, acts like a capacitor. The longer the cable, the larger the capacity, which causes high-frequency roll-off. It acts in the same way as putting a capacitor across the microphone output. This can be eliminated by keeping the cable length short or by having a balanced microphone. Almost no ham transceivers have balanced inputs, but this shouldn't be an issue because most cables are short, and the input impedance of the transceiver is relatively low, minimizing this capacitive effect. Additionally, this capacitive high-frequency roll-off primarily affects frequencies above 3 kHz. A cable would have to be well over 10 feet long for any noticeable effect to take place within the ham bandwidth.

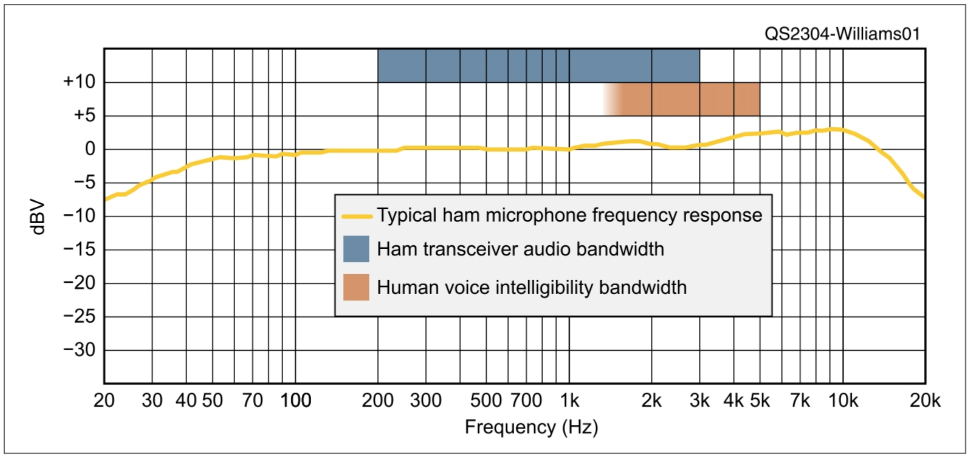
Common Types of Microphones

Carbon: Early microphones utilized a loosely packed carbon element that changed resistance when compressed. With a voltage applied across this element and a capacitive coupled output, the voltage change when the diaphragm compressed and expanded the carbon element would create an electrical response that replicated the sound of the voice or instrument that was then amplified and modulated a transmitter. Carbon microphones have poor frequency response and require a voltage across the element, so they were replaced in most ham radio operations by dynamic or electret-condenser microphones.

Dynamic: The dynamic microphone (see interior view above) is likely the most common microphone in existence today. It is the most rugged design, doesn't require a voltage to be applied across it to function, is extensively used in ham circles, and its mechanism is relatively simple. Much like a generator, it consists of a coil that moves within a permanent magnet. This creates a voltage that's then amplified and utilized in virtually every place you would use a microphone. The frequency response is considerably wider than the bandwidth of a ham transceiver, and it can be fashioned in a number of configurations with either a low- or high-impedance output, balanced or unbalanced output, as well as omnidirectional or cardioid-directional pickup patterns.

Condenser: The condenser microphone (see interior view below) has been around since the 1920s, but it has remained almost exclusively (until recently) found in recording and broadcasting studios. This is partly due to its cost and complexity. It requires a power supply, and up until the 1970s, it required two supplies: a higher voltage applied across the diaphragm and anode, and another supply to power the amplifier that brought the very low signal up to a level that made it usable, as well as matched its impedance to the preamplifier. The audio signal was derived by the variation in capacitive reactance between the very thin diaphragm and the fixed anode. In the





This graph shows the typical ham microphone frequency response.

1970s, manufacturers permanently polarized the diaphragm so that the high-voltage supply was no longer required. Most of the professional versions of this microphone still use a polarizing supply, which is almost always applied through the microphone connection from the preamplifier's phantom supply, which provides the bias voltage across the element and powers the amplifier.

The permanently polarized condenser microphones are called electret condenser microphones, and they're commonly used in ham radio today. Many of the microphones sold by Icom and Yaesu utilize this technology. The condenser microphone has a very wide frequency response from below 50 Hz to well over 20 kHz. This is, as stated earlier, a far wider response than can be utilized by the modern transceiver. They are relatively inexpensive, and with the required preamplifier they have an adjustable low-impedance output that's well-matched to the preamplifier built into almost all modern ham transceivers. Most of these same transceivers have a low voltage available on the microphone input to power the microphone. The condenser microphone also has extremely good transient response. This is the instantaneous response of the microphone's diaphragm to the audio wave that's moving it. It is the most faithful of all the microphones because the movement of the diaphragm is extremely small, and the diaphragm itself is extremely thin, which affords a very fast and faithful response to the audio waveform that excites it. This is good in a quiet environment (such as a recording or broadcast studio or quiet ham shack), but it can be problematic in a ham shack with noisy fans because it'll pick up every sound within its environment.

Ribbon and Ceramic: Ribbon microphones, such as the Altec 639, were popular in the golden age of radio and have good frequency response but a relatively low output, and are heavy and expensive. Ceramic or crystal microphones, such as the Astatic D-104, are still found in many ham shacks, but mostly as part of an antique collection. These microphones created an electrical output caused when the diaphragm flexed the crystalline substrate, which exhibited an electrical voltage that replicated the sound wave that excited it. These microphones have a very high output level, as well as high impedances and an accentuated frequency response from 2 kHz up to well above the ham bandwidth. In order to work with modern ham transceivers, they usually require an impedance-matching transformer.

Conclusion

I think it's important for hams to understand microphones, what they can and can't do, what they were designed to do, and how they're meant to be utilized in ham radio. The more you understand what you're purchasing, the better you'll be able to optimize your system for your intended usage, be it a long conversation or a DX pileup.

Lindy Williams, K6EB, worked as a radio engineer and corporate engineer for more than 55 years in the broadcast industry. He was the Corporate Chief Engineer for Lotus Communications Corporation. Lindy earned his ham radio license in 1957 and quickly earned his General. After being active for several years, he became busy with work and being in the US Army. Lindy became a relicensed ham in 2019 and is now an Amateur Extra-class operator. He can be reached at **lindy@lyndenlwilliamsconsulting.com**.

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