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Understanding Radio Waves

Rachel Baughn reminded me recently that I have been writing for *Monitoring Times* for just a little over ten years now. Hard to believe I've gone from being the new kid on the radio writing block to being one of *MT*'s "Institutions." Frankly, the fact that I have, as Lord Buckley used to put it, "stomped on the Terra" for as long as I have without being actually placed in an institution is probably a bigger marvel than generating a monthly column.

Anyway, this humbling thought first led me up in the attic to the box that contains all those back issues of *MT*. This trip down memory lane further led me to realize that there are quite a few topics I have covered in that time that, for beginners and even some old timers, bear repeating. From time to time I intend to re-approach some of these subjects. This is not meant to be "Uncle Skip's Greatest Hits," but rather a fresh look at the kind of important material that all beginners need to get the most out of our hobby.

Most people who first enter the radio hobby start out with only the most basic exposure to radio's various "modes." Those who have never seriously tried to hear anything beyond their car radios are essentially only familiar with two of radio's modes, those being **amplitude modulation** (AM) and **frequency modulation** (FM). Most folks get through life without knowing anything more than that about radio. But, as beginning radio monitors you not only want to know more about this subject, you *need* to know more about it. This is mainly because, as a radio monitor, you have likely purchased a receiver that has several more modes of operation beyond the more familiar AM and FM modes. What do they all mean?

AM, FM, and other modes like CW, SSB are all just a jumble of letters circling a receiver control knob to most beginners. The problem has always been one of trying to come up with a nontechnical way to tell folks about these very technical basics of radio. The solution I have used in articles, books and speaking engagements over more than ten years of experience comes out of my misspent youth at the Jersey Shore. I spent many summers at the beach working on turning my skin into something that is putting my dermatologist's daughter through law school. Surfing has remained for me the best the way to explain all those positions on a receiver's mode switch.

Back in the citizen's band (CB) boom years of the early seventies, some people used to enjoy making horses' patoots of themselves by keying down their microphones without saying anything. Sadly, you can still hear this moronic behavior on some segments of the 75 meter amateur radio bands. This crude form of jamming is known as "throwing a carrier." The **carrier** is just what its name implies. It is the signal that serves to carry the information to your receiver.

Just like those red hot days of the CB craze, a steady, unbroken carrier is little more than a waste of electricity. It communicates nothing at all by itself. The carrier signal becomes the radio signal that we all know and love *only* when it is modulated in some way. **Modulation** is the process of manipulating the carrier signal in some way to allow it to convey **information**. This modulated signal is then **demodulated** by the circuits in your receiver allowing you to hear the audio.

Clear as mud, huh? Now you see why I have leaned so heavily on the surfing analogy all these years.

Think of the ocean. If you are a life-long, landlocked resident of the Midwest, head to your video store and rent *The Endless Summer* or any other surfing movie that has more boards than bikinis in it. You'll get the idea.

If the surf is down and there are no waves to speak of, that would represent an unmodulated carrier.

Okay, now let's all visualize that the surf is up. The waves are breaking on the beach at different heights or speeds. These waves of varying size and spacing could be thought of as representing modulation of the ocean/carrier. But of course, as any surfer will tell you, not all waves are created equal. These different waves/modulations are going to react differently and (dropping the analogy for a second) will require different receiving equipment (demodulation equipment) to be heard and understood.

Continuous Waves

While continuous waves would represent every surfer's dream, to radio folks continuous wave signals are best known as "CW." CW is the simplest form of transmission — a plain unmodulated carrier simply switched on and off in a unique pattern. The dots and dashes of the International Morse code are formed by someone hitting a key to turn the carrier on and off. Think of these dots and dashes as waves of equal height and speed washing up on the beach. Imagine they start coming in sets of three and sets of five with a lull in between each set. The duration of the sets and the spaces in between are like dots and dashes.

Since an unmodulated carrier has no "sound" to it, your receiver has to jump through a few hoops to give you something you can hear. Most modern receivers have a CW position on their mode switch. Older receivers will often have a BFO switch. BFO stands for Beat Frequency Oscillator. In either case, the switch serves to turn the "soundless" CW signal into a recognizable series of audio tones. The "demodulation" happens in the listener's head when they translate the pattern of dots and dashes into letters and numbers.

Learning to copy CW signals can be a lot of fun. Many amateur radio operators still enjoy using this mode. Pick up a code practice tape from one of the advertisers in *MT* and join in the fun.

Amplitude Modulation

Now imagine that the waves are coming toward the beach spaced exactly 20 feet apart and that they hit the beach every five seconds. The only "change" you can see occurring is that all these otherwise equal waves are different heights. Getting back to radio, this change in **amplitude** (a fancy word for height) can be interpreted as a change in voltage at the receiver that can then be translated into an audio signal. Eureka, voices that come out of the air!

Frequency Modulation

If you have spent any time tuning around with an AM radio or have done some listening on the shortwave broadcast bands, you have probably noticed that there is a lot of noise out there. Atmospheric and people-made noise can get in the way of your listening pleasure. Radio pioneer Edwin Armstrong got peeved enough at all this background noise that he set to work to develop a different form of modulation: one that would give a very clear signal that was esentially free of static.

Thus, FM was born. Armstrong figured that you could keep the amplitude constant and then **deviate** or change the frequency back and forth off of the center frequency. Back to the beach! Imagine the waves coming toward the beach are all the same height. The difference now is that the waves no longer hit the beach spaced uniformly apart. Now they are hitting the beach faster or slower, that space between each successive wave is changing instead of its height.

Doing this gave a clear, static-free signal. The trade-off was a reduction in the distance the signal could be practically used. However, most radio services aren't interested in sending a signal all the way around the world. For this reason, most local communication is done these days in the FM mode. Police, fire, business, amateur radio operators and others make wide and varied use of FM in the VHF and UHF frequency ranges. (Thus giving rise to the monitoring hobby of scanning.)

Since most modern scanners cover such a wide range of frequencies, the beginner can get really confused about the two primary types of FM signals out there in scanner land. Knowing the difference can be important when setting the controls on your scanner.

Single Sideband

If you have been tuning across the shortwave frequencies for any length of time, you have no doubt run across some signals that sound like a duck quacking in a tunnel. These are **single sideband** (SSB) signals. From the earliest days of radio, folks were always trying to do two things: cram more signals into less space and get more signal from a given amount of power. SSB does both jobs remarkably.

To explain this we will need to stretch the limits of our surfing analogy. Imagine that you are seeing the wave pattern we dreamed up for AM — waves equally spaced but with varying heights. Now imagine that the waves are generating an equal, mirror image of themselves underneath the waves. The way you generate SSB is to start with a low-powered AM signal (one with waves on the top and underneath). Circuits in the transmitter serve to remove one of the side bands (the lower wave or the upper wave) *and* the carrier (i.e., remove the ocean. See, I told you this was going to get weird.)

Now the transmitter amplifies the remaining sideband (the oceanless waves become tidal waves). This produces a signal that is about four times as efficient as a regular AM signal with the same amount of power behind it. It also only occupies half the space of a standard AM signal. Almost like getting something for nothing, but not quite: On the receiving end, all you hear is that duck sound.

Unless, of course, your receiver is designed to accept this form of modulation. Remember when we talked about the Beat Frequency Oscillator (BFO) in relation to CW signals? The BFO signal serves as a substitute for the missing sideband, giving you a normal voice instead of duck noises. Most modern receivers have done away with the BFO in favor of a mode switch that will include CW (as previously discussed) as well as (USB) **upper sideband** (that's for the waves on top) and (LSB) **lower sideband** (for those mirror image waves beneath the sea). Both modes are used, so if you hear a duck voice and switching to one position does not do the trick, try the second. If you are using a receiver with a BFO you simply adjust the BFO Pitch control to get the same effect.

Hang ten!