Why The Sideband Convention?

Why the Sideband Conventions? The Rest of the Story…
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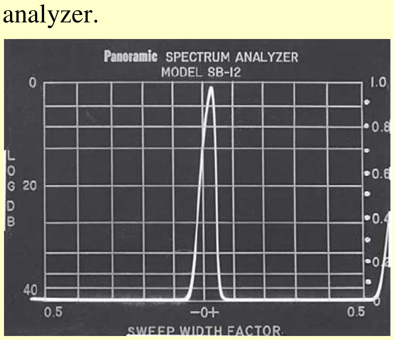
In 1963, I was an 8-year old shortwave listener, tuning into international broadcasters such as Radio Moscow, the BBC, and Radio Netherlands via their relay site on the island of Bonaire in the Netherlands Antilles. Shortwave listening was a great way to learn about world geography. Along with the broadcasters, I also tuned into the local amateur radio operators rag chewing on 75 meters, at least I did for a few months. Then, strangely, although I could hear them, I could no longer understand them. Their voices were all garbled, sounding like Donald Duck, only worse. It turns out that 1963 was a pivotal year for hams. Single sideband (SSB) had arrived *en masse* and in the space of a short time, the amplitude modulation (AM) that my little receiver understood practically disappeared from the ham bands.

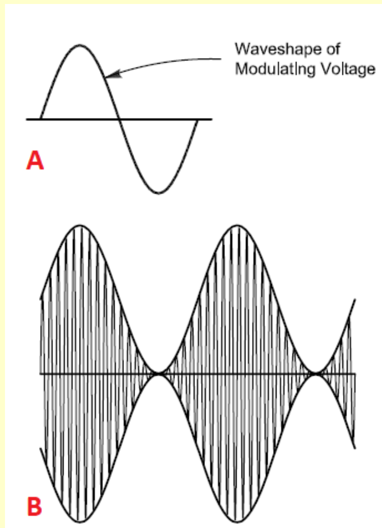
Not long ago, a club member posted a question on the reflector about why we use Lower Sideband (LSB) on 80-meters and 40-meters, but Upper Sideband (USB) on 20-meters and above. He received a prompt and correct response, but there is a little more to the story and an opportunity to touch on a bit of our history and take a look at the modulation & mixing techniques that go into our radios. You might also learn something that keeps you out of trouble.

Modulation begins with a carrier, or more accurately, a reference signal, shown in figure 1 on a spectrum analyzer.

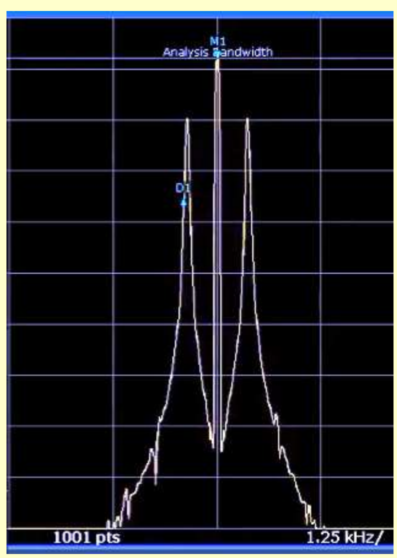


The carrier is a pure, unmodulated radio frequency (RF) signal. CW operators, sending Morse code, simply turn the carrier on and off to transmit. But if you're sending a voice communication, we need to modulate that carrier. That's done with a mixer circuit. As you probably recall from your license examination, when you mix two frequencies, the output is two signals, one at the sum of the two input frequencies and the other at the difference of the mixed frequencies.

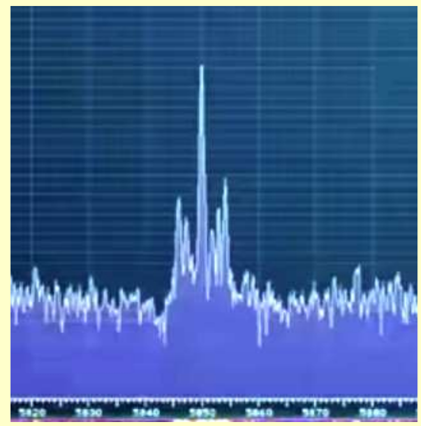
This mixing can be visualized as in figure 2. Figure 2-A shows the modulating signal, say a 3,000 Hz pure tone. Figure 2-B shows how the tone is imposed on the carrier causing it to vary in amplitude but not in frequency.



Note that the distance between the wave peaks inside the modulation envelope remain the same even as the amplitude changes. If we look at this modulation on a spectrum analyzer, figure 3, we see that the modulation products appear on either side of the carrier.



These products are our sidebands, one upper and one lower. If our carrier frequency is 3,980 kHz, then the lower sideband is centered on 3,977 kHz and the upper sideband is centered on 3,983 kHz. Figure 3 shows these sidebands as nice, clean, spikes on the spectrum analyzer. That's because the modulating signal in this case is a pure 3,000 Hz sine wave, probably a note you can hit when you whistle. In practice, voice communication is a complex waveform with lots of different audio frequencies. A realistic spectrum display of actual voice modulation is seen in figure 4, taken from a panadapter showing lots of audio content in the sidebands.



As the frequency of the audio content increases, each sideband moves farther away from the central carrier frequency.

A lot of power goes into transmitting that carrier and the two sidebands, and since the two sidebands carry identical modulation content, wouldn't it be nice if we could eliminate all but one sideband? The mathematics for doing just that is practically ancient, from 1914. The first single sideband experiments took place in 1915, the same year that a patent was granted for the technique. The technology was refined by the U. S. Navy and by Bell Telephone Laboratories, but it didn't catch on in the amateur ranks until after World War II.

Nowadays we're on a first-name basis with Single Sideband, but SSB's full name is Single Sideband Suppressed Carrier (SSBSC) since the carrier and one sideband are filtered out before the signal leaves the transmitter.

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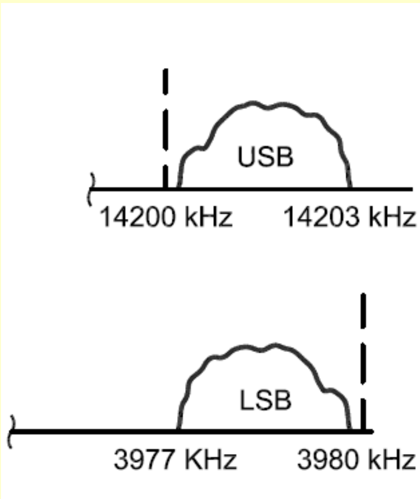
Why The Sideband Convention? (cont'd)

The location of those sidebands is graphically shown in figure 5. This is the part that can keep you out of trouble.



Take a good look at figure 5 and note the dashed line indicating the carrier frequency, or where the carrier would be if it were transmitted. That is the frequency that's displayed in glowing digital numerals on your rig, *not* the frequency of the sideband. This is why the carrier is more properly called a *reference frequency*, since the carrier is not there, only its ghost. And how can that get you into trouble? Suppose you hold a general class license and park your VFO on 3,800 kHz, then call CQ using LSB. Your sideband, the actual frequency of your transmission, falls into the advanced class portion of the band. Similarly, if you swing over to 20 meters and set your VFO on 14.350 MHz with USB, your upper sideband signal is entirely outside of the amateur band. The FCC takes a dim view of such operation.

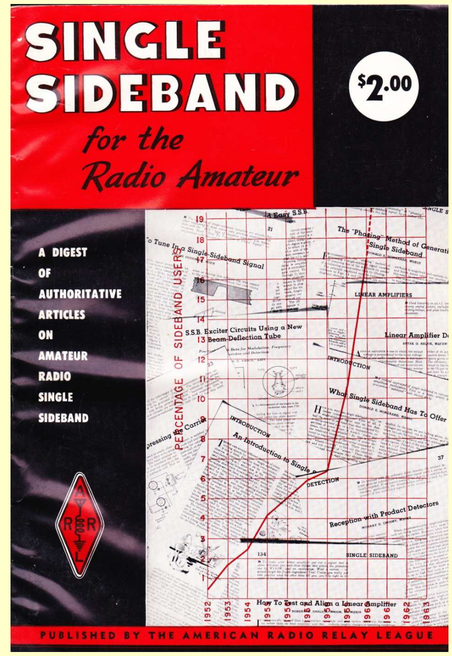
So that explains sidebands but why do we use LSB for 80- and 40-meters but USB for 20-meters and above? That's a matter of history and we must largely thank Anthony Vitale, W2EWL, for this quirk of fate. In March of 1956, Vitale published an article in March 1956 *QST*, "Cheap and Easy S.S.B.". The cheap part came from basing his sideband rig on a military surplus ARC-5 transmitter that could be picked up for under $8.00. Even for 1956, that's dirt cheap.

These ARC-5 transmitters were real work horses for the military during the war and they still may be found for sale at hamfests today.

Figure 6 shows an ARC-5 in the collection of the Smithsonian Air & Space Museum. The ARC-5 was not a single sideband rig, but it had the virtue of being readily converted into one.

The ARC-5 used a 5 MHz VFO. In Vitale's scheme, a 9 MHz signal was generated and mixed with the 5 MHz signal from the VFO which was then mixed with the audio content. Mixing two RF signals works just like the mixing of one RF and one audio signal as we earlier described. The lower sideband result of this mixing lands on 4 MHz, since 9 minus 5 is 4. That puts the LSB in the 80-meter band. Similarly, 9 plus 5 is 14, placing the USB in the 20-meter band. So, the ARC-5 provided LSB coverage from 4.0 MHz to 3.5 MHz, and USB coverage from 14.0 MHz to 14.5 MHz. And that's largely how the convention of using USB & LSB on particular bands developed. There is no requirement to stick to the convention, and there were, of course, other rigs capable of transmitting SSB. But if you had one of those more sophisticated rigs and you wanted to converse with someone running an ever-popular ARC-5, you would have to meet them on their ground.

The ARRL was really behind a big push to get amateurs to switch from AM to SSB. The bands were crowded in the late 1950s and early 1960s, and sideband is much more economical in bandwidth, with each SSB QSO taking up less than half of that needed for a full AM signal. To encourage the change, in 1962 the ARRL collected dozens of SSB articles and published, *Single Sideband for the Radio Amateur* (figure 7), which included Vitale's 1956 piece along with others such as, "Which Sideband is he Using?" and "Cheap and Easy S.S.B. Goes on 15."



That's not quite the end of this story. To demodulate a single sideband transmission, you need to have the carrier. The key is to generate that carrier locally, inside the receiver, in a local oscillator. Using the example we started with, take the 3,977 kHz modulated sideband, mix it with a 3,980 kHz signal inside the receiver Beat Frequency Oscillator (BFO) and out pops the original 3,000 Hz tone. And, alas, my little shortwave receiver that I had in third grade lacked a BFO. All I heard is what you can hear if you switch your transceiver to AM and tune across the voice segments of our bands. I suspect that little ARRL publication tipped the scale for the hams in my area of Florida, convincing them to get on the SSB bandwagon and, unknowingly, leaving a little shortwave listener in the dark. I was stuck listening to a bunch of Donald Ducks.