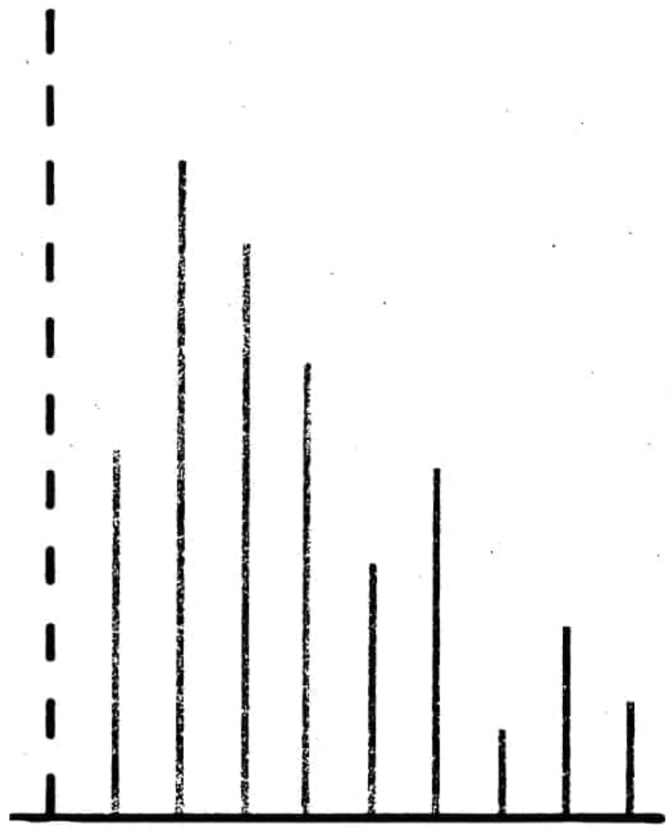
What You Should Know About SINGLE SIDEBAND



By Robert Smith, W1LLF

A little theory shows you why SSB has many advantages over AM.

SINGLE SIDEBAND (SSB) is becoming a big thing with amateurs these days. And Citizens Band operators are interested in it, too, because it offers a solution to the problems of crowded channels and limited range for a 5-watt signal.

Why the growing interest in SSB? In a nutshell, these are the advantages it offers: first, more of an SSB transmitter's power is used for producing an effective signal at the receiver than is the case with regular AM radio. In CB, for example, SSB will turn 5 watts of input power into roughly 20 watts of effective power. Looking at it another way, if you take the power of your AM rig and go single sideband you'll get a much greater transmission range. Furthermore, power isn't wasted in transmitting a carrier that, as we'll see later, is entirely expendable.

Secondly, a sideband signal occupies much less space in the radio spectrum—exactly half the space required by a regular AM signal. This is important on crowded bands.

Thirdly, in long-distance AM communications, the distortion caused by fading is reduced considerably if the transmission is SSB.

Fourthly, annoying whistles on a crowded band caused by the heterodyning of carriers are eliminated since SSB has no carrier on the air.

SSB is not new. Engineers started experimenting with it in the early 1930's. But since more and more new hams and CBers are getting on the bandwagon, we'll start at the beginning to explain what it's all about. You'll find it

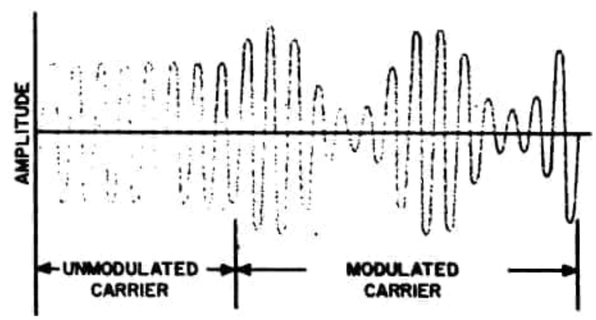


Fig. 1—Conventional AM waveform pattern is composite picture of the carrier and two sidebands.

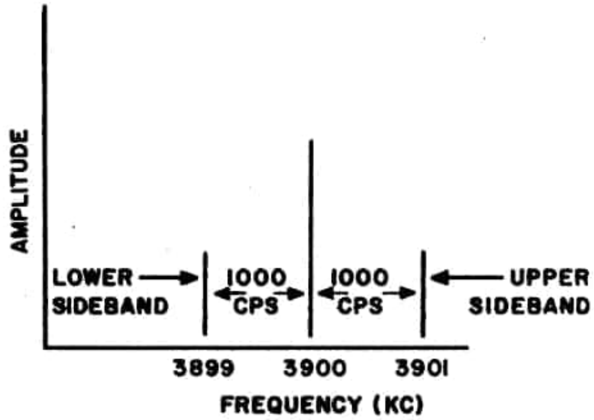


Fig. 2—Spectrum diagram shows amplitude and frequency relationships of carrier and sidebands when the modulation is a 1,000-cps audio tone.

easier to understand SSB by reviewing amplitude modulation (AM) theory. (See ALL ABOUT MODULATION, March '63 ELECTRONICS ILLUSTRATED)

Visualizing the Signal. Most explanations of AM are illustrated with waveform or envelope patterns that you see when monitoring your transmitter's output on an oscilloscope. The pattern in Fig. 1 of an unmodulated and a modulated RF carrier is shown this way. (For further illustrations of this type, see BUILD THE EI CITIZENSCOPE on page 16.) The shortcoming of this pattern is that it doesn't show the relationship to the carrier of what are called side frequencies, or sidebands.

When you apply an RF and an AF signal to the final stage of a transmitter, you'll end up with four signals—the original RF carrier, the carrier frequency plus the audio-modulating frequency, the RF carrier minus the audio modulating frequency, and the audio frequency itself. (But the audio gets lost in the shuffle, so forget about it.)

The side frequencies (RF plus audio and RF minus audio) change in amplitude in step with the amplitude changes of the audio signal. But, believe it or not, the amplitude of the carrier doesn't change a bit! You can see this easily on the S-meter of a receiver sufficiently selective to tune through each side frequency and the carrier of a signal.

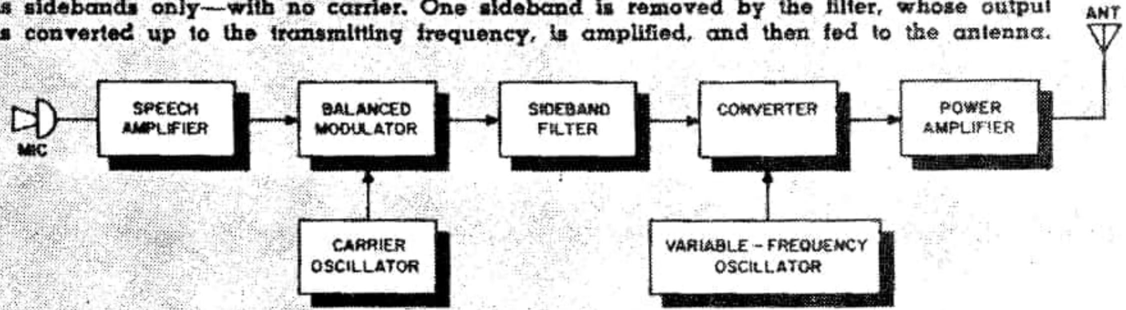
Assume your carrier is 3,900 kc. If you whistled a 1,000-cps tone into your mike, two side frequencies—one at 3,899 and another at 3,901 kc—would appear at your transmitter's output, in addition to the 3,900-kc carrier. This is shown in Fig. 2, a spectrum picture of the complete signal. Here you see amplitude vs. frequency. Figure 1 showed only amplitude vs. time. The amplitude of the side frequencies is determined by how loudly you whistle.

If two people whistled different tones at the same time, there would be two vertical lines on either side of the carrier, as shown in Fig. 4A.

Therefore, a complete radio signal of a 1,000-cps audio tone consists of the 3,900-kc carrier and two side frequencies. In other words, three RF signals are transmitted. Forget about the old notion of the carrier carrying the modulation; it does no such thing. The carrier is just something that the audio beats against to produce two new signals. And it is these side frequencies *only* that carry—or, shall we say, represent—the modulation. At the receiver, the carrier is needed only by second detector to convert side frequencies back to audio.

Between the transmitter and the re-

Fig. 3—SSB transmitter. RF and AF are mixed in balanced modulator, whose output is sidebands only—with no carrier. One sideband is removed by the filter, whose output is converted up to the transmitting frequency, is amplified, and then fed to the antenna.



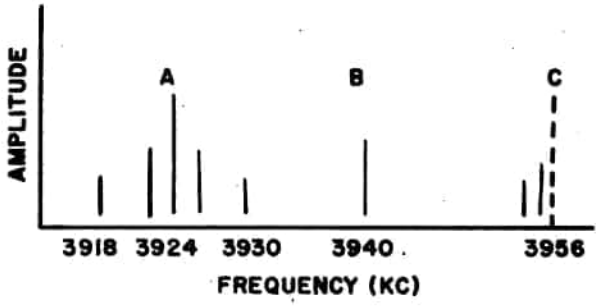


Fig. 4—Spectrum view of part of 80-meter band shows AM signal at A, a CW signal at B, a lower-sideband signal (carrying two audio tones) at C.

ceiver the carrier does nothing. But it requires a lot of the transmitter's power just to be there for the ride.

In an SSB transmitter, there still is a carrier but after it does its job of forming side frequencies it is suppressed and not transmitted. The two side frequencies are mirror-images of each other, so we can eliminate either the upper or lower one. After all, the difference between 3,900 kc and 3,901 kc is 1,000 cps, and so is the difference between 3,900 kc and 3,899 kc.

At the receiver we substitute a home-brew carrier from the BFO and beat it against the side frequency in the second detector. The side frequency won't know the difference and will give us back the 1,000-cps audio just the same.

For example, when you tune a receiver to 3,901 kc, the first detector or mixer is fed a 4,356-kc signal from the local oscillator. This brings the incoming signal down to the 455-kc IF. If the BFO is adjusted so its frequency is 454 kc, mixing it with the 455-kc IF in the second detector will give us back the 1,000-cps audio signal.

For CW reception, it doesn't matter too much what the BFO frequency is. One operator may like a 700-cps tone, while another prefers 1,000 cycles. But for SSB reception, if the BFO frequency is set too far from or too close to the sideband the original signal will have too high or too low a pitch.

Power Advantages. The amateur power limit is based on the DC input power to the transmitter's final stage. A CW transmitter running a kilowatt input power delivers about 700 watts to the antenna and all of the 700 watts is a usable signal that contributes to the output at the receiver. A fully modulated AM transmitter running a 1-kw input on phone delivers 700 watts (average power) of *carrier* to the antenna. But this is just carrier and does not contribute to receiver output (though it does move the S-meter). The maximum average sideband power which would contribute to receiver output is 350 watts, half the carrier power. This is divided into two sidebands (only one of which is needed) of 175 watts each. So, with 1 kw input power on regular AM, you get only 175 watts of usable power. That's quite a waste—approximately 82%.

But with an SSB transmitter, 1 kw average power input will get you 700 watts average power output—and all of it is *useful* power at the receiver. And 700 watts compared to 175 watts is a 6db gain. Another way of stating this is to say that a 1-kw SSB transmitter would do as much for you as a 4-kw AM transmitter.

Tuning an SSB Signal. One way to get a better idea of what we've been talking about is to imagine we're tuning an SSB signal. At some time when things aren't too hectic, a spectrum view of part of the 80-meter band might look like Fig. 4. The signal at A is an AM signal, identified by the large carrier in the center and the flanking side frequencies. The signal at B is an unmodulated carrier or code (CW) signal at the moment the sender's key is held down. The signal at C is an SSB signal and the dashed line represents the spot where the carrier once was. (The lower sideband is being transmitted.)

Now consider the tuning knob on your receiver a device that can move a window from one end of the 80-meter band to the other. The purpose of the window is to enable you to look at only a small portion of the band at a time. How much of the band the window sees depends on its width, which corresponds to the receiver's selectivity curve. Let's tune across the signals in Fig. 4.

In tuning, we might set the dial to 3,924 kc. That frequency then would be centered in the window shown in Fig. 5A. Now let's move the window all the way to the left in Fig. 4—to just below 3,918 kc—and then start moving it back to the right. As the sidebands below 3,924 kc fall within the window, we hear one side frequency beating against the other (the two marks to the left of the carrier) and the sound will be gibberish. As the window moves farther right, enough of the carrier will be admitted to beat against the side frequencies, and you have intelligible sound. As the window continues to move to the right it admits the two lower sidebands, the two upper sidebands and the carrier (five signals altogether) and the audio is clean. As we tune to a still higher frequency, we reach a point where only the upper side frequencies are visible and again the sound becomes distorted.

Continuing our tuning, we hear nothing until we approach the signal at B. When it appears in the window, we hear a change in the normal hiss of the receiver, indicating a CW signal. Switch on the BFO (the line in Fig. 5B) and we hear code. Moving the BFO pitch control changes the pitch. The relationship between the BFO line and the window is changed by the BFO pitch control. When we tune the receiver, we move the window *and* the BFO line together without changing the relationship between the two. If the BFO is on and centered in the window and we tune from the left across the signal at 4B, we first hear a high-pitched signal, and then gradually a lower-pitched signal, as the BFO line and the spot where the carrier was (dashed line), get closer together.

Let's approach the signal in Fig. 4C from the left with the narrower window in Fig. 5C. When the left sidebands first appear in the window, audio output will be produced by the beating between the side frequencies. Moving the BFO line to the right toward where the carrier should be will cause the sound to go from a low pitch to normal. Now move the BFO line to the right side of the window (5D) and adjust the control so the BFO frequency approaches the point where the carrier should be (dashed line, Fig. 4C). At first, the sound will be high-pitched. When the BFO line is directly over the carrier line, the BFO will be in the correct frequency relationship with the sidebands and speech reproduction will be normal.

You can now see that in order to receive an SSB signal without having to constantly readjust the BFO pitch on your receiver, the BFO oscillator must be extremely stable.

Inexpensive communications receivers may have an unstable BFO. This means that you may have to keep your hand on the BFO pitch control constantly. One way of solving the problem is to add a voltage regulator tube to the receiver to supply regulated DC to the BFO.

If you want to learn more about SSB theory and equipment, refer to these books: Single Sideband for the Radio Amateur, published by the ARRL; New Sideband Handbook, by Don Stoner, published by Cowan Publishing Co., and the Single Sideband Communications Handbook, by Harry Hooton, published by Howard W. Sams, Inc.

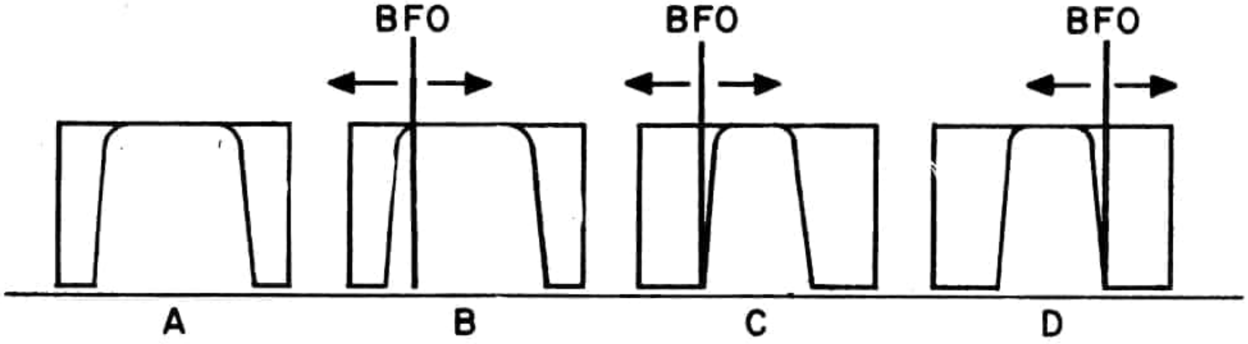


Fig. 5—Tuning a receiver is like moving a window, whose width corresponds to IF selectivity, across band. BFO frequency (vertical line) is moved within window by BFO pitch control. Tuning knob moves window and BFO line. BFO line must be set directly above carrier line in Fig. 4C for perfect SSB reception.