A Radical Approach to Single Sideband

Revolutionary Ideas for Simplifying 'Phone Communication

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• Here is an article that no discerning 'phone man can afford to pass up. Although the ARRL Laboratory staff has not had an opportunity to confirm Mr. Rapp's findings, past experience with his disclosures have shown us (and our readers) what we can expect from this sage.

There can be no question in the mind of any active radio amateur that the most progressive step in the past pentad has been the immediate and wholehearted acceptance of single-sideband telephony. One has only to listen in on any of the low-frequency 'phone bands and hear the pioneers patiently explaining the virtues of s.s.b. to the younger and more timid amateurs to realize that some really splendid work is being done. Many old-timers can be heard jocularly referring to the medium as "Chinese modulation" or "those Donald Ducks," in an obvious effort to put the newcomers at ease.

However, because there is still some reluctance on the part of technically-unskilled amateurs to adopt single-sideband technique and thus enjoy its advantages, the author feels that the time is right to disclose his latest invention. Although originally developed for patent purposes only, the invention is too meritorious to be withheld from radio amateurs, who are always willing to try anything if it is simple and cheap enough. Ergo, before disclosing the invention and the circuits, it is well to review a few basic principles.

The generally-acknowledged advantages of single-sideband are greater effectiveness for the same total power to the transmitter, ability to use voice-operated break-in, and freedom from TVI. On the debit side of the ledger are the use of unfamiliar circuits, inability to use a.v.c. and S-meter at the receiver, and the tendency of SWLs to overlook such a signal in favor of one of the a.m. variety. It occurred to the author that what was needed to make single sideband universally acceptable was a simplification, both at the transmitting and at the receiving end, and this reasoning was confirmed by consultation with several other experts in this and allied fields. Since "a clear statement of the problem is the first step toward a solution,"[1] no time was lost in getting down to work. Through fortuitous and careful design, the eventual solution also overcame the objectionable characteristics of conventional (and now old-fashioned) s.s.b.

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[1] Humperdinck, E., "Orfeo ed Euridice," Part IV.

[2] Rapp, "The Double-Spectrum Theorem," *QST*, April, 1952.

The Approach

Referring to the literature on single sideband, it is almost amusing to observe how blindly one investigator follows another in approaching the problem, with the inevitable result that they have all overlooked the very obvious simplification that will soon be disclosed. For example, every author starts out by describing a double-sideband-plus-carrier a.m. signal, and then laboriously tells of methods for first eliminating the carrier and then one sideband. It is this line of reasoning that has resulted in a blind spot in the thinking which, fortunately, is about to be removed.

Your author approached the problem from another tangent. Having observed that s.s.b. operators still suffer occasionally from BCI (interference to broadcast receivers), and recalling that narrow-band f.m. is immune to BCI troubles, combining the merits of n.f.m. with s.s.b. seemed like a fruitful avenue of approach. It was, and the final solution was really too good to be true. It is being disclosed now so that others can appreciate its advantages.

The Solution

As all amateurs know, an f.m. signal is generated by a *reactance modulator* working on an oscillator to swing the frequency back and forth about a mean frequency called the *carrier* frequency. To generate a single-sideband-f.m. signal, the author cleverly reasoned that it was only necessary to swing the frequency *on one side of the carrier* — on the low side for the low sideband, and on the high side for the high, or upper, sideband. Fortunately, this offered no great problem, since part of the technique had already been disclosed in an earlier paper.[2] Hence, the generator for a s.s.b.-f.m. signal requires only a speech amplifier of sufficient gain, a "positive/negative" modulator driving a reactance modulator, and an oscillator followed by suitable amplifiers. The desired sideband is selected, of course, by switching to either the "positive" or the "negative" modulation condition.

Astute readers will immediately ask, "But what about carrier elimination?" This is a good question, but one that shows a lack of basic understanding of the system so far. It should be obvious that the carrier isn't present while it is busy swinging over the "sideband" portion of the spectrum, and hence *it is only necessary to eliminate the carrier while one isn't talking.* This is not a difficult problem, and is solved by the method current in vogue among the s.s.b. pioneers; namely, voice-operated break-in. By minimizing the "hold-in" time, the carrier is only apparent between very short pauses, and this slight disadvantage is more than overshadowed by the obvious advantages of the entire system. A balanced modulator can be used, of course, if the ultimate in tube efficiency is desired, but the other method is the simple approach.

Unlike the old-fashioned s.s.b., this new system needs no carefully-designed mixers for band changing, since s.s.b.-f.m. is like conventional f.m. in this respect and requires only frequency multiplication for bandchanging. Furthermore, there is no real need for careful adjustment of linear amplifiers as there is with the older s.s.b., and a Class C amplifier will handle a single-sideband f.m. signal just as well as will a Class AB_1, AB_2 or B amplifier. This feature eliminates the need for special bias supplies and an oscilloscope, as well as the need for careful adjustment when shifting frequency. The use of Class C stages throughout results in the highest possible efficiency, but care must be taken to prevent the generation of high-order harmonics that may interfere with TV reception in the vicinity. As a result of these tolerant parameters, s.s.b.-f.m. can be applied to any existing transmitter by making a few simple changes in the oscillator. A block diagram of the basic exciter is shown in Fig. 1,

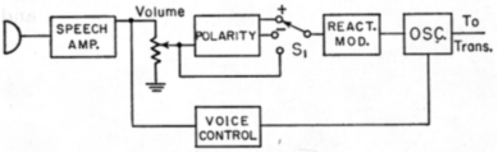

Fig. 1 — **A block diagram of the basic exciter. S_1 is the sideband-selector switch. The "+" and "−" points are for upper- and lower-sideband operation — the third position gives conventional f.m. operation and is not necessary except for comparison and tune-up purposes.**

and receiving tubes and low-power components can be used throughout.

The Reception of S.S.B.-F.M.

The reader may be wondering what must be done at the receiving end to copy a s.s.b.-f.m. signal and, we are proud to say, this is one of the delightful aspects of the system. It has been pointed out on several occasions that conventional s.s.b. is difficult to tune in — some observers report it is impossible with a conventional a.m. 'phone receiver — but s.s.b.-f.m. eliminates any and all such troubles. It is tuned just like narrow-band f.m. (Signal detuned slightly, to fall on one side or the other of the "slope" of the i.f. characteristic. This is called "slope detection," for obvious reasons.) However, one significant difference becomes immediately apparent, and it is one of the ways an operator can recognize a s.s.b.-f.m. signal in a band loaded with a.m., s.s.b. and n.f.m. signals. In the reception of s.s.b.-f.m., if the receiver is tuned to the *wrong side* of center, the speech becomes inverted, so there is actually only one correct side. Thus the selectivity of the receiver is increased, because the signal only comes in at one spot on the dial. (Some operators object to the broadness of n.f.m., because it comes in at two spots on the dial. However, n.f.m. is, of course, a double-sideband system, and the two-spot tuning is not so surprising if you stop and think of it in

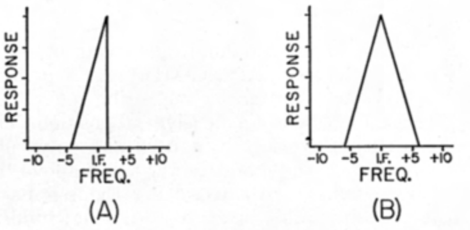

Fig. 2 — **(A) Ideal i.f. characteristic for receiving s.s.b.-f.m. Selectable-sideband reception can be used. (B) Ideal i.f. characteristic for general s.s.b.-f.m. reception. Notice that this approaches the i.f. characteristic of current receivers.**

this manner.) But, indubitably, the greatest advantage of s.s.b.-f.m. over old-fashioned s.s.b. is that *the need for careful tuning is eliminated*, since the s.s.b.-f.m. need only be tuned on the correct-slope side. There is no longer any need for careful carrier reinsertion! (Remember that the swinging of the carrier is generating the sideband. The carrier has never been eliminated, hence it does not require reinsertion.)

An ideal receiver i.f. characteristic for s.s.b.-f.m. would be one that looks like a right triangle, if everyone agrees to the use of only one sideband and whether it shall be the upper or the lower. Failing this, the best receiver characteristic would be one with a double-ramp configuration. Actually, however, the difference in performance between the ideal and a conventional i.f. characteristic is slight.

Financial Considerations

Of interest to the impecunious amateur is the investment required for any new type of equipment. One of the criticisms of s.s.b. has been that it is too expensive, since it wastes the large audio tubes and transformers associated with a 'phone station. Unfortunately, s.s.b.-f.m. offers no solution for this complaint, if one already has reached the legal power limit. However, it is suggested that if one's present transmitter has not yet reached the legal limit (this varies throughout the world and even within countries), he may be able to sell his excess audio equipment to some hi-fi enthusiast among the Cadillac station-wagon set.

Any way it is computed, s.s.b.-f.m. is more economical than either a.m. or s.s.b. Its effectiveness being what it is, practically no time will be spent in making fruitless calls. And once QSO has been established, it is practically certain that no time will be wasted in needless repeats. On a strict dollar-for-dollar basis, a s.s.b.-f.m. transmitter shows a 47.2 per cent superiority over a kilowatt s.s.b. rig and a 71.4 per cent advantage over a kilowatt a.m. rig. *In hock veritas.*