Inverted Audio for D.S.B.*

BY E. L. WARDEN†, W4PGI

By inverting the audio signal in a 7360 balanced modulator tube, and, using this inverted audio to modulate a d.s.b. rig, many of the problems of receiving d.s.b. are eliminated. Receiving d.s.b. becomes as easy as s.s.b. In fact, the adventurous amateur will find that inverted audio for s.s.b. has its virtues in combating QRM.

THE use of double sideband suppressed carrier has appeal to many of us because of the extreme simplicity of this type of transmitter. The almost complete lack of critical circuitry will permit the amateur with a flat wallet to go on phone with a minimum of cash outlay. Unfortunately, after a short period of operation with this type of emission, it will be somewhat annoying to find that a large percentage of amateur receivers cannot copy double sideband suppressed carrier effectively.

The reason that a large percentage of receivers cannot copy d.s.b. is the fact that extreme skirt selectivity is required to reject the undesired sideband in the r.f. If not rejected, there will be phase cancellation between the sidebands in the second detector of the receiver and the signal will be unintelligible. A receiver with an almost rectangular selectivity characteristic is required to copy d.s.b. A receiver with this degree of skirt selectivity is normally found in the price range of 500 to 600 dollars. One type of receiver that can copy d.s.b. is the "Synchronous Receiver," which has a phase locked local oscillator. This type of receiver, however, appears to be somewhat of an advanced type, and you will probably not find one for sale at the corner radio store!

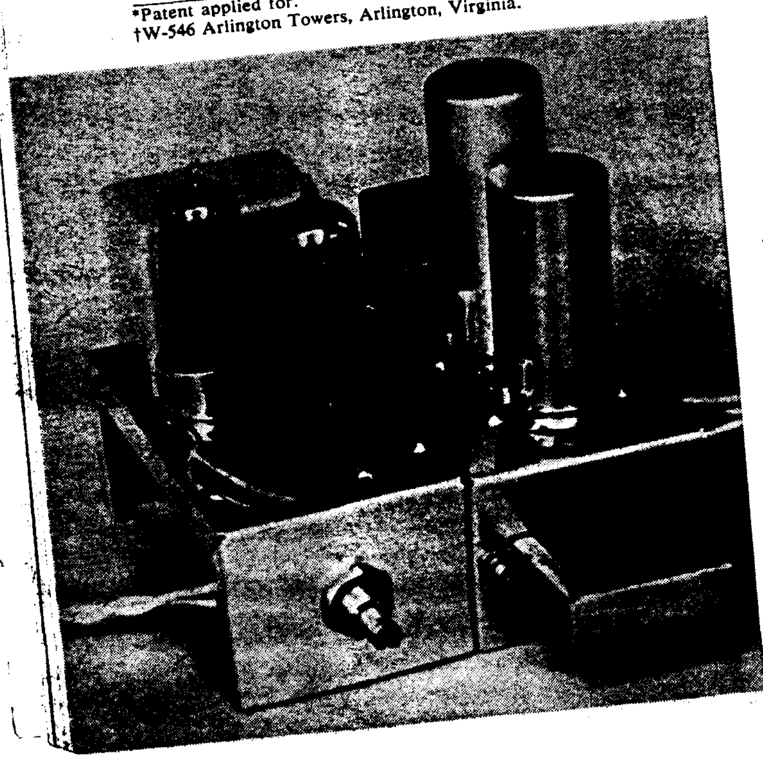
A.F. Inversion

By using a technique known as audio frequency inversion, it is possible to generate a double sideband suppressed carrier signal that can be copied with conventional receivers, while still maintaining the extreme simplicity in the r.f. stages of the d.s.b. transmitter. Audio frequency inversion plus double sideband suppressed carrier will give you inverted double sideband suppressed carrier.

The description of the transmitter is as follows (see fig. 1): The audio input is heterodyned against the local oscillator in the audio balanced modulator. The output frequencies of the audio balanced modulator consist of the sum and difference frequencies between the audio input and the local oscillator. The sum frequencies are filtered out in the low pass filter and the output of the filter consists of only the difference frequencies. If for instance it is desired to transmit an audio frequency response of from 200 to

*Patent applied for.

†W-546 Arlington Towers, Arlington, Virginia.



The completed audio inverter ready to modulate a d.s.b. or s.s.b. transmitter. Output is push-pull and for s.s.b. applications it must be converted to unbalanced output. The right hand chassis contains the oscillator, and speech amplifier (V_1) and the balanced modulator (V_2). The oscillator transformer is on the front lip and T_2 is behind V_2. The left hand chassis contains V_3, V_4, T_3 and Z_1 to the rear. The control on the front lip is the A.F. FEED THRU BALANCE.

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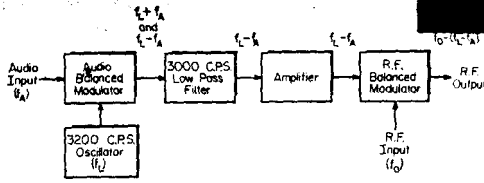

Fig. 1—Block diagram of the d.s.b. inverter unit shows how the balanced modulator inverts the audio spectrum. The filter eliminates the sum f_1+f_a, and only f_1-f_a is fed to the r.f. balanced modulator

3000 c.p.s., one may choose the local oscillator frequency of, say, 3200 c.p.s. Thus for an audio input frequency range of from 200 to 3000 c.p.s., the output of the filter consists of frequencies of 3000 to 200 c.p.s., respectively. In other words, the audio frequencies are inverted, or occur in the output in the reverse order of the frequencies which are applied to the input.

The output of the filter is amplified by a conventional audio amplifier, and is applied to a high level r.f. balanced modulator, which is excited by a suitable source of radio frequency. The r.f. carrier is removed by the r.f. balanced modulator, and the output r.f. frequencies consist of an upper and lower sideband. It is to be noted that the signal is still double sideband suppressed carrier, except that the audio frequency components of the sidebands have been reversed. The transmitted bandwidth is still the same as d.s.b. or conventional a.m.

Since the audio frequencies have been inverted, to demodulate this type of signal, it is only necessary to tune the radio receiver (with the b.f.o. on) to either the upper side of the upper sideband or the lower side of the lower sideband. The receiver will re-invert the desired sideband in order that the intelligence can be understood. The undesired received sideband will be translated to a higher audio frequency so that phase cancellation cannot take place. Additional effective attenuation of the undesired sideband will be accomplished by the i.f. selectivity and the limited high frequency response of the audio frequency amplifier in the receiver, and the limited high frequency response of the human ear. It has been determined that the undesired sideband will be inaudible, even when a receiver of poor skirt selectivity is used.

From inspection of the schematic that is given for a transmitter of this type (see fig. 2) it is apparent that the complexity is much less than many other phone transmitters (for instance, single sideband types). The r.f. circuitry is no more complex than most c.w. transmitters. This type of transmitter appears particularly attractive for use in ultra-high frequency applications, where the design of single sideband transmitters becomes somewhat unwieldly. It is not necessary to generate the signal at a low frequency and heterodyne several times to the operating frequency, like many single sideband transmitters do. The generation of the i.d.s.b. signal is accomplished at high level, and at the operating frequency of the transmitter. The electrical efficiency of the final r.f. balanced modulator is good, since it operates class C and also has a very low idling plate current between modulation peaks (in comparison to many linear class AB_1 amplifiers, which may be rather inefficient and have a higher idling current).

Advantages vs Disadvantages

There will, of course, be criticism about this type of emission, since it requires twice the bandwidth of single sideband. It was not the intention to replace single sideband with inverted d.s.b.; the intention was to make d.s.b. compatible for use with conventional types of receivers and to avoid much of the complexity and critical circuitry normally associated with s.s.b. The transmission of two sidebands does, however, come in handy when very high levels of QRM are encountered; if one sideband is jammed, the receiving operator can tune to the other one.

Since the characteristics of a modulation technique are normally compared to conventional amplitude modulation, it is important tô remember that most of the interference caused by a.m.

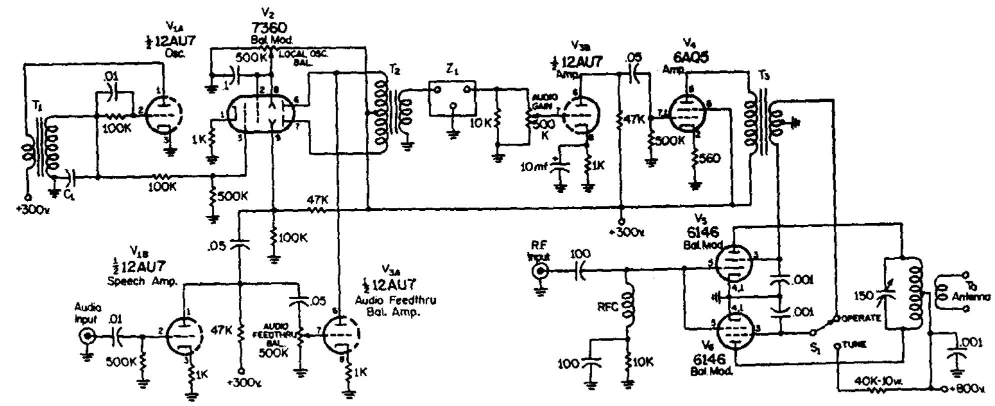

Fig. 2—Circuit of the inverted d.s.b. transmitter. Capacitor C_1 is approximately 0.002 mf and must be adjusted to place the oscillator at 3,200 c.p.s. Transformer T_1 is a standard 50L6 output transformer; T_2 and T_3 are both Triad M1-X units and Z_1 is a 3000 cycle low pass filter, UTC model LMI-3000. All capacitors greater than one are in mmf, less than one in mf, unless otherwise noted; all resistors are ½ watt unless otherwise indicated.

is by the carrier. It is sometimes assumed that two-thirds of the power of an a.m. signal is in the carrier; this is certainly true when the carrier is modulated 100% by an audio tone. However, when voice modulation waveforms are considered, the power of the carrier is a much larger percentage of the average radiated power. A reasonable estimate of this may be as much as 80%. Thus it is seen that even though two sidebands are transmitted by i.d.s.b., the level of the interference is reduced considerably. A much larger number of stations can operate without excessive interference, since the average radiated power is much less.

This article is directed primarily toward the hams which are still using a.m. who have probably not converted to s.s.b. because of the complexity and cost involved. The use of s.s.b. is unquestionably the ultimate, in regard to spectrum economy. If it is desired to utilize most of the advantages of suppressed carrier and eliminate heterodyne interference, and at the same time avoid the critical circuitry of s.s.b., the use of inverted double sideband suppressed carrier may prove to be a practical choice. Most final amplifiers which have push-pull or parallel tetrodes can easily be converted to a high level r.f. balanced modulator by connecting the control grids in parallel and the plates in push-pull to a balanced tank. By feeding the inverted audio into the screens in push-pull, you will then be in business.

Inverted Audio for S.S.B.

No doubt, the question will arise as to the possibility of using this inverted-speech technique with s.s.b., so the unit described herein was tried out on an s.s.b. rig with the following results.

Reception of s.s.b. with inverted speech requires that the receiver's b.f.o. be tuned to the other side of the passband or approximately ±3 kc each side of the suppressed carrier instead of directly to the i.f.; however, most s.s.b. receivers have a fix-tuned b.f.o. in which case the sideband selector must be set for the opposite sideband than that which is being transmitted. and the receiver tuned for normal s.s.b. intelligence. The *indicated* frequency will be off by about 3 kc, but the actual frequency of the transmitter will not have changed. If sidebands cannot be switched at the receiver, switching them at the transmitter instead, will accomplish the same result. In this regard, caution must be taken when operation is conducted near the band edges to make sure the switched sideband will not fall outside of the band limits.

[*Editor's Note:* Initial performance results indicated that received i.s.s.b. signals were sharper and produced less crud over a given bandwidth. Unwanted sideband suppression, after demodulation, was greater than that experienced using conventional speech with s.s.b. This is probably due to the inversion of the high-energy low-frequency speech components. At this writing, time was not available for a more comprehensive evaluation; however, it is expected that more data will be available shortly. In any event, individual experimentation with inverted speech for s.s.b. should show up some interesting possibilities.]

Construction and Adjustment

The transmitter is a converted c.w. rig which had parallel 6146's in the final. The final was converted into a high level r.f. balanced modulator by reconnecting the plates in push-pull to a balanced tank. Inverted audio is fed into the screens in push-pull. The TUNE-OPERATE switch will put screen voltage to one of the tubes to facilitate loading into an antenna. With the TUNE-OPERATE switch in the TUNE position, adjust the antenna loading until the plate current is about 150 ma.

The audio frequency inverter was built in a pair of mini-boxes. The inverter is located adjacent to the converted c.w. transmitter. By substitution of capacitors, vary C_1 until the local oscillator is operating at 3200 c.p.s. Put a scope across the output of the low pass filter. Adjust the local oscillator balance control for a null on the scope. Put the scope and a pair of earphones across the secondary of the output transformer of the 6AQ5. Advance the audio gain control and speak into the microphone. Adjust the audio feed-through balance control until there is a minimum of normal sounding voice in the earphones. The voice will sound inverted and unintelligible when this control is adjusted properly.

After the audio inverter is operating properly, connect it to the high level r.f. balanced modulator. After the antenna loading is adjusted for approximately 150 ma of plate current with the TUNE-OPERATE switch in the TUNE position, snap the switch to the "operate" position. Advance the audio gain control and speak into the microphone. The plate current will kick upward on modulation peaks. With the aid of a scope adjust the audio gain control until the modulation envelope just begins to flat-top on modulation peaks. Then back off the gain control slightly, in order that the modulation envelope does not flat-top. You are now ready for a QSO. ■

"Oh, I never knew what amazing invention he's working on."