Two Sidebands

for Less than the Price of One

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A good strong carrier was a prerequisite for any self-respecting amateur radio-telephone station for many years. More recently, it has been demonstrated that the transmission of such a carrier actually penalizes the operator of a phone transmitter by unnecessarily re- stricting the useful information carrying power which can be obtained from a given final am- plifier stage. Radio amateurs are becoming increasingly conscious of the fact that a car- rier signal is—if you'll pardon the expression —pretty much of a dead beat when it comes to voice transmission.

With this in mind, and with an eye on a pair of 811-A's which of late had known only the hardships of forty meter cw operation, this operator began to ponder the problem of giving the phone bands another try. Single sideband operation was considered, but a search through the junk box revealed nothing in the way of phase-shift networks, lattice filters, or money.

At about this same time, W2CRR was turn- ing out an article for CQ on a suppressed- carrier system of double-sideband transmission. A quick look at what he was proposing was enough to show the main appeal of DSB to the average ham—SIMPLICITY. Here was a modulated final amplifier that could be de- signed to run at any power level, and which would not waste valuable watts in the trans- mission of a carrier.

There was only one fly in the ointment. 811-A's are triodes, and the simple screen grid modulation scheme suggested by Costas wasn't applicable in the case of the afore- mentioned final. However, this amplifier was designed for linear operation and it had been used several years earlier for single-sideband work. So why not build a lower power DSB exciter to drive it? Why not indeed!

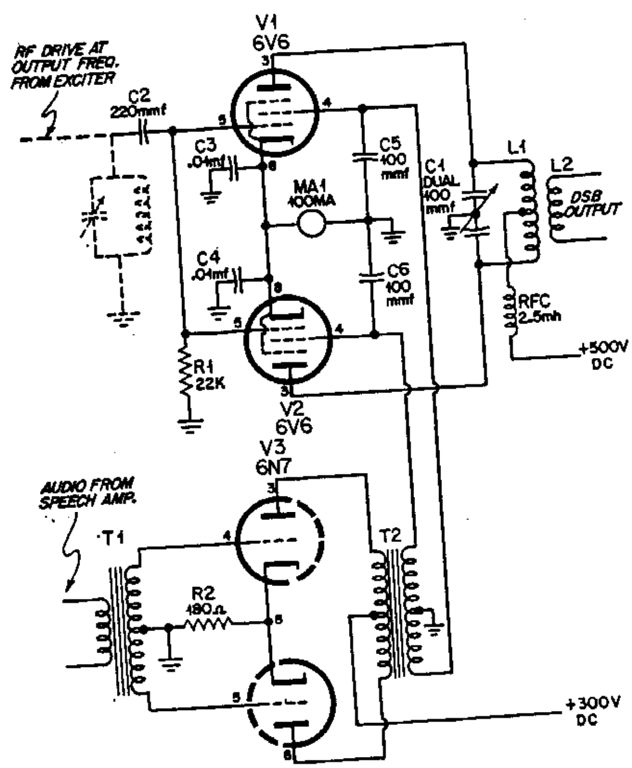

Fig 1. Proper Valves for C5 and C6 are 1000 mmf rather than 100 mmf as shown.

The Circuit

A short pencil and paper session resulted in the schematic diagram of *fig 1*. This rela- tively simple arrangement is not claimed to be completely new and novel. For the most part the familiar looking components are arrange in a manner which is quite orthodox. The tw 6V6 tubes are connected as a balanced modu lator, and are screen modulated by the 6N operating as a push-pull audio stage.

Study of this circuit will reveal a few de tails which differ from a conventional scree modulated stage. Although the control gri are in parallel, the plates are connected i push-pull. The result of this is to cancel o the carrier signal which would normally developed across the output tank circuit. Th cancellation is a result of the two tubes wor ing in opposition in the plate circuit wh their control grids are driven in phase.

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the screen grids are at ground potential. T2 is a transformer originally designed for class B driver service. In order to provide the necessary impedance step-up (the screen grid impedance is higher than the desired load impedance on the audio modulator), the transformer windings -re interchanged. The winding labeled "primary" is actually used as the secondary, and the old secondary then becomes the primary. The 6N7 audio modulator tube is biased to operate in the class AB region. The remainder of the circuit is quite conventional with the possible exception of the 6V6 plate voltage which will be discussed later.

In the absence of any audio signal, the cathode current of the 6V6 tubes rests at a low value since the voltage on the screen grids is zero, and the control grids have a negative bias produced by the rf drive applied to them. An audio signal fed to the primary of T1 will be amplified by the 6N7, and it is of interest to discuss the effect of the resulting audio voltage across the secondary of T2. Since this secondary winding has its center tap returned to ground, the voltages applied to the screens of V1 and V2 will be of opposite phase. As the screen of V1 is driven positive, the plate and screen currents flowing in that tube will increase. At the same time, the negative-going voltage on the screen grid of V2 will cut off the plate and screen current flow in the latter tube. When the audio signal reverses polarity, the current in V2 rises and V1 is then completely cut off.

Now it has already been pointed out that the method of connecting the two 6V6's is such as to cause cancellation of the carrier signal. However, this cancellation effect does not apply to the sidebands which result from the modulation process, and so the output signal obtained across L2 consists of the usual symmetrically related pair of sidebands, but without the usual carrier. As a result, there is output power when you talk, and when you stop for breath, the output drops to practically zero. (Even the best behaved circuits may well allow a smidgen of carrier to sneak through, but experience with this circuit has shown that the amount of carrier at the output isn't worth the slight additional complexity of a special balancing control.)

An interesting feature of this circuit is its self-neutralizing operation. Users of screen grid tubes know that steps frequently have to be taken to prevent self oscillation at the operating frequency. In low power circuits, the "gimmick" capacitor is often the answer to this problem. In this balanced modulator, however, the grid-to-plate capacitance of one tube neutralizes the other, and no trace of self-oscillation has been detected on any band from 10 through 75 meters.

Although the tube manufacturers might raise their eyebrows at the plate voltage applied to the 6V6's, readers of CQ should be well-hardened by now to circuits operating at somewhat higher than rated plate voltage specifications. In normal AM operation, no one would be concerned about using 250 volts on the plates of these tubes, and it is well known that 100% modulation will result in peak plate voltages twice the value of the applied D. C. In DSB operation, therefore, the philosophy is that since the tubes will stand that voltage, why not run them there. Of course, care must be taken not to exceed the average plate and screen dissipation capabilities of the tubes, but since each tube works only 50% of the time during modulation, and loafs along at low current without modulation, this is not a severe limitation.

Typical operating conditions for this circuit are shown in *fig 2*. Under these conditions, the output of this balanced modulator is more than adequate to drive the 811-A linear to 300 watts input.

	No Modulation	With Modulation
Balanced Modulator Grid	3.2 ma.	2.8 ma.
Balanced Modulator Cathode	13 ma.	53 ma.
Audio Modulator Cathode	4 volts	5 volts

Fig 2. Operating Data

The balanced modulator has also been used directly into the antenna with good results. It is always surprising to the newcomer in suppressed-carrier transmission to see how effective relatively low power can be. With every watt being utilized as useful "talk power," a 25 watt transmitter can do a creditable job.

The more suspicious readers may have already looked for the "real" schematic which shows the numerous other components not revealed in *fig 1*, but which are "always" required to make the simplified circuits shown in *most* Fig 1's work properly. Search in vain, Gentle Reader. This *fig 1* is IT. With this circuit tied on the end of your low power buffer or frequency multiplier, and a few volts of audio to apply to the primary of T1, you are in business. You can if you wish, fancy it up with refinements like cw/phone operation; but if all you want to do is to try DSB, nothing more complicated is required.

The driver which provides grid excitation for this balanced modulator need have only low power output capabilities. A 6AG7 with 300 volts on the plate and 100 volts on the screen has been found to be more than adequate either when running "straight-through" as a buffer, or when used as a frequency multiplier.

Audio requirements are equally modest. 5 or 6 volts R.M.S. at the primary of T1 will do the job nicely, and almost any speech amplifier can be utilized. The speech equipment at W2SBI incorporates a clipper and low-pass filter, and the low impedance output from a cathode follower drives T1.

Tune Up Procedure

This balanced modulator operates directly at the desired output frequency. Your exciter (which should have good frequency stability just as is required for SSB) is tuned up in the normal fashion to obtain the desired grid current in the 6V6's. This current has not been found to be particularly critical, so don't worry too much if it can't be adjusted precisely to the value shown in *fig. 2*.

Since there is no carrier output from this balanced modulator, tuning can be accomplished only with modulation. With a suitable load connected to the output of L2, and with fairly tight coupling between L1 and L2, modulate with a steady tone and adjust C1 for maximum output. Then adjust the output level of the speech amplifier for normal operation as shown in *fig. 2*.

If your station equipment includes an oscilloscope, it is easier to determine how well the DSB rig is working. When the audio from one side of the secondary of T2 is connected to the horizontal deflection plates of the cathode ray tube, and rf voltage is taken from across the load on L2 to provide vertical deflection, the resulting pattern under modulation conditions will be a double trapezoid or "bow-tie" as it is usually called. This is the same pattern obtained in a two-tone test of a linear amplifier, and a little thought will confirm that two sidebands should generate such a pattern. With this test setup, the usual tendency to crank up the audio gain an excessive amount will show up as flattening-off of the rf peaks.

Circuit Refinements and Variations

There are additional niceties that some constructors might wish to include. One, which has already been mentioned, is provision for cw operation. This can be readily done by providing the following switching functions:

1. Open one filament lead to V2
2. Reduce plate voltage from 500 to 300
3. Insert 470 ohm 2 watt cathode bias resistor in V1-V2 cathode ground return lead (required for protective bias only when previous stage in exciter is keyed)
4. Disconnect V1 screen grid from secondary of T2 and return it to +300 volts through 47,000 ohm 2 watt resistor.

The result of this operation is to make V1 a conventional amplifier (still neutralized by the grid-to-plate capacity of V2). The output on cw is approximately the same as the peak output under DSB conditions.

Another refinement suggested by W2HNH is provision for easier tune up on DSB by switching one of the screen grids to a dc source. Although this has not been tried on this particular balanced modulator, a value of +50 volts on the screen of V1 (or V2) should provide sufficient carrier for tune up purposes.

Voice control operation is almost a must on SB operation, and any of the popular schemes for accomplishing it are directly usable for DSB.

Other tubes may be used in this same circuit. Both 6L6's and 6F6's have been tried with equally satisfactory results. For higher power outputs, 807's or 6146's are good bets, but you will probably have to modify the value of the grid bias resistor for best operation with these tubes and the higher operating voltages they require.

Another variation of this circuit would be to operate the control grids of the balanced modulator in push-pull and the plates in parallel as was suggested by Costas. This permits use of an unbalanced pi-network in the output circuit.

DSB Operation

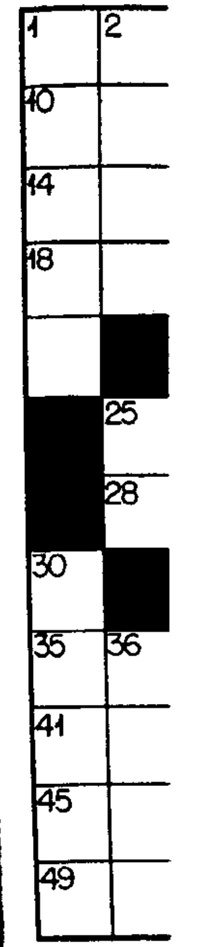
Several months operating experience with DSB has provided an interesting cross-section of results. There are still amateurs who don't know how to receive suppressed carrier transmission—either SSB or DSB. They are the toughest to work since it is rather difficult to instruct them on tuning procedures if they can't understand you in the first place!

The technique for tuning DSB is essentially the same as for SSB. In a conventional receiver, the audio gain control should be advanced toward maximum, the rf gain (or sensitivity) turned down, and the bfo switched on. DSB is most easily tuned if sufficient selectivity is available in the receiver to attenuate one sideband. If the receiver is rather broad, as in the case of many unmodified surplus jobs, tuning can be a problem. The listener with such equipment may notice a flutter on the modulation when he is zero beat with the carrier frequency. This comes about as a result of the lack of phase synchronization between the suppressed carrier and the carrier inserted at the receiver. If one sideband can be attenuated to some extent in the receiver, this flutter will disappear.

In receivers equipped with crystal filter, Q-5er, Q-multiplier, or any of the selectable sideband adapters, there should be no real problem in reception.

The majority of SSB stations worked have

[*Continued on page 114*]



Answers are

For further information, check number 47 on page 126.

DSB *[from page 56]*

not realized that this was DSB until they were told. Those who did catch on immediately were generally the ones who habitually check sideband suppression of received SSB signals, or else who did not have their receiver set up for optimum rejection of the unwanted side-band, and hence experienced some tuning difficulty.

A surprising number of SSB enthusiasts have expressed genuine interest in DSB operation. An even greater number of AM and cw operators have reacted favorably to this mode of transmission when they saw the ease with which they could hop on the suppressed carrier phone bandwagon. All are quick to realize that the same basic circuitry can be applied to a kilowatt final as well as to the low power unit described in this article.

No article on amateur transmitters is complete without mention of TVI. This balanced modulator has been operating as the driver for the 300 watt linear final on 20, 40, and 75 meters for several months. Contrary to the good practices employed by more ambitious constructors, the DSB unit, as well as the final, is completely unshielded. The station is located in the primary coverage area of two VHF television stations. The only reported case of TVI was apparently caused by overloading the receiver with the transmitted signal, and a high pass filter purchased by the owner of the set in question cured the trouble.

The use of a properly operating linear final goes a long way toward minimizing TVI. Since the amplifier is linear, the harmonic content of the output signal is extremely low. In areas where the signal levels obtained from the television stations are somewhat poorer, all the same precautions are advisable in the construction of DSB equipment as are recommended in any other type of amateur transmitter. This is particularly true of balanced modulators operating at higher power levels (such as the kilowatt final mentioned a few paragraphs earlier). Since these balanced modulators are in the Class C condition of operation when modulation occurs, the usual harmonics will be generated. Shielding and filtering is the only answer in this case.

The time has passed when sheer power is the answer to amateur radio communications problems. Progressive techniques are now required in the competitive atmosphere of our crowded bands. The simple circuit described in this article allows the average experimentally-inclined amateur to try suppressed carrier phone transmission with only a minimum cash outlay.

The author acknowledges the helpful suggestions of W2CRR and K2KID, without whose encouragement this article would surely not have been written. ■