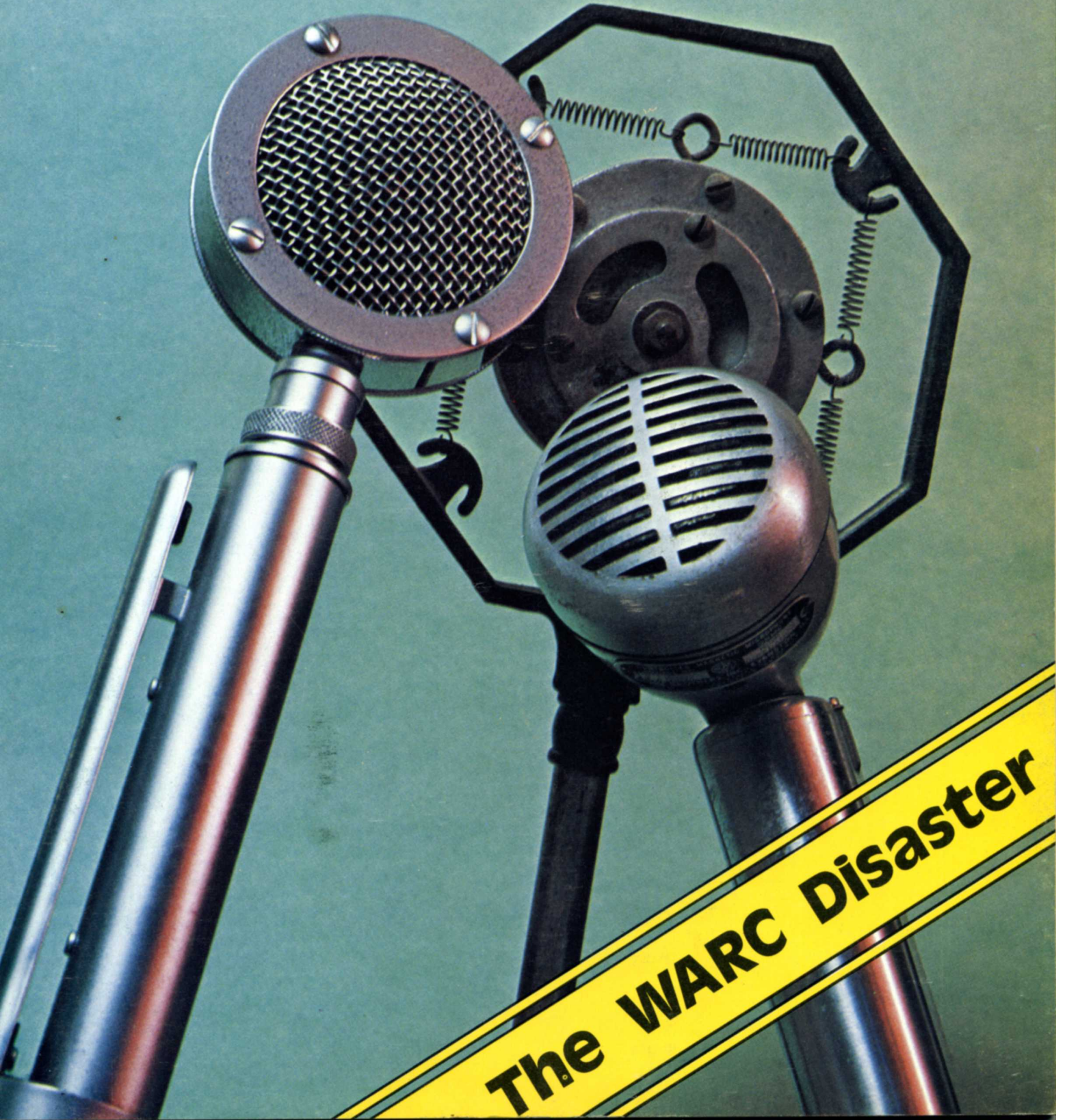


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The WARC Disaster

SSB: The Third Method

-- bet you can't even name
the first two

I first ran across this particular method of SSB generation some years ago when involved in a communications course. At the time I was deeply involved with getting a phasing type SSB generator on the air and only gave this method a casual glance. Never having heard of this method in the amateur journals, or of a commercial unit using this type, I was inclined to write it off as an impractical method, as I am sure many others have done before and since. This assumption couldn't be further from the truth, as the

Third Method is in direct competition with the filter method. It requires neither sideband filter, nor wideband audio phase shift network (as in the phasing method), does not require critical adjustment, and any misadjustment results in interference to the user only.

As you can see, this method has much to offer the radio amateur and indeed the commercial user. The original paper on this subject was by D. K. Weaver, Jr., titled, "A Third Method of Generation and Detection of Single Sideband Signals," *Proceedings of*

the IRE, December, 1956. At present this method is used in commercial equipment manufactured by Redifon Telecommunications, England, and has been since a unit was introduced in 1960.

Enough of the selling job on the Third Method - let's get into the circuit description. If you will refer to the block diagram of Fig. 1, you will note that we have four balanced modulators. These can be of any configuration. Balanced modulators A1 and B1 are operating at audio frequencies, so layout is not too critical. The circuit also

requires phase shift networks. Since these are operating at only one frequency, obtaining an exact phase shift is no problem and even RC networks can be used. This application also lends itself well to digital schemes, one of which is shown in Fig. 3. The low pass filter (the one from the original paper is shown in Fig. 4) is also operating at audio frequencies and can be constructed using LC networks. It is also possible to use active audio filters.

The input audio consists of 300 to 3,000 Hz, the normal bandwidth of speech communications. When these frequencies are mixed (in balanced modulator A1) with the 1800 Hz oscillator, the modulation products that appear in the output are as shown in Fig. 2(b). In particular, note that the lower sideband is "folded" over. This results from the choice of carrier frequency. The carrier frequency is actually in the middle of the audio spectrum to be transmitted. As an example, consider an input audio signal of 500 Hz. When it is mixed with the carrier frequency of 1800 Hz, the modulation products (sum and difference components) are 1300 Hz and 2300 Hz. Next consider an input audio frequency higher than the carrier frequency, for example, 3100 Hz. When it is mixed with an 1800 Hz signal, the modulation products are 1300 Hz and 4900 Hz. Thus at the output of balanced modulator A1 we have a lower sideband which has the audio frequencies higher than 1800 Hz folded back on top of the lower audio frequencies - and all this is contained in a bandwidth of 1500 Hz. An upper sideband also extends from 2100 Hz to 5100 Hz. The upper sideband is then filtered out by the low pass filter, leaving only the lower sideband as shown in Fig. 2(c).

This "folded" lower sideband is then applied to balanced modulator A2, where it is mixed with the rf carrier.

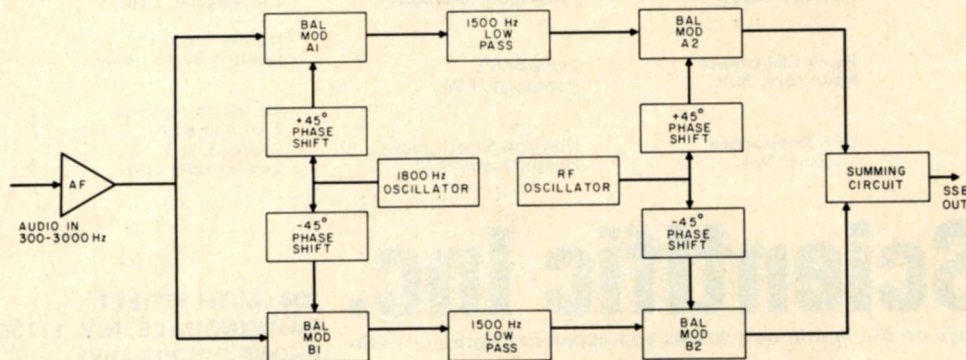


Fig. 1.

The rf carrier may be the operating frequency, or a lower frequency which is then heterodyned to the operating frequency. The output of this balanced modulator is shown in Fig. 2(d). It consists of the 0-1500 Hz "folded" sideband from modulator A1 as two double sidebands of the rf carrier, which is balanced out in A2. A careful analysis of this diagram will reveal that we are once again back to our original bandwidth of 3,000 Hz. Also, because there are both high and low original audio frequencies represented in both the resultant sidebands of balanced modulator A2, we will have both inverted and direct speech contained in the 3,000 Hz bandwidth of Fig. 2(d).

It has been shown by the phasing method of SSB generation that by using two modulator chains of the proper phases we can generate two sets of sidebands, which when added together result in cancellation of the unwanted sideband and reinforcement of the wanted sideband. Much the same technique can be used here, with the Third Method. By using two modulator chains, as shown in Fig. 1, and the proper phase shift networks (quadrature), which as stated before are for only one frequency and can be made to exhibit the exact phase shift needed with little trouble, and then adding the output of these two chains, we can reinforce the wanted sideband and cancel the unwanted sideband. The result is illustrated in Fig. 2(f). For additional clarity, the outputs of modulator chains A and B are shown in Fig. 2(e). Note that both sidebands occupy the same frequency spectrum, as well as the 180 degree phase difference between the lower sidebands.

It can be seen in Fig. 2(f) that the carrier frequency of the SSB signal, in this case for upper sideband, appears 1800 Hz below the rf oscillator frequency of the generator.

This means that the carrier frequency of the sideband signal is actually not generated (due to the use of the folded sidebands). Therefore, any misadjustment of the final balanced modulators will result in the rf carrier appearing in the middle of the sideband spectrum and causing an 1800 Hz tone to be heard on the receiving end. The important fact is that no out-of-channel interference will occur. Only the user will suffer from misadjustment. Another important fact is that if there is incomplete sideband cancellation, again no out-of-channel interference will occur. The unwanted sideband will appear in the same spectrum as the wanted sideband, causing interference to the user only.

This method of single sideband generation has some very positive advantages over both the filter method and the phasing method of single sideband. I have included some sample circuitry of various parts of the Third Method SSB generator. If you are considering building an SSB generator, I hope that you will give serious consideration to the Third Method. Though it is rather complex, the construction and alignment is simplified, due to the fact that most of the circuit is at audio frequencies. The advantages are many. If anyone is interested in a more detailed and mathematical description of the circuit operation, any of the references listed will be of help. Good luck with

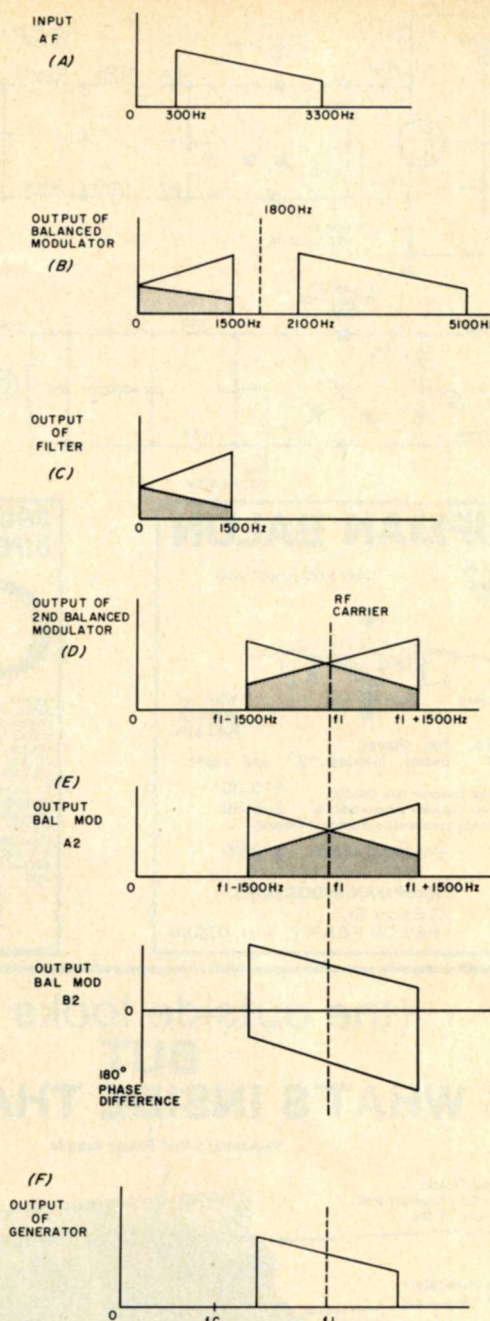


Fig. 2. (a) Represents average speech power distribution. (f) $F_C = F_1 - 1800$ Hz (upper sideband output).

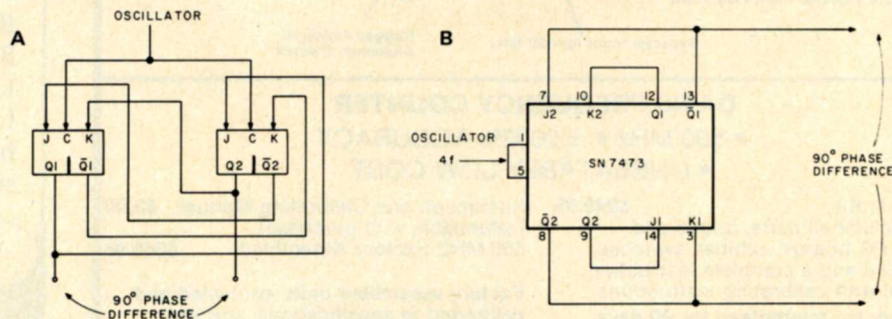
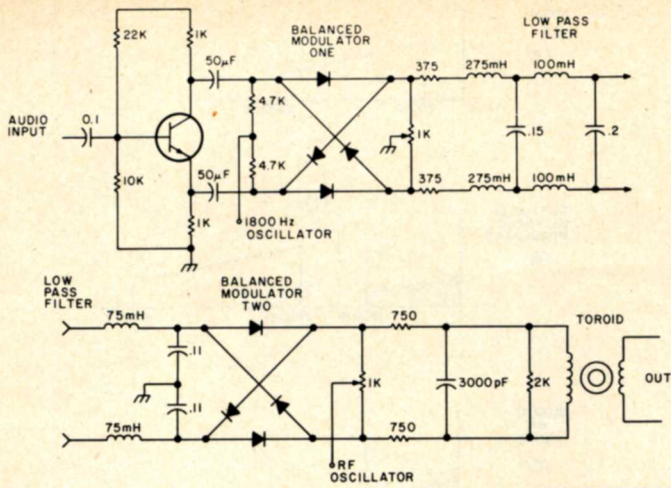


Fig. 3. (a) Using two JK flip-flops to obtain a 90° phase shift for use in Third Method generators; oscillator frequency must be four times the desired output frequency, i.e., for 1800 Hz output, oscillator frequency is $4 \times 1800 = 7200$ Hz. (b) 90° phase difference network using dual JK master-slave flip-flop 7473.



building a Third Method generator, and I hope to hear many of you on the air. ■

References

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Fig. 4. Example of modulator-filter chain for Third Method generator. Two are required for complete generator. All diodes: 1N34. Any NPN transistor is suitable. Summing of both modulator chains can occur at toroid.