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RADIOTRANSMISSION WITHOUT DISTORTION

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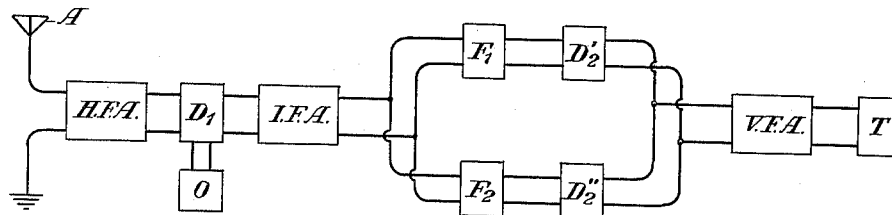


Fig. 1

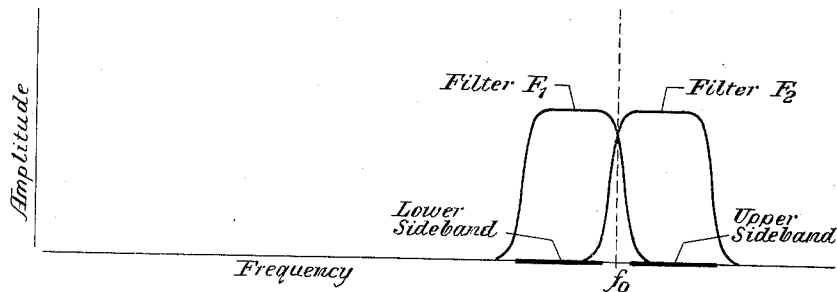


Fig. 2

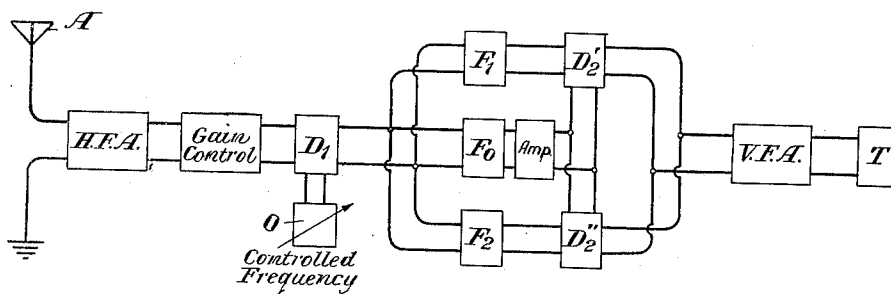


Fig. 3

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RADIOTRANSMISSION WITHOUT
DISTORTIONRalph Kimball Potter, Landing, N. J., assignor
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5 Claims. (Cl. 250—20)

This invention relates to radio transmission without distortion, and more particularly to means for preventing harmonic distortion in double side band short wave radio reception. The object of my invention is to prevent the undue introduction of harmonics of the telephone or other message frequencies which arise in connection with selective fading, which is particularly likely to be present in short wave signaling.

I have found that when both side bands and carrier of short wave signals are received and demodulated in the usual way, the selective fading of the carrier is accompanied by an increase in the harmonics of the telephone or other message in much the same way that distortion is increased by overmodulation at the transmitter. Thus, if a double band and carrier frequency wave of components p , $p+q$ and $p-q$ is received and demodulated, each side band with the carrier p will yield the message frequency q , and the two side bands together yield the harmonic $2q$ and higher harmonics, of which the one mentioned is generally the more serious. If the carrier wave p is eliminated or very much reduced by selective fading, the q terms are absent or relatively weak and the $2q$ terms are heard much more markedly. This is different, it will be observed, from the effect of general fading where all the radio frequency components are equally attenuated, for in that event the relative value of harmonic to fundamental remains about the same or is reduced.

It appears that the fading in short wave signaling is very largely if not chiefly due to different portions of an emitted wave reaching the receiving station by different paths and setting up a wave interference pattern in the region of the receiver. Since the effective length of one or more of the paths may change in an irregular manner, the wave pattern is continually changing, and at times portions of the wave pattern for which there is quite complete or total neutralization of a given frequency, such as the carrier, may fall on the receiver station. Since such fading is generally selective, the harmonic distortion imposes a serious limitation upon the quality in short wave signal transmission. Further, since the introduction of these harmonics arises from the cross-modulation of the side bands, it appears that they could be avoided by the reception of the carrier and a single side band only. It is found, however, that single side band reception has certain fundamental distortion characteristics which are less desirable than those for double side band reception.

The presence of these difficulties in short wave signaling is discussed in an article by me in the Proceedings of the Institute of Radio Engineers for April, 1930. As described in that article, the wave interference which is evidently responsible

for selective fading produces spaced depressions in the high frequency signaling band which move across the frequency spectrum as the relative lengths of the interfering paths change. Since single side band reception provides a low frequency equivalent of the interference pattern which is appearing in the high frequency band, the minima show a tendency to move about. In the double side band case, the opposite side bands produce what might be described as a compensating effect, so that the minima remain in a somewhat more fixed position and may not, on the average, be so deep, for when parts of one side band fade out the corresponding portions of the other side band are often present at a high amplitude. Thus it is seen that there are certain advantages in using both side bands, but also certain disadvantages. Similarly, there are certain advantages in using a single side band, and also certain disadvantages.

The method of reception to be described and which constitutes my invention combines the advantages of both single side band and double side band reception. In brief, the invention consists in transmitting both side bands and the carrier of the signal. At the receiver the signal is demodulated or "beat down" to an intermediate frequency and suitably amplified. A band pass filter then separates out part of the carrier with the lower side band, and another passes a part of the carrier with the upper side band. The outputs of these band pass filters are then separately demodulated to the voice frequency or other message frequency, thus avoiding the formation of the harmonic terms. These demodulated components at the voice frequency are then combined, thus providing the advantage of double side band reception. As a modification of the above the side bands and carrier may be separated into three channels, and after suitable amplification of the carrier the latter may be introduced at the two low frequency demodulators.

The invention will be better understood by reference to the following description and the accompanying drawing in which Figure 1 is a block representation of the receiving station circuit; Fig. 2 gives the characteristics of certain band filters shown in Fig. 1; and Fig. 3 shows a modification of Fig. 1.

Referring more particularly to Fig. 1, there is shown a receiving station with an antenna A. The normal signal, consisting of a carrier and upper and lower side bands, is received thereon and amplified by the high frequency amplifier HFA. In the demodulator D₁ it is demodulated or "beat down" with a high frequency wave from a local source O of oscillations to produce an intermediate frequency. This intermediate frequency is then amplified by the intermediate

frequency amplifier IFA in the output of which is a branched circuit, each branch comprising a band pass filter and a demodulator. The characteristics of these filters F_1 and F_2 are approximately as represented in Fig. 2. The one branch with the filter F_1 passes the lower side band and a part of the carrier, and the other branch passes the upper side band and the carrier. At the output of the filters F_1 and F_2 are demodulators D_2' and D_2'' , respectively. These demodulate separately the lower and upper side bands of the intermediate frequency signal with parts of the intermediate frequency carrier. The voice frequency outputs of the two demodulators are then combined and amplified by the voice frequency amplifier VFA in the output of which is connected any suitable indicating device T, such as a telephone receiver or loud speaker.

It will be seen that the circuit as thus described has the advantage mentioned above, namely, that the cross-modulation products do not enter for the reason that the two side bands are not impressed upon the same demodulator. It also has the advantage of the double side band reception in that if there is selective fading in one side band, there will not in general be the corresponding fading in the other side band, and the two side bands together will in general give an average amplitude showing much smaller variations than either side band alone.

In the operation of such a receiving set certain auxiliary features are desirable, although not essential to the operation of the circuit. Such features are shown, for example, in Fig. 3 which includes all the elements of Fig. 1 but in addition certain others. For example, it is important to maintain accurate tuning of the receiver so that the frequency relation of the intermediate side band to the filter characteristics is not upset by a variation in frequency of the transmitted carrier. To this end Fig. 3 shows the local oscillator O as automatically controlled, the frequency of this local oscillator being regulated to yield a constant difference with the received carrier frequency. As a result the intermediate carrier frequency in the output of the amplifier IFA remains substantially constant, keeping its correct position with respect to the filters F_1 and F_2 . Fig. 3 also shows an automatic gain control which would change the gain of the earlier receiver stages to compensate changes in the received carrier signal. Obviously, this gain control could be located at any desired point in the receiving circuit, but I have shown it for illustrative purposes as following immediately the high frequency amplifier HFA. Any of the means now known in the art for such gain control or for control of the frequency of the oscillator O, would be appropriate. Also, in this Fig. 3, I have shown the modification mentioned above in which the output of the intermediate frequency amplifier is divided into three channels, the additional one selecting the intermediate frequency carrier f_0 by means of the filter F_0 . This carrier may then be amplified to any desired extent and supplied to the demodulators D_2' and D_2'' . The message-frequency components of the demodulators are then recombined in the manner described above. In this circuit the filters F_1 and F_2 would be of a band width sufficient to pass only a relatively small amount of carrier since carrier for the separate demodulation in D_2' and D_2'' is supplied by the filter F_0 .

It will be observed that the wave which is to be received is one made up of three components,

namely, the carrier frequency and the two side bands, and that at neither the transmitting or the receiving end has there been any shift of phase relationship between these three components. They are received in normal phase relationship and are maintained in this normal phase relationship so long as they exist. Also, the demodulation products appear in normal phase relationship to each other so that they combine additively to give the message frequency.

It is obvious that in addition to the above, various other modifications might be introduced and certain features eliminated without departing from the spirit of my invention. Thus, it is seen that it may not be necessary or desirable in certain cases to step down to an intermediate frequency, but the received antenna signals might go directly to the selective branch circuit, either with or without previous amplification.

What is claimed is:

1. The method of radio signaling which consists in receiving a carrier and its two side bands all in normal phase relationship, separating the two side bands from each other, deriving a message from each side band, and combining the two messages additively in a single indicator.
2. The method of radio signaling which consists in receiving a carrier and its two side bands all in normal phase relationship, demodulating these to an intermediate frequency, separating the two side bands while maintaining their normal phase relationship, demodulating these separately to message frequency, and combining the two resulting messages additively in a single indicator.
3. In a high frequency signaling system employing a carrier frequency and its two side bands all in normal phase relationship, a receiving station, means thereat for separating the side bands from each other, means for demodulating them separately to message frequency, and an indicator in which the two resulting message components are additively combined.
4. In a high frequency signaling system employing a carrier frequency and its two side bands all in normal phase relationship, a receiving circuit comprising means for demodulating to an intermediate frequency, a divided circuit associated with the said means, filters in each branch adapted to pass in one branch the upper side band and carrier and in the other branch the lower side band and carrier while maintaining normal phase relationship, demodulators in each branch, and means for combining the demodulation products additively in an indicator.
5. In a high frequency signaling system employing a carrier frequency and its two side bands all in normal phase relationship, a receiving station, means thereat for demodulating to an intermediate frequency, said means comprising an oscillator of controlled frequency yielding a fixed difference of frequency with the received carrier frequency, a divided circuit associated with the output thereof, filters in each branch adjusted in one branch to pass the upper side band and carrier and in the other branch the lower side band and carrier while maintaining normal phase relationship, demodulators in each branch, means for combining the demodulation products additively in an indicator, and gain control in the receiving circuit adapted to automatically adjust for variations in the amplitude of the received antenna signal.

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