F-M SPECIAL

NAEB NEWSLETTER

Office of Executive Secretary
Urbana, Illinois
February 15, 1940

Editor's Note: Every NAEB member should be interested in progress; therefore, should be interested in frequency modulation. The following article, prepared by Jim Ebel, Chief Engineer of WILL, is presented here to whet your interest.

FREQUENCY MODULATION

By A. James Ebel, Chief Engineer, WILL

Frequency modulation, is it just a grand pipe dream or is it the coming thing in radio broadcasting? That question is before the commission, the industry, and the general public today. Of more importance to us is, where does educational broadcasting fit in this picture? The answer to this and many other kindred questions is not at hand at the present time. It is one of those intangibles with which we will have to live for several years before anything of definite value will be known.

Our purpose in presenting this discussion is to outline some of the established facts and then to raise certain questions which are pertinent. No attempt will be made to discuss the technical operation of frequency modulation because the author is far from an expert on the subject. Rather, we have included a partial bibliography of frequency modulation which may be consulted for that information.

First let us review the advantages of the frequency modulation system. Probably the outstanding attribute of the system is the noise reduction. For wide band frequency modulation this can be shown to be 25 DB. Note that this is reduction and not elimination. Secondly, the system can transmit a wide range of audio frequencies without increasing the signal to noise ration. Thirdly, the system from transmitter input to discriminator output (i.e. second detector output) exhibits a greater dynamic range for the transmission of music. In the fourth place, due to the limiter action the interference ratio between stations is two to one instead of 25 to 1, simplifying the allocation problems insofar as a single frequency is concerned. And, finally, wide band frequency modulation has a number of engineering niceties which must not be overlooked. All of the host

of problems caused by the variation of amplitude at high powers are eliminated. Linearity need not be maintained beyond a limited degree both in transmitter radio frequency sections and receiver radio frequency and intermediate frequency sections. In some respects it is almost a dream come true to the operating engineers.

Now having examined the advantages of this system, let us mention a few of the disadvantages. In the first place a wider band is needed for each allocation (200KC for frequency modulation, 30KC for amplitude modulation of equal fidelity). In the second place there will be a very definite adjacent channel problem because the action of the limiter tends to nullify the selectivity curves of the radio frequency and intermediate frequency sections. In the third place, service area is limited to about 100 miles over flat terrain (note that transmission is possible beyond the first horizon). However, frequency modulation will give more coverage per watt up to a certain point. And in the fourth place the receiver tuning problem is rather difficult. Because of shape of the discrimination characteristic, each station comes in at three points, two of them giving rise to rather poor reception. (One solution is the use of push button tuning, with all its evils)

With the above material in mind, let us raise two more fundamental questions. First, does the listening public want high fidelity? And second, cannot amplitude modulation transmit as high fidelity as frequency modulation?

The widespread use of tone controls on the radios of present day leads us to wonder if high fidelity is really desired. It is true that the high tones in most receivers are unpleasant to listen to because of distortion and unequal distribution. Furthermore, since the average receiver cuts off between 4,000 and 5,000 cycles a true picture of the high tones is not presented, especially when the bass is often attenuated at the same time. However, the economic demand for the poor present day receivers is further reason to wonder about the acdeptability of high fidelity.

The fundamental listening habits of the American people are tied up in this question. High fidelity requires a much higher attention level than the soothing rumble of the over-bass compensated present day receiver. It is absolutely impossible to listen to a program of high quality music on a high fidelity receiver and at the same time play bridge or engage in other diversions.

Furthermore there is the question as to whether the directors of broadcast stations will allow voice to be transmitted at its normal level. As long as maximum coverage is a consideration they most certainly will not. It is the same old question of quality versus quantity.

As pessimistic as this may seem it does not mean that we should not strive for high fidelity. If there are higher cultural values to be attained thru the use of high fidelity then it is the duty of educational stations to educate the public to an appreciation of them. The habits of the American people have been changed in other

respects; there is no reason why their listening habits cannot be changed. Oddly enough however the education could well start at home. I am not sure that all educational stations and their personnel are sold on high-fidelity themselves.

Assuming for the moment that high fidelity is considered desirable let us consider the question as to whether frequency modulation is the answer to the problem, whether satisfactory results may be obtained by amplitude modulation. A number of studies have been made to determine what the maximum frequency need be for high fidelity transmission. The answer seems to be that very little if any improvement is gained by transmitting frequencies above 10,000 cycles. Recent studies with respect to permissible distortion seem to indicate that with wide frequency response the figure must be reduced to two percent.

Let us now examine a typical high fidelity system in the light of the above questions. The allowable dynamic range--i.e. volume range between the softest and the loudest passages, is limited on the one hand by the neighbors who will probably object to full volume passages and on the other by the intrinsic noise level of the room. This limits the dynamic range in the listeners room to not more than 60 DB and often as in the case of apartment buildings to a much lower figure. Considerable frequency distortion is introduced by standing waves in the listening room, spatial distribution of the radiated sound, and the variation of absorption with frequency. Remember, all of these limitations are introduced by environment before the reproducing system is even considered.

The next link in the system is the loud speaker. The best speakers at the present time introduce considerable frequency and amplitude distortion. The amplitude distortion is of two types; nonlinear distortion and transient distortion. The second type is most objectionable and contrary to common belief occurs at both low and high frequencies. It is a type of distortion which tends to make the high notes sound more piercing than normal.

In the audio amplifier of the receiver very little distortion of either type need be introduced. The noise level is up slightly however, and tends to curtail the dynamic range to a minor degree.

All of the distortion considered thus far is common to both systems and will not be changed by the change in system of transmission.

Taking the next link to be from transmitter input to detector output, it is agreed that the F. M. system will have a decided advantage over A.M. with respect to noise level. Therefore the dynamic range of this section of the transmission system will be wider for F.M. than for A.M. However the A.M. system can be made to have a dynamic range of 50 DB. With respect to frequency and amplitude distortion the systems can be made of equal fidelity, although the noise level increases with an increase of acceptance band in the A. M. system.

When we consider the speech input systems which are common to both A.M. and F.M. we find that there is a further limitation of the

dynamic range due to the inherent noise level of the low level amplifiers and mixing circuits. Frequency and amplitude response can be made very excellent, but in order that microphones be made to respond to a wider frequency band it can be shown that the sensitivity is reduced correspondingly which further limits the dynamic range at the lower levels. In the studio the room noises place a definite lower lovel on the transmitted sound if the program is to be kept out of the "mud".

One other link which has not been considered is that of telephone lines. Their limitations as to frequency response and noise level are well known and may be considered as a bottle neck for either system. Much better quality may be had by using radio frequency relays.

From the above discussion of the transmission system it can be seen that the advantages of F. M. as to high fidelity are partially nullified by the limitations of the other elements of the transmission system. There is no doubt but that improvements can be made but they will have to be very drastic to be effective. The fact remains that A. M. can give much higher fidelity reception than it now gives.

There can be no question but what wide band F. M. is an outstanding development and will be utilized a great deal in the future. I can see nothing to equal it for connecting links between broadcast transmitters since it is so far superior to telephone lines and can be retransmitted many times by virtue of its very low noise level and high fidelity characteristics. The question remains however, will it replace or supplement Amplitude Modulation for broadcasting. What are your ideas?

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FM HEARING POSTPONED

At the request of a number of interested parties for more time in which to complete their material, the informal hearing before the Federal Communications Commission in the matter of aural broadcasting on frequencies above 25,000 kilocycles, which was scheduled for February 28, 1940, has been postponed to March 18, 1940.

The final date for the filing of written statements, sketches, drawings, etc., in connection with argument, has been extended to March 11. In order to expedite the proceedings, witnesses will not be permitted to read prepared statements into the record during the hearings.

FCC TO ACCEPT EXPERIMENTAL F-M APPLICATIONS ON NON-BROADCAST BANDS

To obtain more factual data about frequency modulation for services other than broadcast, the Federal Communications Commission today announced that it will accept applications for such experimental authorizations on the frequencies allocated to those services above 30,000 kilocycles.

This applies to such services as emergency, aviation, and those miscellaneous radio services not directly involved by the Commission's informal engineering hearing, scheduled to begin February 28, primarily to consider frequency modulation as applied to the standard broadcast service.

Frequency modulation is claimed to offer definite advantages over existing amplitude modulation systems in the police and aviation services. In the police service, each system is under the direct control of one licensee who can plan and control the installation and operation of both the transmitting and receiving systems. There are approximately 1,000 police radio systems with more than 6,000 transmitters (including headquarters and patrol cars' now using amplitude modulation.

On the basis of the reports required to be submitted under the experimental rules, and after observation of operation by Commission personnel, decisions will be reached as to whether and under what conditions frequency modulation can be regularly authorized for use in the non-broadcast services.

"Staticless radio, as developed by Major Edwin H. Armstrong, is to be tested in Chicago by the Zenith Radio Corporation, to which the FCC has issued a station construction permit. The power is to be 1 kilowatt; the channel 42,800 kilocycles.

"The program of research and experimentation which the applicant proposes is expected to obtain data, particularly on the merits of wide-band and narrow-band modulation, which will be helpful at the informal engineering hearing on aural broadcasting on high frequencies, to open before the Commission on Feb 28, in Washington.

"To compare the merits of two systems of ultra-short wave broadcasting, 'amplitude modulation' and 'radio frequency modulation', the latter popularly called 'staticless', the FCC has granted Finch Tele-communications, Inc., of New York a permit to operate Station W2XWF on 42.18 megacycles.

"The 1,000-watt transmitter is nearing completion atop the Manufacturers Trust Building at Columbus Circle. Both aural and facsimile tests are planned, according to W. G. H. Finch, president of the organization." New York Times, Jan. 14, 1940.

A collaboration among the Maryland Institute for Technology in the Humanities,
University of Wisconsin-Madison Department of Communication Arts,
and Wisconsin Historical Society.

Supported by a Humanities Collections and Reference Resources grant from
the National Endowment for the Humanities

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