VOICE INTELLIGIBILITY IN SATELLITE MOBILE COMMUNICATIONS

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We have been involved in development of voice communications systems capable of operating over channels having low carrier-to-noise ratios, and giving output speech having good intelligibility.

This effort is part of the larger scope effort being conducted in the field of satellite based air traffic control systems. In this area of work, the power limitations of the satellite drastically limit the power available to the channels. In addition, because of antenna problems on the aircraft, and in general, propagation effects, these channels may be subjected to extreme amounts of fading.

It should be pointed out that the work being done in the voice communications field is directly applicable to commercial voice communication systems. Today I will talk about one of these developments, called "amplitude control technique." This method, when implemented on an analog voice communications system, improves the performance of these systems when operating over a noisy channel.

The amplitude control system has been implemented with a narrowband FM system. Now, the amplitude control system works in the following two ways with voice systems. As we know, speech consists of a series of phonemes, having various amplitudes. When the speech is transmitted over a noisy channel, the lower level phonemes tend to be masked by the noise, and therefore their contribution to the received intelligibility is nullified.

The amplitude control technique eliminates this problem by presenting at the transmitter equal amplitude phonemes. So that the low level phonemes, when they are transmitted over the noisy channel are now above the noise, and will contribute to the output intelligibility.

The second way the amplitude control technique improves voice reception is that a listener to a noisy channel over an extended period tends to get fatigued in the sense that his ability to understand what is being transmitted is greatly decreased. So, the amplitude control technique provides for squelching the noise when speech is not being transmitted.

The setup to demonstrate this technique is shown in Figure 1. Basically, we have a tape player which contains prerecorded intelligibility tapes. We have an AGC circuitry, which takes the incoming speech and makes it equal amplitude. We then send it into a typical narrowband FM transmitter, which is then sent into a channel that has a noise input, thus simulating a communication channel.

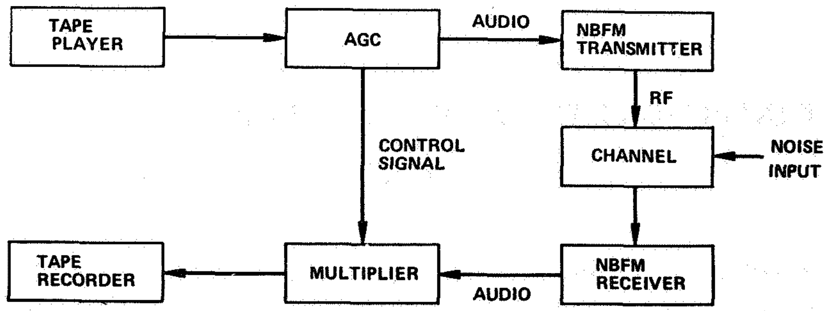

Figure 1. The laboratory test setup used to demonstrate the amplitude control technique.

From there, it is received by a typical narrowband FM receiver, which outputs into a multiplier. The control signal is then fed into the multiplier, restoring the audio to its original format. It is then recorded for later evaluation.

The proof of the pudding in any system is how well does it perform. Figure 2 shows the type of performance obtained by this amplitude control technique. These results were obtained from tests conducted in the Prince Georges County High Schools. Word intelligibility percent is plotted as a function of voice channel carrier to noise power density. We see that at 49 decibel-hertz, we have approximately equal performance for the controlled and uncontrolled situation.

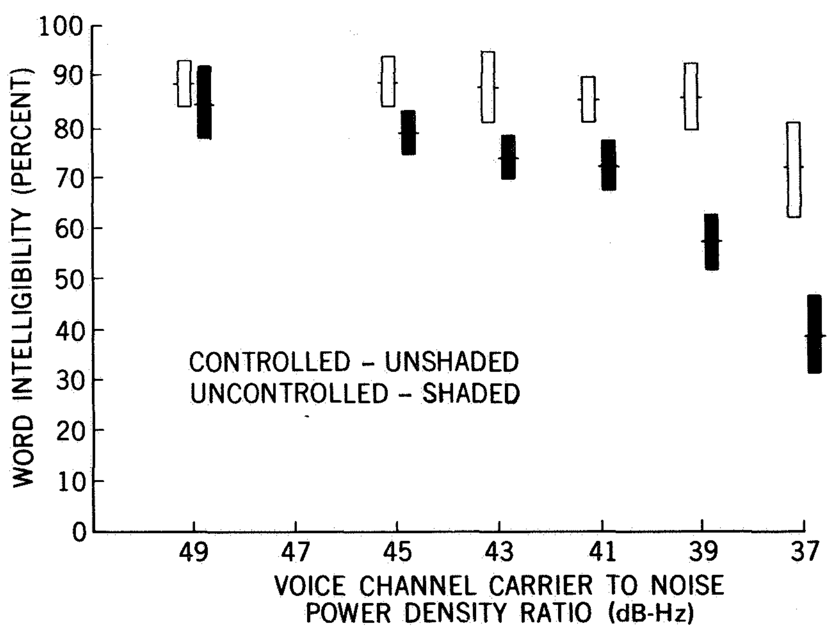

Figure 2. Graphical presentation of the received output speech intelligibility as a function of voice channel carrier-to-noise power density ratio, both with and without amplitude control.

But when we get down to extremely low carrier-to-noise power density conditions, we note that the controlled system has significant improvement over that of the uncontrolled system. In fact, we're seeing for these type of word intelligibility tests, about a 4 dB improvement. Figure 3 shows more clearly what has happened to the listener groups. Here we have the number of listener groups in percent versus the listener score in percent. We see that for the 49 decibel-hertz carrier noise range, we have approximately equal performance. However, slightly better performance results from controlled than from uncontrolled amplitude.

But if one goes down to the very low carrier-to-noise power density range of 37 decibel-hertz, we notice significant improvement in the listener groups by the use of this amplitude control technique. In fact, we even have some people for this particular word list scoring in the 90 to 100 percent range.

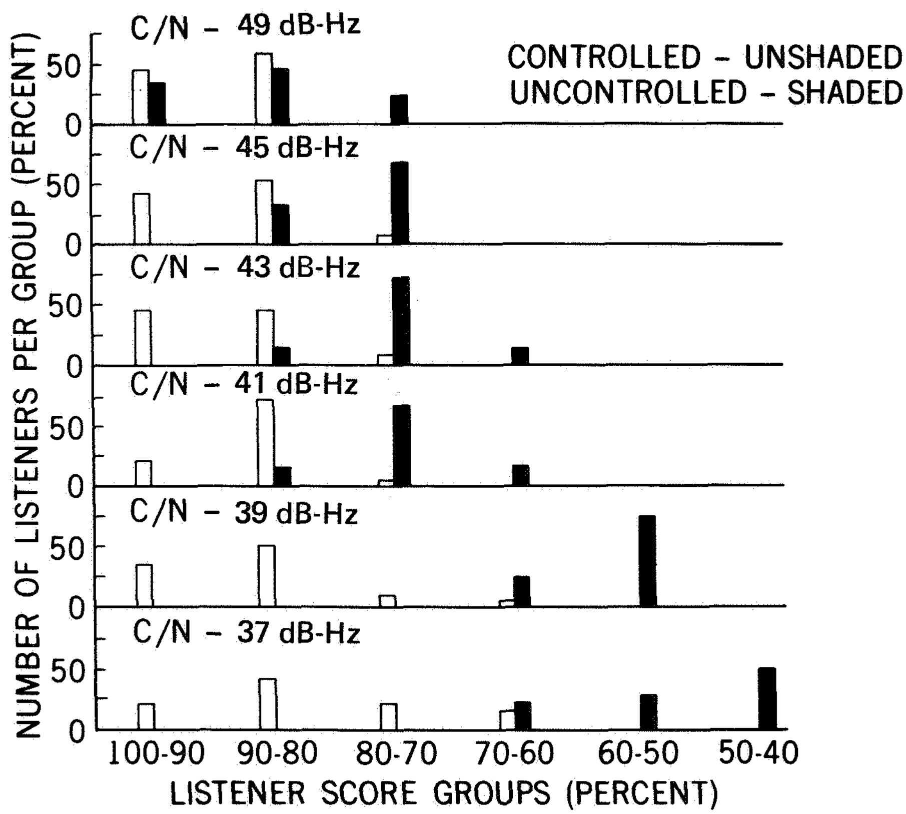

Figure 3. Graphical presentation of the distribution of the number of listeners as a function of listener score groups.

In conclusion, we have found that the amplitude control technique, when applied to analog voice systems, does lead to significant improvement of their performance. We are going to use the amplitude control technique as part of the advanced voice communications systems that we are developing at Goddard.

MEMBER OF AUDIENCE:

In a practical system, how are you going to carry along the restoration?

MR. WISHNA:

Well, it is anticipated that the control voltage will be modulated along with the audio, using a frequency multiplex system. The control voltage is contained at present in a 30-Hz bandwidth.