# AN ADAPTIVE NARROW BAND FREQUENCY MODULATION VOICE COMMUNICATION SYSTEM

**Sheldon Wishna**

A narrow band frequency modulation (NBFM) communication system which provides for the reception of good quality voice at low carrier-to-noise ratios has been built for the position location and aircraft communication equipment experiment of the ATS F program. The high level of performance of this system is obtained by designing a limiter and phase-lock loop combination as a demodulator so that the bandwidth of the phase-lock loop decreases as the carrier level decreases.

This adaptive feature provides for the improvement in voice reception in two ways. First, by reducing, at low carrier-to-noise levels, the demodulation closed-loop bandwidth, the detected noise for the remaining low frequency voice spectrum is decreased, which in effect increases the remaining voice spectrum signal-to-noise output. The masking effect of the noise makes the intelligibility contribution of the high voice frequencies under high noise conditions negligible so that it is more advantageous to low-pass filter the voice spectrum and thus improve the signal-to-noise ratio of the lower voice spectrum.

Second, reduction of the phase-lock loop bandwidth at low carrier-to-noise levels extends the onset and reduces the rate of degradation caused by demodulation thresholding, which is an operating point where a large degradation of the output signal-to-noise ratio occurs for a small reduction in the input carrier-to-noise ratio.

Figure 1 is a block diagram of the NBFM demodulator as designed for use with ATS F. Another unit has been built and flight-tested as part of the European Space Research Organization Balloon/Aircraft tests conducted last summer. As is shown in the block diagram, the demodulator consists essentially of the limiter and the phase-lock loop combination.

Figure 2 illustrates the adaptive properties of the demodulator. It is seen that, as the input carrier level decreases, the demodulator bandwidth decreases. For example, for an input carrier-to-noise ratio of 49 dB-Hz, the demodulator bandwidth is approximately 4000 Hz; however, at an input carrier-to-noise ratio of 41 db-Hz, the demodulator bandwidth has decreased to 2100 Hz. This provides a nearly two-to-one bandwidth reduction.

Figure 3 is a plot of the output voice articulation index as a function of the input carrier-to-noise ratio for a laboratory-built demodulator. Articulation index is a measure of voice intelligibility with 95 percent sentence intelligibility occurring at an articulation index of 0.4. The extreme linearity of the NBFM curve is very evident. A calculated plot of a conventional NBFM voice communication system having similar RF and voice processing characteristics is shown for comparison.

One should note that 95-percent sentence intelligibility is obtainable at about 41 dB-Hz. Because of the small deviation employed, only approximately 8 kHz of the RF spectrum is required. The adaptive NBFM system provides, at low carrier-to-noise levels, an improvement in response of approximately 4 dB over that obtained from a conventional NBFM system.

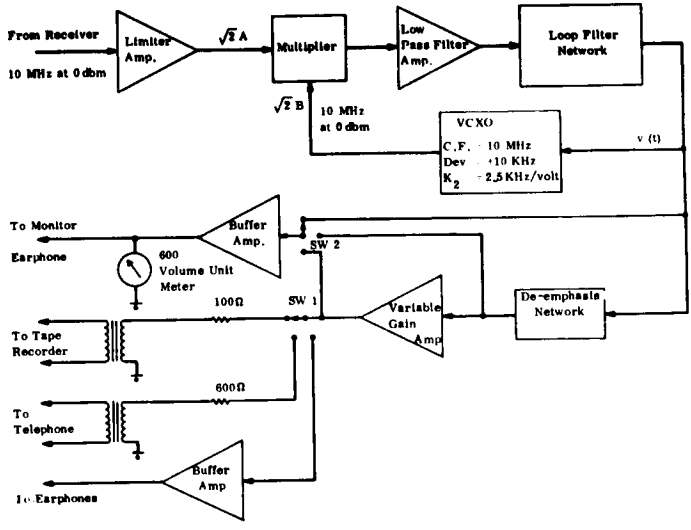


Figure 1—Demodulator block diagram.

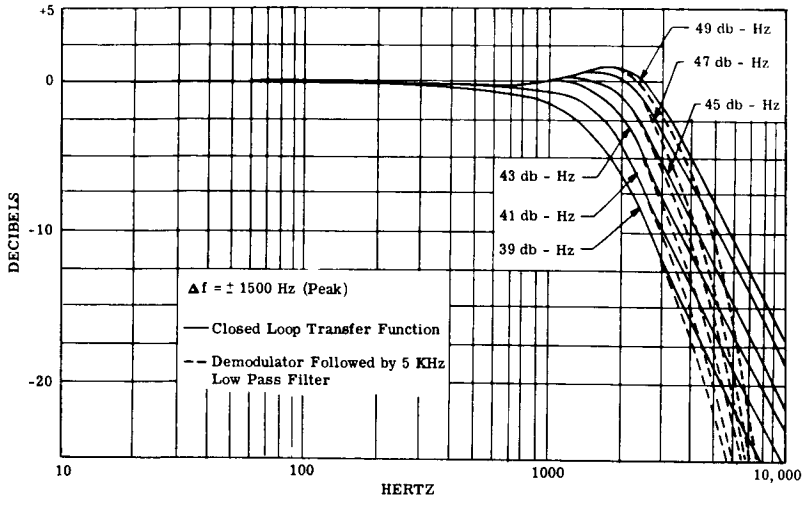


Figure 2--Closed-loop response of phase-lock loop versus carrier-to-noise spectral density.

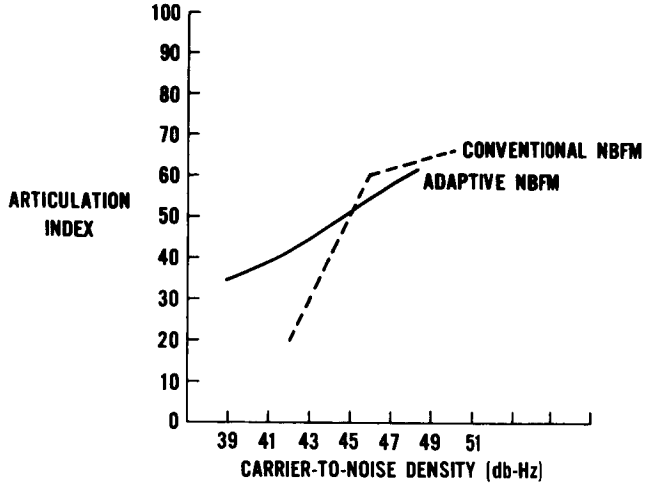


Figure 3--Articulation index versus carrier-to-noise density (FM, 3-kHz voice truncation, clipping such that peak-to-rms ratio is 6 dB, pre-emphasis using 6 dB/octave, 10-kHz RF bandwidth).