# Future of SSB in a Digital Voice Environment

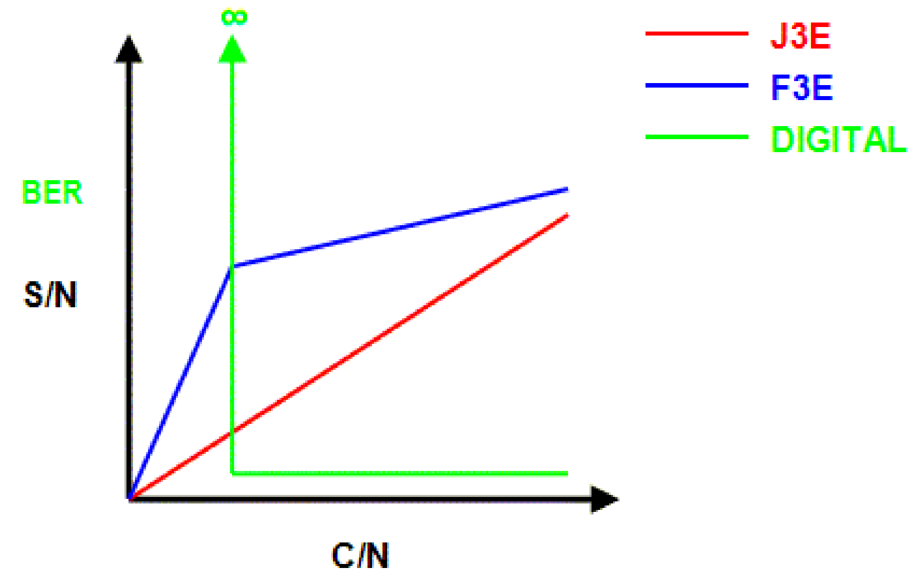
by Adam Farson*, VA7OJ /AB4OJ

Recently, I had occasion to reply to a question about the future of SSB in the "digital world". Here is a summary:

I believe that SSB will stay around indefinitely, as it is still the most bandwidth- and power-efficient method for voice transmission.

The use of any emission type is governed by the ITU, not by equipment manufacturers. Given the fact that all military, maritime, aviation and commercial fixed and mobile HF services use SSB and ISB, the ITU will not be changing those rules for a very long time. Even if ITU approval is granted for a bandwidth-efficient digital voice mode, SSB and ISB will continue to be authorised for the indefinite future, because of their proven ability to "get the message through" under conditions where the digital mode fails.

**Fig.1: Simplified S/N vs. C/N curves for various modes.**




Apart from the regulatory aspects, we must consider how path performance degrades with decreasing C/N (carrier-to-noise) ratio for each emission type. The curves in **Fig.1** are illustrative:

To simplify matters, I have assumed that the thresholds for FM and a digital voice mode (dependent on RX/TX synchronization) occur at the same C/N ratio. This need not be the case, of course. It will be seen that SSB (J3E, red) has a linear relationship between C/N and S/N; there is no threshold "knee" as such. Modern DSP-based, heuristic noise-reduction (NR) techniques can often extract a usable baseband when the carrier is "down in the noise" (S/N < 3 dB). This has certainly been my experience with the IC-756Pro series of DSP transceivers, for example.

With FM (F3E, blue), when the threshold is reached with declining C/N, the S/N will degrade much more rapidly than for the J3E case, but intelligible voice audio is recoverable 3 to 6 dB below threshold - as long as incidental AM due to man-made noise is not too severe. Threshold-extension techniques (e.g. using a PLL demodulator with a loop filter cutting off at $\mathbf{f_m}$) can push the threshold back along the C/N axis as much as 7 dB.

FM modulation index $\mathbf{m = \Delta f / f_m}$ where $\mathbf{\Delta f}$ = peak deviation and $\mathbf{f_m}$ = highest modulating frequency.

Carson's rule: $\mathbf{TBW \sim 2 * (\Delta f + f_m)}$ where TBW = transmitted occupied bandwidth.

A characteristic of FM is that as **m** increases, the S/N above threshold will be higher for a given C/N at the receiver, but the threshold "knee" moves to the right with increasing **m**. For **m** = 1 (typical in VHF or UHF FM systems with $\mathbf{\Delta f} = \pm 2.5$ kHz and $\mathbf{f_m}$ = 2.5 kHz), the Carson's-rule occupied bandwidth is 2 (2.5 + 2.5) = 10 kHz. Compare 2.5 kHz occupied bandwidth for a typical SSB signal, which will be intelligible at a C/N ratio well below the FM threshold.

Note that when C/N is sufficiently high to fully saturate the FM receiver's limiter *(full quieting)*, S/N will be higher than for the same C/N value in the SSB case. The reason for this is that AM noise which would be fully suppressed in the FM receiver will still appear in the SSB receiver's baseband output.

Now, let's consider the digital voice signal, which will generally be some form of PCM or ADPCM (adaptive differential PCM, or adaptive delta modulation) superimposed on some form of PSK. Assuming $\mathbf{f_m}$ = 2.5 kHz, the codec sampling rate is 5 kHz. Again, assuming that deltas in the quantized baseband level can be transmitted in 4 bits with acceptable quantizing distortion, we have a symbol rate of 5 * 4 = 20 kb/s. Some polyphase PSK systems can compress this 20kB/s bitstream into an RF occupied bandwidth of 8 kHz or so; this is still wider than SSB. (A simple calculation based on Shannon's Theorem, assuming only two possible RF carrier states, yields approximately 20 * 1.6 = 32 kHz occupied bandwidth.)

Next, let's look at what happens to the C/N vs. BER curve (green) as C/N approaches threshold. At threshold, the receiver loses sync with the transmitter, and all is lost. By contrast, a skilled operator, using an NR-equipped receiver, will be able to copy a weak SSB signal which appears "buried in the noise". ***This fact alone will keep our old friend J3E around for quite a while yet!***

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Adam Farson started his Ham career in South Africa as ZS1ZG (1962-64) and ZS6XT (1964-68). There is a capsule history of his early Ham career on his website http://www.ab4oj.com/. His **ICOM page** contains excellent technical info on various models.