Transmitter SNR for Maximum Coverage

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***Abstract*—The generally accepted notion that DTV coverage will not be materially improved if the transmitter's SNR were raised from 27 dB to 32 dB is shown to be true only for perfect links. In real world links a significant improvement in coverage would materialize.**

***Index Terms*—Dynamic range, link degradations, transmitter SNR.**

SEVERAL publications [1], [2] have suggested that, for the ATSC standard, the transmitter's Signal-Noise error magnitude ratio (SNR)[1] need not exceed 27 dB. Elaborating, reference [1] states the following: "This 27-dB value provides a *worst* case VSB receiver S/N threshold degradation of no more than about .3 dB, from 15.0 to 15.3 dB" [1].

The threshold SNR of an ideal ATSC demodulator, defined as the SNR that produces bit error rate of 3×10^{-6}, is indeed 15.0 dB. However, the threshold SNR of actual receivers was measured at the Advanced Technology Test Center at 15.19 dB [3]. The Federal Communications Commission measured the threshold SNR of actual receivers at 15.3 dB [4]. For this paper we define the receiver's own threshold as $\mathrm{RxSNR} = 15.2$ dB and the threshold SNR required at the receiver do decode an impaired link as $\mathrm{TSNR_{Rx}}$.

As shown in Fig. 1, the assertion that exceeding the 27 dB level will result in negligible improvement in coverage assumes an ideal receiver connected directly to the transmitter's mask filter. That is, no in-channel noise is generated at the receiver regardless of the desired signal level and no degradation to the SNR between the transmitter and the receiver.

In the real world there are several SNR degradations in the link between the transmitter and the receiver starting with the transmitting antenna. The propagation channel may contain cochannel and adjacent channel interference and echoes. At the receiver, the equalizer adds white noise that depends on the echoes. Further, intermodulation and cross-modulation products are generated in the desired channel at the tuner. More noise is generated at the receiver due to the impedance mismatch between the input of the antenna and the input to the tuner [5]. Interference from off-channel clusters of DTV channels and from unlicensed devices would further degrade the overall SNR at the tuner [6].

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[1]Also referred to as Modulation Error Ratio (MER)

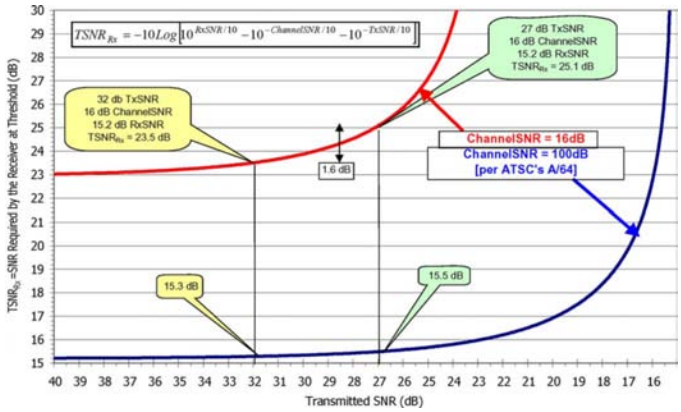

Fig. 1. Minimum receiver SNR in perfect and poor links.

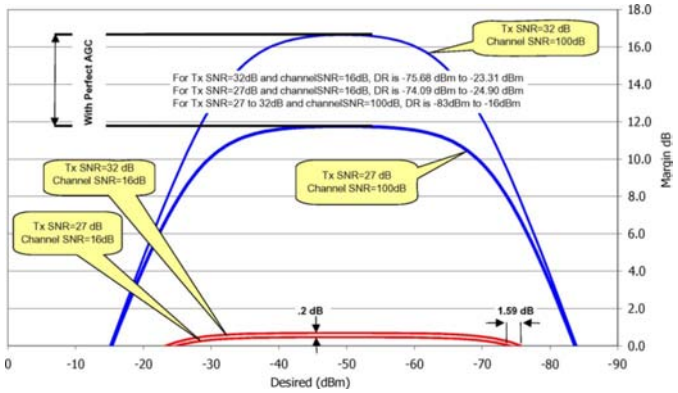

Fig. 2. SNR margin @ Rx vs Tx SNR and channel SNR receiver's $\mathrm{IP_3} = 8$ dBm and $\mathrm{NF} = 7$ dB.

A hypothetical example of an imperfect channel is shown in Fig. 1. Here the ChannelSNR, the antenna-to-antenna SNR including interference and echo equalization, is 16 dB. In this case, the threshold SNR required at the receiver $(\mathrm{TSNR_{Rx}})$, is 23.5 dB if the transmitter's SNR (TxSNR) is 32 dB and 25.1 dB, or 1.6 dB higher if the TxSNR is only 27 dB. For $\mathrm{ChannelSNR} = \infty$, the case addressed in [1] and [2] as shown in Fig. 1, the difference is only .20 dB.

A more accurate treatment based on calculating the receiver's dynamic range [7] is shown in Fig. 2. The receiver's dynamic range (DR) together with the SNR margin ultimately determines the quality and extent of the DTV service. The dynamic range depends on the receiver's noise figure and linearity. Fig. 2 shows how the SNR margin[2] and the dynamic range of a typical receiver shrink with link impairment (channelSNR). In poor links, when the SNR margin is almost eliminated, the dynamic range of the receiver is higher by 3.14 dB if the transmitter's SNR

[2]dBs above the 15.2 dB threshold of visibility for the ATSC standard.

is 32 dB compared with transmitter's SNR of only 27 dB. At midrange the difference is only .20 dB, but it is the dynamic range extension that matter most in poor links.

I. Conclusion

Broadcasters who maximize their transmitter's SNR will enjoy better coverage in noisy and interference-prone links. The analysis shows that when channel imperfections are taken into account the dynamic range of the receiver would be extended if the transmitter SNR were improved. Specifically, raising the transmitter SNR from 27 dB to 32 dB could improve the SNR margin at receivers in areas subject to poor propagation by 1.60 dB. Such margin would be a significant improvement to DTV service availability. If a common antenna serves multiple channels, the maximization of the SNR, the channel multiplexer should be part of the equalization loop.

References

[1] C. Eilers and G. Sgrignoli, "Digital television transmitter parameters-analysis and discussion," *IEEE Trans. Broadcast.*, vol. 45, no. 4, Dec. 1999.

[2] "Transmission Measurement and Compliance for Digital Television," Advanced Television Systems Committee, May 30, 2000, Doc. A/64A, This ATSC document is now in the process of being revised from a "Standard" to a "Recommended Practice.".

[3] W. Bretl and G. Sgrignoli, "Summary of the grand alliance VSB transmission system laboratory tests," *IEEE Trans. Broadcast.*, vol. 42, no. 3, June 1996.

[4] S. R. Martin, Test of ATSC 8-VSB Reception Performance of Consumer Digital Television Receivers Available in 2005 FCC/OET TR 05-1017, Nov. 2, 2005.

[5] O. Bendov, Y. Wu, C. W. Rhodes, and J. F. X. Browne, "Planning factors for fixed and portable DTTV reception," *IEEE Trans. Broadcast.*, vol. 50, no. 3, Sept. 2004.

[6] O. Bendov, "Limits on fixed broadband devices for interference-free operation in the DTV spectrum," *IEEE Trans. Broadcast.*, vol. 53, no. 4, Dec. 2007.

[7] O. Bendov, "Preventing interference to DTV broadcasting in every market from unlicensed or uncontrolled clusters of broadband devices on unoccupied DTV channels," *IEEE Trans. Broadcast.*, vol. 54, no. 2, June 2008.