Chapter 3. Combined Source and Channel Coding for High-Definition Television

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3.1 Project Description

The purpose of this project is to develop a high-definition television system (HDTV) for terrestrial broadcasting that has high-spectrum efficiency, effective suppression of analog channel impairments (ghosts, noise, interference, and frequency distortion), a feasible transition scenario, reasonable cost, good interoperability with other media and applications, and permits nondistruptive improvement over time. To this end, a two-stage spread-spectrum system has been simulated in accordance with the plans discussed in *RLE Progress Report Number 134.*

In spread-spectrum television, the video signal is divided into a large number of narrow-band components so that the symbol length is larger than the temporal spread of the echoes. All echoes arrive within one symbol time, eliminating intersymbol interference. Each narrow-band component is spread to the full spectrum width (6 MHz) by multiplying it with a different pseudorandom sequence. All the products are added and transmitted. At the receiver, the components are separated by multiplication by the same sequences, whose orthogonality ensures elimination of crosstalk.

Unfortunately, echoes reduce the orthogonality of the random sequences. While scrambling is helpful because it causes interference to become random noise, the noise level is still excessive. It is not theoretically possible to design sequences that have adequate cross-correlation performance when time-shifted.

We have found a possible solution to this problem by using orthogonal frequency-division multiplex (OFDM). This channel-coding method, invented at Bell Laboratories in the 1960s, also divides the signal into narrow-band components. Each signal is modulated on a separate carrier. The signals in adjacent channels are orthogonal, permitting their complete separation at the receiver. A guard interval is inserted between symbols to ensure that all ghosts arrive entirely within one integration period. A very simple implementation is provided by the use of the Fourier transform. This generates a baseband version of the transmitted signal in a single operation.

OFDM, which has been used in Europe for digital audio broadcasting, is being investigated now for digital video broadcasting by a number of laboratories. At a meeting held at MIT in October 1992, all European and Canadian OFDM projects were represented. A particularly attractive version of OFDM, called single-frequency networks (SFN), was discussed at some length. In this method, the receiving area of a television station is filled with a cellular network of low-power transmitters, operating on the same frequency. The multiple signals seen at each receiver, particularly if omnidirectional receiving antennas are used, constitute "active echoes," which are suppressed by OFDM. This arrangement results in a much more uniform signal level at the receivers, obviating the need for a soft threshold. It also permits much higher spectrum efficiency, since stations serving contiguous areas can use the same frequency. The "no-man's land" between stations, in which directional antennas would have to be used, are about the same width as the cells. Thus, to provide about 20 independent services in each locality, not much more than 20 (instead of the 68 which are needed at present) channels must be allocated for television service.

We are now actively pursuing the goal of configuring our system to support the SFN concept. There is some uncertainty about the precise manner in which the echoes combine at the receiver and we are considering a field test to elucidate the phenomenon.