COMPARISON OF VITERBI AND SEQUENTIAL DECODING WITH A NOISY CARRIER REFERENCE

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Summary. Performance of convolutionally encoded telemetry systems with Viterbi decoding or sequential decoding is well understood for the additive white Gaussian noise channel with coherent detection of bi-phase-shift-keyed signals. Significant degradation from ideal performance can occur due to correlated noise resulting from low signal-to-noise ratios in the receiver carrier tracking phase-locked loop. Performance at the lower telemetry data rates on the two Pioneer Jupiter deep space probes provides examples of the effect of correlated noise on a sequential decoding system. Performance degradation needs to be quantified as a function of carrier signal-to-noise ratio (P_c/N_o2B_{1o}) and carrier-tracking-loop-bandwidth-to-symbol-rate ratio (B_1/R_s) in order to provide design and analysis information on such effects. Analytical modeling is extremely difficult, particularly where B_1/R_s is neither very large nor very small.

This paper presents results obtained from processing and analyzing data collected at two NASA deep space communications facilities. An alternating 1,0 symbol sequence was used to PSK modulate a 32,768 Hz square-wave subcarrier which phase modulated an S-band carrier. Data rates ranged from 16 to 4096 symbols per second in binary steps. Signal strength and modulation index were set to yield desired combinations of P_c/N_o2B_{1o} and normalized symbol signal-to-noise ratio (E_s/N_o). The standard Deep Space Network configuration of S-band receiver with 12 Hz threshold loop bandwidth, Subcarrier Demodulator Assembly, and Symbol Synchronizer Assembly (SSA) was used. The raw data were digital magnetic tape recordings of the SSA outputs, quantized to 256 levels. These data were used as inputs to an analysis program at Ames Research.Center that included simulations of the Pioneer 10/11 rate 1/2, k=32 sequential decoder, and an optimum rate 1/2, k=7 Viterbi decoder. Capability to vary data quantization, frame size, and data interleaving was provided. Program outputs included performance statistics for the channel, sequential decoder, and Viterbi decoder. For a sufficiently long tail sequence, the sequential decoder performed with virtually zero undetected bit errors for real-time operational limits. The primary sequential decoding performance indicator was the computation curve which is a function of symbol rate, E_s/N_o, and P_c/N_o2B_{1o}. Direct comparisons between sequential decoder frame erasure rate and Viterbi decoder undetected bit error rate were made using identical data. Data interleavers of various size

were used before decoding to study the extent of the channel memory and determine the amount of degradation that could be recovered by interleaving. This information can be used to provide more accurate link designs for future communications systems, and to aid in the selection of error correction coding system types and interleaver sizes where erasure rate and undetected bit error rate axe critical parameters.