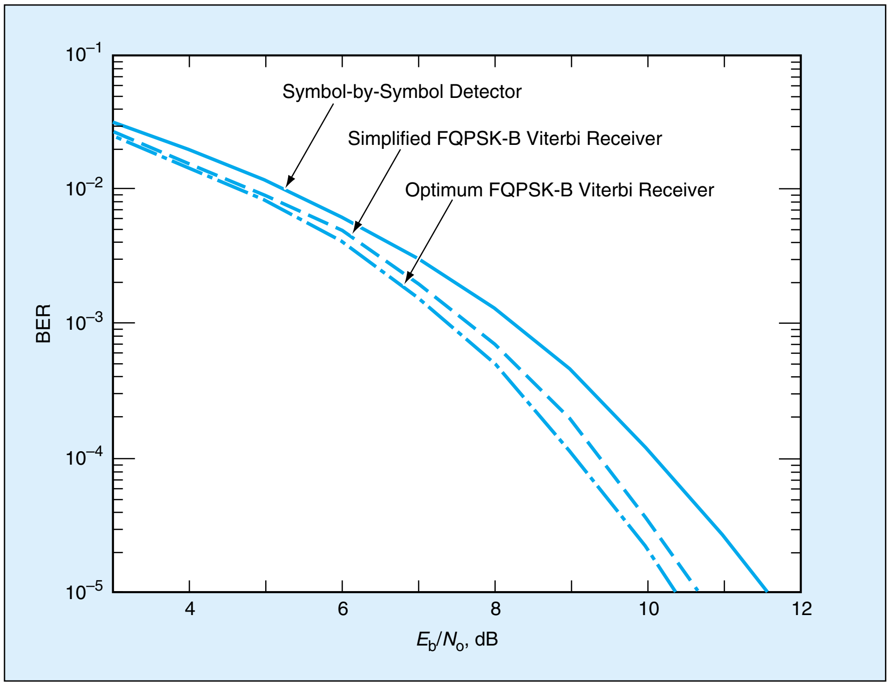
Simpler Alternative to an Optimum FQPSK-B Viterbi Receiver

Performance is only slightly below that of the more-complex optimum version.

NASA's Jet Propulsion Laboratory, Pasadena, California

A reduced-complexity alternative to an optimum FQPSK-B Viterbi receiver has been invented. As described below, the reduction in complexity is achieved at the cost of only a small reduction in power performance [performance expressed in terms of a bit-energy-to-noise-energy ratio (E_b/N_0) for a given bit-error rate (BER)].

The term "FQPSK-B" denotes a baseband-filtered version of Feher quadrature-phase-shift keying, which is a patented, bandwidth-efficient phase-modulation scheme named after its inventor. Heretofore, commercial FQPSK-B receivers have performed symbol-by-symbol detection, in each case using a detection filter (either the proprietary FQPSK-B filter for better BER performance, or a simple integrate-and-dump filter with degraded performance) and a sample-and-hold circuit.



Performances of Three FQPSK-B Receivers were evaluated by computational simulation.

In comparison with symbol-by-symbol detection, Viterbi demodulation (based on a trellis-coded interpretation of FQPSK) provides better BER performance because it takes advantage of the memory inherent in an FQPSK-B signal and can be designed to be optimum for demodulating FQPSK-B. In the trellis-coded interpretation, FQPSK is regarded as having been generated by transmitting one of 16 shaped waveforms (8 unique waveforms and their negatives) based on a 16-state trellis. In the decoding/demodulation process, the receiver correlates the baseband received signal with each of the 16 FQPSK waveforms and the Viterbi algorithm searches through the FQPSK trellis, which includes four transitions to each of the 16 states. To be able to implement the Viterbi algorithm, the receiver must include 16 correlators — eight for the in-phase and eight for the quadrature channel. This receiver design is likely to be too complex to be practical in typical commercial applications.

The simplified FQPSK-B Viterbi receiver is based on grouping the 16 waveforms into four groups of four waveforms each. The received FQPSK-B signal is correlated against the average of the waveforms in each group. By appropriate selection of the waveforms for the groups, the trellis can be reduced from 16 states with four transitions per state to two independent two-state trellises with only two transitions per state. Due to the similarity between the FQPSK waveforms, this simpler receiver has only a small E_b/N_0 penalty, compared to the full Viterbi receiver, while still offering significant performance gain relative to the FQPSK-B receiver using the proprietary FQPSK-B detection filter. The simplified FQPSK-B Viterbi receiver requires four correlators, and the amount of computation needed to generate each decoded bit is only one-eighth of that of the optimum FQPSK-B receiver.

The simplified FQPSK-B Viterbi receiver concept has been tested by computational simulation, and compared with both the optimum FQPSK-B Viterbi receiver and symbol-by-symbol detector using the FQPSK-B proprietary filter. In the simulations, ideal carrier and symbol synchronization was assumed. The simulated channel included a nonlinear solid-state power amplifier operating in full saturation. Because of the shorter constraint length of the reduced trellis, the truncation path length (decoding depth) needed for the simplified FQPSK-B Viterbi receiver was only one-fifth of that needed for the optimum FQPSK-B Viterbi receiver. The results (see figure) show that the simplified FQPSK-B Viterbi receiver can be expected to perform better than the symbol-by-symbol detector using the FQPSK-B proprietary detection filter, and almost as well as does the optimum FQPSK-B Viterbi receiver.

This work was done by Dennis Lee, Marvin Simon, and Tsun-Yee Yan of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

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