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Abstract Title: Iterative and Combined Trellis Decoding of GMSK and FQPSK with Short Constraint Length Convolutional Codes

Abstract Text

Due to already congested space frequencies and growing demand for high data rates, modulations with bandwidth efficiency and sharp spectral roll-off are becoming increasingly important to avoid interference with adjacent channels. Two such bandwidth efficient modulations with constant or near-constant envelope properties suitable for space applications are GMSK (Gaussian Minimum Shift Keying) and FQPSK (Feher-patented QPSK). However, as with most bandwidth efficient modulations, GMSK and FQPSK suffer degradation in terms of bit error rate (BER) for a given Eb/No with respect to more bandwidth consuming modulations such as unfiltered binary phase shift keying. Recent papers have shown that iterative detection of serial concatenated convolutional codes (SCCC) can yield remarkable coding gains. Using the trellis-coded interpretation of FQPSK and GMSK, a SCCC can be created by applying a short constraint length convolutional code and pseudo-random interleaver before the FQPSK or GMSK trellis-coded modulation (TCM). This paper investigates the application of iterative detection to convolutionally coded FQPSK and GMSK to improve BER performance, as well as combining the TCM with the convolutional code to form a larger combined trellis.

A search for good convolutional codes to be used with iterative detection of the FQPSK and GMSK is conducted. The methodology for selecting good codes is described in the paper, and a table of "best" convolutional codes with short constraint lengths for the two modulations is presented for various rates. Modifications to the FQPSK and GMSK trellis codes are then considered, with the additional constraint of preserving the constant envelope and bandwidth efficient properties. The bit error probability of the iterative receiver using the "best" codes found for a given rate and constraint length are simulated for each modulation.

The simulated iterative receiver consists of a bank of matched filters to the modulation waveforms, followed by a soft-input-soft-output (SISO) decoder for the TCM. The extrinsic soft output of the TCM SISO is deinterleaved and decoded by the convolutional code (CC SISO). The extrinsic soft output of the CC SISO is interleaved and sent back as soft input information to the TCM SISO. This decoding loop is iterated over until the soft information has reached a steady state value. The bit error rates using the iterative receiver are simulated and compared with standard Viterbi decoding of the TCM and convolutional code.

We also introduce an enhanced trellis for GMSK and FQPSK created by combining the modulation trellis with a short constraint length convolutional code. By combining trellises rather than treating them separately as in a standard concatenated convolution code, hardware simplifications can be made. For instance, an interleaver is no longer needed to break up the error bursts from the inner trellis code. Only one Viterbi decoder is required instead of two, although it has a greater number of states. Simplifications to the combined trellis encoder structure relative to the two separate encoders are also possible as shown in this paper.

Bit error rate simulations using the combined TCM and CC trellis are performed using a single Viterbi decoder. The combined trellis decoder has improved BER performance compared with the separate Viterbi decoding of the two concatenated codes, because no soft information is lost between the decoders. The bit error performance of GMSK and FQPSK with the combined trellis decoding is compared with standard decoding of the concatenated code. Finally, a BER comparison is made between the combined trellis decoder and the iterative receiver, using codes that result in roughly equal computational complexity for the two methods.

Simulation results show that the combined trellis decoder performs up to 0.5 dB Eb/No better than the separate Viterbi decoding of the TCM and convolutional code, with the iterative receiver providing even better performance at higher Eb/No.

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