

Acquisition Performance Comparison of the Generalized Maximum A Posteriori Symbol Synchronizer Versus the Data-Transition Tracking Loop

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Recent interest in employing powerful codes, such as turbo codes, for deep-space downlink communications motivates development of receivers operating at low symbol signal-to-noise ratios (SNRs), perhaps as low as -10 dB. At these values of symbol SNRs, traditional receivers using the data-transition tracking loop (DTTL) may experience difficulties in terms of symbol acquisition and tracking. The traditional DTTL is a suboptimal closed-loop implementation derived from the maximum a posteriori (MAP) estimation of the symbol epoch of a rectangular pulse stream in an additive white Gaussian noise (AWGN) environment.

A closed-loop symbol synchronizer, such as the DTTL, is obtained by using the first derivative of the log likelihood function of the symbol epoch to approximate an error signal. When a rectangular pulse waveform is used, the derivative of the log likelihood function does not exist; hence, strictly speaking, a closed-loop estimator such as the conventional DTTL does not exist for the rectangular pulse. Since the conventional DTTL approximates the first derivative of the rectangular pulse shape by a narrowing pulse at its edges, it is pulse shape dependent. If a waveform other than the rectangular pulse shape is used for transmission, the conventional DTTL suffers a degradation during tracking and acquiring. Furthermore, the conventional DTTL was derived based on the high SNR assumption and data transition density equals 0.5. Its performance will be degraded in applications of low SNRs and data transition density other than 0.5.

In this paper, a generalized symbol synchronizer based on maximum a posteriori (MAP) estimation is derived for arbitrary non-overlapping pulse shape and data transition density. A simplified realization of this new symbol synchronizer is presented. Similar symbol synchronizer based on MAP estimation has been discussed in the past [1], however, it has been assumed that the data transition density was 0.5. The MAP symbol synchronizer described in this paper is the optimal synchronizer for arbitrary pulse shape and data transition density. It received little attention in the past mainly because it had been thought of as a "one-shot" estimator. In this paper, it will be shown that the generalized MAP symbol synchronizer not only can continuously update the estimate every symbol time as does the closed loop scheme, but also is less complex in implementation compared to the conventional DTTL.

There has been very little work done in the past to compare the performance of the generalized MAP symbol synchronizer with the traditional DTTL. This paper presents extensive computer simulation study to compare the performance of the two symbol synchronizers. It is shown that the generalized MAP symbol synchronizer can operate at very low symbol SNRs where the DTTL fails. Furthermore, the MAP symbol

synchronizer reduces the initial acquisition time by at least an order of magnitude compared to the DTTL at low SNRs. It has also been shown that the MAP symbol synchronizer is suitable for minimum-shift-keying (MSK) signaling waveform.