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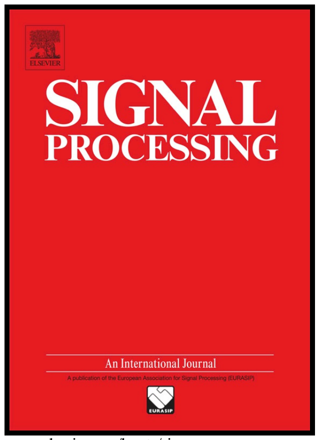

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BLIND ROLL-OFF ESTIMATION FOR DIGITAL TRANSMISSIONS

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ABSTRACT

This paper addresses the problem of estimating the roll-off factor of a received communication signal. We study two new statistical estimation methods that determine the roll-off factor by minimizing the difference between the theoretical and empirical power or power spectral density of the received signal. Another interesting contribution is the derivation of the roll-off Cramér-Rao bound which provides a reference in terms of estimation variance. Simulation results conducted on synthetic data allow the performance of the proposed methods to be evaluated. They are compared to a recent technique based on the amplitude fluctuations of the power spectral density associated with the received communication signal. The estimation methods are shown to be robust to channel impairments (including white Gaussian noise and synchronization errors). The proposed strategies are finally tested on real signals with known ground truth showing their possible application to digital communication problems.

Keywords: blind roll-off estimation, Cramér-Rao bound.

1. INTRODUCTION

Linear and non linear digital modulation classification has received a lot of attention in the literature. Several classification rules based on the maximum likelihood method [29, 9, 20, 8, 11, 4, 15] or on appropriate features [22, 10, 24, 5, 13, 21] extracted from the received communication signal have been investigated. The robustness of the resulting classifiers to synchronization errors or channel impairments has also been studied [30, 2]. However, in order to classify digital modulations efficiently, the receiver has to know or has to estimate some key parameters associated with the transmitted communication signal. These key parameters include the symbol rate and the shaping filter roll-off factor. Their imperfect knowledge decreases the performance of any digital modulation classifier. Estimating the symbol rate of a communication signal has received much attention in the literature. For instance, several symbol rate estimators take advantage of the cyclo-stationnarity of communication signals [12] [6]. This paper focusses on the roll-off estimation problem for classical transmission systems which are based on linear modulations relying on square root raised cosine (SRRC) shaping. To our knowledge, the only available roll-off estimation method is based on the waveform of the received signal [26]. This may be explained by the negligible impact of roll-off mismatched factors on the BER (see [18] or [27]). However, the performance of a digital modulation classifier is affected by a roll-off estimation error. Indeed, a roll-off error induces some noise enhancement (ISI introduced because the Nyquist criterion is no longer fulfilled) and some reduction in the power of the useful signal (absence of matched filtering). This impact is particularly significative for new high order constellations. Figure 1 shows an example of a possible high order transmitted constellation (32-APSK, in DVB-S2 standard [1]). Figure 2 shows how this constellation can be disturbed when the receiver roll-off factor is different compared to the transmitter's one (transmitter roll-off $= 0.7$, receiver roll-off $= 0.2$), especially in the presence of other impairments such as noise or errors on the carrier frequency. The ISI due to the fact that the Nyquist criterion is no longer fulfilled Nyquist criterion is no longer fulfilled and the reduction in SNR due to the absence of matched filtering lead to increase the degradations in the received signal and further disturb the digital modulation classification process.

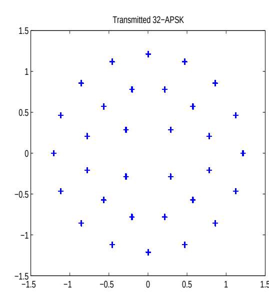

Fig. 1. Transmitted 32-APSK constellation.

Another advantage of estimating accurately the roll-off