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Author: Mr. Azam Mehboob
University of South Australia, Australia

Dr. Kelvin Layton
University of South Australia, Australia
Prof. William Cowley
South Australia University, Australia
Dr. Gottfried Lechner
University of South Australia, Australia

CONSTELLATION OPTIMIZATION FOR NONLINEAR SATELLITE CHANNELS

Abstract

Increasing demand for high-resolution satellite imagery, coupled with the scarcity of available spectrum, necessitates the use of spectrally efficient modulation schemes in future satellite downlinks. However, transmitting these modulations with high peak to average power ratio (PAPR) is quite challenging considering the nonlinear nature of the satellite channel. The onboard traveling wave tube amplifier (TWTA), when driven closer to saturation for maximum power efficiency, produces nonlinear signal distortion resulting in the constellation deformation or warping. In addition, memory introduced by the filters in the transmit chain causes intersymbol interference (ISI), in the form of signal clusters around each constellation point, at the output of the matched filter. This constellation warping and clustering result in a severe performance degradation.

Amplitude Phase Shift Keying (APSK) modulation schemes are more robust against these nonlinear distortions than rectangular Quadrature Amplitude Modulation (QAM) counterparts. APSK constellation parameters need to be optimized for the nonlinear channel, such as the number of rings, ring radii, and constellation points in each ring. In [1], De Gaudenzi et al. provided a two-step optimization procedure for APSK constellations. An APSK constellation is first obtained for a linear AWGN channel by maximizing the mutual information and then optimizing for the nonlinear channel using constellation pre-warping. In this work, we present a novel method to optimize constellations for nonlinear channels in a single step by directly maximizing a Euclidean distance metric at the output of the matched filter.

Simulations have been performed with an accurate model of a TWTA amplifier, obtained from real satellite data, showing that our proposed method allows an uncoded 16-APSK system to achieve 0.6 dB lower total degradation at BER of 10-2 when compared with the uncompensated case. This performance gain is comparable, even slightly better, than the existing two-step method. In addition, our method offers more flexibility in incorporating clustering spread into the constellation optimization to better compensate for nonlinear ISI, a topic of our ongoing investigation.

[1] De Gaudenzi, Riccardo, A. Guillen i Fabregas, and Alfonso Martinez. "Performance analysis of turbo-coded APSK modulations over nonlinear satellite channels." IEEE transactions on wireless communications 5.9 (2006): 2396-2407.