Jack Wolf's Analog Codes for Peak-to-Average Ratio Reduction

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Multi-tone modulation (DMT, Discrete Multitone, OFDM, Orthogonal Frequency Division Multiplex) has the disadvantage of a quite high peak-to-average ratio. Clipping of the high amplitudes caused by amplifiers and D/A-(A/D)-converters leads to additional noise. We show that, in principal, so-called Analog Codes (Reed-Solomon Codes over complex numbers) can be used for eliminating this noise. RS Codes can be defined as the samples of a polynomial with limited degree of $K-1$ where K is the number of information symbols. This allows to correct spiky clipping disturbances by polynomial interpolation. In the decoding of RS codes, other possibilities like the extension of the syndrome using a shift register with coefficients given by the error-locator polynomial are also well known. In the case of clipping, the receiver could easily detect the error position by simple thresholding leading to the special case of erasure decoding.

We found that, of course, the performance of the method is dependent on the succession of the non-linearity and the filtering involved. Two extreme situations have been considered: having all filtering after the clipping and vice versa. These scenarios halfways represent the DMT (wireline) and OFDM (wireless) applications, respectively. A filtering after the non-linearity can be almost completely equalized by the time- and DFT-domain equalization in the multi-tone receiver, and thus, has no influence on the performance. Filtering preceding the non-linearity, however, leads to more and higher peaks to be clipped (over-shooting). Thereby, the error/erasure-correcting capability of a RS code is easily exceeded and clipping-noise reduction gains are reduced drastically. Anyway, the out-of-band noise caused by clipping will not make the method attractive for OFDM applications. In the case of DMT, it may be a worthwhile alternative, if the out-of-band power and especially the filling of notches in the spectrum at amateur-radio bands are not an issue.

For further information, see, http://www.ftw.at/publication_en.html.

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