1 Theory, assumed state of knowledge

Lecture (CE II/Script): Chapers 6; Equalizers, especially sections 6.2.3, 6.2.4

2 What is shown?

A digital transmission over an AWGN channel with linear distortions and decision feedback equalization (DFE) is considered in this demo. The model and the simulation are on symbol interval basis and the linear distortions are given by the impulse response vector $\underline{h} = [h_1, h_2]$. Both impulse response values can be modified. Three topics are considerd in detail:

DFE Principle

An antipodal transmission is taken here with the number of coefficients in the feedforward transversal filter being $NV + 1 = 5$.

Rzz Matrix

The structure of the correlation matrix R_{zz} is emphasised with red lines to see the submatrices A to D. The upper matrix belongs to the wanted signal, the lower to the noise. The number of coefficients of the feedforward transversal filter is fixed to $NV + 1 = 5$.

Scatterplots

The influence of the impulse response of the transmit channel on the intersymbol interference could be studied with the help of "scatterplots". They show transmit symbols $x(k)$ and/or estimates $\tilde{x}(k)$ at the receiving side in the complex plane. The transmission is with 4PSK, and the number of coefficients of the feedforward transversal filter can be variied. There are four scatterplots:

- $x(k)$: transmit symbols
  The 4 values for 4PSK are shown in the complex plane.
- $\tilde{x}_0(k)$: output of the channel matched filter at the sampling instants
  All ISI is still present
- $x_v(k)$: output of the feedforward transversal filter
  The non-causal ISI is minimized.
- $\tilde{x}(k)$: estimated values before decision
  The causal ISI is eliminated because of the feedback

3 What is demonstrated?

The purpose of this demonstration is to deepen the understanding of the DFE principle by looking at the above mentioned detail topics. The number of coefficients for the feedforward transversal filter can be set arbitrary. With the third topic (output of the feedforward transversal filter) the influence of this number on the residual ISI should be studied. For strong ISI – for $\underline{h} = [1, 1]$ e.g. – a value greater than 30 is needed. The residual ISI in $\tilde{x}(k)$ becomes obvious for the noise-free case.

The drawback of the MMSE criterium, which was used to calculate the coefficients, should also become obvious: The 4 centers of the estimates before decision ($\tilde{x}(k)$) will be drawn to $\tilde{x}(k) = 0$ for an increasing noise level. For a transmission with M QAM and $M > 4$ this means that the decision thresholds must be corrected according to the current SNR.