HW4: Channel Equalization

In this problem set, consider a received signal model

$$y_k = \sum_{l=-L}^{L} f_\ell x_{k-\ell} + n_k$$

where f is the ISI channel impulse response, x_k is the binary data symbol at time k ($x_k \in \{-1, 1\}$), and n_k is the AWGN noise sample ($n_k \sim N(0, \frac{N_0}{2})$).

Consider three ISI channel scenarios

1. $f_\ell|_{\ell=-4}^{4} = \begin{bmatrix}0.04 & -0.06 & 0.07 & -0.21 & -0.5 & 0.72 & 0.36 & 0.21 & 0.06\end{bmatrix}$
2. $f_\ell|_{\ell=-1}^{1} = \begin{bmatrix}0.41 & 0.815 & 0.41\end{bmatrix}$
3. $f_\ell|_{\ell=-2}^{2} = \begin{bmatrix}0.227 & 0.460 & 0.688 & 0.460 & 0.227\end{bmatrix}$.

Note that all channels are normalized ($\sum f_\ell^2 = 1$) and one of them is asymmetric.

1. Design 9-tap and 15-tap symmetric zero forcing equalizers (ZFE). Run Monte Carlo simulations to evaluate the bit-error rate performances of the equalizers against all three channels. Make sure that the BERs go down to at least 10^{-4} level and record your results as functions of $\frac{E_b}{N_0}$.
2. Design 9-tap and 15-tap symmetric MMSE equalizers. Run Monte Carlo simulations to evaluate the bit-error rate performances of the equalizers against all three channels. Make sure that the BERs go down to at least 10^{-4} level and record your results as functions of $\frac{E_b}{N_0}$.
3. Now design one decision-feedback equalizer with 4 feedback and 5 feed-forward taps and another with 7 feedback and 8 feedforward taps. Also run Monte Carlo simulations to measure equalization performances for all three channels. Make sure that the BERs go down to at least 10^{-4} level and record your results as functions of $\frac{E_b}{N_0}$.

Before generating the figures and preparing your report, go through the next page.

Instructions on Figures, Report and Submission:

You are expected to implement the equalizers on your own, therefore do not use the equalization toolbox. Your code has to be understandable (commenting, meaningful variable names etc).

For each channel, create one semi-logarithmic BER vs E_b/N_0 figure by following the instructions below.

- Each figure will have 6 curves in total. ($\{$ZFE, MMSE, DFE$\} \times \{$9 taps, 15 taps$\}$)
- Name each curve, show the legend and make sure the legend does not block the curves. (*semilogy(...,'DisplayName',CurveName)*).
- Curves for ZFE equalizers will be red.
- Curves for MMSE equalizers will be blue.
- Curves for DFE equalizers will be black.
- Curves for 9-tap equalizers will have 'x' as its marker.
- Curves for 15-tap equalizers will have 'o' as its marker.
- All curves will be straight lines (no dashed or else.)
- Axes have to be squared (*axis square*).
- Background have to be gridded (*grid on*).
- Set the font size of the figure to 14 (*set(gcf,'FontSize',14)*).
- Label both axes. No need for a title, instead caption the figures in your report.
- Make sure your curves go down to at least 10^{-4} BER level.
- Limit the axes appropriately (no blank spaces).
- You will end up with 3 different figures (one for each channel).

In your report, comment on the change in performance when...

- ... the number of taps are increased for the same equalizer and channel,
- ... the equalizer is switched for the same channel and tap number.

Your report does not need to exceed two pages. Zip the three m-files with your report pdf and upload it on the moodle. Late submission is penalized with 10% per day.