E2 203 Wireless Communications (Jan.-Apr. 2023) Programming Assignment 4

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Set up an OFDM transmit-receive chain with N subcarriers and a cyclic prefix of length CP samples. The transmissions pass through a multi-path channel. Let $X(k)$ be the DFT of the time-domain transmitted signal $x(n)$, where $0 \leq k, n \leq N-1$.

To estimate the channel, the transmitter inserts N_p pilots (instead of data) on subcarrier indices $0, S-1, 2S-1, \ldots$, where $S = N/N_p$. Let $\mathcal{S} = \{0, S-1, 2S-1, \ldots\}$ denote the set of all subcarriers that carry pilots. Let H_k denote the subcarrier gain on subcarrier k. The pilot symbol p is equal to 1 on all subcarriers.

1) Use all the received pilot symbols Y_k, $k \in \mathcal{S}$, to get an LMMSE estimate of $H_0, H_1, \ldots, H_{N-1}$.
2) Instead of using all the pilots, build the LMMSE estimate using only the signals received on the nearest two pilot subcarriers.[1]
3) Use linear interpolation of the estimates obtained from the nearest two pilot subcarriers to estimate the channel gain.

Tasks:

1) Plot on the same figure the MSE of the channel estimate obtained from the above three methods as a function of the SNR for a specific subcarrier i.
2) When MPSK symbols are embedded on each data subcarrier, plot the SEP vs. SNR for a specific subcarrier with the perfect and estimated channel estimates.
3) Do so for the following channels:
   a) L-tap deterministic channel model:

$$h(n) = \frac{1}{\sqrt{L}}, \text{ for } 0 \leq n \leq L-1. \tag{1}$$

   b) Stochastic L-tap channel with exponential power delay profile:

$$\mathbf{E}\left[|h[n]|^2\right] = \frac{\left(\frac{1}{2}\right)^{n+1}}{1-\left(\frac{1}{2}\right)^{L}}, \ 0 \leq n \leq L-1. \tag{2}$$

   All taps undergo Rayleigh fading.

Note: The values of N, k, L, S, CP, and M will be specified separately. Run and try your code for the following values: $N = 16$, $S = 4$, $M = 4$, $L = 6$, $k \in \{1, 2, 3\}$, and CP $= 4$.

Please set up the simulations from scratch. Do not use any off-the-shelf OFDM function in Matlab.

[1]For the boundary subcarriers, only one nearest pilot subcarrier is available.