Collaborative Exercise 2

August 2, 2018

Name:	Student ID:

Problem A:

Write answer to the following questions about OFDM communication system drawn in Fig 2.

1. Given channel coefficients $\mathbf{h} = [h_0, h_1, 0, 0]^{\mathrm{T}}$, calculate its cyclic shift matrix $\overleftrightarrow{\mathbf{H}}_{\mathrm{cp}}$ to calculate receive signal $\mathbf{y} = [y_0, y_1, y_2, y_3]^{\mathrm{T}}$ via convolution with transmit signal $\mathbf{s} = [s_0, s_1, s_2, s_3]^{\mathrm{T}}$ with cyclic prefix of one symbol (sample).
2. Calculate 4×4 Fourier transformation matrix $\mathbf{F}$ and inverse Fourier transformation matrix $\mathbf{F}^{-1}$, and verify $\mathbf{F}^{-1}\mathbf{F} = \mathbf{I}$.
3. Calculate frequency response of the channel $\tilde{\mathbf{h}} = \mathbf{F}\mathbf{h}$ and draw their gain when $h_0 = 1$ and $h_1 = 1$.
4. Confirm $\mathbf{F}\overleftrightarrow{\mathbf{H}}_{\mathrm{cp}}\mathbf{F}^{-1} = \mathrm{diag}(\tilde{\mathbf{h}})$ when $\mathbf{h} = [h_0, h_1, 0, 0]^{\mathrm{T}}$.
5. Explain why Inter Symbol Interference is not occurred on frequency domain receive signal $\tilde{\boldsymbol{y}} = \mathbf{F}\mathbf{y}$, when frequency domain transmit signal is $\tilde{\mathbf{s}} = \mathbf{F}\mathbf{s}$.

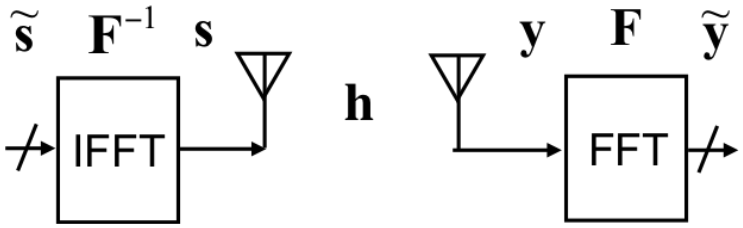

Figure 2: OFDM communication system.

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Problem B:
Write answer to the following questions about SISO, SIMO, and MIMO communication systems when $P/\sigma^2 = 100$ and $B = 1$ [Hz], where P is transmit power, σ^2 is noise variance, and B is occupied bandwidth. For calculation, you can use $\log_2(1+\gamma) \cong \log_2(\gamma)$, $\log_2(100) \cong 6.6$ and $\log_2(3) \cong 1.6$.

1. Calculate SNR γ and channel capacity C of a SISO system when the channel response is given as $h = 1/2$.
2. Calculate SNR γ and channel capacity C of a SIMO system with MRC diversity when channel vector is given as $\mathbf{h} = \left[1/2\,, \sqrt{3}/2\right]^{\mathrm{T}}$.
3. Calculate SNR γ and channel capacity C of a MIMO system with MIMO diversity (1st eigenmode) when channel matrix is given as
$$\mathbf{H} = \begin{bmatrix} 1/2 & 1 \\ \sqrt{3}/2 & 0 \end{bmatrix}.$$
4. Calculate SNR γ_1, γ_2 and channel capacity C_1, C_2 of two streams over the MIMO channel given in question 3 when spatial multiplexing (ZF interference cancellation) is used instead of the MIMO diversity.
5. Calculate SNR γ_1, γ_2 and channel capacity C_1, C_2 of two streams over the MIMO channel given in question 3 when SVD-MIMO is used instead of the MIMO diversity.
6. Compare the calculated capacities for SISO, SIMO, and MIMO systems, and give remarks.