Advanced transmission methods exam 08.03.2012

1. Consider a radio channel with the impulse response $h(t) = e^{-t/\tau}$, $0 \le t < \infty$, $\tau = 2\mu s$.

The power spectral density of channel noise is $N_0 = -20 dBm/Hz$.

a) What is the frequency response of the ZF (zero forcing) equalizer?
b) What is the frequency response of the MMSE (minimum mean-square error) equalizer?
c) Let a 40-kHZ signal is transmitted over the channel. What is the noise power in the bandwidth of the transmitted) signal:

- without equalization?
- with the equalizer (a)?
- with the equalizer (b)?
  Please compare your results.

2. Consider a transmission over a Rayleigh fading channel with the average signal-to-noise ratio (SNR)=10dB.

Find a power adaptation maintaining a fixed bit-error probability. What is the maximum data rate that can be achieved under this policy if the symbol time is $1\mu s$, the outage probability is 0.1, and the target bit-error probability $P_b \le 10^{-3}$?

3. Consider variable-rate variable-power M-QAM transmission over a Rayleigh fading channel with the average SNR=20 dB.

a) What is the optimal adaptive method maximizing the data rate R under a target bit-error rate P_b ?
b) What is the optimal adaptive method minimizing the bit-error rate under a target data rate R?
c) What is the SNR cut-off value, below which the transmission is suspended under the optimal transmission strategy if the target bit-error rate $P_b \le 10^{-3}$?

4. Give an explanation to the diversity and multiplexing gains in multi-antenna transmission. What is the diversity gain for a 4x4 MIMO system operating over a Rayleigh channel if the multiplexing gain is 2?

5. Consider a MIMO system with the channel gain matrix $\mathbf{H} = \begin{bmatrix} 0.2 & 0.9 \\ 0.5 & 0.6 \\ 0.4 & 0.7 \end{bmatrix}$.

Assume that the transmit precoding and receiver shaping were used to transform this channel into parallel independent channels.

What is the maximal data rate that can be transmitted over the parallel SISO channels under M-QAM modulation on each channel with optimal power adaptation across the channels given a total power constraint P and target BER $P_b \le 10^{-4}$?

Assume that the constellation size is unrestricted, and $P_b \le 0.2 \exp[-1.5\gamma/(M-1)]$.