Exercise 6 in SSY135 Wireless Communications
Rate and power adaptation

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1. Find the power adaptation for QPSK modulation that maintains a fixed $P_b = 2 \times 10^{-3}$ in nonoutage for a Rayleigh fading channel with the average of $\gamma = 20$ dB. What is the outage probability of this system?
   Hint: The BER of MPSK modulation can be approximated as
   $[P_b \approx \frac{2}{\log_2 M} Q\left(\sqrt{2\gamma_b \log_2 M} \sin\left(\frac{\pi}{M}\right)\right)$.

2. [G-9.9] Consider a discrete time-varying AWGN channel with four channel states. Assuming a fixed transmit power $\bar{P}$, the received SNR associated with each channel state is $\gamma_1 = 5$ dB, $\gamma_2 = 10$ dB, $\gamma_3 = 15$ dB, and $\gamma_4 = 20$ dB, respectively. The probabilities associated with the channel states are $p(\gamma_1) = 0.4$ and $p(\gamma_2) = p(\gamma_3) = p(\gamma_4) = 0.2$. Assume a target BER of 10^{-3}.

   (a) Find the optimal power and rate adaptation for continuous-rate adaptive MQAM on this channel.

   (b) Find the average spectral efficiency with this optimal adaptation.

3. Consider a discrete time-varying AWGN channel with four parallel channels. Assuming a fixed transmit power $\bar{P}$, the received SNR associated with each channel state is $\gamma_1 = 5$ dB, $\gamma_2 = 10$ dB, $\gamma_3 = 15$ dB, and $\gamma_4 = 20$ dB, respectively. Assume a target BER of 10^{-3}.

   (a) Find the optimal power and rate allocation for the channels using deterministic water-filling.

   (b) Find the total spectral efficiency with this optimal adaptation.