Solution of Homework # 7

1. (a) The coherence bandwidth is $B_c = \dfrac{1}{T_m} = 0.4348$ MHz. SInce $B_c < B$, the channel is frequency-selective. Alternatively, the symbol period is

$$T = \frac{1}{2.375 \times 10^{-6}} = 0.4\ \mu\text{s}.$$

Since $T < T_m$, the channel is frequency-selective (That is, the system experiences intersymbol interference, or ISI, due to multipath).

(b) The coherence time is

$$T_c = \frac{1}{B_D} = \frac{c}{2f_c} \cdot \frac{1}{v} = \frac{3 \times 10^8}{2(500 \times 10^6)} \cdot \frac{1}{v} = \frac{0.3}{v},$$

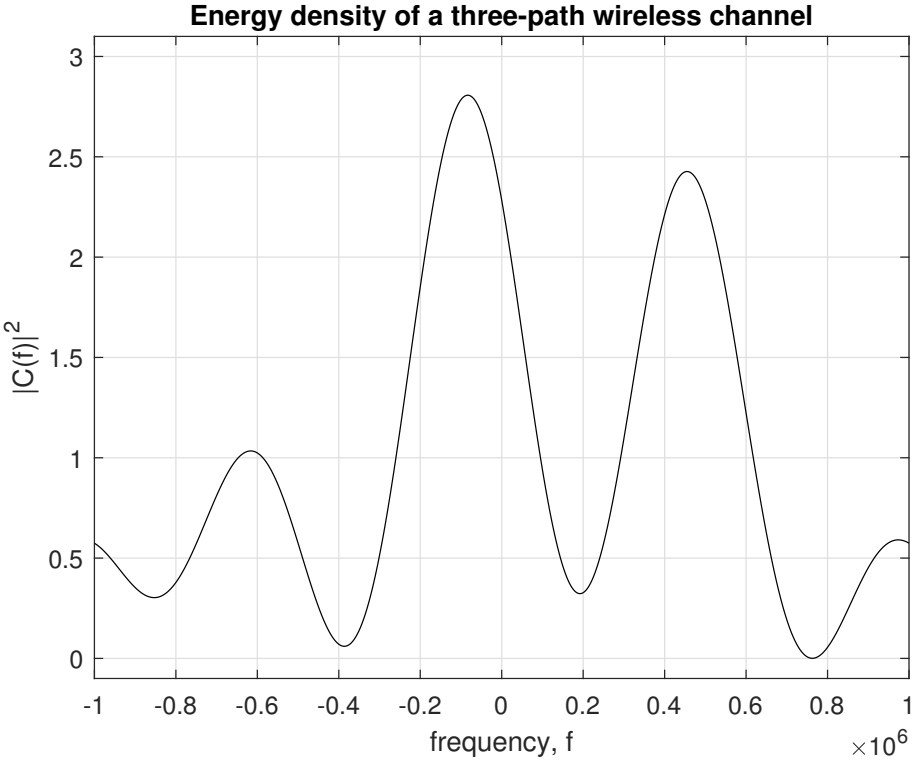
where v is the mobile speed. For fading the be very slow, the inequality $T_c \gg T$ must be satisfied. This gives, with $R = 2.375 \times 10^6$ symbols per second,

$$\frac{0.3}{v} \gg \frac{1}{R} \quad \longrightarrow \quad v \ll 0.3R, \text{ or } v \ll 7.125 \times 10^5 \text{ m/s}.$$

An aggressive estimate is

$$v_{\max} = 0.1\,(7.125 \times 10^5) = 7.125 \times 10^4 \text{ m/s or } 159382 \text{ mph}.$$

2. (a) Frequency response:



(b) QPSK modulation ($\ell = 2$) with a bit rate $R_b = 2$ Mbps, has a symbol rate $R = R_b/\ell = 10^6$ symbols/s (bauds). The signal bandwidth is

$$B = 2W = \frac{1+\alpha}{T} = (1+\alpha)R = 1.2(10^6) = 1.2 \text{ MHz}..$$

Delay spread: $T_m = 2 \times 10^{-6}$. Coherence bandwidth: $B_c = 1/T_m = 500$ kHz. Since $B > B_c$, the channel is frequency selective.

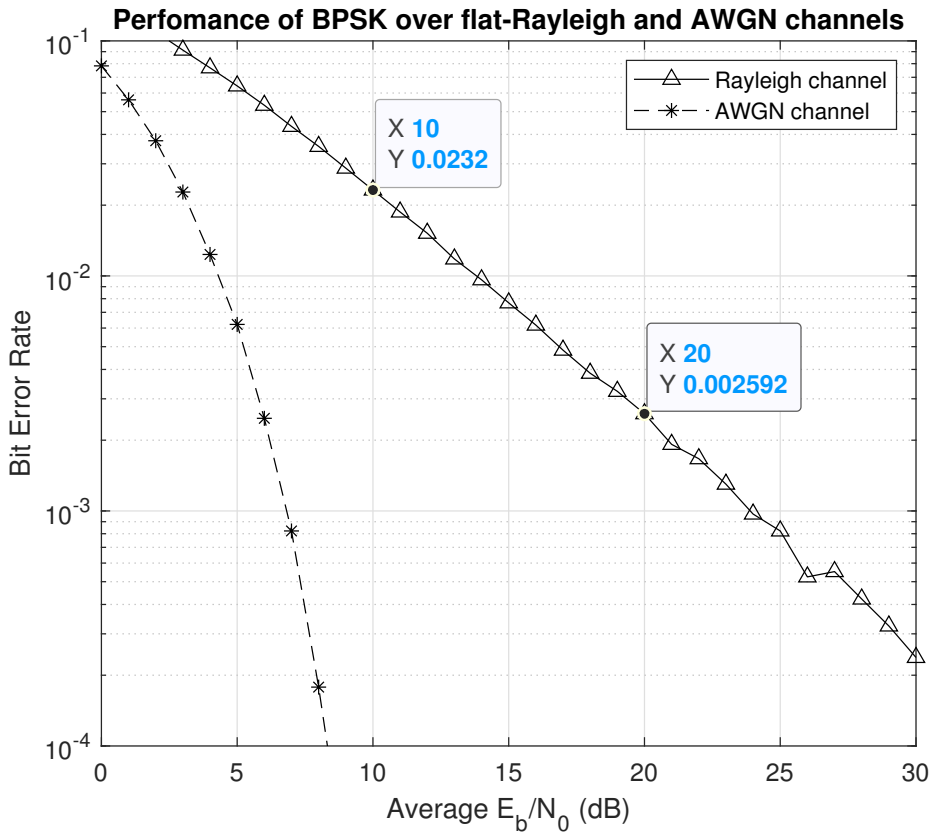
(c) The supported speed is $v = 67.056$ m/s. A center frequency $f_c = 900$ MHz gives

$$B_D = 2vf_c/c = 1.0729 \text{ kHz}.$$

Since $B \gg B_D$, the fading process is slow.

3. BPSK modulation under flat Rayleigh fading

(a) Simulation results (ID number: 123123) below.



(b) The diversity order is very close to 1 as expected:

$$D = -\frac{10\log_{10}(0.002592/0.0232)}{20-10} = 0.9519$$

(Other ways to estimate D exist, depending on the data points selected.)