Exercise 9

10.2modified

A mobile moves at a speed of 50 m/s towards another mobile. The other mobile also moves at the same speed as the first mobile and, furthermore, it moves towards the first mobile. The first mobile transmit at 900 MHz. What is the Doppler shift experienced by the second mobile? What Doppler shift would the second mobile experience if it moves the same direction as the first?

10.add

Consider an additive white Gaussian noise (AWGN) mobile channel. The received signal at time t is given by

$$y(t) = u(t) + n(t) \tag{1}$$

where $u(t)$ is the transmitted symbol and $n(t)$ is the noise. Assume that the variance of the modulated signal is 1. For BPSK signal, the analytical expression of bit error rate (BER) as function of E_b/N_0 (bit energy per noise ratio) is given by

$$p_b = Q\left[\sqrt{\frac{2E_b}{N_0}}\right] \tag{2}$$

where Q is the complementary error function

a) Use (2) and plot the BER as function of E_b/N_0 in dB, logarithmic y-axis.

b) Create a Matlab routine that simulates the BER of BPSK transmission based on (1). Use this to verify the analytical expression in (2) and the result in 2a.
Theoretical hint:

$$\gamma = \frac{Signal}{Noise} = \frac{E\{u^2(t)\}}{2\sigma_n^2}$$

where σ_n is the noise variance, and assuming the variance of the single is 1 we get

$$\gamma = \frac{1}{2\sigma_n^2}$$

The signal-to-noise ratio γ (S/N) is related to the symbol-energy-to-noise ratio (E_s/N_0) and is given by

$$\frac{E_s}{N_0} = \frac{ST_s}{N/W} = \frac{ST_s}{NT_s} = \frac{S}{N} = \gamma$$

where T_s and W are the symbol period and noise bandwidth respectively. The bit-energy-to-noise ratio E_b/N_0 is then given by

$$\frac{E_b}{N_0} = \frac{\gamma}{m} = \frac{1}{2m\sigma_n^2}$$

where m is the number of bits per symbol and for BPSK m = 1. The noise variance as function E_b/N_0 is then given by

$$\sigma_n = \frac{1}{\sqrt{2\frac{E_b}{N_0}}} \qquad (3)$$

Simulation hint:
Define a range of E_b/N_0 e.g. -11 to 11 dB with 0.1 step size and use (3) to obtain the corresponding range of noise variance σ_n

For each σ_n

- Generate a vector of random noise *n* with variance σ_n, you may use the **randn** function in matlab
- Generate a vector of random bits *u* 1 and -1
- Add vectors *n* and *u*
- Detect the bits and compute the BER

end

Then plot the computed BER as function of E_b/N_0 using logarithmic y-axis.

c) Consider a Rayleigh fading channel. If the average power being received by a stationary mobile receiver is 15 dB, what is the probability that the received power will be less than 5 dB?

d) Consider an antenna transmitting at 900 MHz. The mobile station is travelling at a speed of 40 km/h and is receiving/transmitting data at 270 kbs. Examine whether the channel fading is slow or fast?

11.3

A non-line of sight channel is measured to consist of two taps with P_1 = -10 dBW, τ_1=3 μs and P_2 = -15 dBW, τ_2 = 5 μs. Find the total excess delay, mean delay and RMS delay spread. What is the impact of introducing a line-of-sight tap with P_0 = 0 dBW, τ_0= 2 μs?

11.5

Calculate the total excess delay, mean delay and RMS delay spread for a channel whose PDP is specified in the following table. Would the channel be regarded wideband for a quaternary data system with a data rate of 20 Mbps?

Tap number	Relive delay (ns)	Average delay power (dB)
1	0	0
2	4	-2
3	6	-4
4	17	-8
5	18	-10
6	50	-6