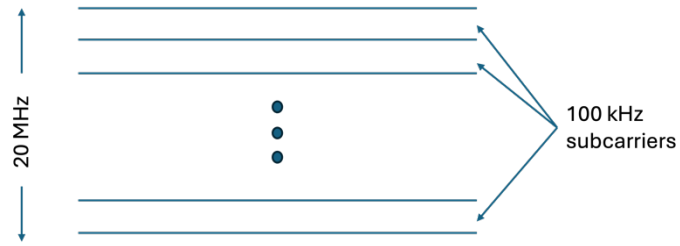
COMP4336/9336 Mobile data networking
Quiz-1 (Fundamentals: Chap 2 and Chap 3) Workout

Q1. The picture illustrates an OFDM scheme, providing information on the OFDM channel bandwidth and subcarrier spacing. How many subcarriers are there?



a) 2
b) 20
c) 200
d) 2000
e) None of these

A1:

OFDM bandwidth = 20 MHz
Subcarrier spacing = 100 kHz
# of subcarriers = $20x10^6/100x10^3$ = **200**

Q2.

To transmit 2-bit symbols, a transmitter uses the following 5-bit codewords (5-bit codewords are eventually transmitted instead of 2-bit symbols):

Data Codeword

00 --> 00000

01 --> 00111

10 --> 11001

11 --> 11110

What errors this coding scheme can detect?

a) 1-bit errors only
b) 1-bit and 2-bit errors
c) 2-bit errors only
d) 3-bit errors only
e) 2-bit and 3-bit errors

A2.

HD(1-2): 3
HD(1-3): 3
HD(1-4): 4
HD(2-3): 4
HD(2-4): 3
HD(3-4): 3

Thus, the minimum Hamming distance is 3, which can detect up to 2-bit errors.

Q3.

To achieve high security, a secret service agent is using a direct-sequence spread spectrum with a spreading factor of 10,000 for all its transmissions. To transmit a message comprising of 10,000 bits, the transmitter will have to transmit

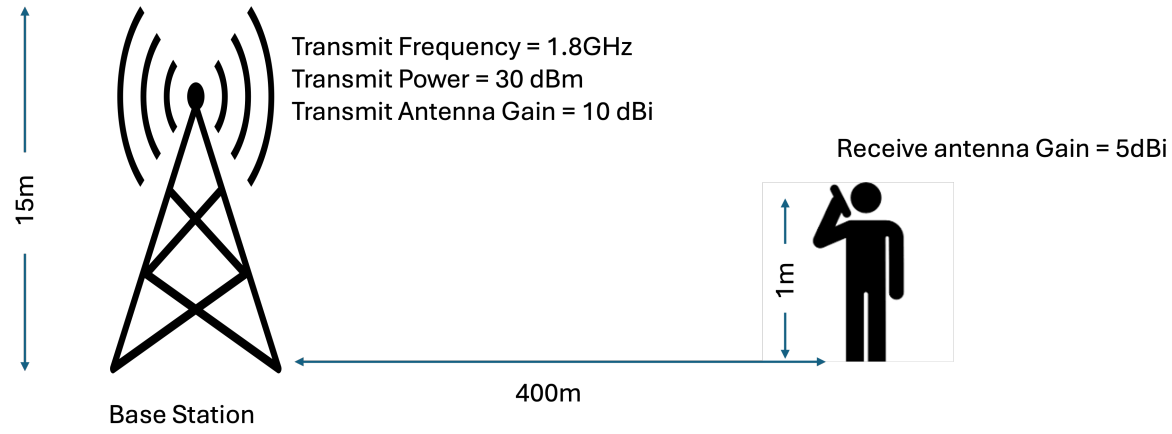
a) 100 thousand bits
b) 1 million bits
c) 10 million bits
d) 100 million bits
e) 1 billion bits

A3.

# of bits transmitted for each message bit = 10,000

# of bits transmitted for 10,000 message bits = 10,000 x 10,000 = 100,000,000 (100 million)

Q4. The picture illustrates an outdoor cellular communications scenario with a user on the ground communicating with a base station through their mobile phone. What is the received signal power (approx.) observed by the user mobile phone?



a) 30 dBm
b) -35 dBm
c) 30 W
d) 62 mW
e) 30 dBW

A4.

$D_{break} = 4(14*4*2*10^9/3*10^8) = 360$m; thus at 400m, the UE is at far field and hence we can use the 2-ray model.

Path loss (dB) = $20\log_{10}[(400x400)/(15x1)]$ = ~80 dB

Therefore, P_R = 30 dBm + 10 + 5 – 80 = -35 dBm (approx.)

Q5. An ambulance is moving towards an observer at a speed of 123.48 km/h while sounding a siren, which emits sound waves at a frequency of 1000 Hz. The speed of sound is 343 meters per second. What would be the observed frequency of the siren when the ambulance is approaching the observer and when it is moving away from the observer?

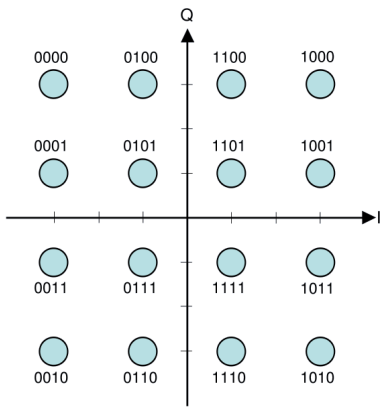
A5.

We consider **sound** wave (not electromagnetic wave).
Wave speed (c) = 343 m/s
Wave frequency (f) = 1000Hz
Vehicle speed (v) = 123.48 km/h = 34.3 m/s
1 hour = 60x60 = 3600s

Doppler shift = vxf/c = (34.3x1000)/(343) = 100Hz

Observed frequency when approaching: 1000 + 100 = 1100 Hz
Observed frequency when moving away: 1000 – 100 = 900 Hz

Q6. What is the minimum phase error in degrees that may convert a valid symbol to another in the given constellation diagram?



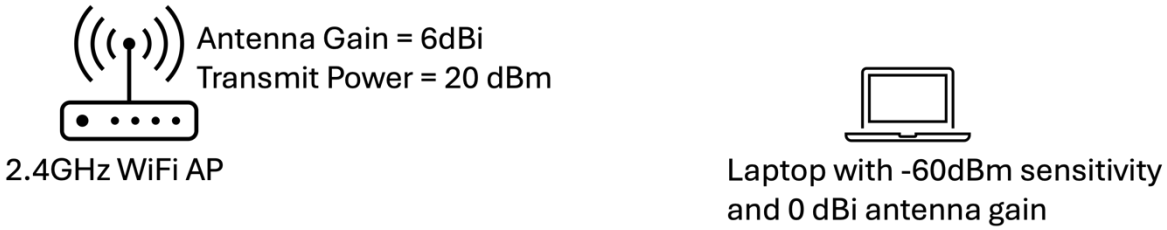
A6.

Each symbol is identified by its amplitude and phase. For a phase error to convert a valid symbol to another, we consider symbols that have the **same amplitude but different phases**.

The phase difference (in degrees) between 1100 and 0100 (both having the same amplitude) is 2 x arctan(1/3) = 2x18.43 = 36.86

The phase difference between any other two symbols having the same amplitude would be higher than 36.86 degrees.

Q7. The picture illustrates a WiFi networking scenario where a laptop is communicating with an Access Point (AP). What is the maximum distance at which the laptop can receive data from the AP?

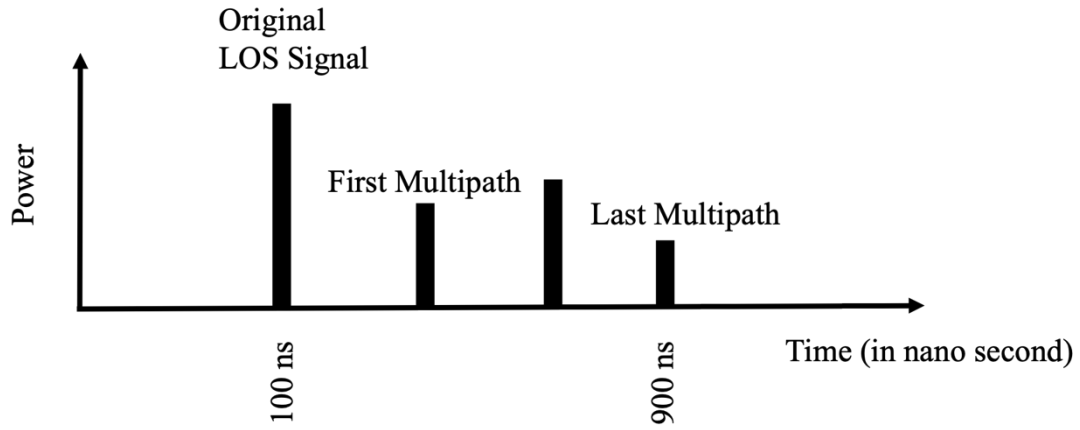


a) 10m
b) 20m
c) 115m
d) 250m
e) 200m

A7.

We can tolerate a maximum pathloss of 86 dB (20+6+60 = 86). 2.4 GHz will lose 86 dB at 200 m. Beyond 200 m from the router, the laptop will receive signal strength below its sensitivity level, -60 dBm, and hence will not be able to decode information.

Q8. The picture illustrates the arrival of the original line-of-sight (LOS) signal and the significant reflected non-line-of-sight (NLOS) signals (multipaths) at the receiver.
Which of the following options represents a valid symbol length (bit interval)?



a) 400ns
b) 700ns
c) 500ns
d) 799ns
e) None of these

A8.

Delay spread = 900ns – 100ns = 800ns.

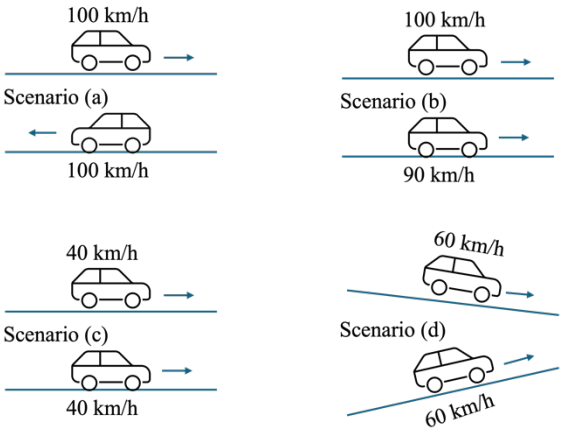
If symbols are shorter than the delay spread, then signals with significant power from previous symbol will interfere with signals from the next symbol. Therefore, the symbol length has to be greater than 800ns in this case.

Q9. Which of the following statements is FALSE?

a) Up to 30 MIMO channels could be created between a 10-anetnna base station and a 3-antenna mobile device
b) MIMO is only useful in the presence of multipath and scattering
c) MIMO can work even with a single-antenna mobile device
d) Beamforming can be achieved without having to move antennas physically
e) a 6x3 MIMO refers to 6 Tx antennas and 3 Rx antennas

A9. Even for LoS-only scenarios, the separation of multiple antennas in MIMO leads to uncorrelated LoS paths, thus providing spatial diversity benefits.

Q10. In all four scenarios, the two cars are attempting to communicate with each other using 2.4 GHz direct WiFi links. The arrows show the direction of travel for the cars. In which of these scenarios will there be NO Doppler shift?



A10. Scenario (c) where the relative velocity between the two cars is ZERO.

End of Quiz-1