



### ***Question 1***

You are designing an OFDM system over a channel of bandwidth 10 MHz. Assume that you are in outdoor environment with a maximum delay spread of 15 microseconds.

- 1) What length cyclic prefix is needed for this system?
- 2) What is the efficiency of a system using 1024 tones?
- 3) Repeat parts (1) and (2) for an indoor environment with a maximum delay spread of 1 microsecond.
- 4) If the number of OFDM tones is fixed, how does the efficiency change as a function of the bandwidth? How does the efficiency change as a function of the delay spread?

### ***Question 2***

In order for OFDM tones to remain orthogonal, the channel must be fixed for the duration of an OFDM symbol. Therefore, we require that an OFDM symbol be no longer than the coherence time of the channel. Consider the same system as in the previous problem, i.e., 10 MHz bandwidth, 15 microseconds maximum delay spread at a carrier frequency of 1 GHz.

- 1) What is the maximum number of OFDM tones such that tone orthogonality is maintained, assuming that users have a maximum velocity of 30 meters/sec. What is the efficiency if this many tones are used?
- 2) Repeat part (1) for a carrier frequency of 5 GHz.
- 3) At what carrier frequency (again assuming a maximum velocity of 30 meters/sec) is the maximum efficiency equal to 90 %, assuming a delay spread of 15 microseconds?

### ***Question 3***

Consider a multi-path channel with a delay spread of 10 microseconds through which it is desired to transmit data at a bit rate of 50 Mbps. Clearly, this represents a severe inter-symbol interference situation if the transmission takes place serially. Hence, it is suggested to use OFDM instead.

- 1) If 8-PSK is to be used as the modulation of choice, choose a SUITABLE number of sub-carriers (that could be used in the IFFT/FFT blocks) as well as the cyclic prefix period. In your design, the useful symbol period should be at least a factor of 10 greater than the delay spread.
- 2) Using the values obtained in (1) above, calculate the chip rate of the system as well as the number of chips in the cyclic prefix (to the nearest integer).
- 3) What is the sub-carrier spacing in your design?