Orthogonal Frequency Division Multiplexing (OFDM)

1. How does OFDM work? Please briefly describe. What are the key advantages of OFDM over single carrier systems?

2. We need to design a system with user data rate of 1Mbps. typical outdoor channels show RMS delay spread $\sigma$ of 10$\mu$s. Determine whether ISI will occur in a single carrier system? If yes, propose a multicarrier system that would avoid ISI. Please note that channel coherence bandwidth is defined as, $B_c = \frac{1}{5\sigma}$ and frequency selectivity occurs when $\sigma < \text{symbol duration}/10$.

3. A list of parameters of a Wireless LAN air-interface (IEEE 802.11a) using OFDM is given below:

- 64 subcarriers, 48 for data, 4 for pilots and 12 null subcarriers.
- Symbol duration 4$\mu$s
- 0.8$\mu$s for CP
- BPSK, QPSK, 16-QAM, 64-QAM
- Convolutional coding with rate $\frac{1}{2}$, $\frac{2}{3}$ ; $\frac{3}{4}$
- System bandwidth 20MHz
- Bit rates of 6, 12, 18, 24, 36, 48 & 54Mbps

Calculate the following parameters:

1. FFT time-period.
2. Subcarrier frequency spacing.
3. For different data rates, different coding scheme and different combination of modulation scheme, calculate:
   a. Coded bits per subcarriers.
   b. Coded bits per OFDM symbol.
   c. Data bits per OFDM symbol.
4. We want to design an OFDM WiMAX system for a 60GHz channel with a max RMS delay spread of approximately 25ns (max delay spread around 200ns). The target bit rate is 80Mbps using rate 1/2 coding and QPSK modulation.

**Suggest the following parameters:**

a. Guard interval and FFT period.
b. Number of FFT points (should be a power of 2).
c. Number of subcarriers used for data.
d. Sampling frequency.