Wireless Communication IC

Homework #3

(Due on 04/11)

Please upload all your codes to the LMS system.
Total points: 100 points

1. Consider one channel power delay profile listed in the following table.

Table 1: Channel power delay profile

Tap	Power	Delay (τ_i)
0	0 dB	0 ns
1	-3 dB	20 ns
2	-5 dB	60 ns
3	-8 dB	80 ns
4	-15 dB	100 ns

   (a) Please list the power ratio of 5 taps in linear scale. (5%)
   (b) Please find the maximum excess delay. (5%)
   (c) Please calculate the mean excess delay. (5%)
   (d) Please calculate the RMS excess delay (τ_{RMS}). (5%)

2. Please generate complex Gaussian random variable (Z=X+jY) with zero mean and unit variance (i.e. the variance of both X and Y is 0.5) to obtain $\gamma_i,\ i = 0,1,\dots,4$.
   (a) Assume that both $h_i(t)$ and $\tau_i(t)$ are time-invariant so that $h_i(t) = h_i$ and $\tau_i(t) = \tau_i$. $g_i = \alpha_i * \gamma_i$, where α_i is the path **magnitude** gain (not power) from Question 1. Now normalize g_i so that $h_i = Kg_i$ and $\sum_{i=0}^{4} |h_i|^2 = 1$, which can keep the same signal energy under the multipath fading channel effect. Please write down your $h_i,\ i = 0,1,\dots,4$. (10%)
   (b) Given that the channel impulse response is written as $\sum_{i=0}^{4} h_i \delta(t - \tau_i)$. Now, use Fourier transform to derive its frequency domain channel response. Write down the equation. (10%)
   (c) Plot the magnitude and phase of channel frequency response in the range of -50 MHz and 50 MHz. (10%)
   (d) If the coherence bandwidth is defined as $B_c = 1/(6\tau_{RMS})$, where τ_{RMS} comes from Q1. Please calculate the coherence bandwidth. (5%) How many subcarriers should be allocated in a 50MHz bandwidth if we want to produce

a flat-fading channel in each subcarrier of an OFDM systems? (5%)

3. Let a transmitter send
" 1, 1, 1, 1, 1, 1" for input data "0" and
"-1, -1,-1, -1, -1, -1" for input data "1" with a sample period of 20 ns ($T_s = 20ns$).
Please randomly generate 8 binary data and write it down.
   (a) Please use command "stem" in Matlab to draw the transmitter output signal, d_n for $n = 0,1,\ldots,47$. (5%)
   (b) Please draw the real part and imaginary part signals of the received signal z_n after multipath channel fading effect, namely
$$z_n = \sum_{i=0}^{4} h_i d_{n-\tau_i/T_s}$$
   Note that you have to use your channel coefficients generated in Question 2. (10%)
   (c) Is there inter-symbol interference (ISI) in the received signals? (5%)

4. If the transmitted RF signal is denoted as
$$\tilde{y}(t) = Re\{(x_I(t) + jx_Q(t))(C(t) + jS(t))\}$$
Ideally, $C(t) = \cos(\omega_c t)$ and $S(t) = \sin(\omega_c t)$ Assume at the transmitter side, IQ imbalance exists, and thus $C(t) = \left(1 - \frac{\varepsilon}{2}\right)\cos(\omega_c t + \frac{\emptyset}{2})$ and $S(t) = \left(1 + \frac{\varepsilon}{2}\right)\sin(\omega_c t - \frac{\emptyset}{2})$. Please demodulate the input signal $\tilde{y}(t)$ and calculate $\tilde{x}_I(t)$ and $\tilde{x}_Q(t)$ in terms of $x_I(t)$ and $x_Q(t)$ with the assumption of perfect demodulation, i.e. $s_I(t) = \cos(\omega_c t)$ and $s_Q(t) = -sin(\omega_c t)$. (20%).