Collaborative Exercise 1

June 28, 2018

Name:	Student ID:

Problem A:
Write answer to the following questions about design of wireless communication systems.

1. Calculate channel capacity C_0 bps when bandwidth $B = 10$ MHz and SNR (SNR at coverage edge) $\gamma_0 = 10$ dB.
2. Calculate coverage d_0 m (distance between basestation and coverage edge) to realize $\gamma_0 = 10$ dB when transmit power $P_t = 10$ mW, transmit antenna gain $G_t = 0$ dB, receive antenna gain $G_r = 0$ dB, carrier frequency $f_0 = 1$ GHz, temperature $T = 270$ K, and propagation channel is modeled as a free space.
3. Calculate user rate at coverage edge C_{UE} bps/UE when UE density (density of user equipment) $\eta = 1000$ UE/km^2.
4. Change carrier frequency from f_0 to $\tilde{f}_0$ to achieve 100 times more user rate than C_{UE} calculated in Problem 3 under conditions of $\tilde{B} = B\frac{\tilde{f}_0}{f_0}$, $\widetilde{G_t} = G_t\left(\frac{\tilde{f}_0}{f_0}\right)^2$, and $\widetilde{G_r} = G_r$.
5. How many more basestations are needed to achieve 100 times more user rate in Problem 4?

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Problem B:

Write answer to the following questions about up/down converters.

1. Calculate and draw power spectrum of baseband (BB) transmit signal $S_B^s(f)$ W/Hz when BB transmit signal $s_B(t)$ is given as

$$s_B(t) = \sum_n a_n \, g(t - nT_s)$$

$$a_n = \begin{cases} +1, if \ m_n = 0 \\ -1, if \ m_n = 1 \end{cases}$$

$$g(t) = \begin{cases} A, if \ |t| \le \frac{T_s}{2} \\ 0, if \ |t| > \frac{T_s}{2} \end{cases}$$

   where m_n is a random binary message at time index n and $g(t)$ is a rectangular pulse with pulse length (symbol period) $T_s = 100 \ ns$.
2. Calculate and draw power spectrum of analytical transmit signal $s_A(t) = s_B(t)e^{j2\pi f_0 t}$ when carrier frequency $f_0 = 1$ GHz.
3. Calculate and draw power spectrum of RF transmit signal $s(t) = \mathrm{Re}[s_A(t)]$.
4. Calculate BB equivalent channel response $H_B(f)$ and draw $|H_B(f)|^2$ when channel impulse response $h(\tau) = \delta(\tau) + \delta(\tau - \tau_0)$ and $\tau_0 = 100 \ ns$.
5. Calculate and draw power spectrum of BB receive signal $S_B^y(f)$ by using equivalent BB system model.