

Radio Engineering Final Exam

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26.6.2017

1. Consider the new narrow-band internet of things (NB-IoT) standard introduced by 3GPP in Release 13 last year. The goal of this standard is to achieve a higher coverage and simpler and energy-efficient user terminals. 3GPP specifies the coverage in terms of the maximum coupling loss (MCL), which is the difference of the eNB TX power and the UE receiver sensitivity. 3Pts

For NB-IoT with a bandwidth of 180kHz, the target MCL is 151dB. Further assume a Tx power of +35dBm and a UE RX noise figure of 9dB. Ignore (i.e. set to 0dB) all antenna gains and fading margins.

- (a) what is the required UE receiver sensitivity?
 - (b) what is the thermal noise level and what is the total noise level at the UE?
 - (c) what is the required signal to noise ratio (SNR) to achieve the UE sensitivity?
 - (d) Assuming a two-path model with $h_{TX} = 15\text{m}$ and $h_{RX} = 1.5\text{m}$, what is the maximum range of the NB-IoT cell?
2. The small scale fading is assumed to follow a Rayleigh fading distribution. Compute the available fading margin for an outage probability of 10% for one and for two antennas (using RSSI selection diversity). 2Pts
3. Consider a correlative MIMO channel sounder using a switched antenna. The channel sounder has a bandwidth of 240MHz and operates at a carrier frequency of 5.9 GHz. It uses a correlation sequence of length of $\tau_{\max} = 3.2\mu\text{s}$. The time it takes to switch between elements is also $3.2\mu\text{s}$. Assume that we use four antenna elements at the transmitter and four at the receiver, what is the total time it take to measure one MIMO channel? What is the maximum speed we can use in order for the channel to remain identifiable? 3Pts

4. What are the challenges in mm-wave communications (frequency range 30GHz-90GHz)? 2Pts
5. Give three different examples of how multiple antennas can be used to improve the capacity of a system. 2Pts
6. What is inter-cell interference coordination, in which scenarios is it used, and how does it improve capacity? 2Pts
7. What makes it possible for LTE networks to employ a cluster size of $N = 1$? 2Pts
8. What is an Erlang B system and what is the trunking gain? Give an example. 2Pts
9. Assume a communication system with two diversity branches. What is the relationship between the correlation coefficient (of the two diversity branches) and the diversity exponent of the system? 2Pts