



UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
School of Electrical and Information Engineering

ELEN 7064: PRINCIPLE OF WIRELESS COMMUNICATION/LONG TERM EVOLUTION

TUTORIAL QUESTIONS

1. Show how an OFDM demodulator works with the aids of equations and block diagram.
2. By showing the direct and delayed paths illustrate the purpose of Cyclic Prefix (Guard Interval) for OFDM symbols in time domain.
3. By using the grid diagrams with the length of radio frame, number of subcarriers, multiple antenna ports, etc, illustrate one radio frame based on time-frequency resource structure in the normal cyclic prefix case defined in LTE standard
4. Given MIMO system model $\bar{y} = H \bar{x} + \bar{n}$ with r receivers and t transmitters (note: $r \geq t$), derive MIMO Zero-Forcing receiver and explain its disadvantages.
5. Based on the outputs from the size-N DFT in the receiver, in what way have the original QAM modulation symbols in the transmitter been changed by the communication link (channel)?
6. By using QAM transmission and a SIMO communication link (e.g. uplink) with $N_R = 8$ receive antennas, apply maximum ratio combining (MRC) on the received vector \bar{r} (this is sometimes also referred to as a kind of receiver-side beamforming) from this system, and determine the result.
7. Consider two transmit antennas and one receive antenna system, use equations to illustrate the principle of Space Time Block Code (STBC).

8. Consider downlink communication to two specific terminals, T_1 and T_2 , within a cell. The received signal to noise ratios are estimated to be $\left(\frac{S}{N_0}\right)_1$ and $\left(\frac{S}{N_0}\right)_2$, respectively, and $\left(\frac{S}{N_0}\right)_1 = 2\left(\frac{S}{N_0}\right)_2$. It is desired to deliver the same bit rate to the two terminals. One way to get some guidance how to allocate resources, i.e. $(BW)_1$ and $(BW)_2$, to achieve this is to use the basic Single Input, Single Output (SISO) Shannon capacity formula with C held fixed.
- (a) Investigate what the capacity formula tells us concerning how to allocate resources to the two terminals to keep the capacity the same. It is also given that the bandwidth efficiency $\frac{C}{(BW)_1} = 1$. The more precise your answer is the better. **(10 marks)**
- (b) A person claims that it is more realistic in (i) to assume that $\frac{C}{(BW)_2} = 1$. Determine if the person is correct or not.
9. Consider a terminal at the cell-edge. If no counter-measures are made:
- What kind of disturbances may then disturb up-link communication from this terminal?
 - What kind of disturbances may then disturb down-link communication to this terminal?
10. Assume LTE downlink (DL) using codebook-based antenna precoding. Assuming 3 transmit antenna and 2 receive antenna. Let $y_{0,1}$, $y_{0,2}$, $y_{0,3}$ denote the value present at the corresponding transmit antennas (and which are sent in the same specific resource element). Specify in detail the values that are obtained in the receiver corresponding to the same specific resource element stated above.