UNIVERSITY OF SOUTHAMPTON ELEC6214W1

SEMESTER 2 EXAMINATION 2019 - 2020

ADVANCED WIRELESS COMMUNICATIONS NETWORKS AND SYSTEMS

DURATION NA MINS (NA Hours)

This paper contains 2 questions

Answer the both questions.

An outline marking scheme is shown in brackets to the right of each question.

This is an open book assessment and contributes 100% of the marks for the module. You should consult your lecture notes when answering the questions. You may also consult other relevant materials.

Ignore the following instruction

A foreign language dictionary is permitted ONLY IF it is a paper version of a direct Word to Word translation dictionary AND it contains no notes, additions or annotations.

4 page examination paper.

Question 1.

(a) Mobile radio channels exhibit both frequency dispersion and time dispersion. Explain the physical quantities that are used to measure the frequency dispersion and time dispersion of a channel, respectively.

Assume that the signal bandwidth is B_S and the signal symbol period is T_S. Give the conditions that classify mobile channels into fast-fading and slow-fading ones as well as give the conditions that classify mobile channels into frequency-selective and flat ones.

[10 marks]

(b) Explain why the fourth generation (4G) mobile network adopts the orthogonal frequency division multiplexing (OFDM) transmission technique in order to support high-rate broadband applications. You should provide your explanation based on the characteristics of mobile channel given in part (a).

With appropriate block diagrams, briefly describe the operations of the OFDM transceiver. You should clearly explain the purposes of the cyclic prefix at the beginning of each OFDM block or symbol.

What is the main drawback of OFDM transmission technique? You should explain this drawback from the characteristics of OFDM transmission signal.

[20 marks]

(c) With the aid of clearly labelled block diagrams for two-stage turbo transmitter and receiver, briefly explain how iterative turbo detection and decoding operates.

[20 marks]

Question 2.

(a) With frequency division duplexing (FDD) and time division duplexing (TDD), a mobile user requires two resource blocks (two frequency slots or two time slots) to achieve full duplexing. Name the duplexing scheme that is capable of achieving full duplexing with only a single resource block. Explain how this full duplexing scheme works with the aid of a system block diagram.

[10 marks]

(b) In a spatial-domain non-orthogonal access system, the base station (BS) equipped with M antennas serves K ($K < M$) single-antenna mobiles with the same resource block based on the TDD protocol.

In uplink reception, what does the BS need in order to perform multi-user detection (MUD)? Describe how the BS obtains this information and give an MUD scheme based on this information.

In downlink transmission, what does the BS need in order to carry out multi-user transmission (MUT) precoding? Describe how the BS obtains this information and provide an MUT precoding scheme based on this information.

[12 marks]

(c) A multiple-input multiple-output (MIMO) system is described by the following MIMO model

$$\boldsymbol{x}(k) = \boldsymbol{H}\,\boldsymbol{s}(k) + \boldsymbol{n}(k)$$

where $\boldsymbol{H} \in \mathbb{C}^{n_R \times n_T}$ is the channel matrix, $\boldsymbol{s}(k) \in \mathbb{C}^{n_T \times 1}$ denotes the transmitted signal vector of the n_T transmit antennas, $\boldsymbol{x}(k) \in \mathbb{C}^{n_R \times 1}$ is the received signal vector of the n_R receive antennas, and $\boldsymbol{n}(k) \in \mathbb{C}^{n_R \times 1}$ is the complex-valued Gaussian white noise vector.

How can you acquire the channel matrix $\boldsymbol{H}$? Design an estimation scheme to obtain an estimate of $\boldsymbol{H}$.

[10 marks]

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(d) With the aid of a clearly labelled block diagram and well-defined equations, briefly describe the operations of the spatial modulation transmitter and receiver.

[18 marks]

END OF PAPER