

S-72.3216

Radio Communication Systems I, Examination, 9.3.2010

**Problem 1.** Explain briefly what tasks the following basic building blocks of a radio system are carrying out

- a) 'Channel coding and interleaving' – block.
- b) 'Signaling' and 'Multiplexing (MUX)' – blocks.
- c) 'TX local oscillator' and 'TX filter' blocks.

**Problem 2.** Answer to the following questions:

- a) Why Orthogonal Frequency Division Multiplexing (OFDM) is sensitive to frequency errors?
- b) Why Time Division Multiplexing (TDM) may have bad (time) delay budget?
- c) Why accurate uplink power control is essential if Code Division Multiplexing (CDM) is applied?

**Problem 3.** Assume Okumura-Hata model (see next page) for average path loss in medium size city, lognormal shadow fading (SF) model and the following parameters: BS antenna height = 30m, MS antenna height is 1.5m, SF standard deviation is 8dB and carrier frequency is 2GHz. If allowed maximum path loss for a system is 137dB and it is required that total path loss is less than 137dB with probability 0.90, what is then the system range? Hint: Values of Marcum Q-function can be found from Figure 1.

**Problem 4.** Assume uplink of a LTE system. Calculate the throughputs (Hint: see next page) in the following cases a) and b). The bandwidth efficiency of LTE system is 0.88, the SINR efficiency is 1.25 and the Resource Block (RB) bandwidth is 180kHz.

- a) Assume that in average 10% of the cell users have SINR round 0dB, 50% have SINR round 4dB, 30% of users have SINR round 8dB and 10% of users have SINR round 12dB. What is the average throughput per RB in the cell?
- b) Assume that new scheduling method is introduced to the cell of the problem a). Then percentages of SINR values 0dB, 4dB, 8dB and 12dB are 5%, 60%, 30% and 5% respectively. What is now the average throughput per RB in the cell?

Is the new method improving cell capacity or coverage?

**Problem 5.** Direct Mode Operation (DMO) is a unique networking feature that is enabled in Professional Mobile Radio (PMR) networks, but not available in commercial Public Land Mobile Networks (PLMN), such as, GSM/GPRS, UMTS, CDMA2000 and so on.

- a) Provide a brief explanation on what is DMO.
- b) With the aid of simple sketches, illustrate various ways how DMO could be utilized in standard TETRA PMR networks?

**Figures and equations:**

$$L_{\text{Hata}} = 69.55 + 26.16 \log_{10}(f) - 13.82 \log_{10}(h_{\text{BS}}) \\ - a_i(h_{\text{MS}}) + (44.9 - 6.55 \log_{10}(h_{\text{BS}})) \log_{10}(r),$$

Medium/small size city,  $i = 2$ .

$$a_2(h_{\text{MS}}) = 0.8 + (1.1 \log_{10}(f) - 0.7) h_{\text{MS}} - 1.56 \log_{10}(f).$$

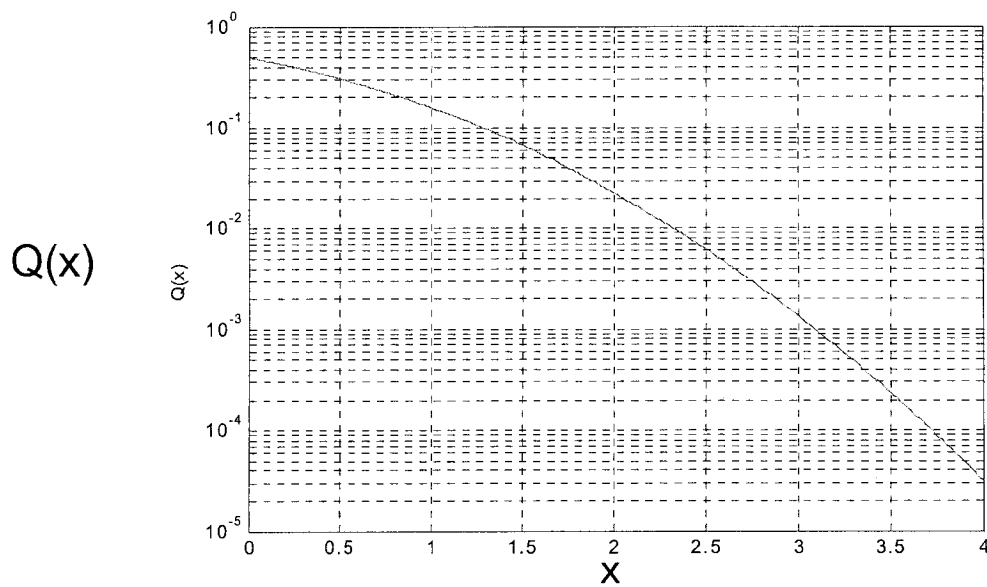


Figure 1 (for Problem 3).

$$TP_{\text{user}} = BW_{\text{eff}} \cdot M \cdot BW_{\text{PRB}} \times \log_2 \left( 1 + \left( \frac{SINR}{SINR_{\text{eff}}} \right) \right)$$