



## Written exam

January 15<sup>th</sup> 2015

# Wireless networks

## EP2950

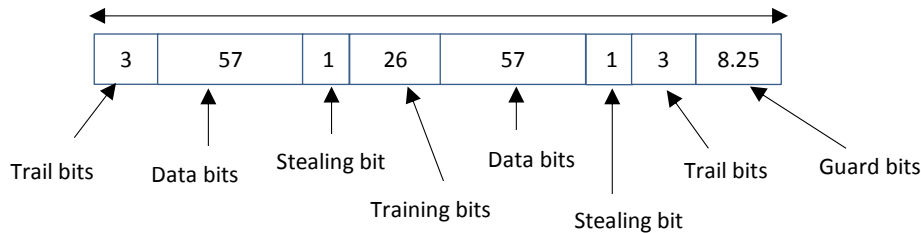
Help material: pocket calculator and four handwritten A-4 pages.  
Maximum points: 50p. The preliminary limit for passing the course is 24p.

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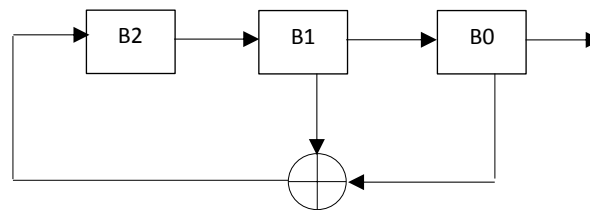
1. A communication link consists of two parabolic antennas. Determine the radius and effective area of the receiving parabolic antenna given that transmitted power is 20 dBm, the received power level is  $10^{-8}$  W, the fading margin is 9 dB, the transmitting parabolic antenna diameter is 1.5 meter, the frequency is 5 GHz, the distance is 10 km. A parabolic antenna with face area  $A$  has the effective area  $0.56A$  and the power gain  $7A/\lambda^2$ . (4p)
2. Is a carrier frequency of 1 MHz a good choice for portable devices such as mobile phones? Motivate your answer. (3p)
3. Free space is  $L_{dB}=20\log(f)+20\log(d)-147.56$  where  $f$  is in hertz (Hz) and  $d$  is in meter (m). Derive and rewrite the equation for  $f$  expressed in GHz and  $d$  expressed in kilometer (km). (4p)
4. If the received signal power for a communication system is -151 dBW and the effective noise temperature at the receiver system is 1500 K, what is then the  $E_b/N_0$  for a link transmitting 2400 bps? (3p)
5. A mobile user travels along the border between two cells in a W-CDMA network. How can the mobile user and the base stations separate traffic from the two cells? (2p)
6. Assume that multipath fading causes delays between the direct beam and reflections in the order of a couple of chip intervals. Why is code division multiple access (CDMA) less sensitive to such fading effects compared to e.g. the GSM system? (2p)

7. The figure below shows the frame format in GSM. (6p)
- Calculate the bit rate for the time slot and data bit rate.
  - Explain the purpose of the training bits and the guard bits in the GSM
  - What is the purpose of the trail bits and the stealing bits?

The timeslot duration is 0.577 ms.



8. The linear feedback shift register below generate an m-sequence as output. The start value is 100. (6p)
- Calculate the m-sequence that is generated by the linear feedback shift register.
  - Calculate the auto-correlation of the m-sequence.
  - Would two m-sequences with two different start values using the same logic as in the figure below be orthogonal? Motivation is required.



9.
  - Determine  $k$  in the Hamming code  $(31, k)$  in order to correct one bit error? (2p)
  - How many check bits are needed in a 15 bit codeword for single error correction and double error detection (SECDED)? (2p)
10. A computer transmits this data block: 1010101010.
  - Construct a forward error correction code that is able to correct a single bit error. Show the transmitted codeword and how it is created. (2p)
  - Assume that the received data bits ha a bit error (in red): 1010101011. Show how the receiver corrects the bit error. (2p)
11. A station in a wireless LAN transmits frames to another wireless station. The frames consist of 160 byte data (voice samples in IP telephony) and 34 byte overhead. The short IFS duration is  $10 \mu\text{s}$  and the DCF IFS is  $50 \mu\text{s}$ . An ACK packet is 14 byte. The transmission rate is 54 Mbps. The channel is idle when packets are sent. Calculate the user data throughput. (6p)
12. In Bluetooth the logical transport link SCO (synchronous connection oriented) uses the previous ARQN (acknowledge number) and the previous SEQN (sequence number). Why? (3p)
13. Two different Bluetooth piconets exist in the same room. How can the masters and slaves separate packets belonging to the respective piconet? (3p)