CARLETON UNIVERSITY

Department of Systems and Computer Engineering

SYSC 4600 – Digital Communications – Fall 2010

Professor H. Yanikomeroglu

04 November 2010

Full mark: 100 points – closed-book, one-page aid-sheet and calculators are allowed – 80 min.s

---

Question 1 (25 pts) – Transmission through a Bandlimited Channel

Consider a wireless cellular operator (such as Bell Mobility, Verizon, or Vodaphone) which has a 3G (third generation) network, with a 5 MHz channel centred around 1900 MHz (carrier frequency).

Assume that the air-interface uses 16-QAM with SRRC (square-root raised cosine) pulses with a roll-off factor of 25% ($\alpha = 0.25$).

(a) (10 pts) Find the data rate that 5 MHz channel can support.

(b) (15 pts) Sketch the amplitude response (magnitude of the transfer function) of the SRRC filter at the transmitter, around the 1900 MHz carrier.

Question 2 (20 pts) – Next-Generation Wireless Cellular Networks

The "Long Term Evolution – Advanced" (LTE-A) is a 4th generation wireless cellular standard being developed. LTE-A is expected to be finalized in 2011; network deployments will likely start in the second half of this decade. The peak data rate that LTE-A targets is 1 Gbits/sec.

It was discussed in the lectures that the peak data rate, R_{max}, can be calculated as

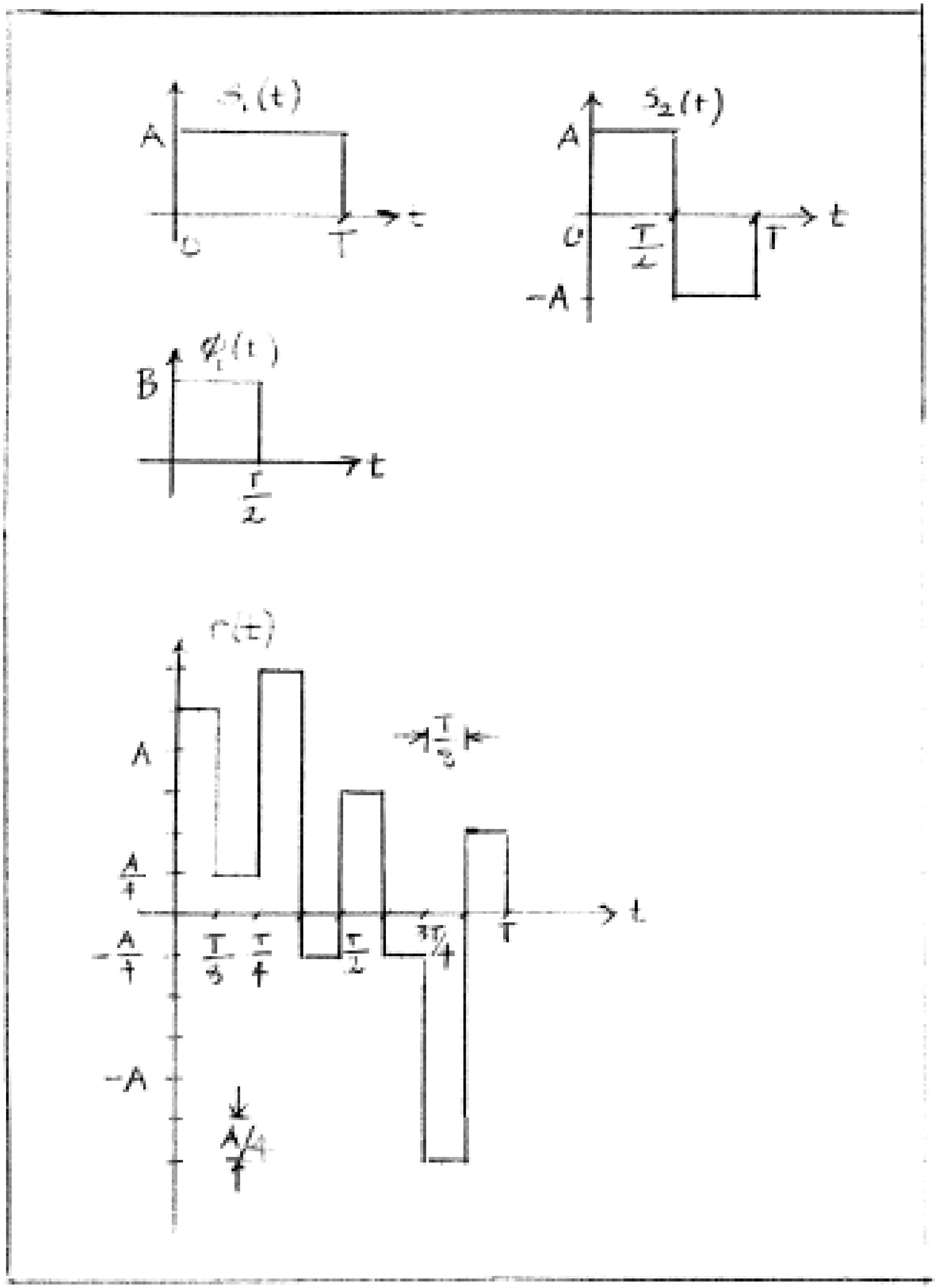
$$R_{max} = n\, W\, \mu \text{ [bits/sec]}, \quad \text{where}$$

- n = minimum(n_{tx}, n_{rx}), where n_{tx} and n_{rx} denote the number of antennas at the transmitter and the receiver, respectively (n is often referred to as the MIMO gain),
- μ is the peak spectral efficiency [bits/sec/Hz],
- W is the total bandwidth [Hz].

Suggest realistic values for n, W, and μ, based on the LTE-A target. Substantiate your suggestions with a brief discussion.

Question 3 (55 pts) – Optimum Detection

The two signals in a baseband binary signaling scheme, $s_1(t)$ and $s_2(t)$, corresponding to symbols 1 and 2, are shown in the below figure.



- The information bits are equally-likely.
- The source produces one bit every T seconds.
- The channel is ideal with zero-mean AWGN.
- The receiver is optimal (minimizes the probability of error).

(a) (5 pts) One of the orthonormal basis functions for the corresponding signal space, $\phi_1(t)$, is also given in the figure. Find B.

(b) (5 pts) Sketch the other basis functions.

(c) (10 pts) Write $s_1(t)$ and $s_2(t)$ in the terms of the basis functions. Draw the signal space, and show the vectors corresponding to $s_1(t)$ and $s_2(t)$.

(d) (5 pts) Write the probability of error expression in terms of bit energy, E_b, and noise power spectral density, N_0.

(e) (15 pts) Consider a received noisy signal (over one bit interval), $r(t)$, sketched also in the above figure. Draw the vector corresponding to $r(t)$ in the signal space.

(f) (5 pts) Sketch the optimum receiver. Based on what detection principle does your receiver operate?

(g) (10 pts) Show the calculations to be performed in the receiver for detection (do those calculations). State the output of the detection (i.e., symbol 1 or 2?).
