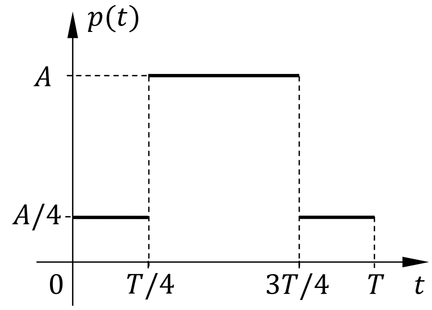
# EE3008: Principles of Communications, Test 2:

## Name ________________________ ID __________

### Question 1 — Bandpass Modulation & Demodulation [45 marks]

**a.** A communication system transmits a bandpass signal $\pm p(t) \cos(t)$ over an AWGN channel with noise power spectrum density $N_0$ W/Hz. The baseband pulse function is shown in Fig. 1.

Figure 1




(i) Calculate the value of $E_b$. **(4 marks)**

(ii) Find the BER at the receiver, expressed in terms of the $Q$-function. **(4 marks)**

**b.** Consider the BPSK signal $A \cdot b \cdot \cos(2\pi \times 10^9 t)$ V at the input of a correlation receiver, with $b = +1$ (bit "1"), $b = -1$ (bit "0"), $A = 2 \times 10^{-2}$ and the data rate is $100$ kbps. Suppose the channel is an AWGN channel with $N_0 = 1{\times}10^{-9}$ W/Hz. Assume a 1Ω termination resistance.

(i) Calculate the difference (i.e., distance) between the correlator output values for the bit value "1" and bit value "0". **(4 marks)**

(ii) Calculate the value of $E_b$. **(3 marks)**

(iii) Find the BER at the receiver, expressed in terms of the $Q$-function. **(4 marks)**

**c.** With the parameter values as in (**b.**) consider the 2ASK signal $A \cdot c \cdot \cos(2\pi \times 10^9 t)$ V at the input of the correlation receiver, with $c = 4$ (bit "1") and $c = 1$ (bit "0").

(i) Calculate the difference between the correlator output for a bit "1" and bit "0". **(4 marks)**

(ii) Which of the BPSK signal in (**b.**) and the 2ASK signal here in (**c.**) gives the *better* BER performance? Motivate your answer. Hint: Compare **b.**(i) and **c.**(i). **(3 marks)**

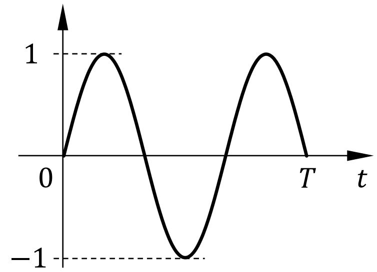
**d.** A QPSK modulation scheme transmits the carrier $\sin(2\pi f_c t + \theta)$ where each symbol, i.e., an information bit pair, is mapped to its respective phase angle according to the rule:

| Information bits: | "00" | "01" | "11" | "10" |
|---|---|---|---|---|
| | ↓ | ↓ | ↓ | ↓ |
| Phase angle, $\theta$: | $0$ | $\pi/2$ | $\pi$ | $3\pi/2$ |

**P.T.O.**

The symbol duration is set to one-and-a-half cycle of the carrier signal. For example, Figure 2 shows the pulse waveform transmitted for the symbol "00".

Figure 2




Neatly, sketch the combined waveform for the five consecutive symbols corresponding to the information bit sequence "11 00 11 01 10". **(14 marks)**

**e.** Consider a Direct Digital Synthesis (DDS) based sinewave generator designed for use in baseband modulation and to be implemented in a Field Programmable Gate Array (FPGA). Sketch qualitatively the anticipated output spectrum if the generator exhibits both deterministic (i.e., repetitive) errors and random errors. Also sketch the ideal output spectrum. **(5 marks)**

## Question 2 — Analogue-Digital & Digital-Analogue Conversion [20 marks]

**a.** Consider Analogue-to-Digital conversion of an analogue signal $x(t)$ of bandwidth 5kHz into a discrete signal. Each sample $x(k)$ is quantized using uniform 2048-level quantization and then represented by a PCM scheme using pulses with duration $T$.

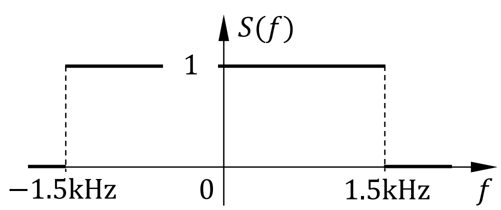
(i) Determine the Nyquist sampling rate for $x(t)$. **(3 marks)**

(ii) Firstly, assume that BPSK is used. Determine the maximum value of $T$ and the corresponding channel bandwidth $W$ of the transmitted signal. (Assume that the first zeros in the spectrum are used to estimate the bandwidth.) **(7 marks)**

(iii) Now, assume that 16PSK is used. Determine the maximum value of $T$ and the corresponding channel bandwidth $W$ of the transmitted signal. **(5 marks)**

**b.** Suppose the signal $s(t)$ has the rectangular spectrum $S(f)$ shown in Figure 3.

Figure 3




(i) Sketch the resultant spectrum of the discrete signal obtained by sampling $s(t)$ at 2.5 kHz. Can $s(t)$ be recovered from this discrete signal? Motivate your answer. **(3 marks)**

(ii) Sketch the resultant spectrum of the discrete signal obtained by sampling $s(t)$ at 3 kHz. Can $s(t)$ be recovered from this discrete signal? Motivate your answer. **(2 marks)**

**Total Marks: 65 Full Marks: 55**