National Technical University of Athens, School of Electrical and Computer Engineering
Introduction to Telecommunications
1st Laboratory Exercise

Question 1
Let sq_triangle (t) be the square of the triangular periodic pulsestring. This signal has a width of A = 4 V and a frequency of fm in kHz which is fm as the sum of the last three digits of each student's Registry Number. If the sum exceeds 9 then the sum of the digits continues until a one-digit number is obtained. An example is illustrated in Figure 1 of an example of a triangular periodic pulse string A = 1 V and a frequency of 1 Hz.

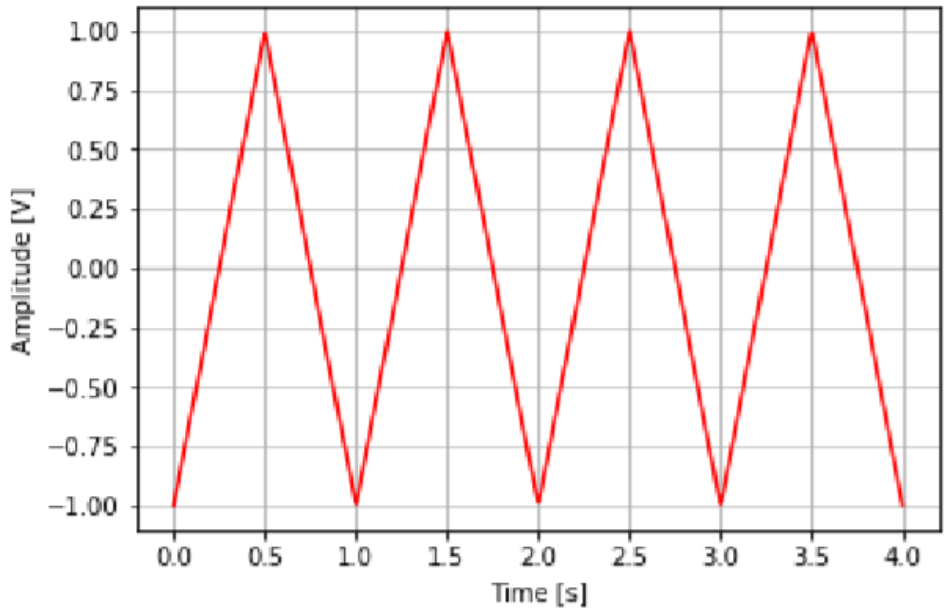

Figure 1: Example of a triangular periodic pulse line

a) Let the above sq triangle (t) signal be sampled at two different frequencies, first with fs1 = 25fm and then with fs2 = 60fm. Give the following three graphs:

(i) Samples after sampling with frequency fs1.

(ii) Samples after sampling at frequency fs2.

(iii) Samples of questions (i) and (ii) in a common diagram.

b) What do you notice if the sq triangle (t) signal is sampled at fs = 5fm? How would you find the minimum theoretical fs in order to accurately reconstruct the signal under discussion? Approach it theoretically and numerically.

c) Let be a sine of z (t) = Asin (2πfmt) of width A = 1 V and frequency fm in kHz. The frequency fm is expressed as the sum of the last three digits of each student's Registry Number. If the sum exceeds 9 then the sum of the digits continues until a one-digit number is obtained.

(i) Repeat sub-queries a and b for the signal z (t).

(ii) Repeat sub-queries a and b for the signal q (t) = z (t) + Asin (2π (fm + L) t), where A = 1 V and L = 1 kHz. What is the resulting signal? Explain shortly.

Note: In the diagrams the horizontal axis expresses time (sec) and the samples do not merge. In the diagrams of queries a and c (i) there are four (4) periods and in c (ii) one (1) period.

Question 2

We consider the input y (t) of the 1st query after sampling fs1 = 45fm to be a uniform quantizer (mid riser). If the frequency fm is good (based on the Registry Number) to quantify by 4 bits, otherwise (if unnecessary) quantize by 5 bits.
A) Diagram the quantizer output. The vertical axis will show the quantization levels (not as a decimal number but as a binary, having Gray coded) and the horizontal axis the time (in sec).

B) Calculate the standard deviation of the quantization error

(i) for the first 10 samples

(ii) for the first 20 samples

(iii) Calculate the quantization SNR for cases (i) and (ii) as well as its theoretical value and explain any differences in the resulting values.

c) After quantization, diagram for a period the corresponding bit stream transmission assuming a BIPOLAR RZ line encoding with a bit duration of 1 msec. The amplitude (in Volts) should be numerically equal to the signal frequency (eg for 1 kHz frequency, the amplitude is 1 V).

Question 3
Considering the sine signal z (t) of query 1 with fs2 = 130fm as the carrier in AM configuration with 0.5 configuration index and information signal m (t) = sin (2π35t):
a) Present the modulated signal by AM signal for four (4) periods of the information signal m (t).

b) Implement a demodulator / surround lighter and diagram the signal after demodulation. The resulting output signal at the demodulator output should coincide with the original information signal prior to configuration. It is recommended to use Python's SciPy library and more specifically the signal.firwin() και signal.lfilter(). Commands.

General Instructions
1 All required graphics should be accompanied by a title, a memorandum and the corresponding captions on the axes. 2 The work will be submitted by uploading a .zip file per group of 2 people which should include: a) The single source code that will execute all queries (must be legible and with comments) and produce the requested diagrams (without external intervention). The file will be either Python (.py) or MATLAB / Octave (.m) b) Two .pdf / .doc text files (one for each Registry Number) that will answer the queries thoroughly and include all charts.

3 The code should faithfully reproduce the diagrams embedded in the submitted .pdf / .doc files, otherwise the work will not be considered.