# THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY ISDN 2602

**Laboratory 1: Analog to Digital Conversion (5%)**

**Answer Sheet**

Please write down your answer here and submit your answer to GitHub by Wednesday (Sep 24th) 23:59

**Task 1: Sampling**

In this task, we will sample several sinusoid signals with different frequencies. The sampling frequency can be changed to observe the effects of sampling.

# C heck Point:

* 1. Are the three sinusoid signals generated by the code analog signals or digital signals? Explain.
  2. Try increasing the sampling frequency from 2 samples/sec to 4, 8, and 16 samples/sec. For each sampling frequency, can you identify the difference between the three sinusoid signals based on the sampled version? For different sampling frequencies, did you observe any aliasing effect?
  3. Based on the Nyquist sampling theorem, what is the minimum sampling frequency for the group of three sinusoid signals? Compare the number with the results of 2). Do they agree? Explain why.

***Fill in the answers to the blanks.***

# T ask 2: Quantization

In this task, we will study how to quantize an amplitude value within a given range, say [-1v, 1v], to several fixed levels. Like Task 1, we will quantize a single-tone sinusoid signal.

# C heck point:

1. Use the **“help”** function to figure out the meaning of “eps” and explain the purpose of the operation that restricts the signal within the range [-1, 1). (Hint: Revise the code to x(x>=1)=1; Run the code, count the number of quantized levels, and answer the question.)
2. The quantization process is done with three lines of code xq=floor((x+1)\*2^(b-1));

xq=xq/(2^(b-1));

xq=xq-1+1/2^b;

Explain the operation of each line and list the range of values xq can take after each operation.

|  |  |  |
| --- | --- | --- |
| Codes | Explain the operation in your own words | Range of values in terms of “b” |
|  |  |  |
|  |  |  |
|  |  |  |

1. In the first line of above code, we perform x+1 to shift the signal up by 1.

However, in the third line, we not only perform xq-1 to shift down by 1, but also add an offset of 1/2^b to the result. Please explain the reason for adding the offset. (Hint: modify the code to remove the offset and observe the difference on the graph.)

1. Increase “b” from 3 to 5. Can you observe the improvement? What is the cost? Determine the corresponding number of bits needed to transmit one period of the sinusoid signal, with b=3 and 5, respectively.

***Fill in the answers to the blanks.***

# T ask 3 – Listen to the Effects of Quantization

In this task, we study the effect of quantization by listening to music with different quantization levels.

# C heck point:

Try increasing the quantization bits and observe the effect of quantization.

1. What is the minimum number of quantization bits needed so that your ear cannot tell the difference between the original and quantized music?
2. From the frequency domain comparison, what components of the original signal are more influenced

by quantization error? Can you explain intuitively?

1. Quantization is mainly done by the line “sq = (ceil(s\*(L-0.5))-0.5)/L”. Determine the possible values “sq” can take for the case “L=2 (b=2)” and “L=4 (b=3)”. (Give “s” some specific values and check the corresponding “sq”.)

***Fill in the answers to the blanks.***

# T ask 4 (Bonus) – Coding

In this task, we will complete the ADC process and generate the binary codes to represent the original analog signal.

# C heck point:

1. The codes for the second step are not well written. Your job is to rewrite the code by using the function “reshape”. Use “reshape” to rewrite the codes between *“%Rewrite the following codes%*” and *“%Donot change codes below%”*.
2. Set the number of quantization bits to be 3. Explain why there are two long periods, where the encoded signal does not change (output “1” and “-1”, respectively)?

***Fill in the answers to the blanks.***

**----------------------------------End-----------------------------------**