CMPE 352 – Signal Processing & Algorithms

Problem Session 7

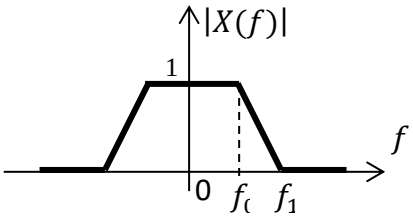
Week of 8 May 2017

Problem 1

(1) What is the bandwidth of an audio signal (signal that is audible by the human ear)?
(2) At what minimum frequency should this signal be sampled?
(3) The compact Disc uses a sampling frequency of 44.1 kHz. How do you explain the usage of this sampling frequency value in connection with your answer to question (2).
(4) Suppose that each digital sample is represented by 16 bits. What is the bit rate of the obtained digital stream?

Problem 2

You would like to control a robot by an Arduino microcontroller with an A/D converter having a sampling frequency that cannot exceed 1 kHz. You measure with a frequency analyzer the spectrum of the signal that is provided by a sensor on the robot and obtain the following spectrum:



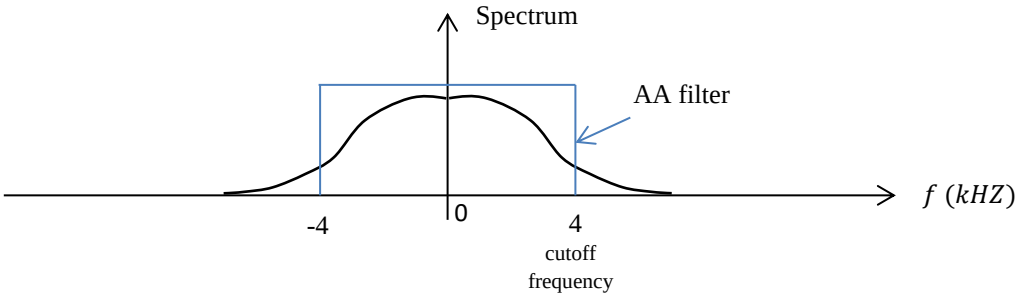
$f_0 = 400$ Hz

$f_1 = 600$ Hz

How would process this sensor signal before sampling it on the Arduino platform (and input the sampled signal to the microcontroller), and what sampling frequency would you recommend to use?

Problem 3

The spectrum of speech prefiltered to about 4 kHz results in very intelligible speech. Therefore, in digital speech applications what sampling rates would you recommend to use? What would be the cutoff frequency of an antialising (AA) filter in that case?



Problem 4

The following three signals, where t is in seconds, are sampled at a rate of 4 Hz:

$$\sin(2\pi t),\ \sin(10\pi t),\ \sin(18\pi t).$$

(a) Show that they are all aliased with each other in the sense that their sampled values are the same.

(b) In Matlab, plot the three waves on top of each other over the interval $0 \le t \le 1$ sec and indicate the sampling instants where the three waves give identical samples.