ICE503 DSP-Homework#6

1. Consider the system shown in Figure 1 for discrete-time processing of the continuous-time input signal $g_c(t)$. The input signal is of the form $g_c(t) = f_c(t) + e_c(t)$. The Fourier transform of $f_c(t)$ and $e_c(t)$ are shown in Figure 2. Since the total input signal is not bandlimited, a continuous-time antialiasing filter $H_{aa}(j\Omega)$ is used to combat aliasing distortion. Its frequency response is shown in Figure 3.

   (a) If the sampling rate is $2\pi/T = 1600\pi$, determine the frequency response of the discrete-time system $H(e^{j\omega})$, so that the output is $y_c(t) = f_c(t)$.

   (b) Is it possible that $y_c(t) = f_c(t)$ if $2\pi/T < 1600\pi$? If so, what is the minimum value of $2\pi/T$? Determine $H(e^{j\omega})$ for this choice of $2\pi/T$.

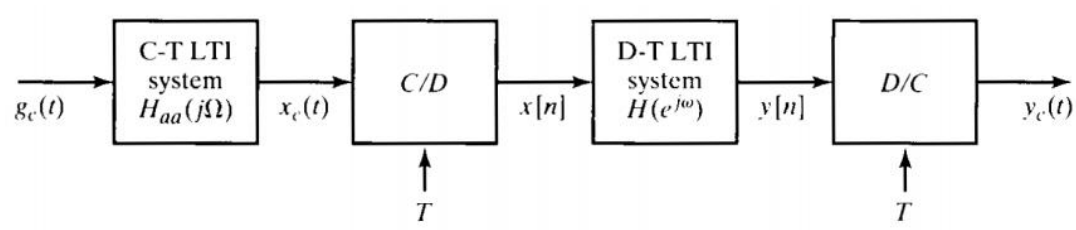


Figure 1: system

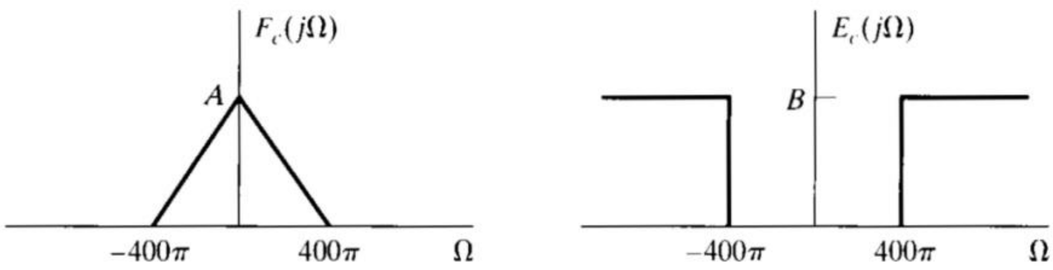


Figure 2: the Fourier transform of $f_c(t)$ and $e_c(t)$

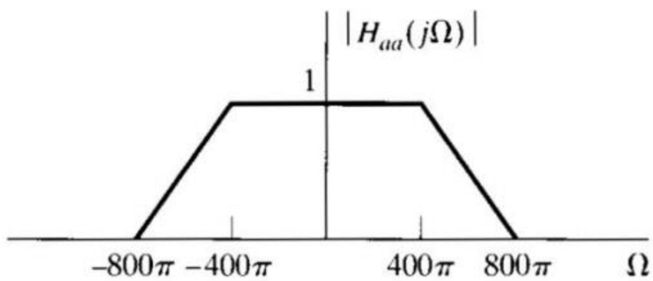


Figure 3: the frequency response of $H_{aa}(j\Omega)$

Matlab Simulation

(a) Generate a continuous-time signal $x_c(\mathrm{t}) = \sin(4\pi\mathrm{t}), 0 \le \mathrm{t} \le 1$. Plot $x_c(\mathrm{t})$ in figure (1). (Hint: since we can't generate a real continuous time signal with MATLAB, we generate $x_c(\mathrm{t})$ with t = 0:0.001:1.).

(b) Generate three discrete-time signals $x[n]$ by sampling $x_c(\mathrm{t})$ with sampling period T = 0.01、0.05 and 0.1 second. Use stem function to plot these three $x[n]$ in subplot(3,2,1)、subplot(3,2,3) and subplot(3,2,5) in figure (2).

(c) After sampling, use the sinc function to reconstruct the continuous-time signal $y_c(\mathrm{t})$. Then, plot these three $y_c(\mathrm{t})$ in subplot(3,2,2)、subplot(3,2,4) and subplot(3,2,6) in figure (2).

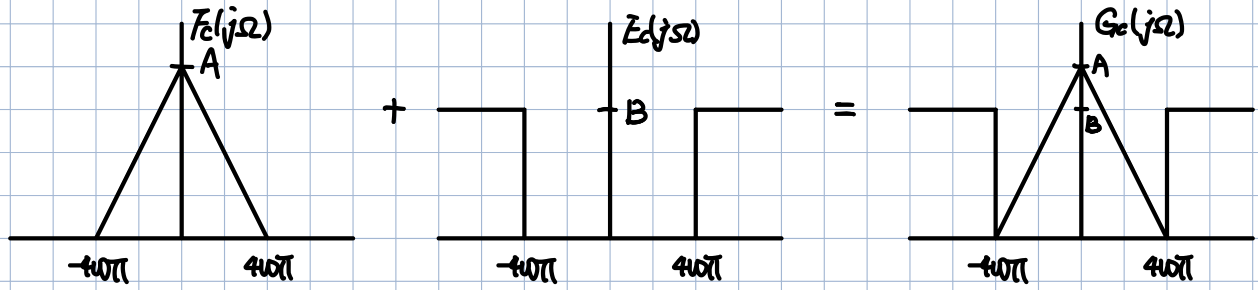
(d) Calculate the mean square error between $x_c(\mathrm{t})$ and three $y_c(\mathrm{t})$.

(e) When the sampling period T = 0.01, quantize the discrete-time signal $x[n]$ with 2-bit (4 levels)、3-bit (8 levels)and 4-bit (16 levels), and round the quantized signal $x_q[n]$ with offset (midrise).Use stem function to plot these three $x_q[n]$ in subplot(3,1,1)、subplot(3,1,2) and subplot(3,1,3) in figure (3).

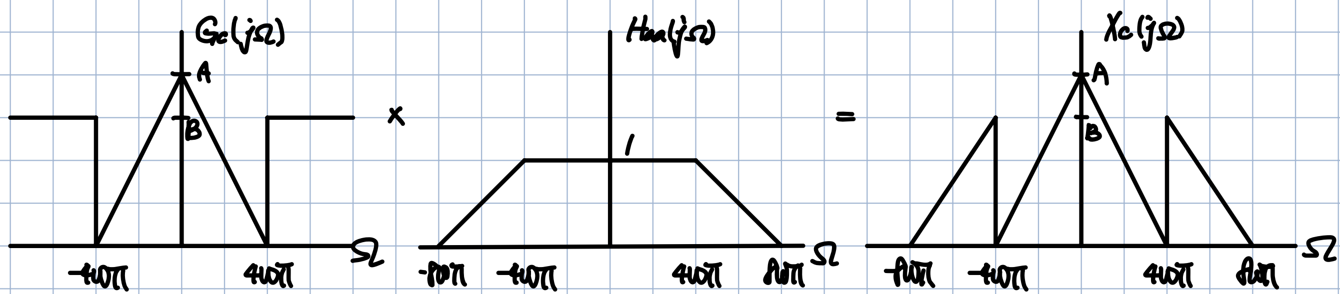
(f) Calculate the mean square error between $x[n]$ and three $x_q[n]$, and discuss the advantages and disadvantages for quantizing with different numbers of bits.

1.

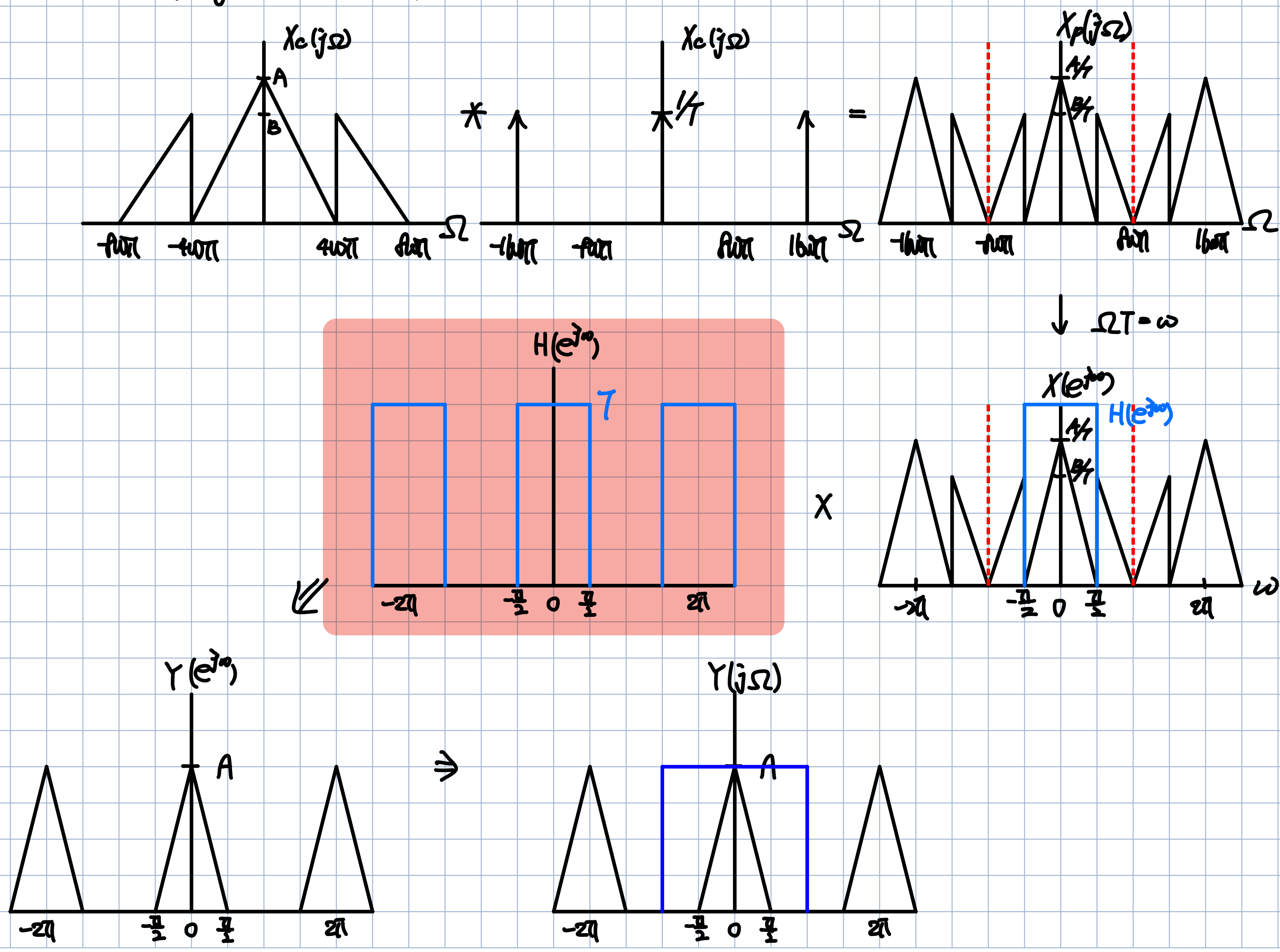
(a) $g_c(t) = f_c(t) + e_c(t) \Rightarrow G_c(j\Omega) = F_c(j\Omega) + E_c(j\Omega)$



$x_c(t) = g_c(t) * h_{aa}(t) \Rightarrow X_c(j\Omega) = G_c(j\Omega)H_{aa}(j\Omega)$



Sampling rate $\Omega_{samp} = \frac{2\pi}{T} = 1600\pi$, $x_p(t) = x_c(t)p(t)$



(b)

When $\frac{2\pi}{T} < 1600\pi$, aliasing will occur. The bandwidth of $x_c(t)$ ranges from -800π to 800π