Signals and Systems ECE 202
Assignment 13

Document and submit your analytic results. Also generate and publish a MATLAB document, where appropriate, for the following exercises. Submit your MATLAB html folder and original MATLAB code (m files).

1. Find the Nyquist rates (twice maximum frequency) for these signals

   (a) $x(t) = \text{sinc}(20t)$

   (b) $x(t) = 4\text{sinc}^2(100t)$

   (c) $x(t) = 8\sin(50\pi t)$

   (d) $x(t) = 4\sin(30\pi t) + 3\cos(70\pi t)$

   (e) $x(t) = \text{rect}(300t)$

   (f) $x(t) = -10\sin(40\pi t)\cos(300\pi t)$

2. Plot the magnitude of the CTFT of $x(t) = 8\text{rect}(3t)$. This signal is not band-limited, so it cannot be sampled adequately to exactly reconstruct the signal from the samples. As a practical compromise, assume that a bandwidth that contains 99 percent of energy of x(t) is great enough to practically reconstruct $x(t)$ from its samples. What is the minimum required sampling rate in this case?

3. How many sample values are required to yield enough information to exactly describe these band-limited periodic signals?

   (a) $x(t) = 8 + 3\cos(8\pi t) + 9\sin(4\pi t)$

   (b) $x(t) = 8 + 3\cos(7\pi t) + 9\sin(4\pi t)$

4. Repeat Example 7.8 (p 540-545), using MATLAB to reproduce Figure 7.66 - Figure 7.72.

5. Plot correlograms of the following pairs of CT and DT signals

   (a) $x_1(t) = \cos(2\pi t)$, $x_2(t) = 2\cos(4\pi t)$

   (b) $x_1[n] = e^{-(n/10)}\cos\left(\frac{2\pi n}{10}\right)u[n]$, $x_2[n] = e^{-(n/10)}\sin\left(\frac{2\pi n}{10}\right)u[n]$.

   (c) $x_1(t) = e^{-t}u(t)$, $x_2(t) = e^{-2t}u(t)$.

   (d) $x_1(t) = \cos(2\pi t)$, $x_2(t) = \cos^2(2\pi t)$

6. Find the autocorrelations of the following CT energy and power signals and show that, at zero shift, the value of autocorrelation is the signal energy of power, and that the autocorrelation function is *even*.

   (a) $x(t) = e^{-3t}u(t)$

   (b) $x(t) = \text{rect}((t-5)/5)$

   (c) $x(t) = \text{rect}\left(2(t-\frac{1}{4})\right) - \text{rect}\left(2(t+\frac{1}{4})\right)$

   (d) $x(t) = 5\sin(24\pi t) - 2\cos(18\pi t)$

7. Find the cross-correlations of the following pairs of periodic signals.

   (a) $x_1(t) = \text{rect}\left(\frac{t}{6}\right) * \text{comb}\left(\frac{t}{24}\right)$,
   $x_2(t) = \text{rect}\left(\frac{t-3}{6}\right) * \text{comb}\left(\frac{t}{24}\right)$

   (b) $x_1[n] = \sin^2\left(\frac{2\pi nt}{8}\right)$, $x_2[n] = \sin^2\left(\frac{2\pi nt}{10}\right)$

   (c) $x_1(t) = e^{-j10\pi t}$, $x_2(t) = \cos(10\pi t)$

8. Find the Energy Spectral Density (ESD) of the following energy signals.

   (a) $x[n] = A\delta[n-n_0]$

   (b) $x(t) = e^{-100t}u(t)$

   (c) $x[n] = 10\left(\frac{7}{8}\right)^n \sin\left(\frac{2\pi n}{12}\right)u[n]$

   (d) $x(t) = A\text{tri}\left(\frac{t-t_0}{w}\right)$

9. Find the Power Spectral Density (PSD) of these signals

   (a) $x(t) = A\cos(2\pi f_0 t + \theta)$

   (b) $x(t) = 3\text{rect}(100t) * \text{comb}(25t)$

   (c) $x[n] = 8\sin\left(\frac{2\pi n}{12}\right)$

   (d) $x[n] = 3\text{rect}_4[n] * \text{comb}_{20}[n]$