HW#2

due 24 June 2010

IMPORTANT In all the plots you produce, do not forget to label the axes properly. Mention all the units (sec, Hz, etc.). Otherwise, you will lose grades.

IMPORTANT If you feel uncomfortable with Matlab, you can study the Matlab tutorial provided in the Appendix for your textbook.

Question 1 - Sampling with different periods

Let

$$x(t) = 10cos(3t) \tag{1}$$

Consider the discrete signal $x[n]$ obtained by sampling $x(t)$ with sampling period T_s such that

$$x[n] = x(nTs) \tag{2}$$

for $-\infty < n < \infty$, $n \in Z$. For:

- $T_s = \frac{2\pi}{300}$
- $T_s = \frac{2\pi}{30}$
- $T_s = \frac{2\pi}{3}$
- $T_s = \frac{2\pi}{0.3}$
- $T_s = \frac{2\pi}{0.03}$

display the first 100 samples of $x[n]$ starting from $n = 0$. In other words, your plots should display $x[0] = x(0)$, $x[1] = x(Ts)$, $x[2] = x(2Ts)$, ..., $x[99] = x(99Ts)$.

Use the Matlab command **stem** while displaying the discrete signals. Comment on your observations.

Note: In the report, for this part, you should provide your code, 5 plots and your comments.

Question 2 - Beat Notes

Let

$$
\begin{aligned}
s_1(t) &= 5cos(2\pi 10t) \quad (3)\\
s_2(t) &= 3cos(2\pi 12t) \quad (4)\\
s_3(t) &= s1(t)s2(t) \quad (5)
\end{aligned}
$$

Plot all of these signals for $0 < t < 2sec$. Use a sufficiently small time increment (for instance, $\Delta t = 0.01sec$) so that your plots look nice. Generate these plots using the Matlab command **plot**. Be sure that your plots display the correct time values on the x-axis. Indicate the units on the axis labels.

Next, plot the spectrum representation of these signals. Do not forget to include the negative frequency components. Take the x-axis limits from $-35Hz$ to $35Hz$. A frequency increment of $\Delta f = 1Hz$ is acceptable. Generate these plots using the Matlab command **stem**. Be sure that your plots display the correct frequency values on the x-axis. Indicate the units on the axis labels.

Note: In the report, for this part, you should provide your code and 6 plots.

Question 3 - Fourier Series

Study section 3-6.1, 3-6.2 and 3-6.3 of your textbook. As you will see, a periodic square wave of the form

$$s(t) = \begin{cases} 1 & for 0 \leq t < \frac{T_0}{2} \\ 0 & for \frac{T_0}{2} \leq t < T_0 \end{cases} \quad (6)$$

and $s(t) = s(t + T0)$ can be written as

$$s(t) = \sum_{k=-\infty}^{\infty} a_k \exp(j\frac{2\pi}{T_0}kt) \quad (7)$$

where

$$a_k = \begin{cases} \frac{1-(-1)^k}{j2\pi k} & for k \neq 0 \\ \frac{1}{2} & k = 0 \end{cases} \quad (8)$$

Let us define $x_K(t)$ as:

$$x_K(t) = \sum_{k=-K}^{K} a_k \exp(j\frac{2\pi}{T_0}kt) \quad (9)$$

Take $T_0 = 1sec$. Within the time interval $[0, 3]$, display $x_K(t)$ for $K = 1, 5, 10, 30, 50, 100$. Use the Matlab command **plot**. A time increment of $\Delta t = 0.01sec$ is sufficient.

Comment on your observations.

(Note: $x_K(t)$ should be a real valued signal. But after your computations, due to very small numerical errors, Matlab may return you a complex valued signal. If you examine this signal carefully, you will recognize that the imaginary part only contains numerical values with amplitudes smaller than 10^{-12}. As stated above, such values are just due to inevitable numerical error, so they should be interpreted as zero. Therefore, if you get a complex valued signal, you should displays its real part. To get the real part, you can use the Matlab command **real**.)

Note: In the report, for this part, you should provide your code, 6 plots and your comments.