Homework 1 – Due Friday 9/18

In this homework we first ask you to check out some important manuals, and then review some of the basics in signals and systems. You should be able to complete this with knowledge from your prior courses, or from reviewing your old textbooks. The last part is some practice with fixed point arithmetic.

1. (6 pts) When working with a new device it is useful to collect and categorize relevant manuals provided by the manufacturer. This has been done for you for the TI C5510 DSP with the result being placed onto the class CD. Unfortunately, in spite of the availability of this collection, students often remain (un)blissfully unaware of what materials have been collected. Hence this part of the exercise.

   Given the manual literature number what is the manual relevant to? You do not have to list the full exact title just enough to indicate that you have at least looked at the title page. For example SPRU587E might provoke the acceptable response `DMA Controller Reference Guide`.

   (a) SPRU281E ______________________

   (b) SPRU328B ______________________

   (c) SPRU376A ______________________

   (d) SPRU592E ______________________

   (e) SPRU595C ______________________

   (f) SLWS106H ______________________

2. (8 pts) Given a waveform, $s(t)$, described by the equation $s(t) = A\sin(2\pi f_s t + \pi/3)$ what is

   (a) the peak-to-peak voltage

   (b) the magnitude

   (c) the rms value (show how you compute it)

   (d) the median amplitude over an integer number of periods

3. (15 pts) Consider an analog signal $x_a(t)$ with Fourier transform $X_a(f)$. Suppose the signal is sampled at a sampling rate of f_s. Assume ideal sampling is used, resulting in a sequence of samples $x(n) = x_a(nT_s)$, $n = -\infty, \cdots, +\infty$, $T_s = 1/f_s$.

   (a) What is the Fourier transform $X(f)$ of $x(n)$?

(b) Now we try to reconstruct the signal by zero-order hold D/A converter, where the reconstructed signal $x_r(t) = \sum_{n=-\infty}^{\infty} x(n)p(t - nT_s)$, and $p(t)$ is the retangular function used for interpolation by the zero-order hold D/A converter:

$$p(t) = \begin{cases} 1, & t \in [0, T_s); \\ 0, & \text{otherwise.} \end{cases}$$

Please derive the Fourier transform $X_r(f)$ of the reconstructed signal $x_r(t)$.

(c) Now consider reconstructing the original signal using a low-pass filter of bandwidth B. Assume the original signal $x_a(t)$ is a baseband signal with bandwidth W. Please give conditions on B, W, and f_s so that $x_a(t)$ is perfectly reconstructed using this low-pass filter.

4. (10 pts) Write the equations for the forward and inverse discrete Fourier transforms (DFTs). Indicate which is which. Don't forget to include the range over which the equations are valid.

5. (10 pts) A time waveform $x(t)$ is sampled at a rate of f_s for T seconds resulting in a set of N samples. The DFT is then taken of the N sample values.

   (a) How are f_s, T and N related (i.e., equation)?

   (b) What is the frequency spacing of the DFT?

   (c) What are the frequencies associated with the $k = 0$, $k = 1$, and $k = 2$ DFT values?

6. (10 pts) Consider the following C program.

```
#include <stdio.h>
#define MAX 6

void printA(int A[])
{
int i;
printf("A={%d", A[0]);
for (i=1; i<MAX; i++)
printf (", %d", A[i]);
printf("}\n");
}
```

```
main (int argc, char * argv[])
{
int A[MAX] = {0, 2, 4, 6, 8, 10};
int *b;
int c;

b=A;
printf("a: %d\n", *b);

b=b+2;
printf("b: %d\n", *b);

*b++=-2;
printf("b: %d\n", *b);
printA(A);

*b++=-4;
printf("b: %d\n", *b);
printA(A);

*b++=4* *--b;
printf("b: %d\n", *b);
printA(A);
}
```

(a) Show the printed result.

(b) Explain what happens in the last assignment statement (`*b++=4* *--b`). Consult the sheet of reference handed out in class.

7. (11 pts) Convert the following values as indicated.

(a) $34_{10} \rightarrow$ base 8.

(b) $34_{10} \rightarrow$ base 16 (hex).

(c) 1011 1101 (2's complement) → decimal.

(d) 1001 1011 (2's complement Q4) → decimal.

(e) 1101 1111 (binary unsigned) → base 16.

(f) $0xF001$ (unsigned hex) → base 10.

(g) $0xF001$ (2's complement hex) → base 10.

(h) $0xF001$ (2's complement hex) → 2's complement binary.

(i) −86 (decimal) → 7-bit 2's complement.

(j) -86 (decimal) $\rightarrow$ 8-bit 2's complement.

(k) $-1\frac{2}{5} \rightarrow$ 10-bit 2's complement Q6.

8. (10 pts) Consider the summation (in decimal) $3.25 + 7.5 + (-4.25)$. Assume we use 2's complement 6-bit Q2 to represent each number. Please calculate this sum in the following cases:

   (a) use 2's complement add without automatic saturation;

   (b) use 2's complement add with automatic saturation upon each addition;

   (c) take result from (a) and round to 4-bit Q0 using 2's complement rounding;

   (d) take result from (a) and round to 4-bit Q0 using convergent rounding.