NDSU ECE 444/644 : HW #3
Due: Mon., 10/5/2020

1. Book problem 2.7-6.

2. Book problem 2.7-14. Use 20 dB of stopband ripple.

3. Book problems 3.1-2(c,d,e) and 3.1-3(a,c).

4. Book problems 3.1-8 and 3.1-9.

5. Letting A and B designate the first two non-zero least significant digits of your NDSU student ID, define a $T = 40$ periodic signal $x(t)$ as

$$x(t) = \begin{cases} 0 & -20 \leq t < -(B+10) \\ -t/(B+10) & -(B+10) \leq t < 0 \\ 2t/(A+10) & 0 \leq t < A+10 \\ 0 & A+10 \leq t < 20 \\ x(t+40) & \forall t \end{cases}.$$

   In this problem, you will implement a method to output a periodic signal $y_K(t)$, the truncated Fourier series (FS) of the signal $y(t) = c_1 + c_2 x(c_3 t)$. That is, output $y_K(t)$ as $y_K(t) = \sum_{k=-K}^{K} Y_k e^{jk\omega_0 t}$, where Y_k are the FS coefficients of the signal $y(t)$.

   (a) Plot the signal $x(t)$ over 2 periods.

   (b) Determine constants c_1 and c_2 to maximize the output amplitude range of $y_K(t)$ yet provide some buffer against saturation and clipping.

   (c) Determine constant c_3 so that $y_K(t)$ has highest possible frequency yet maintains adequate signal quality for $1 \leq K \leq 10$.

   (d) Derive the necessary Fourier series coefficients Y_k. Create MATLAB plots of $y_K(t)$ over 2 periods for $1 \leq K \leq 10$.

   (e) Devise an algorithm to output the desired waveform on the K22F. Validate your algorithm with MATLAB code structured as close as possible to your final C-code implementation. For example, while MATLAB seamlessly supports complex numbers and vector operations, C does not. Thus, represent complex numbers in your MATLAB code using pairs of reals, and compute vector operations using explicit loops, just as you would in C. Of course, if you can devise a way so that you don't need to use complex numbers, that may be preferable...

   (f) Create a project in Keil to output your designed waveform.

   - Output $y_K(t)$ on the DAC channel at a rate of one sample every 0.1 ms (10 kHz sampling rate).
   - The number of terms K used in the approximation $y_K(t)$ must be run-time adjustable between 1 and 10. Adjust the number of terms through button presses (preferred method; one button to increase, the other to decrease) or watch-window (less preferred method).
   - Turn on an LED when you enter the ISR and turn the LED off when you exit the ISR.

   (g) To test your C program on the DSK, complete the following:

   - Verify the output waveform shape for each case using an oscilloscope. Most oscilloscope's in lab will calculate the period, frequency, amplitude and other information pertinent to a waveform automatically. Use these feature to appropriately measure your waveform. How close are your waveforms to theoretical?
   - Use an oscilloscope to measure the LED "on-time". What percentage of the available processing time is being used to generate your waveform? Does the processing time vary with K?

To receive credit for this part of the assignment:

(a) Sign up to demonstrate your working hardware to the course instructor for check-off.

(b) Summarize your approach, findings, and calculations in a short write-up.

(c) Attach a copy of your *properly documented* C-code.