MW 2411 Lab #3
Digital-to-Analog Conversion - DAC

1 Overview

In this lab, you will be introduced to the Digital-to-Analog Converter (DAC) on the Flex-UI/dsPIC33F board. The DAC provided by the Flex-UI board is a Microchip MCP4822. You must write a program that does all of the following (Task 1).

1. Configure the MCP4822 to perform three conversions in such a way that the outputs are 1V, 2.5V, and 3.5V. You must show the conversions using the oscilloscope.
2. After each conversion, you should have a delay of 500ms, 2000ms, and 1000ms, respectively. The delay must be implemented using a Timer and its interrupt.
3. You have to repeat the three conversions in an infinite loop and toggle LED1 in each iteration.

In addition, must analyze a recorded signal in MATLAB by removing noise and determining the frequency of the recorded signal (Task 2).

2 Procedure

Task 1: For the generation of signal, the following steps must be implemented on the Flex-UI/dsPIC33F board:

1. Before getting started, read sections 4.11 and 4.12 in the Laboratory Manual, and the MCP4822 datasheet (especially Section 5 and Section 1: AC Characteristics (SPI Timing Specifications)).
2. You can find an MPLAB X IDE project with template code on the Moodle course page.
3. A demonstration version of the Lab 03 program that you now need to write is provided in compiled form.
4. Update lab03.c such that it fulfills the requirements specified in the Overview section.
   (a) DAC configuration.
      i. Set the proper digital Pins (three pins) to output, as discussed in section 4.11 (this should be done only once).
      ii. Set a reasonable default state (see Section 5 of the MCP4822 datasheet).
      iii. Clear the CS bit before starting a conversion (look at Table 7 in the lab manual to check the bits and ports).
      iv. Now in a loop send the conversions command value (data format described in the MCP4822 datasheet: Section 5, Register 5-1, Figure 5-1, most significant bit first):
         A. Set the SDI bit according to the current bit of the command value

B. Toggle the serial clock, use the SCK bit (SETBIT and CLEARBIT), inserting a Nop() instruction between both (see MCP4822 datasheet Figure 5-1)

v. After the sending clear CS bit

vi. Clear Data Bit (SDI), insert a Nop() after

vii. Toggle the (inverse) LDAC signal, use the LDAC bit (CLEARBIT and SETBIT, with two Nop() in between, see Section 1: AC Characteristics (SPI Timing Specifications)

(b) Remember to insert a Nop() between subsequent Write and Read operations to the same IO port.

(c) The see the output of DAC channel A connect a jumper cable to Pin 5 (DAC_CHAN_A) of Jumper J3 and one jumper cable to Pin 8 (GND) (see Table 8 in the lab manual).

Task 2: The signal processing and analysis of sine waves consists of the following steps to be implemented in MATLAB (use the template `Lab03_Matlab_Signal_Processing.m`):

1. You do not need to record the signal on your own, use the provided signal called `signal.csv` and load it into MATLAB using the `readmatrix()` command. Plot the signal.

2. Design a Butterworth filter. You can use the built-in functions of MATLAB. You must identify the sampling frequency of the signal based on the information given in `signal.csv`. The following characteristics must be fulfilled by the filter you design:

   (a) The passband ends at 30 Hz with an attenuation of maximal 3 dB.

   (b) Some noise is expected in the range of above 200 Hz. These high-frequency components must be reduced by at least 40 dB.

3. Apply the filter to the input signal and plot both the original and filtered signals in the same figure. Add a title, the axis descriptions, and a title to the figure.

4. Fourier transform the *original* signal using MATLAB's built in functions. See the `doc` call and the course slides about how to apply an FFT, e.g., type `doc fft` in the command window. Note that we are only interested in the single-sided frequency spectrum. Plot the resulting spectrum. Take care to remove the DC signal, i.e., the offset V_{offset} by calculating the mean value of the signal. Plot the obtained spectrum into a new figure; only visualize the spectrum up to 500 Hz. Subsequently, Fourier transform the *filtered* signal and plot it into the same figure. Did the filter remove the high-frequency components?

5. Write a function that determines the frequency of harmonic signals (you can assume there is only one harmonic wave in the signal). What is the frequency of the recorded signal provided for analysis in this assignment? Print your result. Note: MATLAB requires to define functions at the end of a script.

The due date of code submission can be found on the Moodle submission page for this lab. Only one member of the group must upload the code (all .c, .h, and .m files that your project uses compressed in one zip file). At the start of Lab 4, each lab group will be asked to demonstrate and explain their Lab 3 code to the lab instructor.

3 Questions to Ponder

The following questions are provided for your lab group to think about. No written response is required.

1. How many different values can be converted by the MPC4822 DAC?
2. How can we increase the precision of a DAC?
3. What would happen if you do not remove the mean (DC signal part) of the signal before the FTT, i.e., how would the plot of the frequency spectrum look?