Lab 4 – Data Conversion: Analog-to-Digital and Digital-to-Analog

1 Introduction

PSoC, along with Arduino and many other MCUs, provides multiple digital-to-analog and analog-to-digital converters. These data converters can be critical in many applications for reading sensors, driving actuators, gauges or lights or for enabling real-time digital signal processing.

2 Procedure

You will design a PSoC based system to perform real-time digital signal processing. The goal will be to extract a pure sine wave from a triangle wave. The range of frequencies that your system must operate over is:

200 Hz to 20 KHz

1) Find the Fourier series representation of a triangle wave, at the maximum frequency
2) Design a suitable analog lowpass filter that will remove some of the high-frequency energy from the maximum frequency triangle wave. Design an analog reconstruction filter to reduce the "stairstep" reconstruction errors at the digital-to-analog converter, which are due to spurious spectral images. There are no "correct" answers, but filters with nominal cutoffs at half the sampling rate (or even less) might be a good start.
3) Research the Nyquist criterion, and determine an appropriate sampling frequency. You will need to justify your choice. There is no one "correct" answer. In general, a higher sampling frequency will result in less "aliasing" distortion.
4) Investigate the various data conversion components available in PSoC Creator. Build a PSoC project that includes an analog-to-digital converter and a digital-to-analog converter.
5) Read each digitized input sample in software, and pass it through an algorithm that will tend to convert your triangle wave to become more sinusoidal. Research algorithms, try things, and do the best that you can.
6) Send your processed samples to the digital-to-analog converter for reconstruction.
7) Observe/record your output when the input is a triangle wave at:
    a. 200 Hz
    b. 2000 Hz
    c. 20,000 Hz

    Record both the input and output waveforms, and waveforms before and after the analog filters. Use the "FFT" feature on your scopes to record frequency spectra – your goal is a single spectral line!

8) Tune your filters and components to get the best possible output quality

3 NOTES

1) You will need to pay attention to the signal amplitude and offset. The PSoC ADC cannot handle negative signals, and it has a limited rage.
2) If your amplitude is too small you will obtain too much "quantization noise" due to the finite precision data conversion components.

4 WRITE A REPORT

The report is to include, but not limited to the following:

a) **Cover Sheet** with Title, Class, Names, etc.
b) **Introduction**.
c) Brief recap of **Procedure**.
d) **Design** information – explain your choices and give full documentation: schematics (both PSoC schematics, and your own circuit schematics), equations, etc. You can paste in code snippets, but use mono-spaced font and ensure that code is well formatted. Include any equations or other relevant information that helps you to explain what, why and how you did what you did.
e) **Results**, presented in tables, figures, or other organized means, and a discussion of the results that you obtained. You should include your debug experiences under **Results**.
f) The report must be understandable to another engineer not working on this project.
g) A conclusion of your results and discussion of anything you found especially interesting or not expected from your work on this project.

REPORT NOTES:

- One report per team
- You may use the IEEE paper format, if you like: (template is 2014_04_msw_usltr_format.doc). In this case the cover sheet info is embedded at the top.
- Microsoft Word, .docx file.
- Upload via GitHub (**one upload per team**).
- Also upload all code files that you wrote, or hand edited (and **only** those files!), via GitHub (**one upload per team**).