Lab 3: Interfacing DAC with TIVA

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I Objective

To setup the TIVA board and interface it with the LTC 1661 DAC. To use the DAC to generate sine/cosine waves and view on the oscilloscope.

II Circuit diagram

The interfacing of the LTC 1661 DAC to the TIVA-C microcontroller is shown in Fig. 1. The chip select bar, serial clock and serial data in is given to the DAC as inputs from the TIVA microcontroller. The reference voltage and VCC are given to a +5V power supply, and common ground is given between the TIVA and the DAC. Since the LTC 1661 consists of 2 10-bit DACs, two outputs can be seen simulateneously. Pins 5 and 8 provide the two sets of outputs, which can be used to view the waveforms on the oscilloscope.

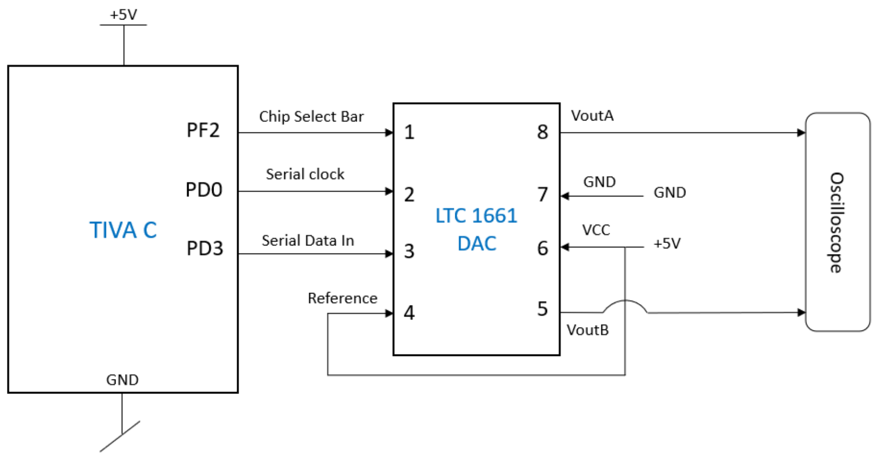

Figure 1: Interfacing the LTC 1661 with TIVA-C microcontroller

The range of output from the DAC goes from 0 to Vref (here, 5V). Since this is a 10-bit DAC, the input digital range goes from 0 to 2^{10} - 1 (1023). Additionally, based on the output frequency of the waveform, the sampling frequency of the DAC is decided.

III Design

3.1 Sampling frequency

We require a 50 Hz output sine wave. The time period of the output sine wave is

$$T = \frac{1}{f} = \frac{1}{50} = 0.02sec \tag{1}$$

Let us consider 128 samples given as digital input to the DAC. Hence, the time between each sample will be

$$Ts = \frac{0.02}{128} = 0.15625ms \tag{2}$$

$$\therefore Sampling\ Frequency, fs = \frac{1}{0.15625m} = 6.4KHz \tag{3}$$

3.2 Generation of samples for sine/cosine wave

We have considered a full-range output amplitude (0 - 5V) for the sine and cosine waves. Hence, the digital input range will be from 0-1023. Since a sine wave has a range of -1 to +1, it needs to be scaled and shifted to produce the range 0 to 1023. This can be achieved using the below expression

$$y = 512 + 512.sin(t)\ ;\ 0 \leq t \leq 2\pi \tag{4}$$

This expression is used in MATLAB to generate the digital samples, which are given to the DAC through the serial data in port.
The above expression generates a sine wave only. In order to generate a cosine wave, we need a phase shift of 90°. This can be achieved by simply providing sample points for the cosine wave that are at 90° shift compared to sine wave. Since we have used 128 samples here, a 90° phase shift would correspond to a shift of 32 (128/4) samples.

3.3 TIVA Programming

The TIVA microcontroller was configured to enable the required GPIO pins(PF2, PD0 and PD3) and set them as outputs. PD0 and PD3 are used to provide the serial clock and serial data to the DAC. Hence, they are assigned to the SSI (synchronous serial interface) present on the TIVA, and configured as SSI clock and SSI transmit pins respectively. The source for the clock was set as the system clock (16 MHz), and divided by 2 to produce an 8 MHz serial clock.

The samples generated by equation (4) were stored in an array in the form of a look-up table, to send to the DAC. In order to achieve the required sampling frequency, a timer interrupt was used. The system timer on the TIVA (Systick) was configured to run on the system clock (16 MHz). This timer can be configured to generate an interrupt everytime it reaches a particular count value. The time period of the systick timer is

$$Tt = \frac{1}{16M} = 0.0625\mu s \tag{5}$$

Hence, to produce an interrupt every 0.15625 ms (sampling time as per equation (2)), the count value required is

$$Timer\ reload\ value = \frac{0.15625m}{0.0625u} = 2500 \tag{6}$$

Using the above count/reload value, the Systick timer was configured to generate an interrupt every 0.15625ms, which is the required sampling time for an output frequency of 50 Hz. When the interrupt is generated, an ISR routine is called, in which the next sample of sine and cosine is sent to the LTC 1661 DAC.

IV Observations and Results

The required configurations and programming was carried out to generate a sine and cosine wave on the two output channels of the DAC. The results as seen on the oscilloscope is shown in Fig. 2.

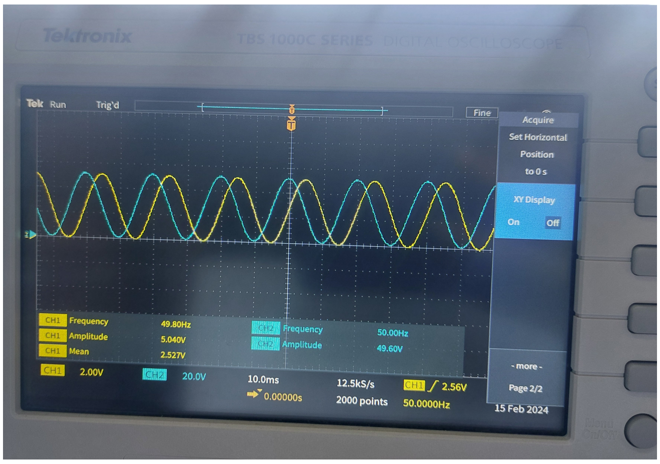

Figure 2: Sine and cosine waveforms from the output of the DAC

V Conclusion

The LTC 1661 DAC was interfaced with the TIVA-C microcontroller to generate required analog waveforms. The output amplitude can be controlled by the input digital range, whereas the output frequency can be controlled by modifying the sampling frequency of the microcontroller. In the case of the sine and cosine waves, it was seen that accurate results were obtained with 128 samples. The in-built timer of the TIVA is useful in generating samples at exact sampling time intervals. It was also seen that any X-Y plot can be generated by providing corresponding digital input samples to the TIVA.