Analog to Digital Conversion and Sampling
Circuits & Signals
EECE2150

Michael Brodskiy

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Partner:	Juan Zapata
Instructor:	Professor Sun

0 Introduction

The purpose of this laboratory experimentation is to familiarize oneself with analog to digital converters, as well as using said converters for real-world sampling. The analog to digital converter (ADC) was used to generate various waveforms, as well as receive a real-world sound signal.

1 Code Integration

Listing 1: Code Used to Integrate ADC

```
%{
daq.getDevices()
s = daq.createSession("ni");
ch = addAnalogInputChannel(s, "Dev5", "ai0", "Voltage");

sub = ch.Device.Subsystems;
s.Rate = 1000;
s.NumberOfScans = 2000;
data1k = s.startForeground();
%figure;
%plot(data, ".-");

dt = 1/s.Rate;
t_end = double(s.NumberOfScans) * dt;
time = [dt:dt:t_end];
figure;
```

```
plot(time, data20k, "r.-");
xlabel("Time(s)");
ylabel("Input Signal (V)");
title("20kHz Sound Sample");
%}
%soundsc(data20k, 20000);
%soundsc(data5k, 5000);
soundsc(data3k, 3000);
%soundsc(data1k, 1000);
%soundsc(data20k, 20000);
```

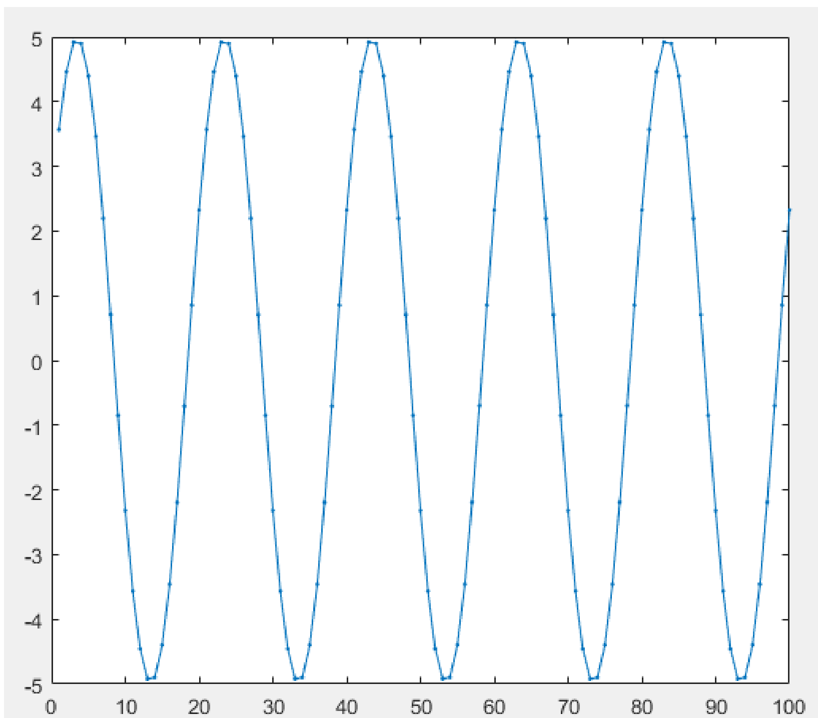

Figure 1: A Generated Test Waveform

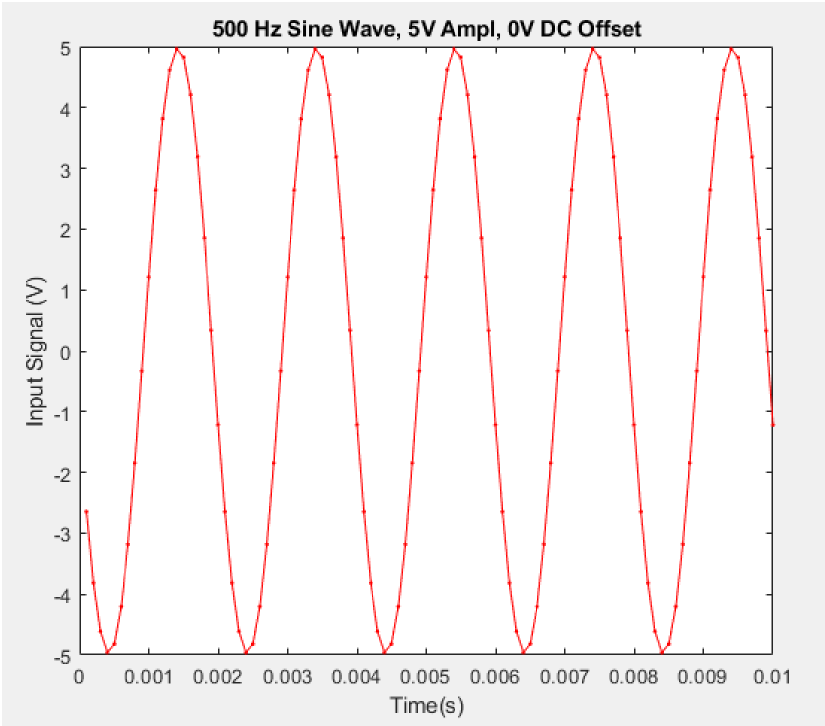

Figure 2: Initial Waveform Configuration

2 Part III[1]

2.1 1

2.1.1 i

2.1.2 ii

The generated waveform, pictured above in Figure 3, matches our expectations. It has approximately .1[mV] of amplitude, and a period of .005[s], which is expected. Additionally, there is no vertical DC shift.

2.1.3 iii

There appear to be no problems with the waveform, other than that the graph does not appear to be entirely smooth.

[1]Parts I and II contained no questions, and, as such, were omitted

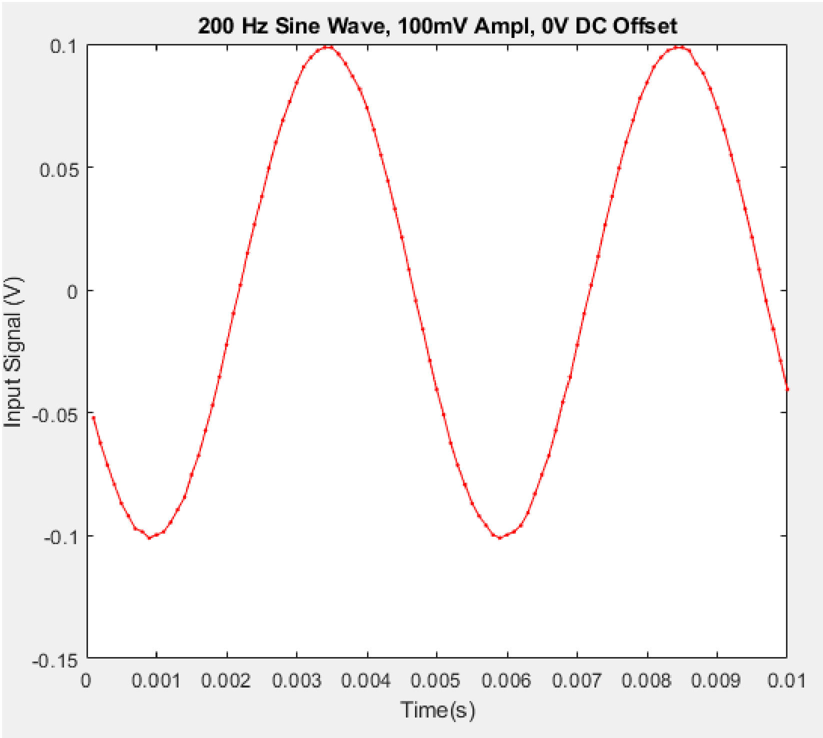

Figure 3: Waveform Generated in Configuration 1

2.2 2

2.2.1 i

2.2.2 ii

The graph does not match our expectations perfectly; though the amplitude and period are correct, there is what appears to be a DC offset, as well as very low image quality.

2.2.3 iii

The problem is caused by the fact that the ADC can not draw changes in voltage that are that small, which makes the graph choppy and rounds down the voltage to the closest step.

2.2.4 iv

The problem can most likely be solved only by increasing the voltage.

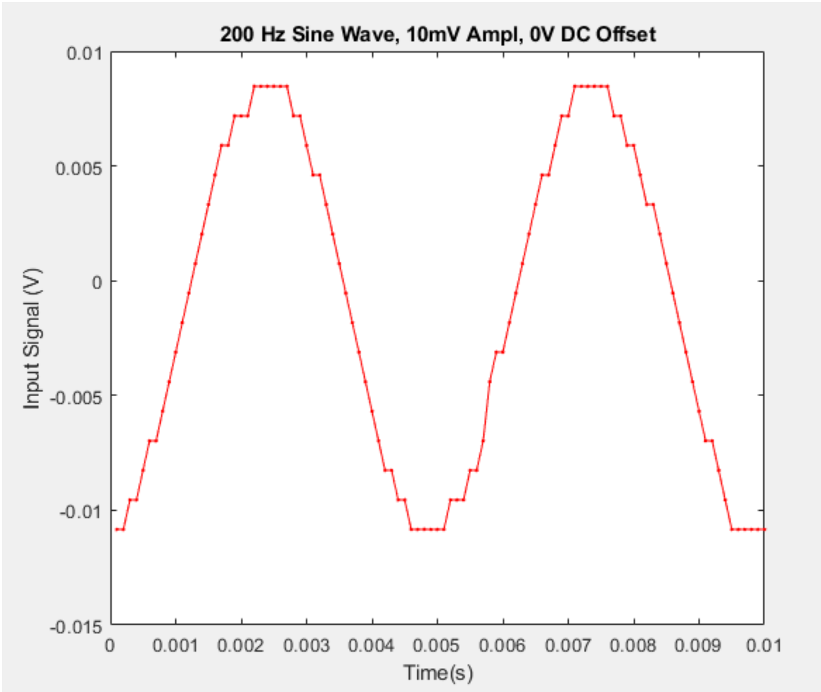

Figure 4: Waveform Generated in Configuration 2

2.3 Q1

A 14-bit register may hold:

$$2^{14} = 16384 \text{ values}$$

The step difference would be:

$$\frac{20}{2^{14}} = 1.22 \cdot 10^{-3} [\text{V}]$$

This explains the above observations, as there are 8 distinct voltage levels in the interval $V = (.1, 0)$. By calculating this, we obtain:

$$\frac{.01}{8} = .00125$$

This value is very close to the estimated step above, which explains why the plot can only plot certain values within this step range.

3 Part IV

3.1 Q2

Because the noise being heard is within human range, it has to be somewhere from $20 - 20,000$[Hz]. More specifically, it is most likely between $2,000 - 5,000$[Hz] because this range is most easily audible for humans.

3.2 Q3

In order to best measure the amplitude of the signals, it is best to sample at least 10 times as much as the greatest frequency of the noise. This would explain why the 20k recording sounded similar to the original noise, but the 5k, 3k and 1k recordings are very different.

3.3 Q4

This explains our results, as, because the noise is most likely in the range of $2,000 - 5,000$[Hz], 20k is the only sampling rate close enough to adequately record the noise.

4 Conclusion

Overall, this laboratory experiment introduced us to the concept of analog to digital converters (ADCs) through the use of MATLAB integration. This, together with the real-world examples involving various noises and frequencies, provided an adequate foundation for ADCs.