ECE2170: Measuring external waveforms with the Red Pitaya

# Goals:

View external signals via the red pitaya, and identify various physical phenomena associated with discrete time systems.

# Tasks/Questions:

For these tasks, you will be viewing multiple waveforms with the Red Pitaya’s Web applications. We will be providing external signals via the provided USB soundcard in the lab kit, the Red Pitaya’s DAC, and optionally, the PC’s native soundcard via the provided MATLAB script. Instructions are contained in the slides, and provided MATLAB mlx script.

## Single channel analysis

**For all of this analysis, set the second channel to output all zeros in MATLAB, as described in the slides and class time instruction.**

### Audio DAC Bandwidth

We have mentioned that audio devices tend to have bandwidth limits in the range of 20kHz due to their sample rate. Let’s experimentally observe this. Using a pure sine wave tone with sufficient amplitude.

1. Show at least one plot demonstrating aliasing in the time domain, and frequency domain.
2. Observe the frequency of the aliased wave appears to have, and comment on what you estimate to be the sample rate (bandwidth) of the card.

Hint: One way to do this is to step through each of the following example frequencies (for example like those given in the table below), and look for when the measured frequency doesn’t match the expected frequency.

|  |
| --- |
| Frequency (kHz) |
| 18 |
| 19 |
| 20 |
| 22 |
| 23 |
| 24 |
| 25 |
| 30 |

### Audio DAC Bit depth and quality

In addition to a sample rate, Audio DACs have a known number of quantized states. We will observe how this can appear by using multiple DACs, and why the rule of thumb of more bits is better is usually true.

For all tests, use a sinewave excitation signal with a frequency of 1kHz. For each sinewave, analyze the samples through both the time and frequency domains.

### USB Soundcard

1. Time domain
2. Frequency Domain

#### (optional) Higher frequency output

As an optional demonstration, set the output frequency to be 10kHz on the Soundcard. Comment as to what appears to be occurring, and if there is any unusual behavior observed. Speculate as to the origin of the atypical behavior if any is observed.

1. Time domain
2. Frequency Domain

### PC Soundcard

1. Time domain
2. Frequency Domain

### (Optional) Red Pitaya Output

The Re Pitaya also has a DAC, which is what the analog outputs employ. We have already viewed some of the signals of the Red Pitaya before, but now let’s examine them for quantization artifacts. For this, configure the red pitaya in the usual Loopback configuration using the SMA cables we have previously used, and configure the output to the same 10kHz sinewave.

1. Time domain
2. Frequency Domain

## Dual Channel analysis

**For all of this analysis, both channels will have non-zero values in MATLAB.**

### Cross talk

We previously observed the effect of cross talk between input channels of the red pitaya. Let’s try to better quantify this now that we can load the waveforms in MATLAB. To Do this, we will setup the soundcard to output two (2) sinewaves of differing frequency, one on each channel, and measure the spectrum of one channel for content of the other.

Capture the cross talk behavior on the red pitaya’s web interface before attempting the MATLAB processing to ensure you can see the cross talk visually. Label in each screen the feature caused by cross talk.

1. Red Pitaya - Time domain
2. Red Pitaya Frequency Domain

After this, acquire the data through MATLAB, and use the variable **ch\_1\_data** to show the effects of cross talk. (Hint, for the frequency domain, plot the amplitude spectrum, and compare the relative magnitudes of the frequency bins in both frequencies)

In the frequency domain, calculate the ratio of strength (in linear and dB) of the fundamental frequency to the ratio of the strength of the frequency of the other channel. Do this for both channels, and comment on any observed asymmetry.