Lab 1 Report

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Problem 1: Sine Wave Generation

To generate a 1.2 kHz sine wave while operating at a sampling rate of 12 kHz, a sine wave of ten samples per period is needed. The ten sampled are stored in a lookup table and output to the right channel lineout jack of the LCDK. At each sample, the index for the lookup table is incremented by one. When the index exceeds the length of the lookup table, a period of the sine wave is completed and the index variable is set to zero. The values of the lookup table are computed as $sin(2\pi k/10)$ for $k = 0, 1, ..., 10$ where k is the index of the lookup table. Shown in the figure below is the oscilloscope reading of the sine wave generated.

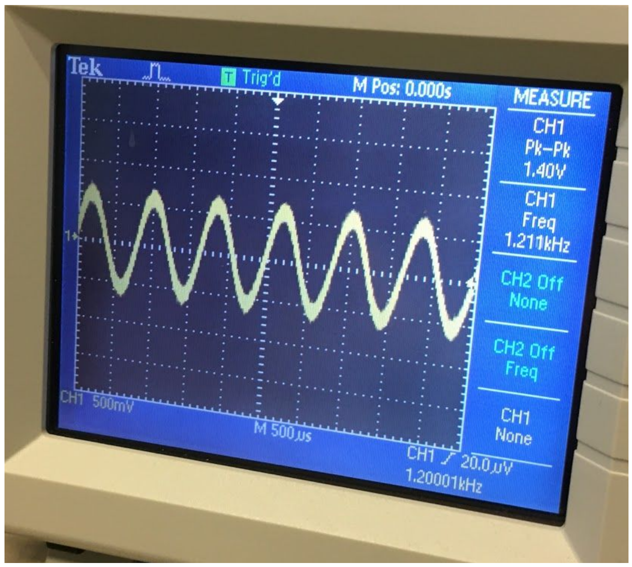

Figure 1: Oscilloscope reading of the sine wave generated.

Below is a GUI that displays the amplitude of the sine wave changing in real-time (with some lag due to the GUI Composer's refresh rate).

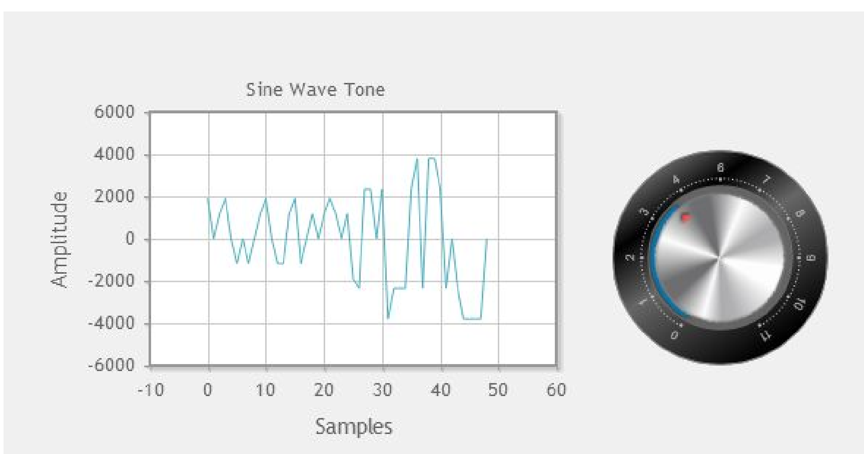

Figure 2: GUI display of the same sine wave responding to a real-time increase in volume.

If the sampling rate is doubled from 12 kHz to 24 kHz, the ten samples which contain a full period of the sine wave will be repeated twice as often. As a result, the frequency will double as the number of times a complete cycle is output will have also doubled. The new sine wave then has a frequency of 2.4 kHz.

Problem 2: DIP Switch and LED

The sine wave generated in Problem 1 was set to be controlled by a DIP switch, with an LED set to light up when the sine wave is activated. This was done by reading the switch value, enabling the LED if the switch is up, and disabling the LED and writing zero to the codec data if the switch is down.

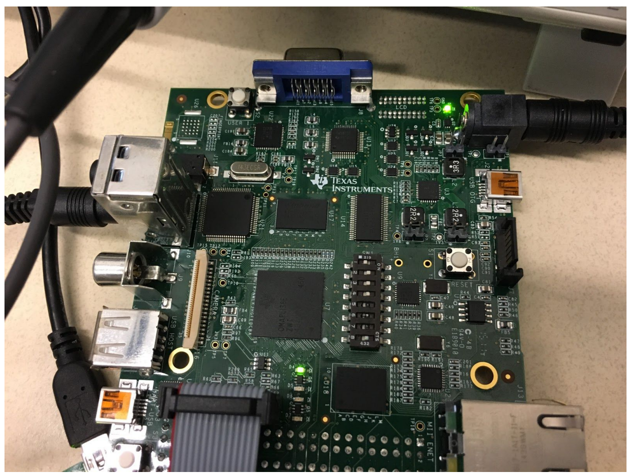

Figure 3: The LCDK board with the D4 LED on, indicating that the DIP switch SW5 is on (up) and the sine wave is enabled.

Problem 3: Line input/output

In Problem 3, we wrote a C program to implement a two channel music player. With two DIP switches, the program controlled whether either lineout channel was on or off. The DIP switch SW6 controlled whether the left channel was enabled while SW7 controlled the right channel. Like in Problem 2, when the DIP switch was in the up position, the switch was considered to be on and vice-versa. This music player implementation allowed music or other audio to be played, with the linein receiving the audio as an input, and transmitting either both (stereo), either (mono) or neither (off) of the audio channels. The LEDs D4 and D5 indicated whether the left and right channels were active, according to the position of the switches. Figure 4 below demonstrates

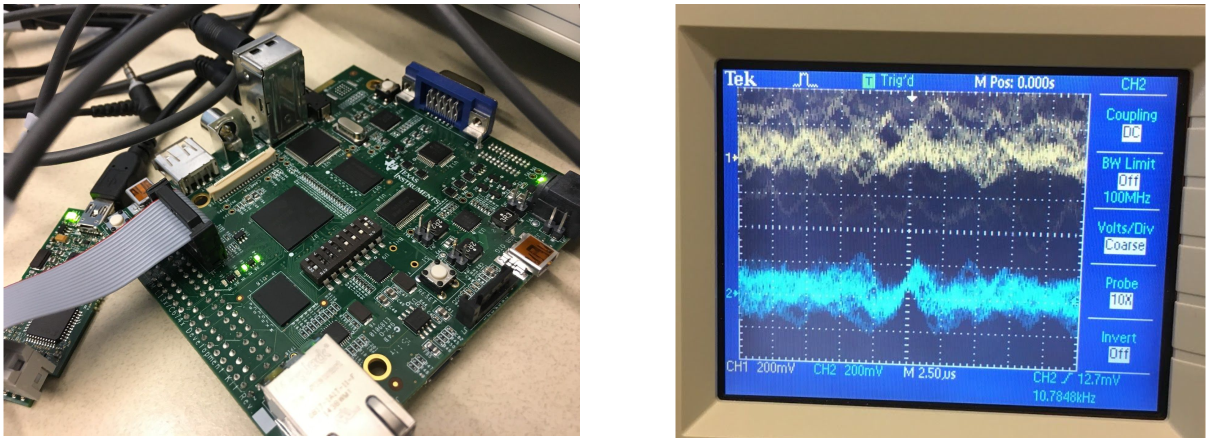

Figure 4: (Left) The LCDK board with the D4 and D5 LEDs on, indicating that the DIP switches SW6 and SW7 are on (up) and both output channels enabled. (Right) The oscilloscope corresponding to the stereo audio/music input and output.

Problem 4: GUI Composer

A signal consisting of the sum of three sine waves of differing frequencies was generated and visualized using a GUI. The sine waves had frequencies of 12 kHz, 8 kHz, and 4.8 kHz and variable amplitudes which are referred to as α, β, γ, respectively. The amplitudes for each sine wave was set to be controlled by dials on the GUI and the amplitude of the signal was visualized as shown in Figure 5.

As the values on the dials are changed, the amplitude of some frequencies become more dominant. For example, the upper left plot shows the sum of two frequencies, which are higher in frequency than the upper right plot that shows the same signal in the upper left summed with a lower frequency sine. A pure sine wave of 8 kHz and 4.8 kHz is shown the lower left and lower right, respectively.

For further confirmation, Figure 6 shows the output signal if all the sinusoid component weights are unity. Notice how Figure 6 is nearly identical to Figure 5's top-right GUI plot. The generated sinusoidal signals were also verified using an oscilloscope as seen in Figure 7.

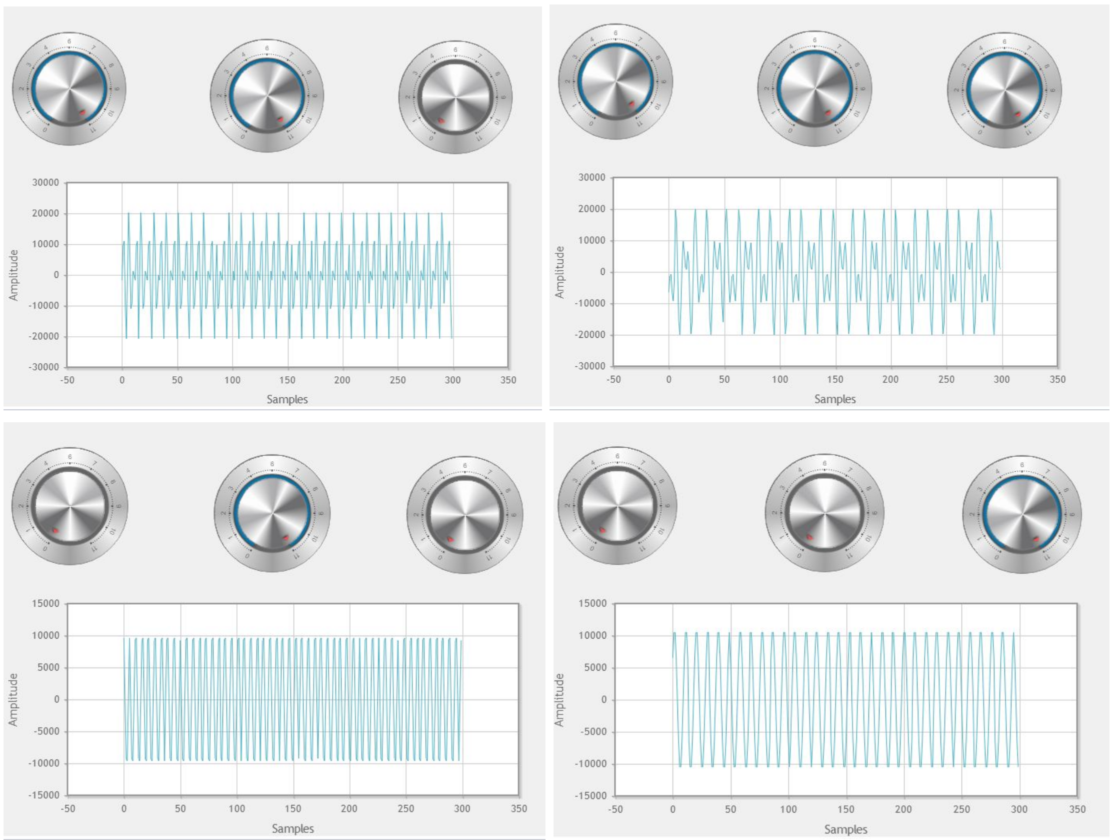

Figure 5: GUI visualizations for: (top-right) equally weighted α, β sinusoid components; (top-left) equally weighted α, β, γ sinusoid components; (bottom-left) only β weighted sinusoid component; (bottom-right) only γ sinusoid component.

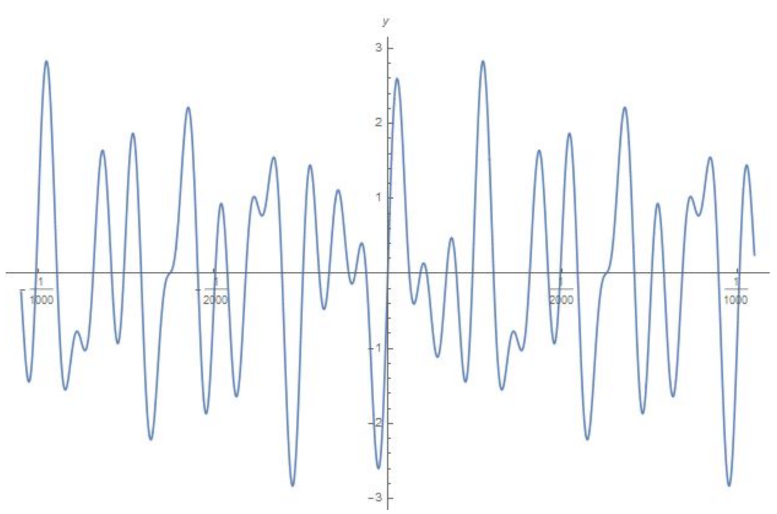

Figure 6: Plot of $y = \alpha sin(2\pi f_\alpha t) + \beta sin(2\pi f_\beta t) + \gamma sin(2\pi f_\gamma t)$, where $\alpha = \beta = \gamma = 1$ and $f_\alpha = 4.8\ kHz,\ f_\beta = 8\ kHz,\ f_\gamma = 12\ kHz$.

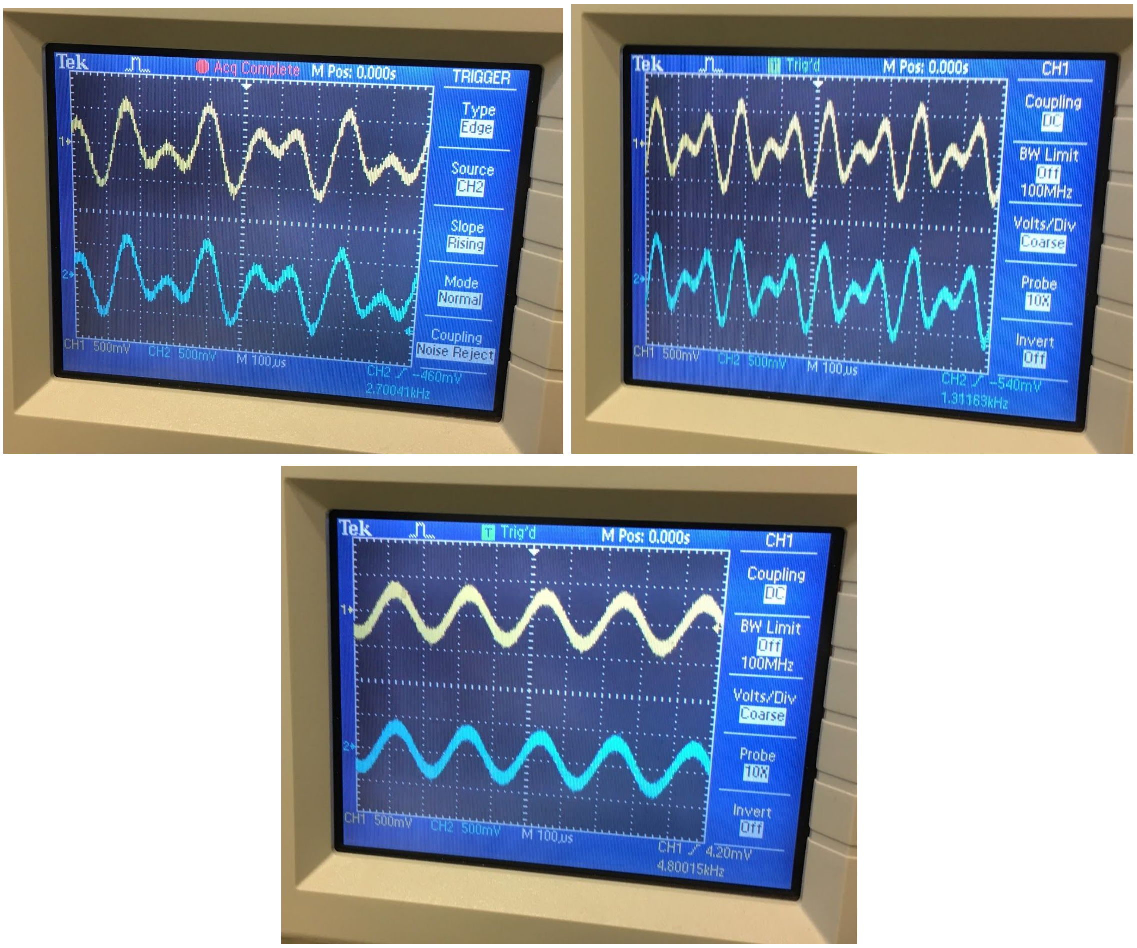

Figure 7: Oscilloscope displays for: (top-left) equal α, β, γ weighted sinusoid components; (top-right) only equal α, β weighted sinusoid components; (bottom) only α weighted sinusoid component.

Problem 5: Microphone Input and AM

For the final lab problem, the LCDK was programmed to implement the amplitude modulation (AM) of an input audio signal. The frequency of the sinusoidal carrier signal was set at 800 Hz and the input audio signal was sampled at 24 kHz. For computational efficiency, a lookup table was calculated for 30 samples. We arrived at 30 as the number of samples N using the formula $N = F_s/f$, where F_s is the sampling frequency and f is the desired carrier signal frequency. The oscilloscope reading of the carrier signal is below in Figure 8.

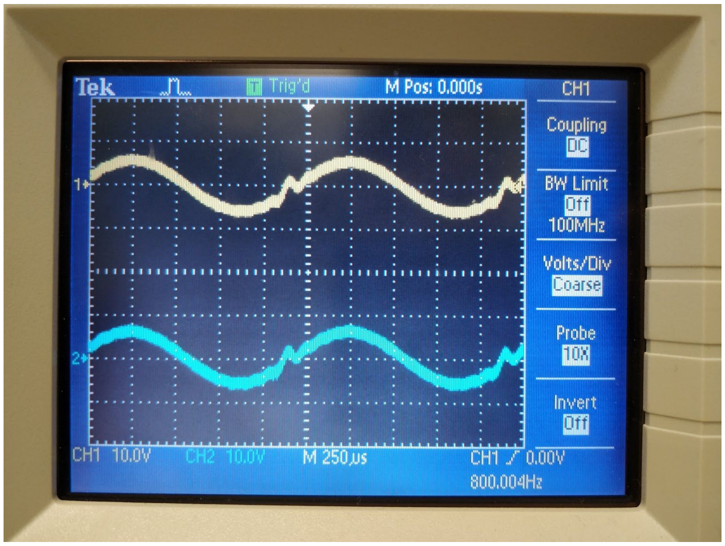

Figure 8: Lookup table 800 Hz sine wave carrier signal read by oscilloscope.

The AM output signal $x(n)$ is defined by $x(n) = c(n) \cdot s(n)$, where $c(n)$ is the carrier signal and $s(n)$ is the input signal to be modulated. In the case of this problem, the input audio signal was the output of a microphone. Note that in the following figures, the input signal is not from a microphone but rather music (at the time of testing, all microphones were in use). A modulated output signal can be found below in Figure 9. As should be expected, when there was no input signal, there was no output signal. By qualitative inspection with headphones, the output signal was an amplitude modulated version of the input music signal. For example, the voice of the singer was modulated to the lower frequency carrier signal.

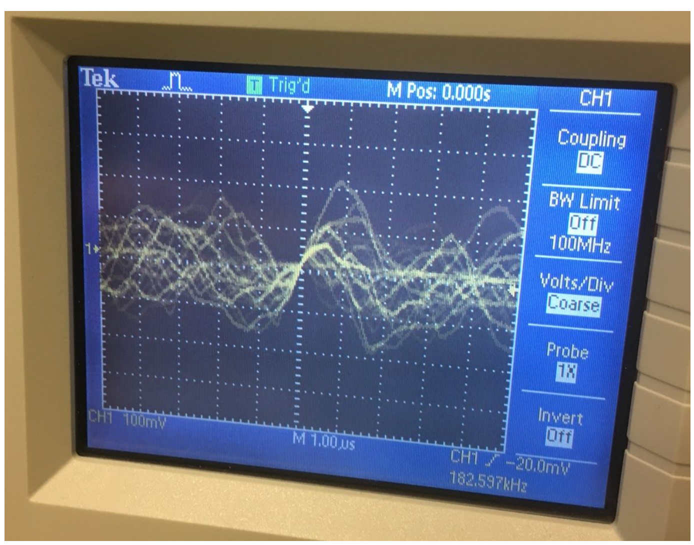

Figure 9. Oscilloscope measurement of amplitude modulation of a music signal.