CENG 448/548 — Real-Time Operating Systems

South Dakota School of Mines & Technology

Laboratory Assignment Five

The goal of this lab is to create a device driver without any pre-existing code. You will have to read the LDP-001 Pulse Modulator (PM) device manual (available under “resources” on D2L). Use the API that is suggested in the manual. You will write the complete driver, including the ISR, to provide the suggested functions.

Part 0: Write the Driver

Copy your project directory into a new directory, or download and use the instructor’s code. Create the driver and add it to your project. The 16550 UART and AXI timer drivers should give you some ideas for how to do that.

Part 1: Test the Driver (basic)

Create a new task in your project (`PM_test_task`) and comment out the nInvaders task. We will work with this new task to develop and test the PM driver code.

1. Have the task configure PM channel 1 for 100 Hz base frequency with 1000 divisions, and set it for 50% duty cycle. Use the oscilloscope to verify that your settings are correct. Next, set it for 0%, 25%, 75%, and 100% duty cycles and verify each one with the oscilloscope. Note that the oscilloscope has the ability to calculate and display the frequency and duty cycle for you.
2. Use a second probe connected to channel 2 to repeat all of the previous experiments with channel 2 using Pulse Density Modulation mode. Compare the waveforms between channel 1 and channel 2. You can display both of them on the oscilloscope at the same time. For a stable display, you should set the oscilloscope to trigger on the PWM signal, and not the PDM signal.

Part 3: Show the Effect of a Low-Pass Filter

Use a third probe to repeat all of the above experiments using pulse modulator channel 0 in **PWM** mode. There is a test point on the board near the audio jack, where you can acquire the signal.

1. Compare to the other two channels with all channels set for a 100 Hz base frequency. Do you notice anything different about the waveforms?

2. Increase the base frequency for all channels to 3 KHz and repeat the comparisons at each of the five duty cycle settings. Do you notice anything different about the waveforms?

3. Run the experiments again with a base frequency of 30 KHz. Do you notice anything different about the waveforms?

Repeat the experiments using pulse modulator channel 0 in **PDM** mode. Compare to the other two channels at all of the previous base frequencies and duty cycles.

1. Do you notice anything different about the waveforms at 100 Hz?

2. Increase the base frequency for all channels to 3 KHz and repeat the comparisons at each of the five duty cycle settings. Do you notice anything different about the waveforms?

3. Run the experiments again with a base frequency of 30 KHz. Do you notice anything different about the waveforms?

Part 4: An Audio Signal

Suppose you want to play audio with 12 bits of audio depth. The range of the values representing the audio would be between 0 and $2^{12} - 1$ inclusive. You could load $2^{12} - 2$ into the BCR. This would mean that a value of 0 in the DCR would correspond to 0% duty cycle, and a value of $2^{12} - 1$ in the DCR would correspond to 100% duty cycle.

1. Assuming that you do this, what is the maximum base frequency for an audio depth of 12 bits?

2. For playing an audio signal with pulse modulation, the base frequency should be above the range of human hearing. Can that be achieved with this device and an audio depth of 12 bits?

Use the pulse modulator device in PDM FIFO mode to generate a 440 Hz sine wave through the audio jack with bit depths of 10, 11, 12, 13, and 14 bits, using the highest base frequency available for each bit depth.

1. Measure the audio signal using the oscilloscope, and verify that it is within $\pm 0.1\%$ of 440 Hz.

2. Listen to the audio signal and report your observations.

3. Repeat the experiments using PWM mode instead of PDM mode.