PROJECT 1 DUE March 10, 2017 NLT 5:00PM

# Audio Synthesizer

## Part1a: AWG

Implement an Arbitrary Waveform Generator with the following specifications.

| | | |
|---|---|---|
| Master Clock | | 100 MHz |
| Waveform ROM Size | | 16384-lines by 10-bits wide<br>*initialized using text file* |
| Up-date Rate | | 12.207 kHz (100 MHz / 8192) |
| Inputs | | |
| | Clock | 100 MHz |
| | Play | 1-bit button to start when pressed<br>*the waveform only plays once* |
| | Rate Divider | 16-bit divider value |
| Outputs | | |
| | Audio | Waveform |
| | Busy | 1-bit play indicator |

## Part 1b: Volume Control

Provide some amplitude modulation (synchronous multiplier) to the signal at the output of the DDS using a DSP block. Use switch 3:0 as the level input.

| | | |
|---|---|---|
| Inputs: | Clock | 100 MHz Oscillator |
| | Audio_in | 12-bit input Tone |
| | Level | 4-bit Volume Level |
| Outputs: | Audio_out | 16-bit output Tone |

## Part 1c: PDM

Integrate a Pulse Density Modulator (PDM) interface to convert a 10-bit audio input into a 1-bit signal for the audio amplifier and headphone jack on the Nexys-4 board.

| | | |
|---|---|---|
| Inputs: | Clock | 100 MHz Oscillator |
| | Audio_in | 10-bit audio input |
| Outputs: | Audio_out | 1-bit PDM signal |

## Part 2a: DDS

Create a Direct Digital Synthesizer (DDS) that produces a continuous sinusoidal signal that can be programed with various step rates to operate at the following frequencies.

| | Note | Frequency | Rate Divider | Error |
|---|---|---|---|---|
| OFF | X (0000) | NA | infinity | 0 Hz |
| | C (0001) | 130.81 Hz | | |
| | D (0010) | 146.83 Hz | | |
| | E (0011) | 164.81 Hz | | |
| | F (0100) | 174.61 Hz | | |
| | G (0101) | 196.00 Hz | | |
| | A (0110) | 220.00 Hz | | |
| | B (0111) | 246.94 Hz | | |
| Middle | C (1000) | 261.63 Hz | | |
| | D (1001) | 293.66 Hz | | |
| | E (1010) | 329.63 Hz | | |
| | F (1011) | 349.23 Hz | | |
| | G (1100) | 392.00 Hz | | |
| | A (1101) | 440.00 Hz | | |
| | B (1110) | 493.88 Hz | | |
| | C (1111) | 523.25 Hz | | |

| | | |
|---|---|---|
| Inputs: | Clock | 100 MHz Oscillator |
| | Note | 4-bit Note based on Table. |
| Outputs: | Tone | 10-bit sinusoidal output |

Using a phase-to-sine lookup table with a 14-bit address input (16384 lines of 10-bit words). Calculate the required rate divider to complete the table above (if the lookup table is operating at 100 MHz) as well as the error from the desired frequency. Use four switches (7:0) to select the note to produce the correct tone at the headphones. Attach the output to the PDM through the Volume Controller.

## Part 2b: Playlist

Implement a 1024-line by 8-bit playlist ROM that increments at a rate of 0.25 Hz and is used to control the sequence of notes bits (7:4) and volume level bits (3:0) to replace the switch input. Program with a song and verify.

| | | |
|---|---|---|
| Inputs: | Clock | 100 MHz Oscillator |
| Outputs: | Note | 4-bit Note |

## Extra: Part 2c: Keyboard Control

What can you do with the USB-UART module to control this with the Keyboard?