Something about the CPEN 311 Lab 1

SOF directory path

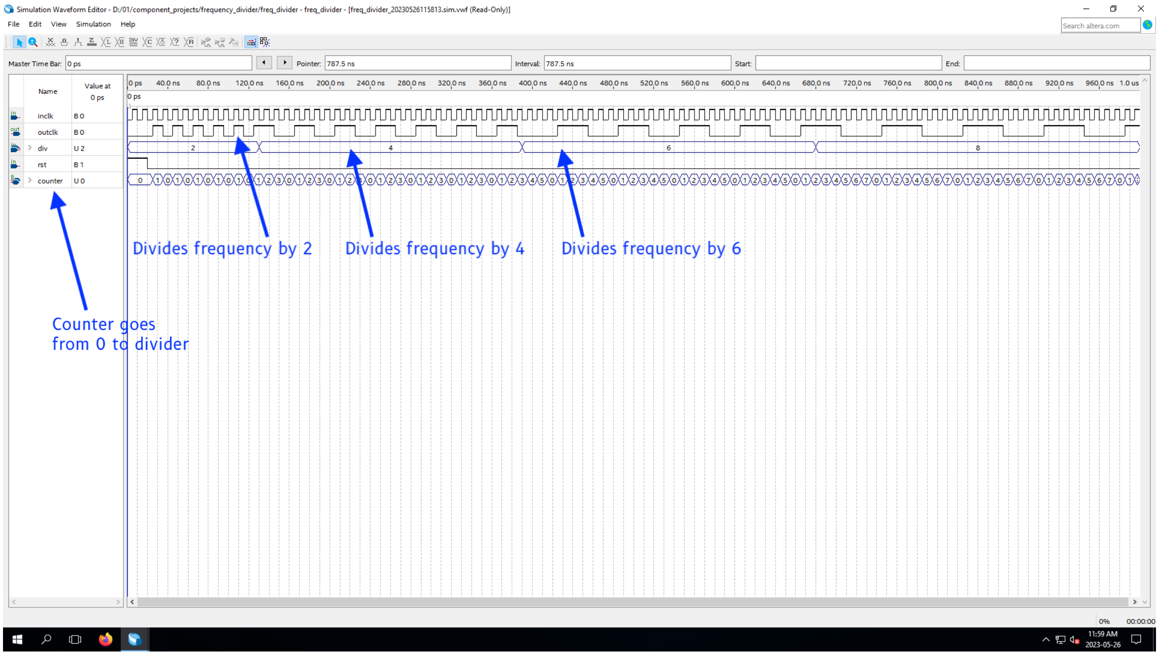
Basic_Organ_Solution.sof

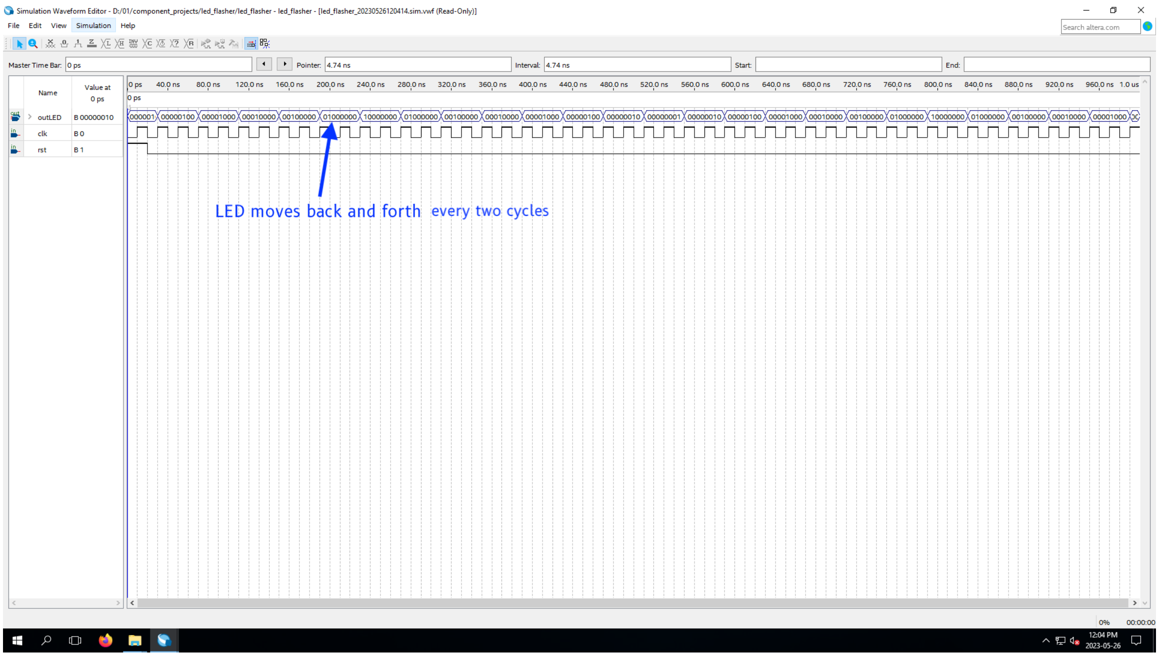
./rtl/Basic_Organ_Solution.sof

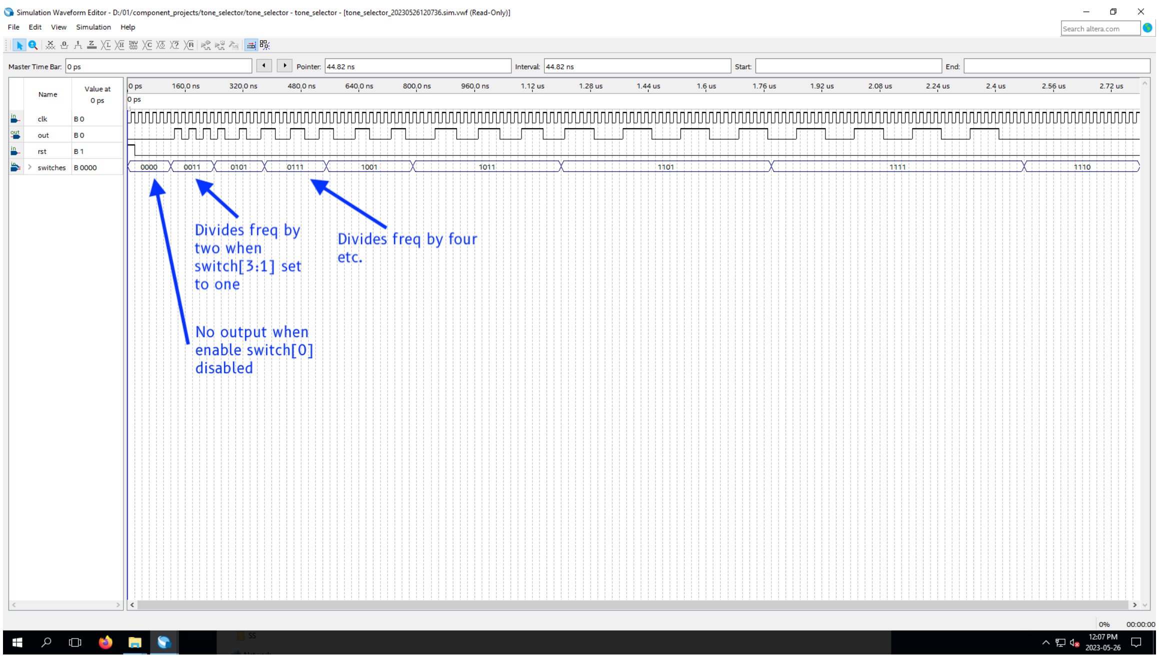
Lab status

- [ ] Frequency divider complete - freq_divider.sv
- [ ] Audio output switch complete - tone_selector.sv
- [ ] Audio pitch selector switches complete - tone_selector.sv
- [ ] Info channel shows note complete - Basic_Organ_Solution.sv
- [ ] Switch positioning on information console complete - Basic_Organ_Solution.sv
- [ ] Something interesting on console complete - Basic_Organ_Solution.sv
- [ ] LED control - complete - led_flasher.sv

Annotated simulation / signaltap screenshots







Information on simulations

All simulations created by quartus simulator.

LED flasher and tone selectors have had their parameters adjusted (change from order of ~100Hz to order of ~20Mhz), because the simulation would take too long. You can see the parameters set in the .sv files to determine the actual period. This is set by a parameter called DIVIDER (or some variant), and for the tone selector, parameters called DO, RE, MI...

The frequency can be obtained by clock frequency / DIVIDER.

Simulation for Frequency Divider

Waveform.vwf ./component_projects/frequency_divider/Waveform.vwf

Actual output freq_divider_20230525180337.sim.vwf ./component_projects/frequency_divider/simulation/qsim/freq_divider_20230525180337.sim.vwf

Simulation for led flasher

Waveform.vwf ./component_projects/led_flasher/Waveform.vwf

Actual Output led_flasher_20230525191546.sim.vwf ./component_projects/led_flasher/simulation/qsim/led_flasher_20230525191546.sim.vwf

Simulation for tone selector

Waveform.vwf

Actual output tone_selector_20230525221445.sim.vwf

Additional information

None

Bonus Question

We peform a fourier transformation.

We recall the fourier series for any periodic function can be written as follows:

$$FS(t) = A_0 + \sum_{n=1}^{\infty} a_n \cos\left(\frac{2n\pi}{T}t\right) + \sum_{n=1}^{\infty} b_n \sin\left(\frac{2n\pi}{T}t\right)$$

eq1.png

Since we know that An and Bn are constants, we will not bother to try and calculate them since the bonus question only asks us to find the xtable of frequencies, and not to come up with a fourier series formula.

However, these are given below for completeness.

$$A_0 = \frac{1}{T}\int_0^T f(t)\,dt$$

$$a_n = \frac{2}{T}\int_0^T f(t)\cos\left(\frac{2n\pi}{T}t\right)dt$$

$$b_n = \frac{2}{T}\int_0^T f(t)\sin\left(\frac{2n\pi}{T}t\right)dt$$

Based on my calculations, not shown here, A0 is 0.5, An is 0, and Bn can be written as $2\pi/n$, where the term only exists when n is an odd integer.

Returning to the important part at hand, we need to calculate the frequencies. We recall for some periodic function such as $\sin(kx)$, the period is given as $2\pi/k$.

Using the equation above, we can see that $k = (2n\pi)/T$, where T is the period of the square wave. Thus, the periods of the fourier series, can be given as T/n.

Recall that $f = 1/T$. Thus, the frequencies of the fourier series can be written as $n/T \Rightarrow nf_{squarewave}$, where n is an odd integer. We limit ourselves to 20KHz.

Suppose we pick a 523Hz square wave. It is comprised of the following sine waves, in Hz:

523, 1569, 2615, 3661, 4707, 5753, 6799, 7845, 8891, 9937, 10983, 12029, 13075, 14121, 15167, 16213, 17259, 18305, 19351, 20397.

Similarly, we can calculate this for all our square waves.

Harmonic	Base Square Wave Frequencies / Hz							
n	**523**	**587**	**659**	**698**	**783**	**880**	**987**	**1046**
1	523	587	659	698	783	880	987	1046
3	1569	1761	1977	2094	2349	2640	2961	3138
5	2615	2935	3295	3490	3915	4400	4935	5230
7	3661	4109	4613	4886	5481	6160	6909	7322
9	4707	5283	5931	6282	7047	7920	8883	9414
11	5753	6457	7249	7678	8613	9680	10857	11506
13	6799	7631	8567	9074	10179	11440	12831	13598
15	7845	8805	9885	10470	11745	13200	14805	15690
17	8891	9979	11203	11866	13311	14960	16779	17782
19	9937	11153	12521	13262	14877	16720	18753	19874
21	10983	12327	13839	14658	16443	18480		
23	12029	13501	15157	16054	18009	20240		
25	13075	14675	16475	17450	19575			
27	14121	15849	17793	18846				
29	15167	17023	19111					
31	16213	18197						
33	17259	19371						
35	18305							
37	19351							

harmonics.png