TO:	Professors J. Hung and V. Nelson
FROM:	"The PokeSquad", Justin Wahlers and Demetris Coleman
SECTION:	003 – Tuesday 3:30 p.m.
DATE:	October 7, 2016
SUBJECT:	Labs 6 and 7 alternate version

The objectives of these laboratory exercises were to implement the LED display and the buzzer, which will be two portions that are integral to the final alternative laboratory design. The design of the two laboratory exercises both consist of a C program and a wiring setup.

Laboratory exercise 6 focused on the implementation of the LED display using a timer. An LED display, which has its schematic featured in Figure 1, was fully implemented to output specific patterns. A timer scheduled specific intervals, where the program would individually output each LED row one by one. Because the human eye cannot perceive this speed, the user sees a single image. The C progam that drove this design is attached, labeled "Lab6_Code". The pins on the LED display were connected to the PC pins on the STM32L100, with the rows connected to PC0 – PC7 and the columns connected to PC8 – PC15. The output of LED display per button is as specified in Table 1.

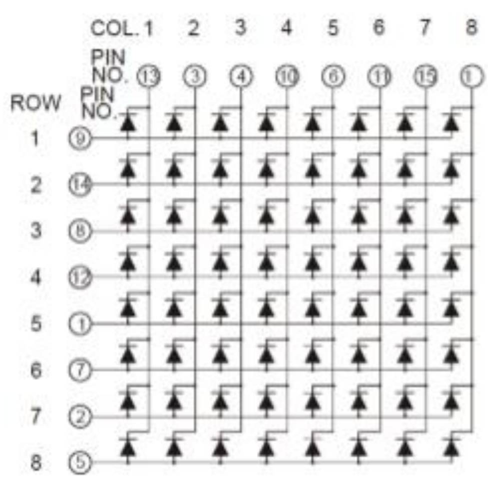

Figure 1: LED display schematic. Resistors connected to the voltage source would be connected to each row

Table 1: Button Outputs and/or Functions

Button	Output/Function
Up	Displays UP Arrow
Left	Displays LEFT Arrow
Right	Displays RIGHT Arrow
Down	Displays DOWN Arrow
Pause	Displays “P”
Reset	Inverts the display’s LEDs (Until pressed again)

In laboratory exercise 7, the pulse wave modulator (PWM) was utilized to drive a speaker to produce specific sounds. The PWM functionality of Timer 10 was utilized to drive the PA6 output pin on the STM32L100. A speaker connected to this pin would then output a sound corresponding to the frequency and duty cycle of the PWM. An output corresponding with the binary representation of each signal was also output through PA2 – PA5. The table below shows the button and the frequency, note, and output that correspond with it.

Table 2: Button Press Specification

Button	Note	Frequency	Binary Output
Up	A	440.00 Hz	0001
Left	B	493.66 Hz	0010
Right	C	523.25 Hz	0011
Down	D	587.33 Hz	0100
Pause	E	659.25 Hz	0101
Reset	No Sound	No Frequency	0000

To output a specific waveform, a count and prescale value was calculated for each frequency. The calculated values of each waveform is shown in Table 3. Note that the frequency is equivalent to the clock speed divided by the count and the prescale values.

Testing Procedure and Observations

Initial testing in laboratory exercise 6 returned a working LED display. The primary observed issue with the design was very dim lighting on the LED display. After tweaking the C program so that each row was given a longer allocated time to shine, the LED display began to light up with a brighter and more uniform intensity. The output of the "up" button is shown in Figure 2.

Figure 2: The "UP" Button

For the 7th laboratory exercise, the testing was fairly similar. The same D-pad was utilized, with each button having a specific action as specified in Table 2. Initially, the waveform was having a much higher frequency than intended, specifically by a multiple of 28.25. This was because it was initially thought that the prescale effected the clock speed by a factor of $2^{\text{prescale factor}}$, instead of just the prescale factor. Changing the prescale factor from 8 to 256 for all cases fixed this issue.

After ensuring that the correct waveform frequency was being output, the speaker was tested. Each button was tested for a correct sound for each note, and the reset button correctly forced the speaker to cease outputting noise. The only specific issue found was the odd delay between the “down” and the “pause” button. If the user pressed the “down” button then the “pause” button in quick succession, a small delay with no sound is audible. This does not occur for any other buttons, but the cause has yet to be determined.

Results

Both laboratory portions worked to the specifications provided. Testing each button on the D-pad in all 10 possible combinations verified the correct operation of the LED display. Each verified output is shown in Figure 3. There are two outputs for each of the five output buttons: one that is normal and one that is inverted.

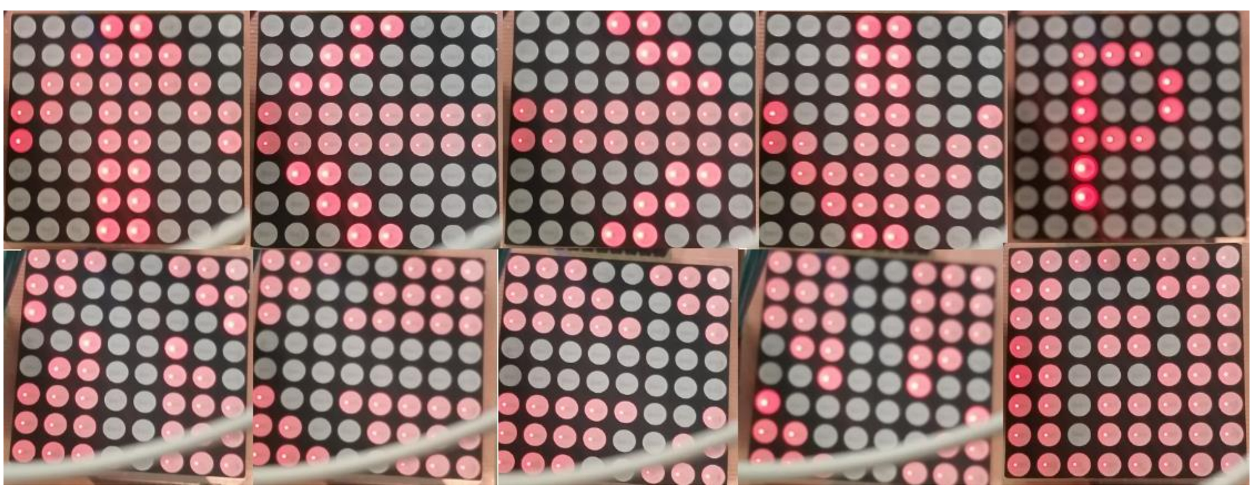

Figure 3: LED Display outputs for each Button Combination

The specific resulting waveforms of the PWM were very close to the specified values in the alternative laboratory 7 specification. Table 3 shows the condensed collection of the oscilloscope measurements of the frequency in the actual circuit against the ideal frequencies. Figures 4 – 9 then feature the oscilloscope outputs and measurement for each button. Note the lack of signal for the reset button in Figure 9.

Table 3: Measured and Ideal Frequencies for each Button

Button	Ideal Frequency	Measured Frequency
Up	440.00 Hz	440.15 Hz
Left	493.66 Hz	492.14 Hz
Right	523.25 Hz	520.85 Hz
Down	587.33 Hz	584.13 Hz
Pause	659.25 Hz	657.90 Hz
Reset	None	None

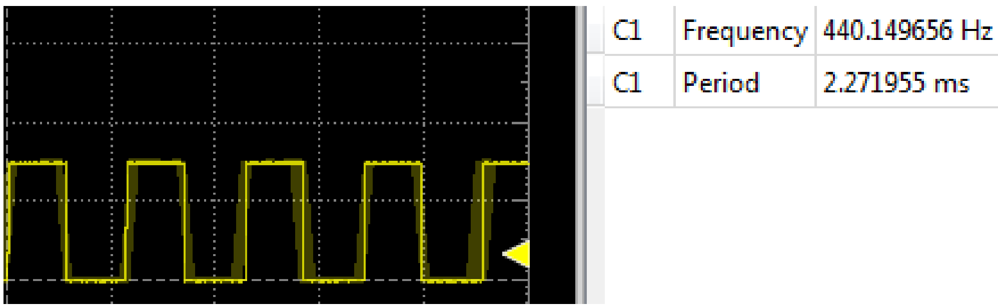

Figure 4: Button “UP” Waveform

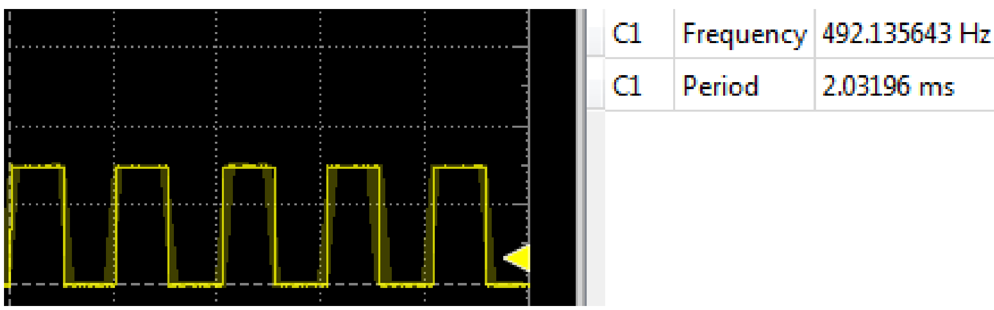

Figure 5: Button “LEFT” Waveform

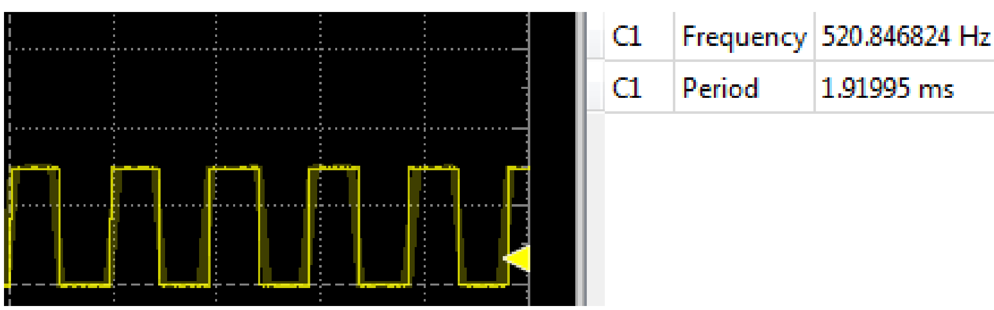

Figure 6: Button “RIGHT” Waveform

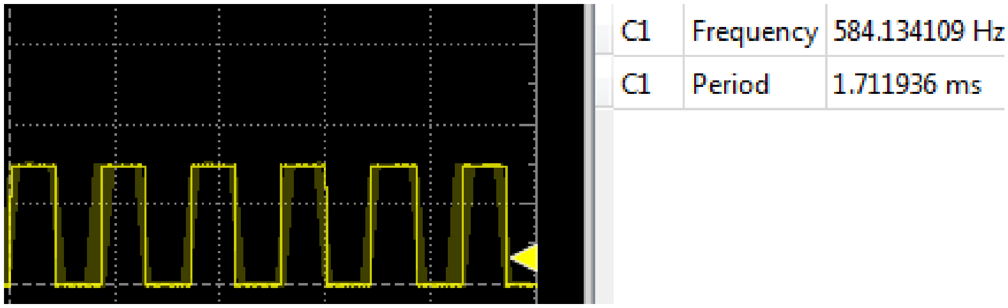

Figure 7: Button “DOWN” Waveform

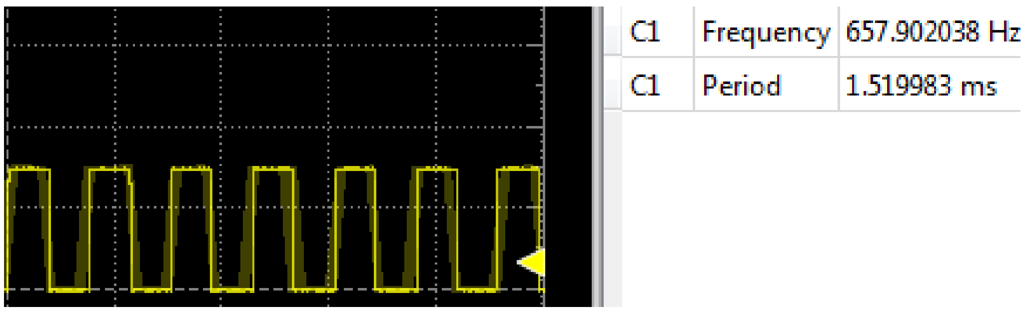

Figure 8: Button “PAUSE” Waveform

Figure 9: Button “RESET” Waveform

The binary value for each output was also recorded using the digital logic analyzer in Waveforms. Figure 10 features the output of “up”, “left”, “right”, “down”, “pause”, and “reset”, respectively. The outputs meet the specifications outlined in Table 2.

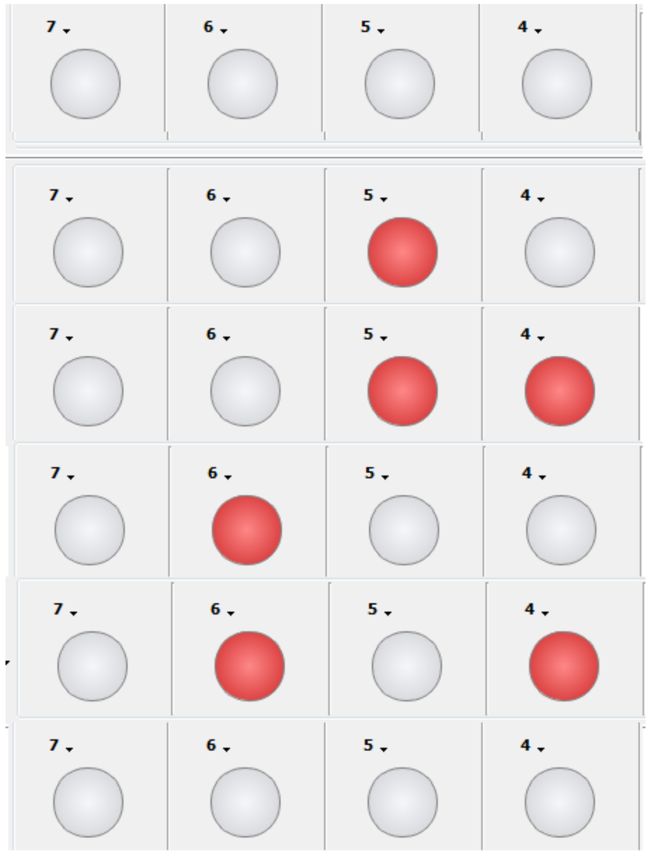

Figure 10: Binary Outputs for Buttons Up, Left, Right, Down, Pause, Reset

Conclusions

The two laboratory exercises detailed the creation of two modules that will be helpful in the completion of the final project. The LED display will be critical in displaying the graphical representation of the created game. The sound will also be useful to give the user audio cues to improve gameplay experience.