Sound Synthesizer

ECE 4710 - Computer Hardware Design

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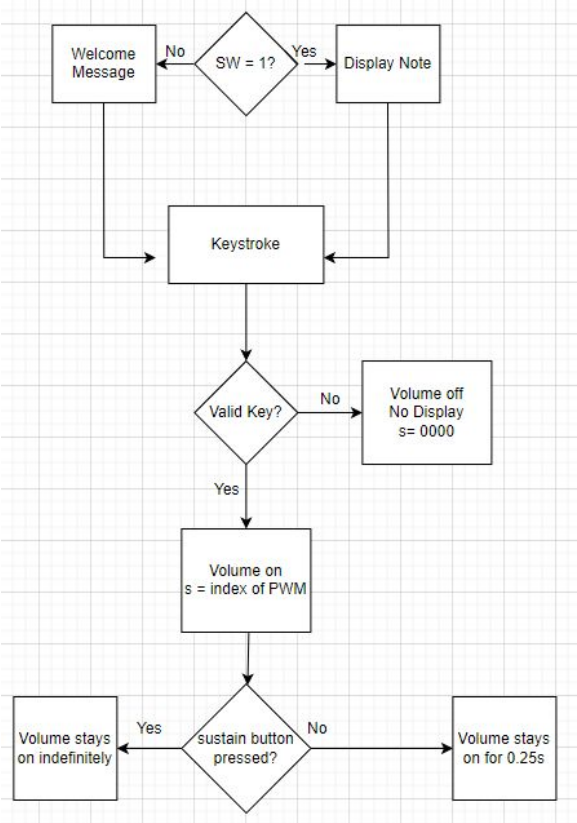
The Idea

- Create a fun tool for musical creativity
- Attempt to emulate a digital keyboard
- Use 16 different keys to produce different notes.
- Features:
  - Notes Display
  - Notes Sustainability
  - Pitch indication

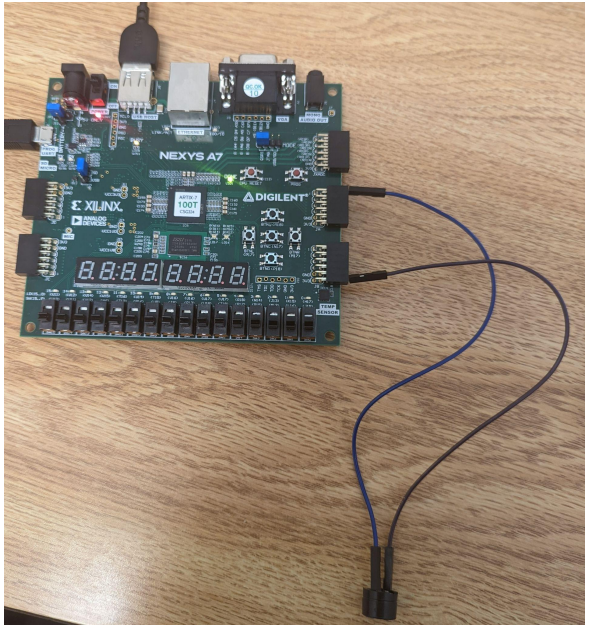
Flowchart


Welcome Message
No
SW = 1?
Yes
Display Note
Keystroke
Valid Key?
No
Volume off
No Display
s= 0000
Yes
Volume on
s = index of PWM
Volume stays on indefinitely
Yes
sustain button pressed?
No
Volume stays on for 0.25s

Hardware

- Nexys A7 100-T
- Piezo Buzzer
- Standard USB Keyboard

–The piezo buzzer has one lead connected to pin **JA1** and the other connected to **ground**

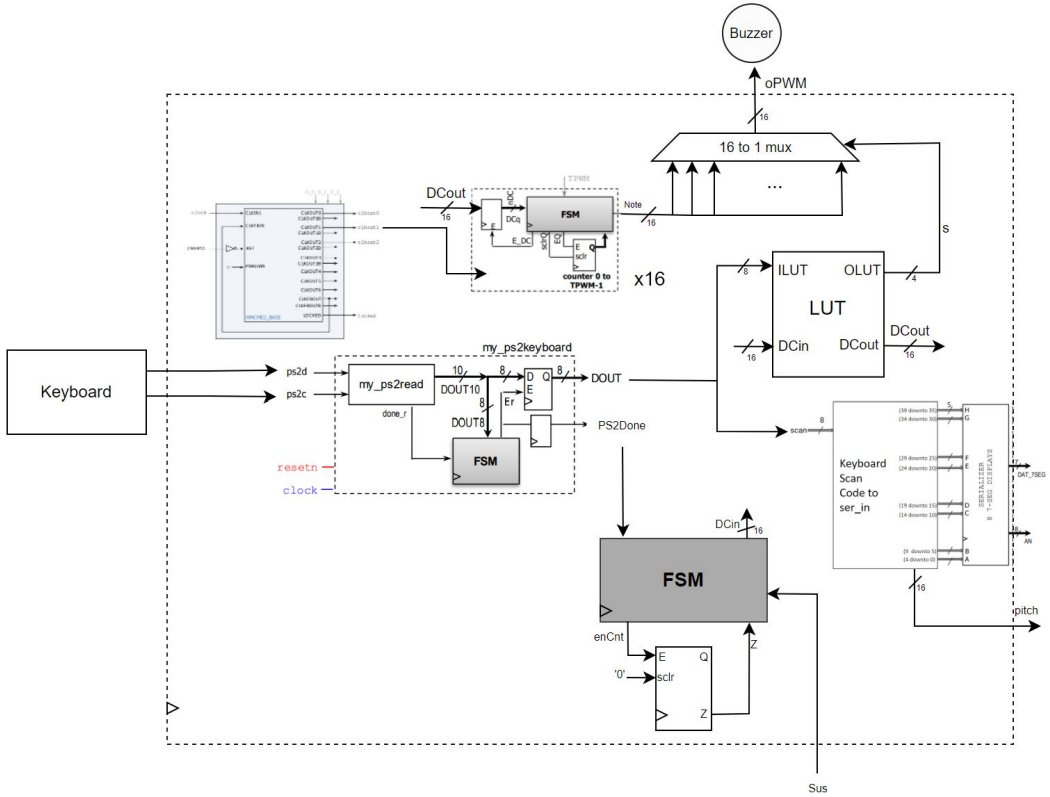


Keyboard Layout

Components

- PS/2 Keyboard
- LUT
- MMCM Clock Divider
- 7 Segment Display Module
- 16 PWM Circuits
- 16-to-1 Mux
- FSM

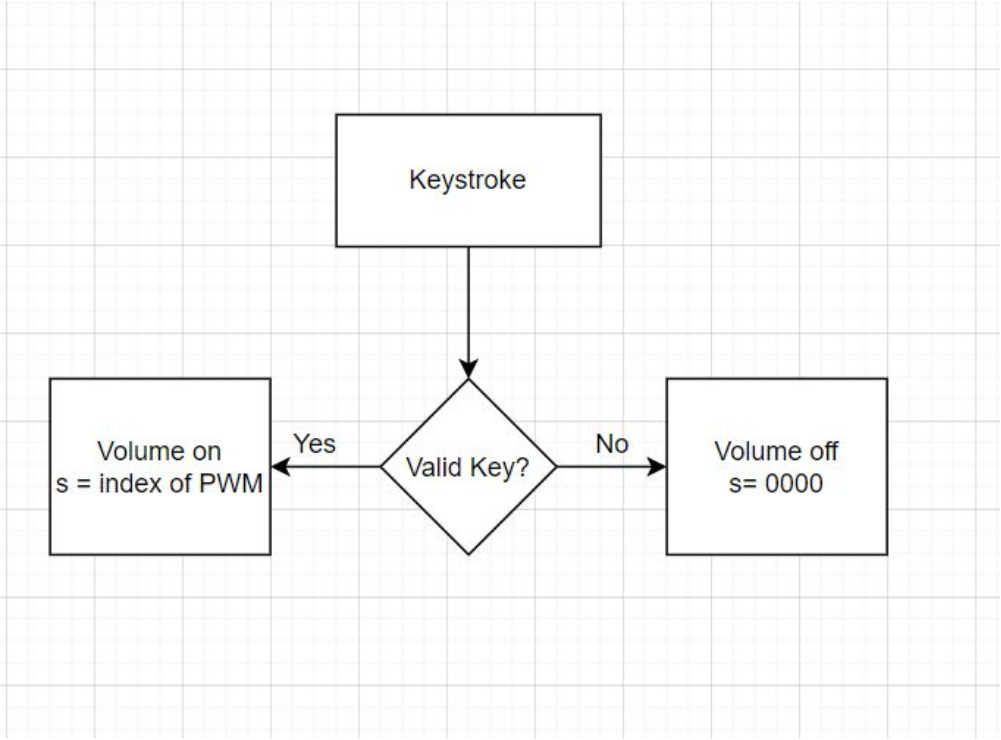
Block Diagram



LUT

- Receives the scancode and duty cycle as inputs
- Outputs the index of the PWM signal the mux should select based on the scancode received
- Outputs the unchanged input duty cycle if one of the 16 keys are pressed
- Outputs a duty cycle of zero if any other key is pressed

LUT


Keystroke
Valid Key?
Yes
No
Volume on
s = index of PWM
Volume off
s= 0000

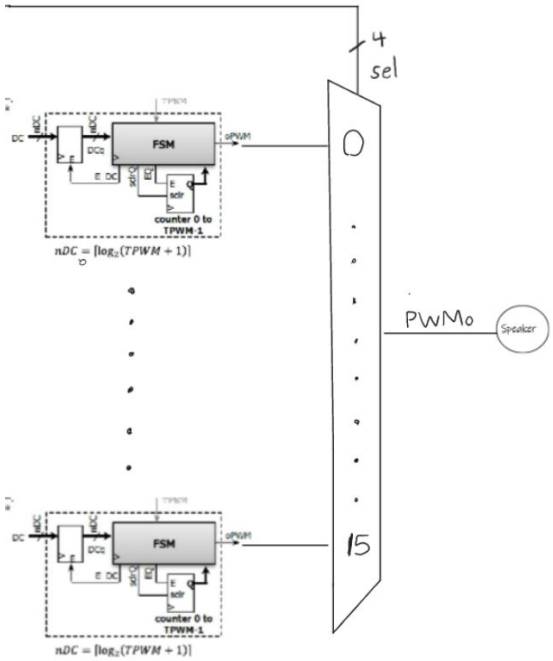
Audio (PWM)

C_5	523.25	65.93
$C^{\#}_5/D^{b}_5$	554.37	62.23
D_5	587.33	58.74
$D^{\#}_5/E^{b}_5$	622.25	55.44
E_5	659.25	52.33
F_5	698.46	49.39
$F^{\#}_5/G^{b}_5$	739.99	46.62
G_5	783.99	44.01
$G^{\#}_5/A^{b}_5$	830.61	41.54
A_5	880.00	39.20
$A^{\#}_5/B^{b}_5$	932.33	37.00
B_5	987.77	34.93
C_6	1046.50	32.97
$C^{\#}_6/D^{b}_6$	1108.73	31.12
D_6	1174.66	29.37
$D^{\#}_6/E^{b}_6$	1244.51	27.72

https://pages.mtu.edu/~suits/notefreqs.html

Audio (PWM)

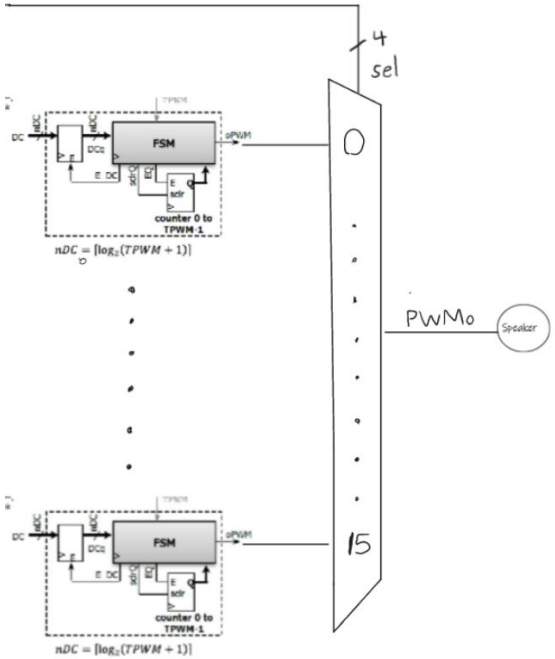
- 16 PWM circuits to generate 16 different notes
- Each takes different TPWM for desired frequency
- DCin is the duty cycle signal and it’s a constant value (For now)
- The output of these circuits are inputted into a 16-to-1 mux which is controlled by an LUT output.



MMCM Clock Divider

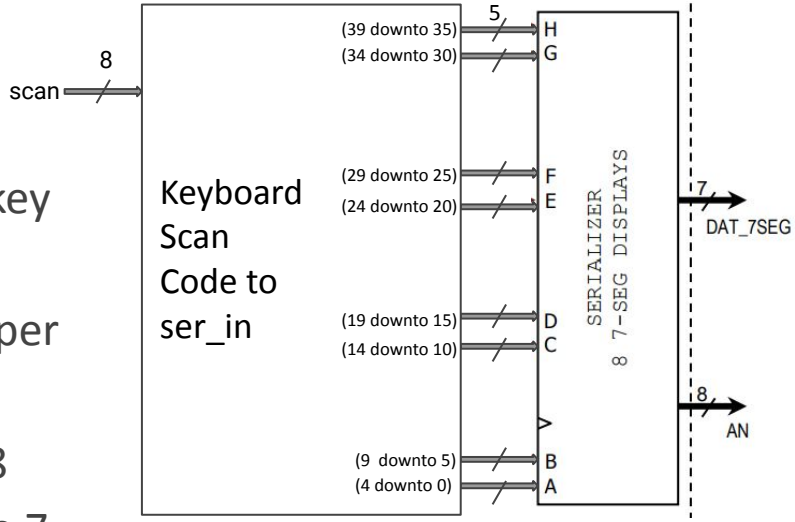
- Since on board clock is 100 MHz, the TPWM parameter (integer) cannot go high enough to achieve the desired PWM frequencies.

- We use a clock divider so that the clock of the PWM module is 25 MHz (for lower frequency modules) and 50 MHz (for higher frequency modules)

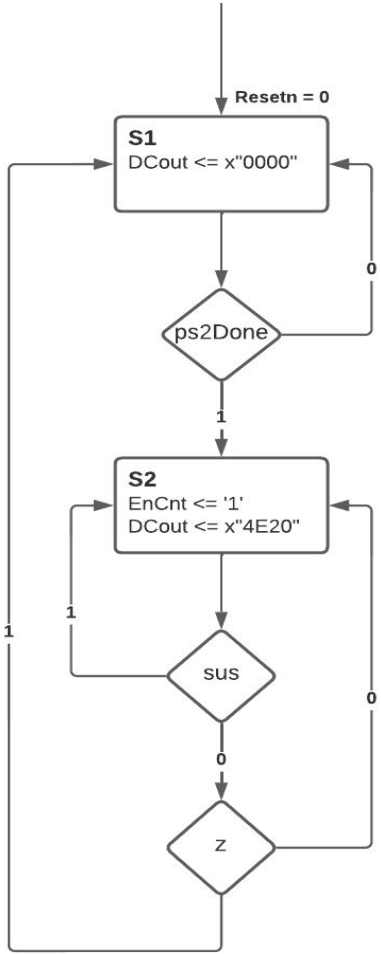


7 Segment Display Circuit

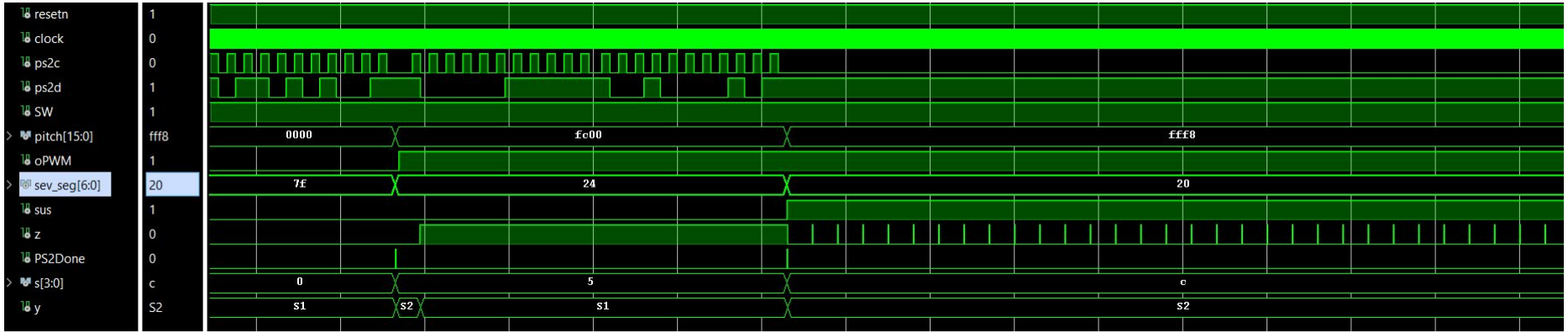
- Controls output to 7 segment display
- Takes 8 bit scan code that identifies the key pressed
- Converts 8 bits to a 40 bit output (5 bits per serializer input)
- Then those 5-bit chunks are sent to the 8 inputs of the serializer which controls the 7 segment displays



FSM


Resetn = 0
S1
DCout <= x"0000"
0
ps2Done
1
S2
EnCnt <= '1'
DCout <= x"4E20"
1
1
sus
0
0
z

Simulation Results



DEMO!