PRINCIPLES AND APPLICATION OF MICROCONTROLLERS
AVR C Lab6: Electronic Piano with 7-segment

Introduction

In this lab, you are required to design and build a digital piano using an AVR ATmega328P microcontroller. The piano you are required to build will only use a small subset of keys. Each key is associated with a frequency which will give a key its own unique musical tone. The musical tones are digitally produced using the timer of the microcontroller and are played through a buzzer. The piano should play a tone as long as the corresponding key is pressed. After completing this lab you should be able to:

- Master in AVR timer programming
- Implement buzzers

Parts List

- A breadboard
- An AVR ATmega328P MCU
- Resistors
- A buzzer
- A 7-segment LED
- Buttons or switches

Musical Note

A musical note, or a pitch, is a waveform at a certain frequency. The waveforms are at different frequencies. This gives each note a distinctive sound. Tone waveforms are sinusoidal and sound smooth and clear. However, sinusoidal waveforms are complex to generate. In this project, we will use square waveforms, which are much easier to implement even though their sound is not as good as sinusoidal waveforms.

The piano you are asked to build will have 7 keys (Fig. 1). Each key is associated with a musical note listed in Table 1. The piano generates a square wave at the specific frequency when the corresponding key is pressed. For example, the piano generates a square wave at a frequency of 261.63 Hz when the key C is pressed. Since period is the inverse of frequency, the cycle duration of the signal is 3.816 ms. In a cycle, the signal connected to the buzzer system is ON for 1.908 ms then is OFF for 1.908 ms and so on. This applies to all piano keys, only the frequencies change.

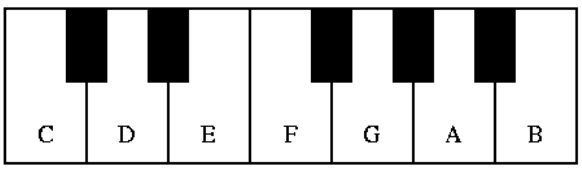

Figure 1: Piano keys

Table 1: Musical note frequency

Note	Frequency (Hz)
C	261.63
D	293.66
E	329.63
F	349.23
G	392
A	440
B	493.88

Procedure

Use Port D as the input from the keyboard, Port B as the output to the 7-segment LED, and Port C as the output to the buzzer. The keyboard is composed of several keys (switches). Connect a switch to a pin of Port D from PD0 to PD6 (Fig. 2). Remember to set up pull-up resistors appropriately if you follow the setup in Fig. 2. A 7-segment display is composed of 7 LEDs. Connect the pins of Port B to the 7-segment display. Refer to Fig. 2 if you use a common anode 7-segment LED. Place appropriate resistors when wiring the display to the microcontroller to prevent burnout. Connect the pin 5 of Port C to a buzzer as shown in Fig. 2. Write a C program that plays a musical tone through the buzzer when a key is pressed. The program also display the musical note on the 7-segment LED.

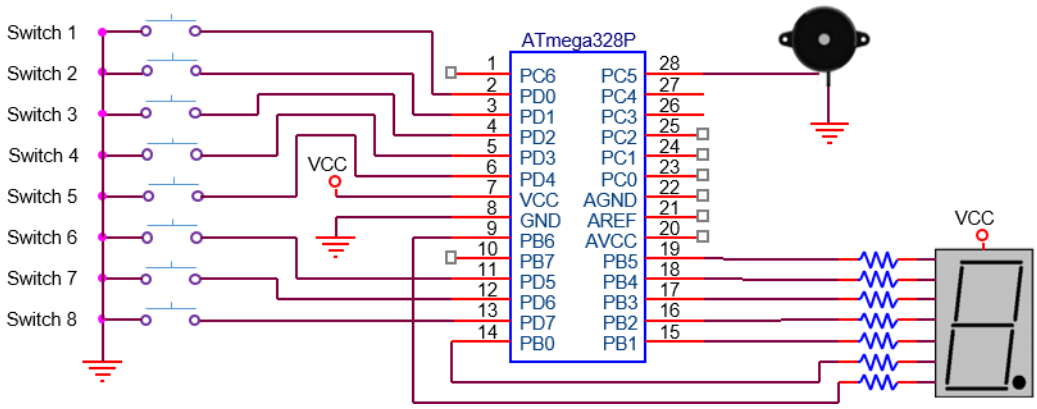

Figure 2: Circuit diagram of electronic piano

Deliverables

Basic points (80%):

Use your piano to play the song “happy birthday”. Demo the result to the TAs, or record it in a video. Upload the followings to ceiba: 1) your C program source code, 2) a photo of your physical circuit, and 3) contributions from each teammate to the lab. The contributions must include the information of the tasks each teammate has done and the contributions in percentage. The total percentage should be 100%. All the teammates have to agree with the contributions before they are uploaded.

Advanced points (20%):

Write a program that plays the song “happy birthday” automatically.