**Rhythm Game Using LCDs**

ECE230 Final Project

Spring 2024

Rowan Sammon

Mateo Olson

Contents

[Introduction 3](#_Toc167261548)

[User Manual 3](#_Toc167261549)

[Setup 3](#_Toc167261550)

[Operation 3](#_Toc167261551)

[Hardware Design 4](#_Toc167261552)

[Overview 4](#_Toc167261553)

[LCD Bit Mode 4](#_Toc167261554)

[Software Design 5](#_Toc167261555)

[Overview 5](#_Toc167261556)

[LCD Driver 5](#_Toc167261557)

[Note Scrolling & Scoring 6](#_Toc167261558)

[MIDI Interpreter 6](#_Toc167261559)

[Verification of Function 6](#_Toc167261560)

[Verification 1 6](#_Toc167261561)

[Verification 2 7](#_Toc167261562)

[Verification 3 8](#_Toc167261563)

[Bill of Materials 8](#_Toc167261564)

[References 9](#_Toc167261565)

# Introduction

We have designed a rhythm game system utilizing the MSP432 board connected to two 2x16 LCDs, one that displays the scrolling notes and one that displays the current score. The two lines of the LCD (which is rotated) form the two lanes of the game. Two buttons correspond to each of the lanes. If the button is pressed when a note is at the bottom of the LCD of the respective lane, the score is increased. This score is displayed on a second LCD. Two buzzers play a song created using a MIDI interpreter. The same MIDI interpreter is used to generate the map that is displayed on the LCD.

An LCD driver utilizes structs containing information about the LCD to perform operations through the LCD. Both LCDs are configured in 4 bit mode and controlled with the LCD driver. A Timer A module of the MSP board controls the timing of the note scrolling using interrupts to rewrite the. The two buttons trigger interrupts that check the current note.

TODO mateo write about midi interpreter and buzzers

# User Manual

## Setup

1. Ensure that latest version of code has been uploaded to the MSP432 board.
2. Connect the MSP432 board to USB A power.
3. Tune the contrast of the LCD using the potentiometer knob.
4. Reset the MSP432 board.
5. Begin playing!

## Operation

Press the buttons in time with the music! The ‘>’ symbols are the descending notes; press the button of the corresponding lane when the ‘>’ note symbol is at the very bottom to increase the score. If you press the button at the wrong time, your score will go down. Go for the highest score you can get!

# Hardware Design

## Overview

A diagram of a circuit board

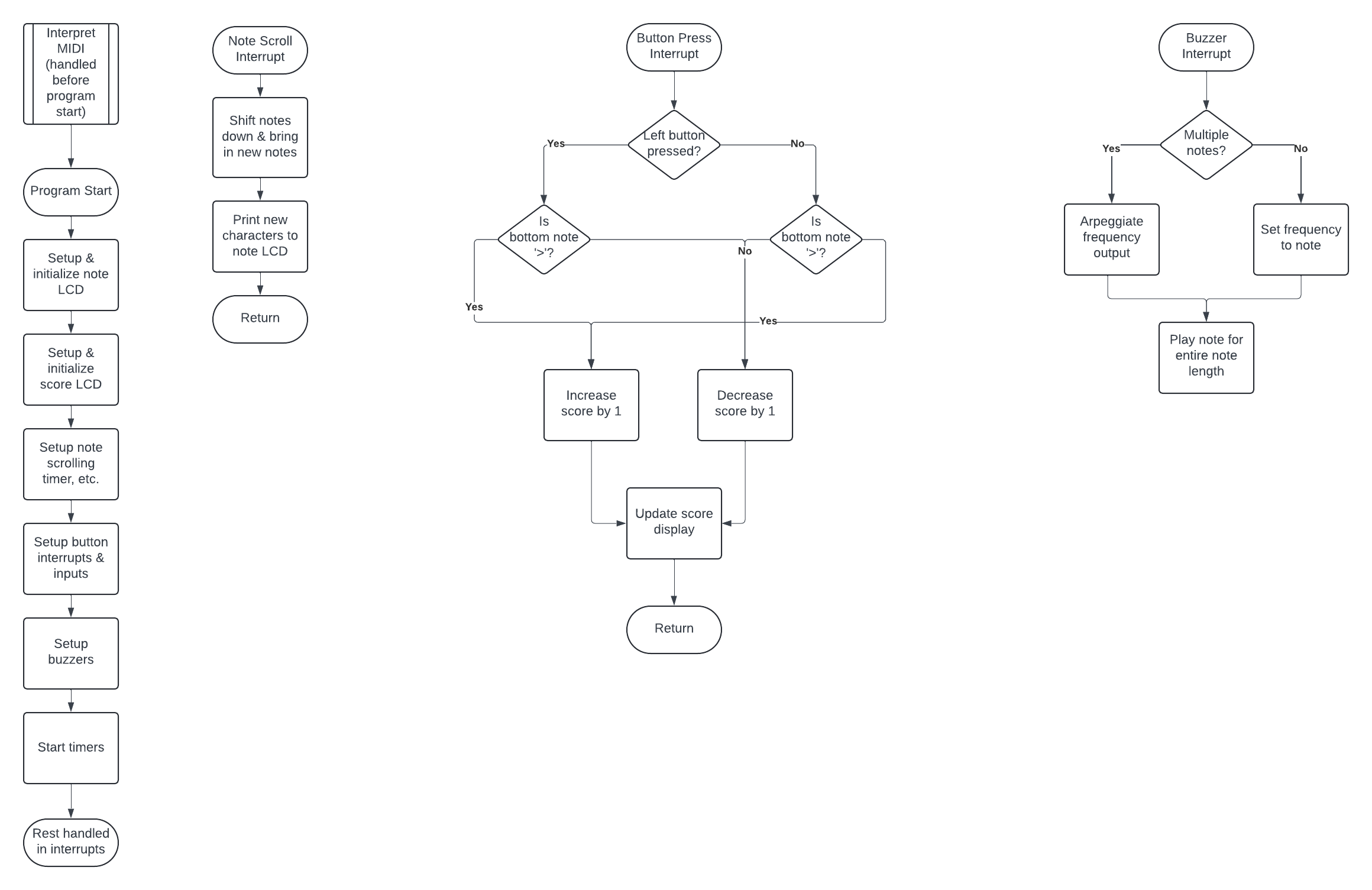
Description automatically generated

## LCD Bit Mode

Both LCDs were connected in 4 bit mode to the MSP432 board. This allows for more pins to be chosen, and less restriction if a pin has failed on the board.

# Software Design

## Overview



## LCD Driver

A struct holds information about the lcd which is used to preform operations for the LCD. This allows it to control multiple LCDs in different configurations at a time. The LCD is configured and controlled using information from the HD44780U LCD datasheet (1).

**typedef** **struct** lcd\_structure{

//16 bit port type (e.g. PA, PB)

DIO\_PORT\_Interruptable\_Type \* PORT;

//16 bit port type (e.g. PA, PB)

DIO\_PORT\_Interruptable\_Type \* RSPORT;

//offset for the 16 bit port

uint16\_t RSMASK;

//16 bit port type (e.g. PA, PB)

DIO\_PORT\_Interruptable\_Type \* EPORT;

//offset for the 16 bit port

uint16\_t EMASK;

//16 bit port type (e.g. PA, PB)

DIO\_PORT\_Interruptable\_Type \* RWPORT;

//offset for the 16 bit port

uint16\_t RWMASK;

/\* config defines states of the

\* bit 7-6- reserved

\* bit 5 - lcd is in busy flag mode (1) or timing mode (0) (busy flag mode is faster/more accurate but requires one extra pin on the MPU,

timing mode is incredibly inconsistent for 4 bit mode)

\* bit 4 - lcd is 5x11 dots mode (1) or in 5x8 dots mode (0)

\* bit 3 - lcd is in 2 line mode (1) or 1 line mode (0)

\* bit 2 - lcd is connected to the higher port (1) or the lower port (0)

\* bit 1 - lcd is connected to the upper (1) or lower (0) part of a port (only matters for 4 bit mode)

\* bit 0 - lcd is in 4 bit mode (1) or 8 bit mode (0)

\*/

**char** CONFIG;

} LCD;

/\* config defines states of the

\* bit 7-6- reserved

\* bit 5 - lcd is in busy flag mode (1) or timing mode (0) (busy flag mode is faster/more accurate but requires one extra pin on the MPU,

timing mode is incredibly inconsistent for 4 bit mode)

\* bit 4 - lcd is 5x11 dots mode (1) or in 5x8 dots mode (0)

\* bit 3 - lcd is in 2 line mode (1) or 1 line mode (0)

\* bit 2 - lcd is connected to the higher port (1) or the lower port (0)

\* bit 1 - lcd is connected to the upper (1) or lower (0) part of a port (only matters for 4 bit mode)

\* bit 0 - lcd is in 4 bit mode (1) or 8 bit mode (0)

\*/

**char** CONFIG;

} LCD;

## Note Scrolling & Scoring

An interrupt connected to TimerA1 controls the note scrolling. After a period of time it shifts all the notes left in the array (this array stores the characters on the LCD screen) and moves a new note into an array, then reprints to the note LCD.

The buttons are configured to create an interrupt when pressed. This interrupt checks what the current note at the bottom of the LCD is (checking the array that holds the characters on the LCD screen). If the current note is ‘>’ it increments the array, otherwise it decreases it. Finally it updates the score displayed on the score LCD.

## MIDI Interpreter

The MIDI interpreter is a separate program that takes a standard .mid file and converts it into an array of bytes. By iterating through this array, it is possible to generate arrays of note frequencies and note lengths, as well as the BPM of the track and the time signature. For our project, we have multiple arrays for each side, splitting the tracks of the MIDI file into a mapping for the left and right sides of the LCD and the two buzzers.

# Verification of Function

## Verification 1

**Requirements:**

Button increases score when pressed with a ‘>’ character, decreases when pressed with any other character

**Equipment Needed:**

* Oscilloscope
* Launchpad/MSP-EXP432P4111

**Setup & Assumptions:**

* Oscilloscope captures must be within an accuracy of 10 μs
  + Capture signal of left button
  + Capture signal of enable pin of LCD
* Left button is configured as active high

**Test Procedure:**

* Wait until a ‘>’ character is at the bottom of the note LCD
* Press the button before the characters scroll
* Verify that the score increases
* Press the button slightly after the characters scroll, so that a ‘>’ character is not displayed
* Verify that the score decreases

**Pass Criteria:**

Score increases when pressed with a ‘>’, decreases when pressed with any other character.

## Verification 2

**Requirements:**

Buzzer note frequency matches note frequency

**Equipment Needed:**

* Oscilloscope
* Launchpad/MSP-EXP432P4111

**Setup & Assumptions:**

* Oscilloscope captures must be within an accuracy of 10 μs
  + Capture signal going to one buzzer at a time

**Test Procedure:**

* Wait for note to be played on one of the buzzers
* Observe frequency of the signal going to the buzzer and compare it to the note that is meant to be played in the MIDI file

**Pass Criteria:**

Buzzer note frequency is within ±.5% of intended note frequency

## Verification 3

**Requirements:**

Buzzer note length matches intended note length

**Equipment Needed:**

* Oscilloscope
* Launchpad/MSP-EXP432P4111

**Setup & Assumptions:**

* Oscilloscope captures must be within an accuracy of 10 μs
  + Capture signal going to one buzzer at a time
  + Note must not be arpeggiated

**Test Procedure:**

* Wait for note to be played on one of the buzzers
* Observe length of the note being played and compare to the length of a quarter note in the MIDI file

**Pass Criteria:**

Buzzer note length is within ±.5% of intended note length

# Bill of Materials

|  |  |  |  |
| --- | --- | --- | --- |
| **Part** | **Quantity** | **Source** | **Cost** |
| LCD1602 Module | 2 | Lab kit | $0.00 |
| Buzzer | 2 | Lab kit | $0.00 |
| MSP432P4111 Board | 1 | Lab kit | $0.00 |
| Various Wires | - | Lab kit & Self Provided | $0.00 |
| 10kΩ Potentiometer | 1 | Lab kit | $0.00 |
| 1kΩ Resistor | 2 | Lab kit | $0.00 |
| Small breadboard | 1 | Lab kit | $0.00 |
| 220Ω Resistor | 2 | Lab kit | $0.00 |
| 100Ω Resistor | 4 | Lab kit | $0.00 |
| 5.1kΩ Resistor | 2 | Lab kit | $0.00 |
| PN2222 | 2 | Lab kit | $0.00 |
|  |  | **Total:** | $0.00 |

# References

1. Hitachi HD44780U LCD driver datasheet - <https://www.sparkfun.com/datasheets/LCD/HD44780.pdf>