PROJECT: MENTAL SPEED

ELEN2021 Microprocessors

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I declare that this is my own work subject to what appears in the final page of the document.

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1. Functionality

1.1. Components

The game comprises of the following (excluding wiring):

a) 1x Keyes Nano
b) 1x Breadboard
c) 1x 7-Segment LED display
d) 2x Push-Button
e) 1x Potentiometer
f) 3x LED Bulb (Red, Green, Orange)
g) 6x Resister (470Ω 5%)

1.2. Game Description

1.2.1. Brief Summary

The game begins when the user presses the right-sided pushbutton (RB) for the first time. During the 60-second game cycle, a light constantly flashes. If the user presses the RB, the game checks whether the sum of the previous numbers – since the last RB press – is a multiple of three. If this answer is correct, the green LED will light up and the user is awarded a point. However, if the answer is wrong, the user will be deducted at most two points, indicated by the red LED lighting up. Each number is displayed for three seconds, however, the left-sided pushbutton (LB) can be used to skip to the next number. When the game ends, the score flashes for two seconds periodically. If the score is greater than ten, the score's 'double' digit is displayed before the 'single' digit. This continues until the next time the user presses the RB – and the game will restart.

1.2.2. Instructions

a) Plug in the Nano to power.
b) Press the RB to begin the game.
c) Press the RB when the sum of the previous digits* are a multiple of three.
d) Press the LB to skip a number.
e) Play until the game completes – try not to get distracted by the flashing light.
f) Press the RB when the score is flashing to restart.

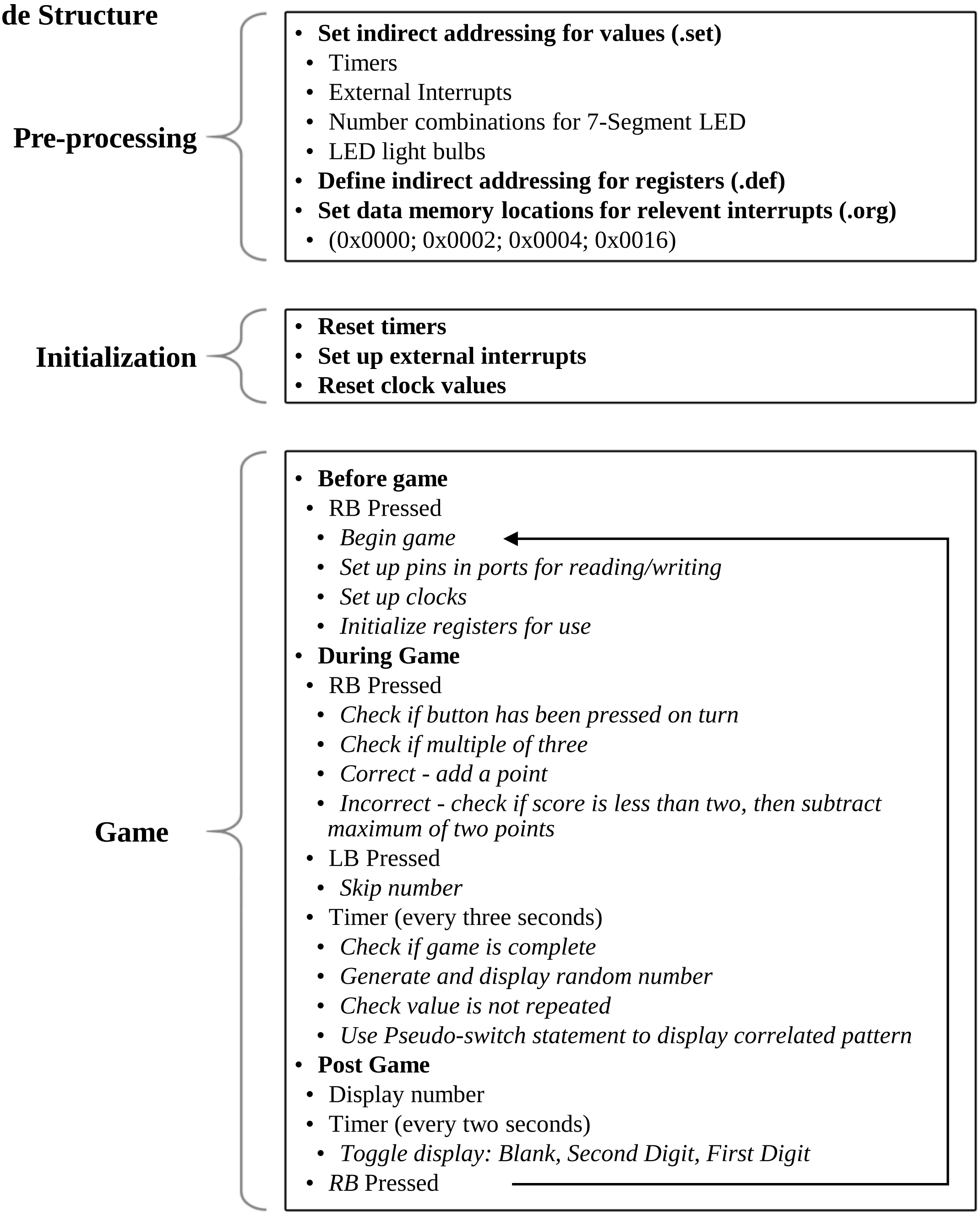
* Since the last time the RB was pressed.

1.2.3. Specification of Hardware Functions

Table 1: A summary of game functions, components, and status

Function	Component	Status
Select a Multiple	Potentiometer	Not Working
Start Game	Push-Button	Working
Display Number	7-Segment LED	Working
Light LED	LED Bulb	Working
Select Answer	Push-Button	Working
Display Score	7-Segment LED	Working
Next Number	Push-Button	Working
Light Distraction	LED Bulb	Working

2. Code Structure



Pre-processing

- **Set indirect addressing for values (.set)**
  - Timers
  - External Interrupts
  - Number combinations for 7-Segment LED
  - LED light bulbs
- **Define indirect addressing for registers (.def)**
- **Set data memory locations for relevent interrupts (.org)**
  - (0x0000; 0x0002; 0x0004; 0x0016)

Initialization

- **Reset timers**
- **Set up external interrupts**
- **Reset clock values**

Game

- **Before game**
  - RB Pressed
    - *Begin game*
    - *Set up pins in ports for reading/writing*
    - *Set up clocks*
    - *Initialize registers for use*
- **During Game**
  - RB Pressed
    - *Check if button has been pressed on turn*
    - *Check if multiple of three*
    - *Correct - add a point*
    - *Incorrect - check if score is less than two, then subtract maximum of two points*
  - LB Pressed
    - *Skip number*
  - Timer (every three seconds)
    - *Check if game is complete*
    - *Generate and display random number*
    - *Check value is not repeated*
    - *Use Pseudo-switch statement to display correlated pattern*
- **Post Game**
  - Display number
  - Timer (every two seconds)
    - *Toggle display: Blank, Second Digit, First Digit*
  - *RB* Pressed

Figure 1: Diagram showing the code structure

3. Circuitry

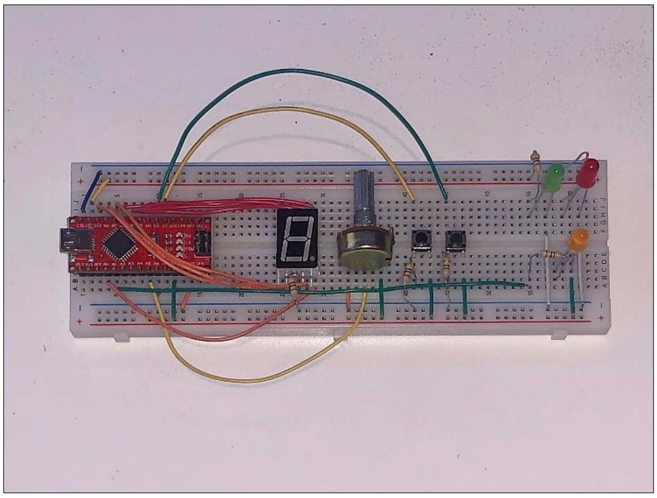


Figure 2: Image of circuitry

Table 2: Table showing the pin list

Description	Use
20/D2/INT0	External interrupt: skip
21/D3/INT1	External interrupt: answer
22/D4/PD4	Top right on 7-segment
23/D5/PD5	Top on 7-segment
24/D6/PD6	Top left on 7-segment
25/D7/PD7	Middle on 7-segment
26/D8/PB0	Bottom right on 7-segment
27/D9/PB1	Bottom on 7-segment
28/D10/PB2	Bottom left on 7-segment
29/D11/PB3	Controls green LED
30/D12/PB4	Controls red LED
4/A0/PC0	Decimal on 7-segment
5/A1/PC1	Controls light distraction
14/GND	Ground in the circuit
12/5V	Voltage supplied
9/A5	ADC pin

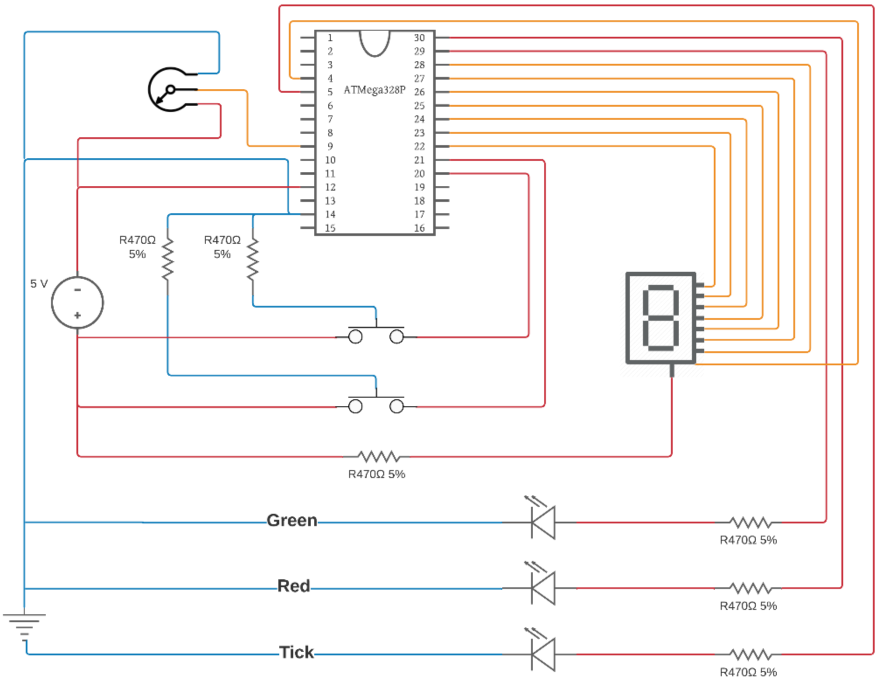


Figure 3: Schematic of circuitry

4. Major design considerations*

Debouncing	Register 'tick' increments every 250ms. It is reset when tick = 12 (3 seconds). If tick is less than 2 (i.e. less than 500ms), you cannot skip ∴ debounces button.
Timer value	Sets OCR1A to 0.25s. This is deliberate because 4 ticks per second for 60 seconds is 240 - the largest multiple of 60 less than 255, so minimal error when skipping. Also, skipping numbers will not be exactly 12 cycles, but will never exceed 239. Will never overflow because 239 + 12 < 255.
Avoid '0' error	When the score is in the single digits, you must skip displaying a 0 in the tens digit by manipulating the variable that tracks what to display
Duplicate seed	If the digit is the same as the previous, the user will not see a change. So, the digit is changed arbitrarily – these considerations were noted in the .asm file.

* Extensive comments of the design process were kept in the .asm file.

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