INDIAN INSTITUTE OF SCIENCE

IISC QUANTUM TECHNOLOGY INITIATIVE

NE223 - ANALOG CIRCUITS AND EMBEDDED SYSTEM FOR SENSORS

Project Preliminary Report

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Date: April 19, 2022

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1 Inverted Pendulum

An inverted pendulum is inherently unstable. In this project, a game that can be played by one person, to stabilize an inverted pendulum mounted on a linear motor or a wheeled chassis with a motor drive via a pin joint which allows free rotation of the pendulum, is designed.

1.1 The Manual Mode

1. The game should begin when the pendulum is set upright within +/-5° and this should be indicated to the player with a green LED and a single beep of a buzzer that lasts for 2 seconds.

2. After the pendulum falls beyond +/-85°, the game is over, and the LED should turn off and 3 beeps should sound each lasting 1 second with 1 second interval. Use a LED display to show the time for which the player kept the pendulum upright.

3. Develop a method to detect if the player is cheating by holding the pendulum upright by hand. If they are cheating, display red light and the game is over which is accompanied by the same indicators as stated above.

1.2 The Automated mode

Furthermore, add a functionality of flicking a switch to automated mode where the user input is ignored, and the program automatically controls the motor to maintain the balance of the pendulum without human input. If at any point, the switch is flicked back to manual mode, the game begins (with all the notifications to the user as stated above).

2 Schematic

Based on the rules of the game, various inputs and outputs to the microprocessor are recognised and the schematic of the machine is drawn.

2.0.1 Inputs

1. User Input: This is the input fed by the user, that specifies the direction and velocity of the motor to balance the inverted pendulum. Currently, we plan to use a **joystick** as the input device.

2. Angle Sensor: This device measures the angle of the inverted pendulum and sends it to the microprocessors. Sensors like **MPU6050** can be used in the circuit for this function.

3. Cheating Sensor: This sensor detects if the pendulum is being held upright by hand. Multiple **touch sensors** can be mounted on the pendulum to detect human touch and if any of them reads high, it indicates cheating and the game is turned off.

4. Mode Switch: This switch decides whether the game in the manual mode or automated mode. A **toggle switch** can be used so that one setting turns the game to manual and the other makes it automatic.In the automated mode, the inputs from the user are ignored.

2.0.2 Microprocessor

The microprocessor used is Arduino Mega. Two of its timers are used for some features of the game.

1. Game Timer: This timer starts when the game begins and stops when it ends. The time from this timer is displayed in the LED display.

2. Buzzer Time: This time is used to time the buzzer beeps, when the game begins and ends.

2.0.3 Outputs

1. Green LED: This turns on when game begins and turns off when game ends.
2. Red LED: This turns on when cheating is detected by the cheating-sensors.
3. Motor Driver: This drives the motor for the motion of the pendulum based on the user inputs.
4. Buzzer: The buzzer beeps for different intervals when the game starts or ends.
5. LED Display: The display shows the time duration for which the game has been on, i.e., the time for which the player kept the pendulum upright.

The schematic of the system is shown in Fig. 1.

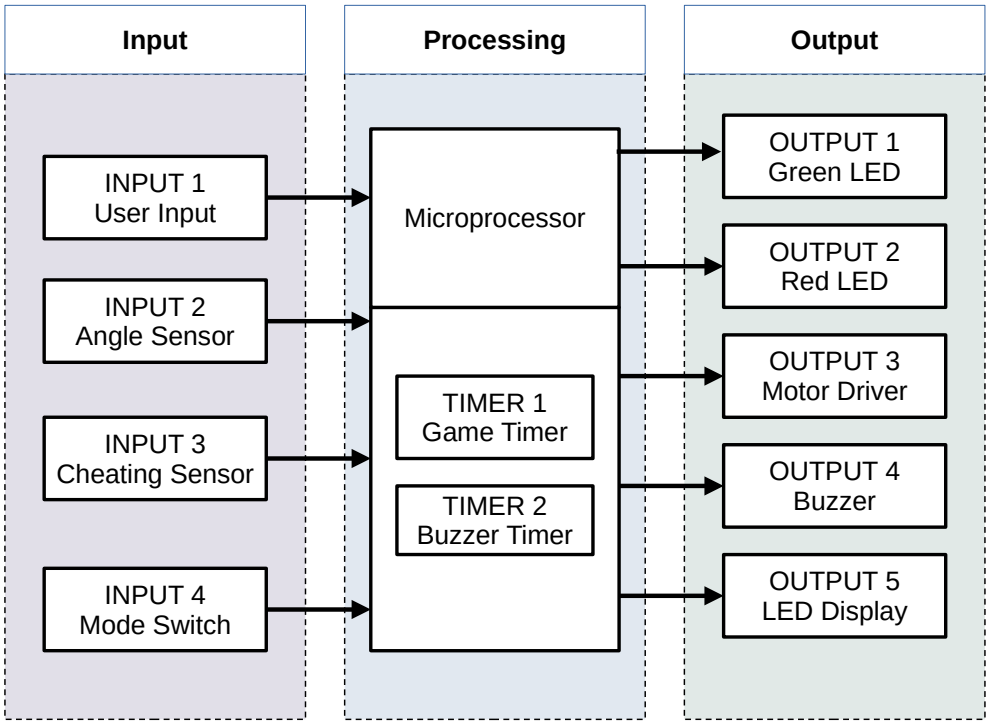

Figure 1: System Schematic of the inverted pendulum game

3 State Machine

The system is designed as a state machine and the state machine diagram explaining the functioning of the machine is shown in Fig. 2.

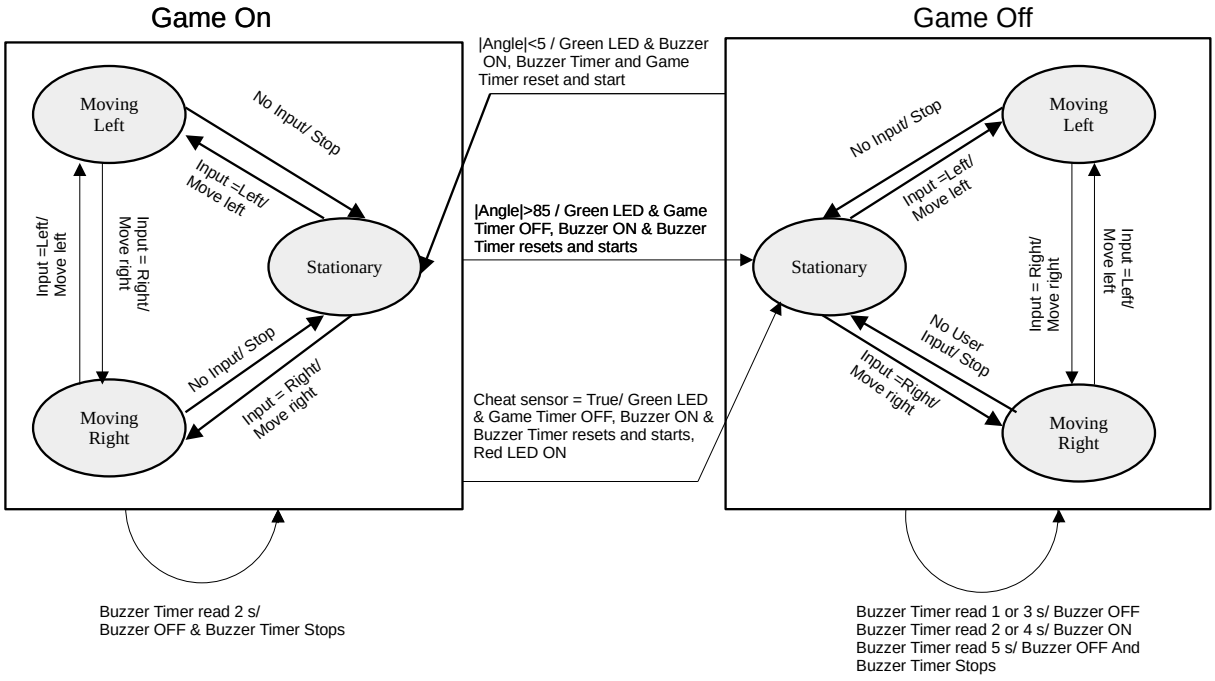

Figure 2: State machine diagram of the inverted pendulum game

The states have been taken to the state of motion of the motor/ pendulum-base since it is the controlled variable in this system. The states are nested in the states - Game On and Game Off to distinguish between the different features of the system in the different conditions.

3.1 Inclusion of the Automated mode

The diagram in Fig. 2 is valid for both manual and automated case. The only difference is that in the manual case, the input comes from the user while in the automated mode the input comes from the microprocessor itself.

The changing of inputs can also be included in the state diagram by nesting the diagram given in Fig. 2 in the states - Manual and Automated. This inclusion in shown in Fig. 3 to create a state diagram for the overall system.

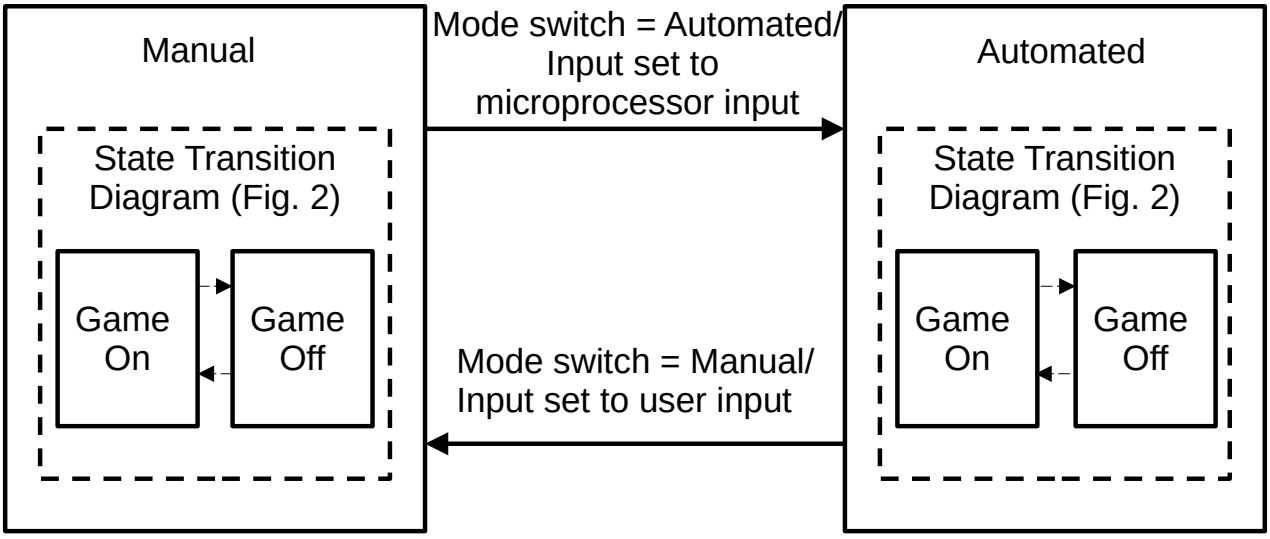

Figure 3: Overall state machine diagram of the inverted pendulum game with manual and Automated modes

4 Circuit Diagram

The circuit diagram is generated using the platform circuit.io.

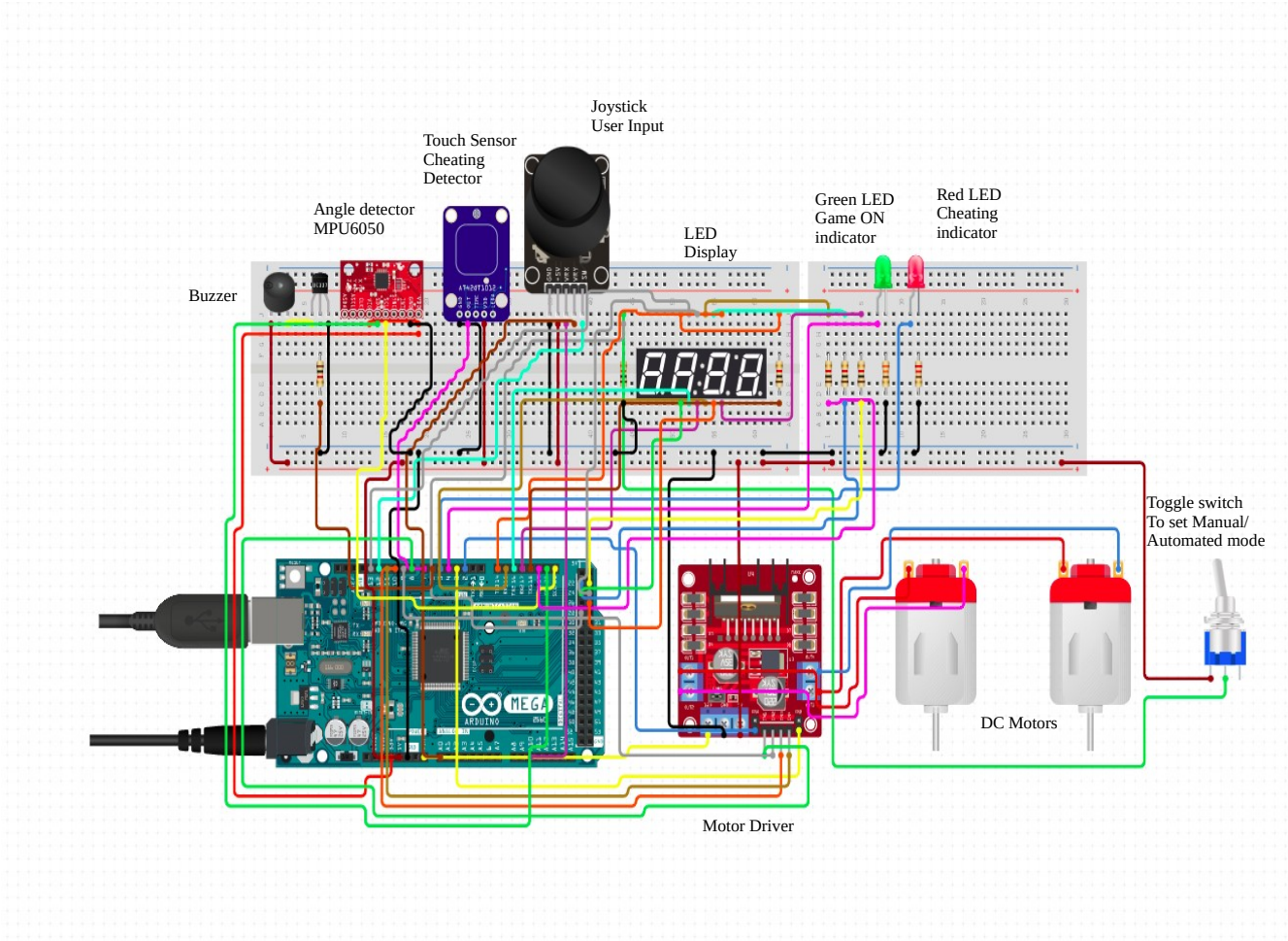

Figure 4: Circuit diagram for the inverted pendulum