REPORT

Design and Simulation of Circuits and Embedded Systems

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Project Title: Automatic Floor Cleaner

1. Introduction

1.1 Description

- An Automatic floor cleaner embedded system is designed which can crawl throughout the room and can collect garbage and dust particles using vacuum pump mounted on this device. The controller is used to drive the motors and the suction unit, also a couple of sensors are used to avoid the obstacles present on the way. This design is used for domestic and industrial purpose.

1.2 Identifying feature

- Avoiding obstacles and path sensing using ultrasonic sensor.
- Falling from stairs can be avoided by IR proximity sensor.
- Calculating obstacle distance.
- Various movement patterns of bot.
- Cleaning dust particles through vacuum tube.

1.3 State of Art/Research

Automatic floor cleaner plays an important role in our busy life, which cleans the house with single press button. This bot is very simple and cost effective when compared with commercial products and it is more compact and portable. Equipped with Ultrasonic and IR proximity sensor these two sensors plays a major role ultrasonic sensor avoids

obstacles until cleaning operation is completed and IR proximity sensor avoids falling from stairs. Due to technological advancement in this new age, robotic vacuum cleaner cleans floors automatically without human intervention. This wonderful device maneuvers around table legs and corners of wherever it is vacuuming.

1.4 Abstract

Automatic floor cleaner is compact robotic system which provides floor cleaning service in rooms, office reducing human intervention. Households of today are becoming smarter and more automated. Home automation delivers convenience and creates more time for people. It is cost effective and performs cleaning activity with more efficiency. Cleaning manually has human error, time consuming and labors involved in cleaning floor may not clean as good as a robotic system. The cleaner will be a step for providing comfortable life by resolving problems in traditional floor cleaning methods. The purpose of this project is to construct a floor cleaner which will be fully automatic providing obstacle detection by ultrasonic sensor and avoiding the bot falling from staircase using IR sensor. The controller is used to drive the motors and the suction unit also a couple of sensors are used to avoid the obstacles. This can be useful in improving the lifestyle of mankind. Automatic floor cleaner is an automated machine that facilitates the user to keep their place clean and hygienic.

2. Requirements

2.1 High level requirements

Id	Description	Category
HL1	Path sensing using ultrasonic sensor	Technical
HL2	Calculating the obstacle distance	Technical
HL3	Movement of the bot	Technical
HL4	Staircase detection using IR sensor	Technical
HL5	Controlling suction power	Technical

Table 2.1

2.2 Low level requirements

Id	Description	Category
LL1	Three directions to be sensed by ultrasonic sensor (Left, right, Front)	Technical
LL2	To send and receive the ultrasonic waves	Technical
LL3	Calculating the distance travelled by ultrasonic waves and multiplying the duration by 0.034	Technical
LL4	Various movement patterns based on obstacle	Technical

LL5	Emitting IR rays through led and capturing reflected rays through photodiode	Technical
LL5	suction of dust particles using Vacuum tube	Technical

Table 2.2

3. Architecture

3.1 Block Diagram

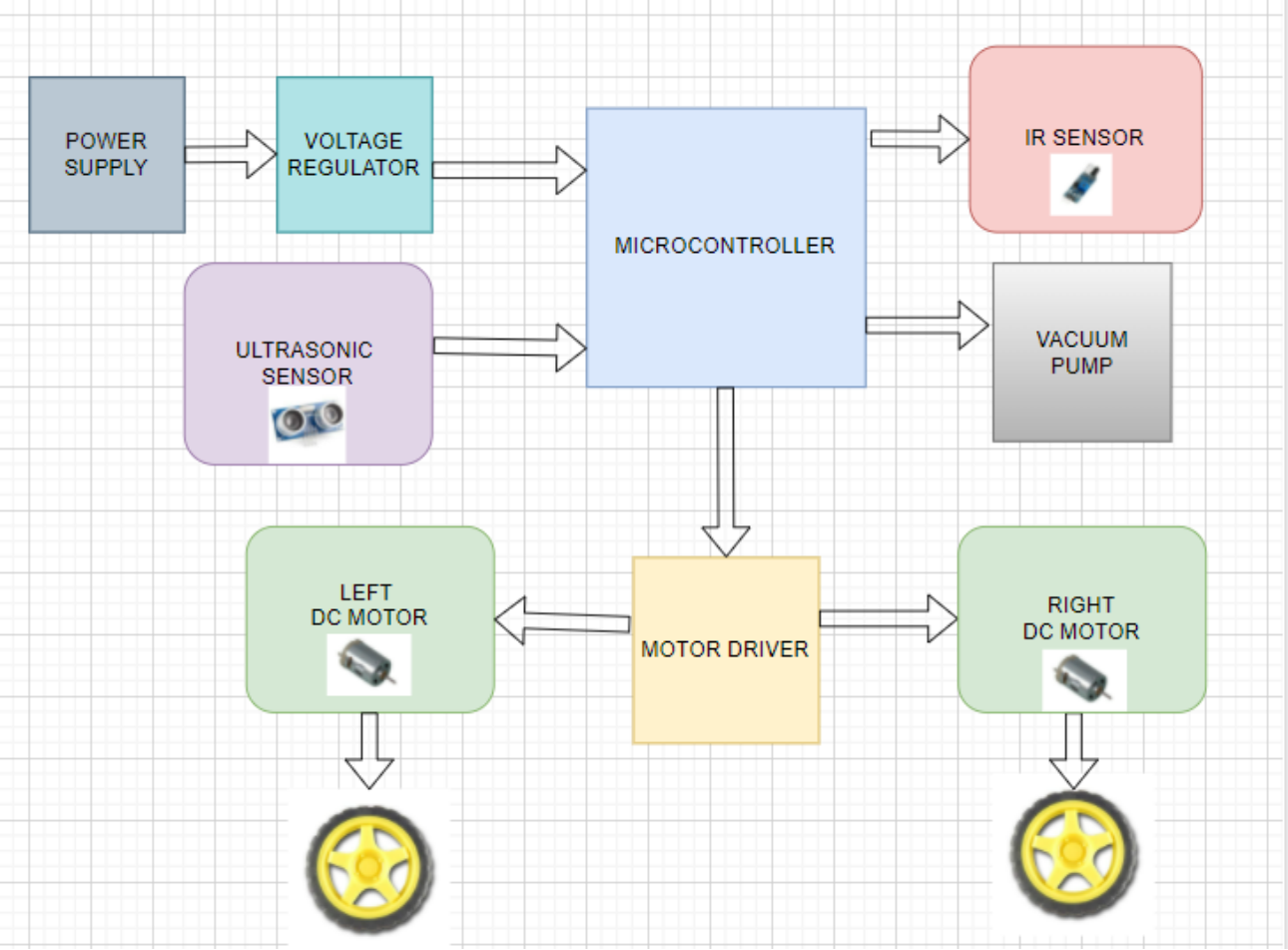

Figure 3.1

3.2 Components used

- This design consists of Arduino controller, Motor Driver, DC motor, Ultrasonic sensor, IR Proximity sensor, Vacuum pump.

1) Arduino UNO

- Arduino UNO is a microcontroller board which has ATmega328 from the AVR family which controls the all process to be carried out in the system.
- There are 14 digital input/output pins, 6 Analog pins, a 16 MHz ceramic resonator, USB connection, power jack, and also has a reset button.
- Its software supported by a number of libraries that makes the programming easier.

2) Motor Driver

- L293D is a Motor Driver IC which is used to connect the motor with the microcontroller and provide them sufficient voltage supply to the design.
- L293D has 16-pins in which 4 are input pins, 4 are output pins, 2 are enable pin, 4 GND pins and 2 pins for power supply. It is used to control DC motors simultaneously to rotate the bot in any direction.

- It works according to the concept of H-bridge. The voltage has to change its direction to rotate the motor in clockwise or anticlockwise direction.

3) DC Motors

- A simple DC motor is used to control the rotation of the machine.
- It converts the electrical energy to the mechanical energy and is connected with the wheels of the cleaner to move it in all directions.

4) Ultrasonic sensor

- Ultrasonic sensors are implemented to calculate the distance between the obstacle and the system.
- In order to detect the edges and to avoid obstacles, ultrasonic sensors are mounted on front, right and left side of wheels.
- It transmits ultrasonic waves and receives the reflected waves and measures the distance to the target by computing the time between the emission and reception.
- For measuring the distance: Distance= ½ (speed of sound * time taken)

5) IR Proximity Sensor

- IR sensors are object or obstacle detection Infront of sensor.
- It has an IR LED and a photodiode, the IR LED emits IR light and if any obstacle comes in front of this emitted light, it will be reflected, and the reflected light will be detected by the photodiode.
- The generated voltage from the reflection will be very low.

- An IR module has three pins - Vcc, ground, and output. Usually, the output goes low when an obstacle comes in front of the sensor

6) Voltage Regulator (LM7805)

- It is a 3-terminal voltage regulator that outputs any voltage to +5V.
- In this design it converts the 7.4V from battery to 5V.

7) Vacuum Pump

- For Cleaning purpose vacuum pump is used instead of conventional blower fans, resulting in higher suction power, leading to shorter cleaning time with better cleaning results.
- The powerful suction thus generated enables to pick metal chips, garbage, paper pieces, dust particles.

3.3 Flowchart

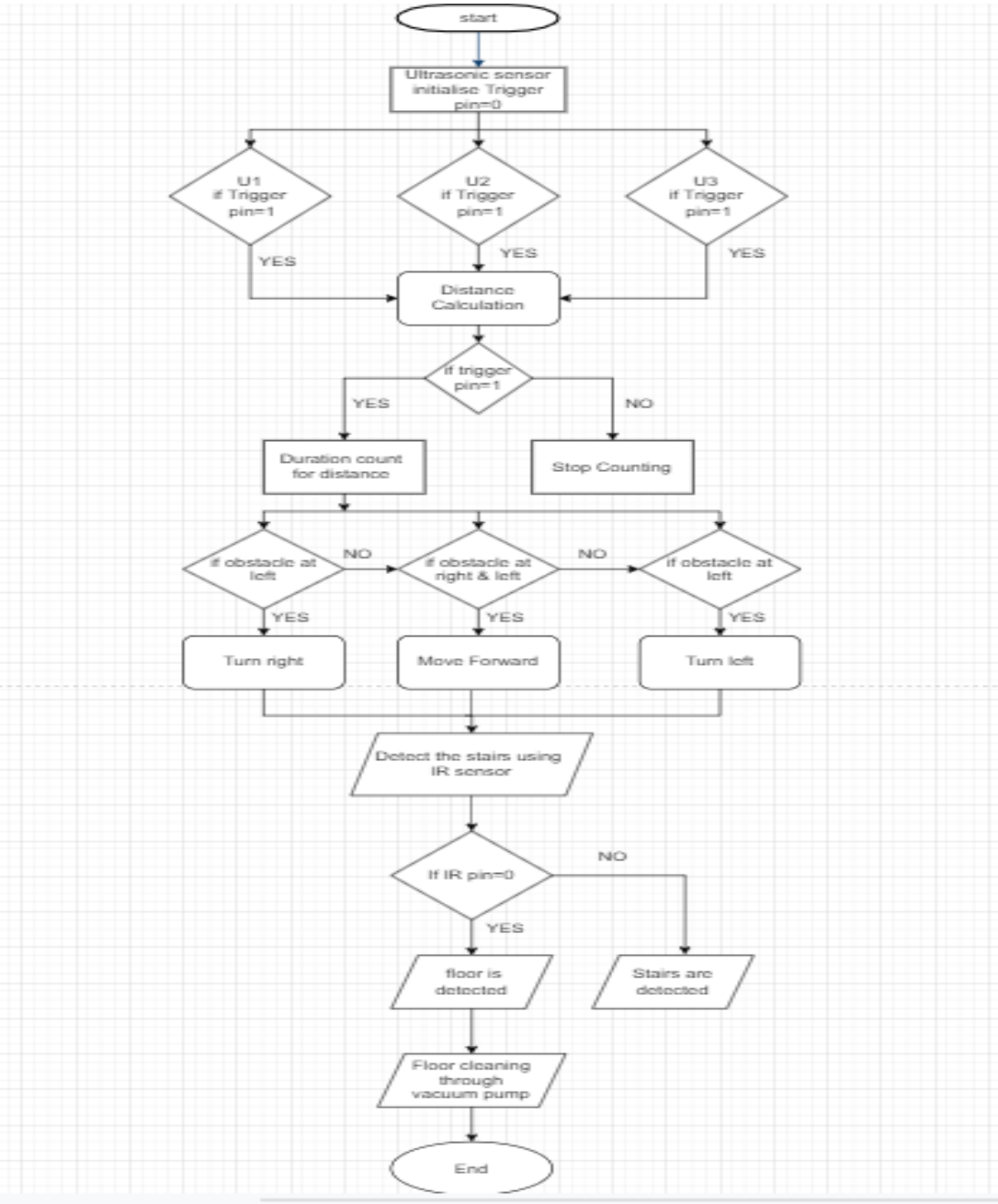

Figure 3.3

3.4 V-Model design

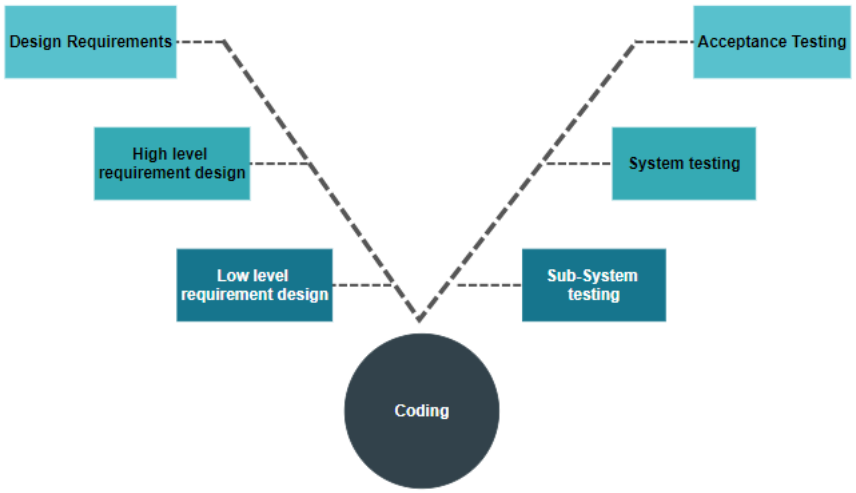

Figure 3.4

3.5 System Design

1. Path sensing unit.
2. Distance calculation.
3. Robotic movement.
4. Staircase detection.
5. Suction unit.

3.6 Sub-system Design

1. Direction control by ultrasonic sensor.

2. Communication through ultrasonic waves.

3. Calculation of travelling duration.

4. Various movement patterns.

5. Avoid bot falling from stairs

6. Vacuum suction of particles.

3.7 Applications of Vacuum cleaner

1) Freshen Upholstery, Pillows, and Carpets.

2) Prevent House Fires.

3) Reduce Indoor Allergens.

4) Exert Insect Control.

4. IMPLEMENTATION

This design is implemented in Arduino software and .elf, .ino, .eep, .hex files are generated. The generated hex file is dumped in SimulIde for simulation of circuit.

1) Obstacle detection and path sensing:

- This is done using ultrasonic sensor.
- Echo-Pin is defined as 6 and trigger-Pin is defined as 7.
- Define trigger-pin as output and echo-pin as input.

2) Distance Calculation

- When the echo-pin is high the pulse is stored in duration variable.
- distance = (duration/2) / 29.1
- LCD is initialized to display the distance in “cm”.

3) Movement of the Bot

- Pins are defined as:

1. Left-Forward = 2;
2. Left-Backward = 3;
3. Right-Forward = 4;
4. Right-Backward = 5;

- To rotate the DC Motors:

1. Left-Forward = high;
2. Left-Backward = low;
3. Right-Forward = high;
4. Right-Backward = low;

4) Stairs Detection

- In this system I have used push button as stairs detector.
- When the user presses the push button it indicates that stairs are detected.

5) Vacuum cleaning

- In this system there is use of LED light blinking as a power suction vacuum cleaning.
- As push button is pressed the LED will glow.
- In the absence of stairs vacuum cleaning is done.

5. Test plan and Output

5.1 High level Test plan

Test ID	Description	Expected i/p	Expected o/p	Actual o/p	Status
HL_1	Path sensing using ultrasonic sensor	Program execution	Obstacle detection and path sensing	Obstacle detection and path sensing	✔
HL_2	Calculating the obstacle distance	Program execution	Display of Distance on LCD	Display of Distance on LCD	✔
HL_3	Movement of the bot	Program execution	Rotation of DC motor through driver L239D	Rotation of DC motor through driver L239D	✔

HL_4	Staircase detection using IR sensor	User execution	pressing the push button by user as a interrupt	pressing the push button by user as a interrupt	✔
HL_5	Controlling suction power	Program execution	Blinking of LED light	Blinking of LED light	✔

Table 5.1

5.2 Low level Test plan

Test ID	Description	Expected i/p	Expected o/p	Actual o/p	Status
LL_1	Three directions to be sensed by ultrasonic sensor	Program execution	Directions and obstacles are detected	Directions and obstacles are detected	✔
LL_2	To send and receive the ultrasonic waves	Program execution	trigger and echo pins perform this task	trigger and echo pins perform this task	✔
LL_3	Calculating the distance travelled by ultrasonic waves and	Program execution	Distance in cm unit is displayed on LCD	Distance in cm unit is displayed on LCD	✔

	multiplying the duration by 0.034				
LL_4	Various movement patterns based on obstacle	Program execution	DC motors rotate accordingly	DC motors rotate accordingly	✔
LL_5	Emitting IR rays through led and capturing reflected rays through photodiode	Program execution	Push button saying stairs detected	Push button saying stairs detected	✔
LL_6	suction of dust particles using Vacuum tube	Program execution	Blinking of led light	Blinking of led light	✔

Table 5.2

6 Output:

1) Sub-system 1 and 2

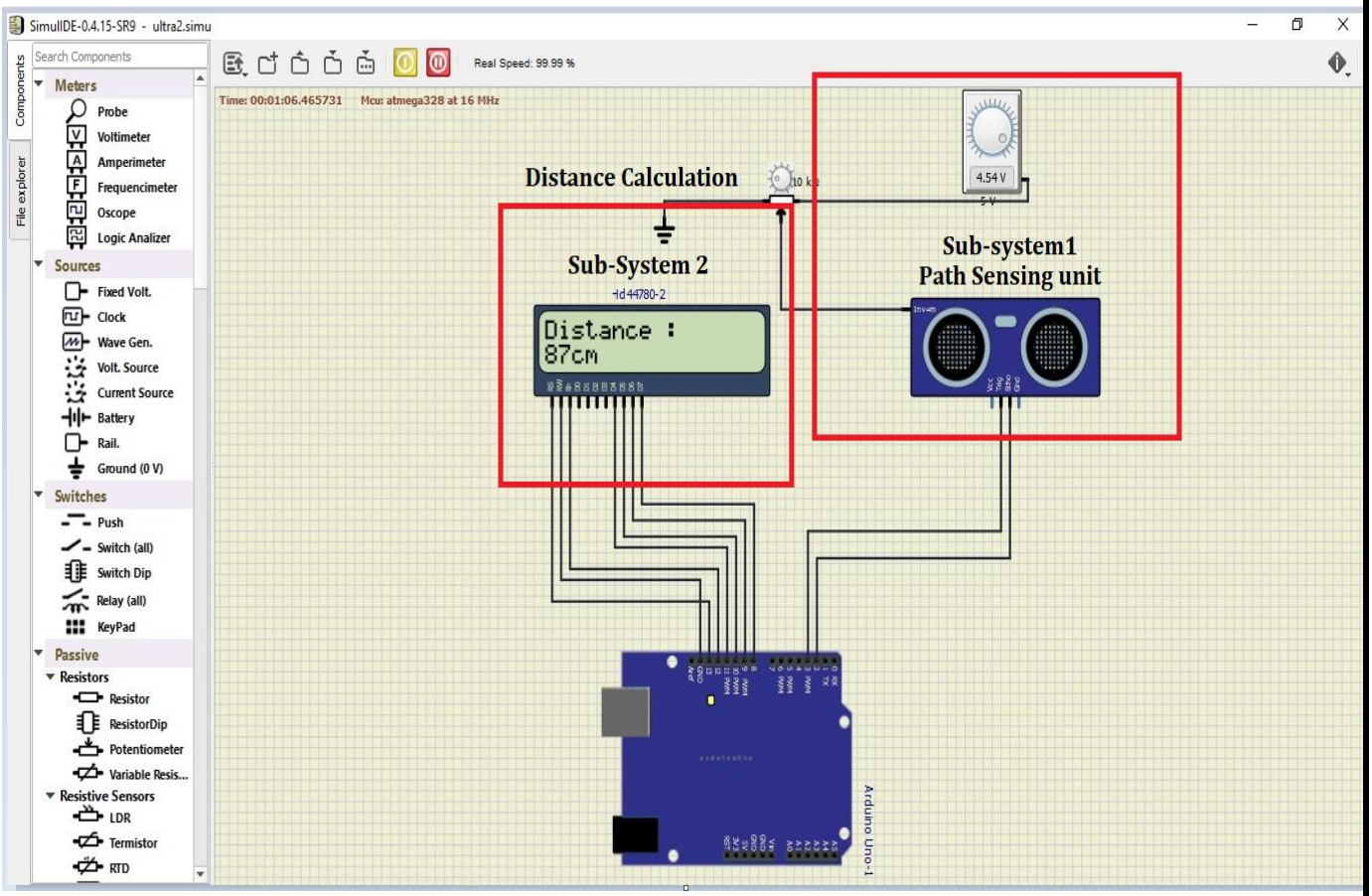

Figure 6.1

2) Sub-system 3

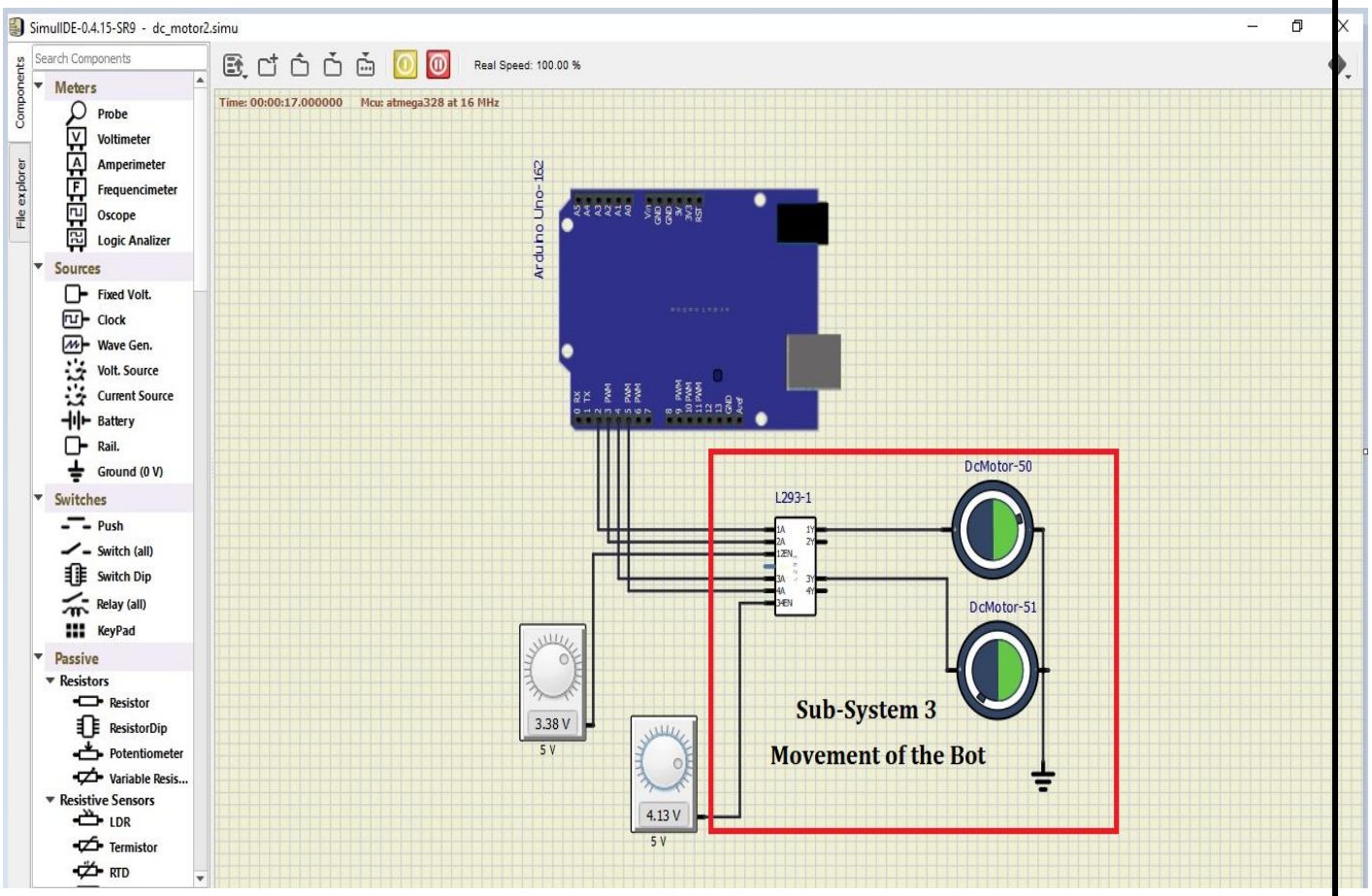

Figure 6.2

3) Sub-system 4 and 5

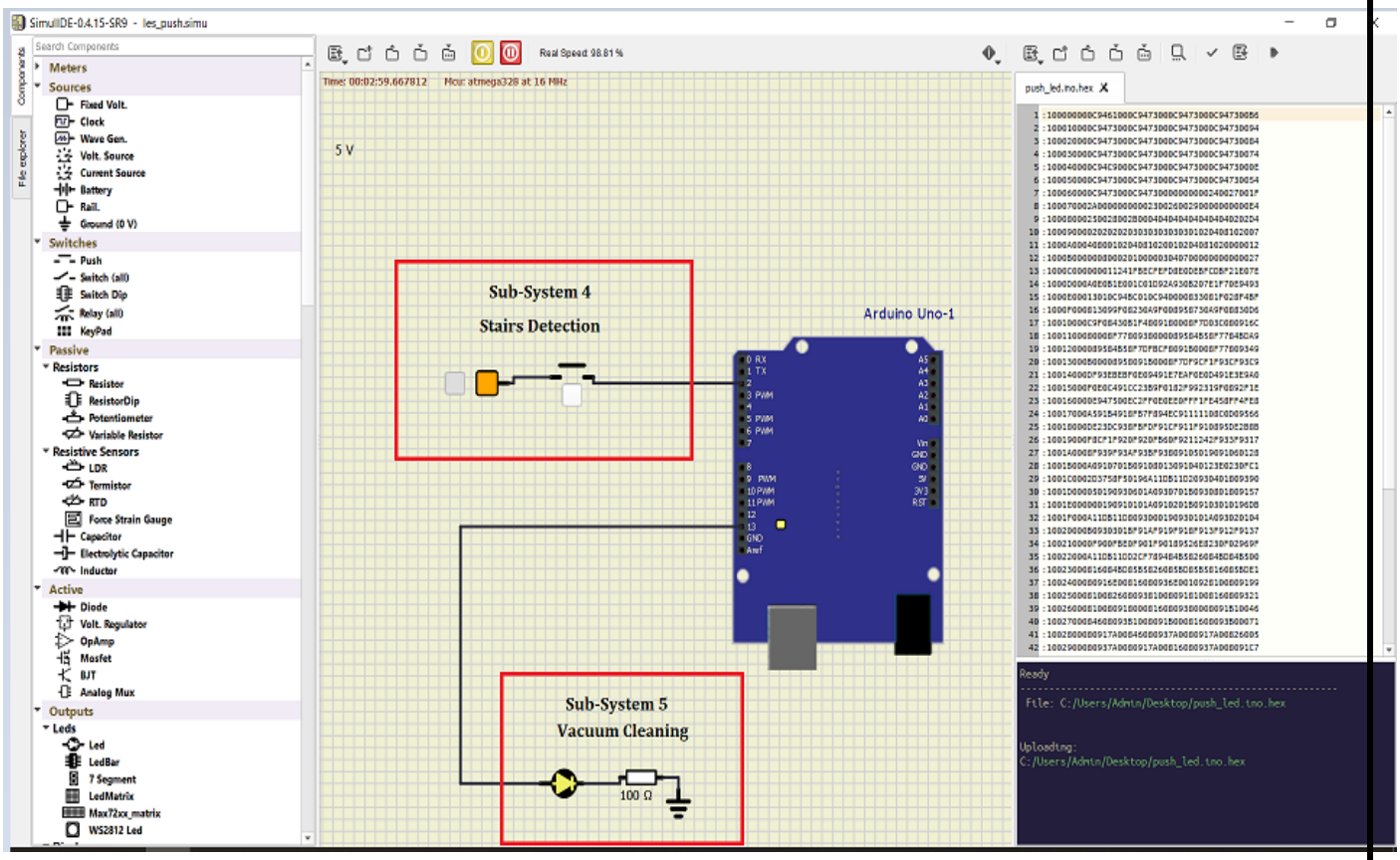

Figure 6.3

4) Simulation output

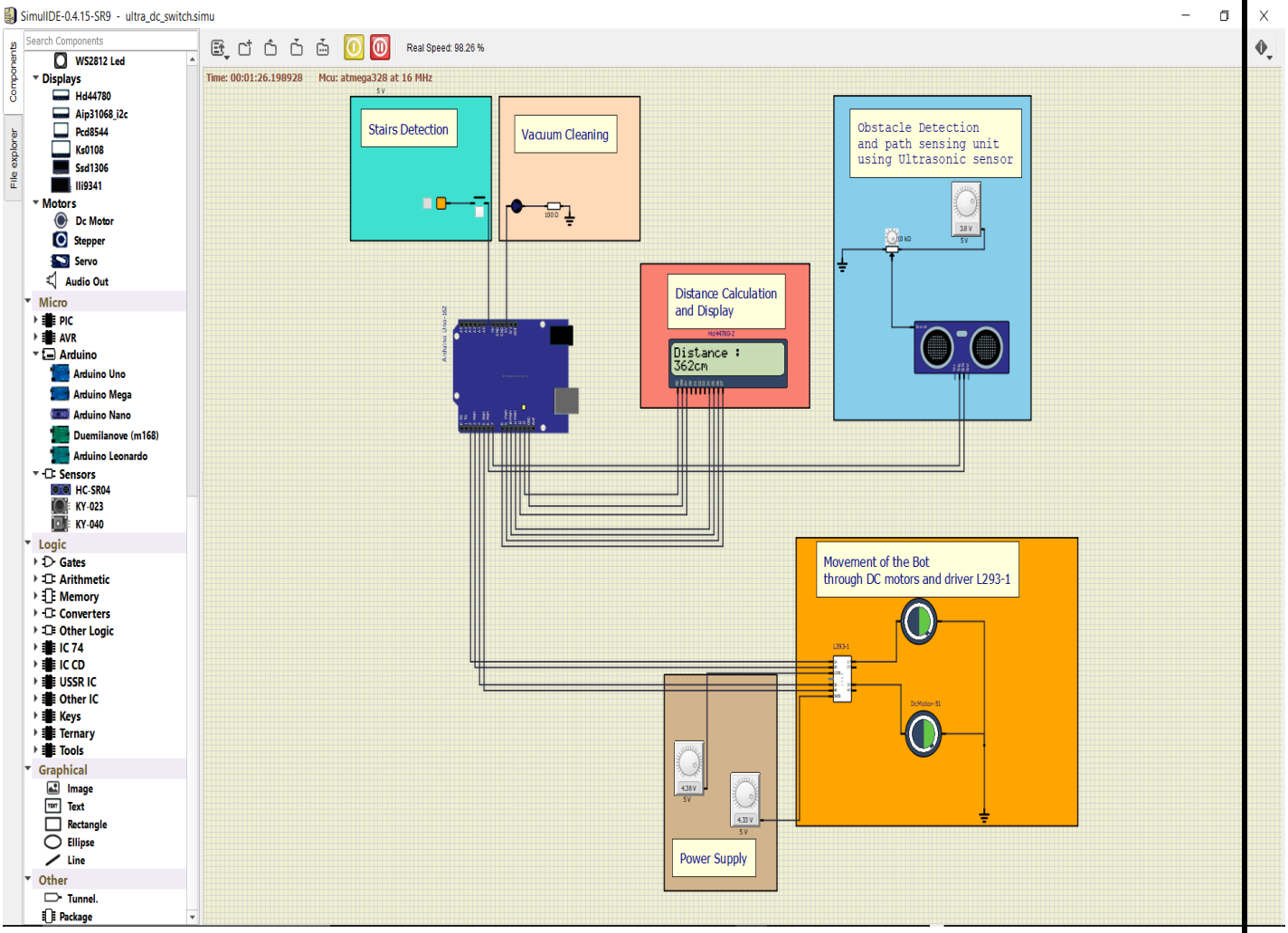

Figure 6.4