KIE1001 Laboratory 1
Sem II, 2022/2023
Mini Project: Line Following Robot Without Microcontroller
Duration: 3 weeks (Week 11 – Week 13)

Introduction

Line follower robot is a machine that follows a line, it may be a black line or a white line. The line following robot is beginner-friendly and interesting to understand and build. While line follower robots are popular and common to be built with Arduino or other microcontrollers, let's try to build the same without a microcontroller and actually understand the logic behind its working as well as use basic electronics to design the logic circuit. As the name already indicates, the robot is basically going to follow a line, but more advanced versions can be built. Let's try a simple, basic line following robot here. The robot basically consists of a pair of infrareds (IR) sensors to detect the line and two motors to control the movement and direction.

Parts and Components

No	Item	Unit
1	2WD Smart Robot Car Chassis	1
2	LM324 IC	1
3	L293D IC	1
4	Breadboard 16.5x5.5cm	1
5	74HC04 IC	1
6	IR LEDs, Transmitter and Receiver (2 pair)	1 set
7	Resistors 100k, 220 ohm, 1k (2 each)	1 set
8	Preset (variable resistor) (10k) (2 unit)	1 set
9	LEDs	2
10	Wires / Jumper Wires	-
11	9V Battery	1
12	StripBoard (Small) 6x14cm	1

Phase 1: Understanding the Working Principle

The line following robot works on simple logic obtained by combining the comparator circuit and L293D motor driver working. The infrared (IR) sensors give the output to LM324 comparator integrated circuit (IC). The IC gives high output when IR LEDs detect some object in front of it (or in our case, detects white light). Then the comparator IC gives high output (VCC). This is used as the input signal to decide whether to drive the motor or not. Since each IR sensor is associated with each motor, we can run the motor forward by driving both the motors and we can make turns by driving only one of the motors at a time. Block diagram of the overall system is shown in Fig. 1.

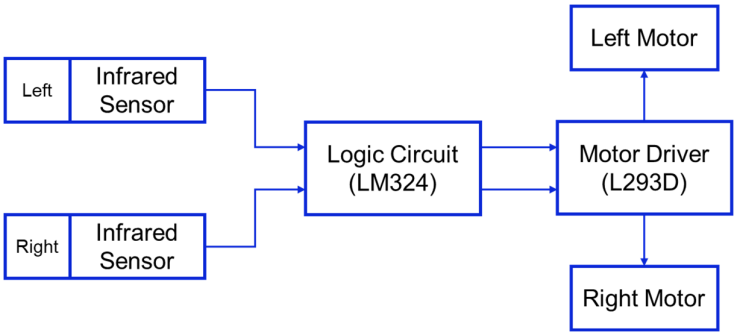

Fig. 1: Block diagram of the overall system

1. Understanding the working of IR sensor

   IR sensor is the reason why the robot is able to follow the line. The IR sensor basically consists of Infrared Transmitter (IR LED) and IR Receiver (Photodiode). Sometimes, IR LED and Photodiode together is called OptoCoupler or PhotoCoupler. The IR Transmitter LED, as its name suggests, transmits IR light. Infrared transmitters could be of different types based on their wavelengths, output power, and response time.

   When the IR LED transmits an IR ray if any object is present to block the IR rays, the surface of the object will reflect IR rays and the IR photodiode is sensitive to these rays. The IR photodiode receives these reflected IR rays and hence, the resistance and output voltages vary accordingly. Using this variation of output voltage (or resistance of photodiode) we can build the logical circuit. This is the basic working principle of the IR sensor; we will use this to detect the presence of the line. Now, IR rays are reflected when a white surface is present but a black surface will absorb. Hence, we will be able to detect where a black line is present and we can build a logical circuit to follow this line.

   (Tip: *to check if the IR transmitter is transmitting, use the camera (mobile phone camera will also do) to see the IR transmitter. You will see a purple glow at the center of the IR LED*.)

2. Power supply

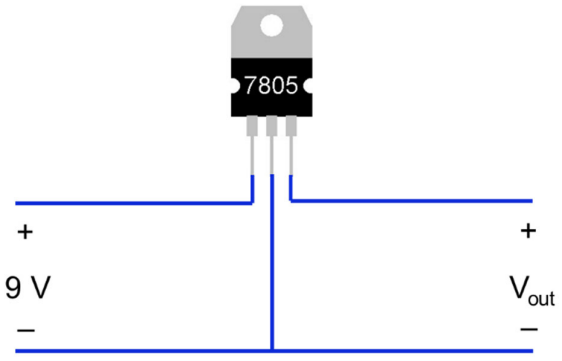

Fig. 2: Power supply connection

   i. Measure V_{out} using multimeter

3. Working of L293D Motor Driver IC

L293D is a motor driver IC. It's used to drive the motors (hence the wheel of the robot). As shown in the pinout of the L293D IC, it can control two motors. It can change the speed of the motors based on the current supplied to the motors; it can control the direction of the motors based on the input; it can also start or stop the motors. Pin diagram of L293D IC is shown in Fig. 3.

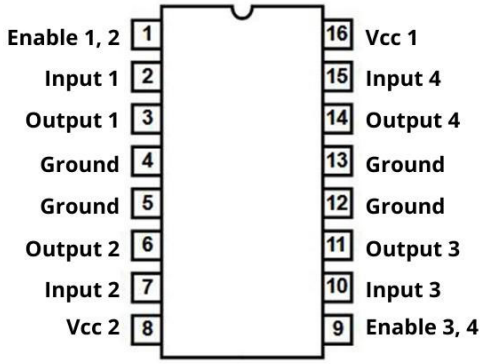

Fig. 3: Pin diagram of L293D

Connect the motor driver IC (L293D) according to the schematic in Fig. 4.

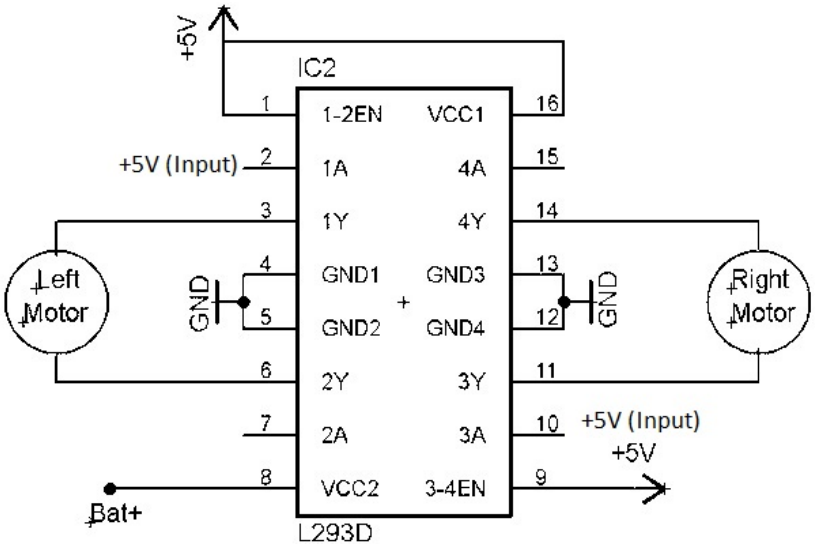

Fig. 4: Connection of L293D motor driver IC with the motors

4. Building IR Sensor with LM324 IC

The pinout of LM324 and the circuit connections of the IR sensor are as shown Fig. 5 and Fig. 6. We're using a single LM324 IC to control both the IR sensors. LM324 is powered up using VCC and GND pins which are 4 and 11 respectively. LM324 is an Op-Amp comparator IC that gives a high output (VCC). The photodiode is reverse biased and a voltage divider is created using a 100k resistor and fed as input to the inverting terminal.

The other voltage divider is created using a 10k preset and given as input to a non-inverting pin, pin 3 of the comparator. The IR LED is powered up by forward biasing it using VCC and GND. Pin 1 is output so we connect LED with current limiting resistor and take the output of the sensor from here to feed as the input for the motor driver.

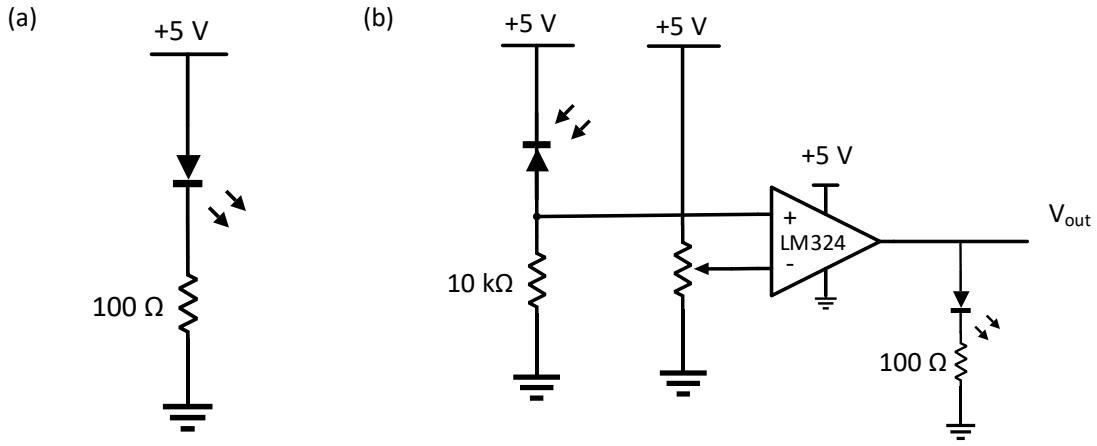

Fig. 5: (a) Infrared transmitter (b) Infrared receiver

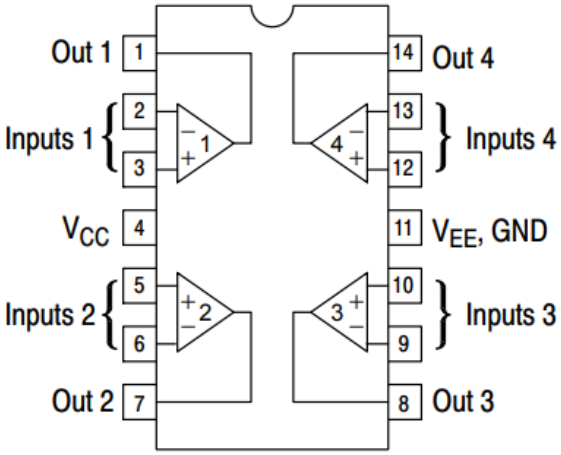

Fig. 6: Pin diagram of LM324 IC

Tune potentiometer until the LED is turned on when the IR sensor is pointed towards white surface and LED is turned off when the IR sensor is pointed towards black surface.

5. L293D Motor Controller Circuit

Pins 4, 5, 13, and 12 are shorted and connected to Ground. Pin 8 and 16 is the VCC pin. These two pins power the IC and the voltage with which the motors run, should be given here. Since we're using a 9V battery, we're going to short both the VCC pins (pin 8 and pin 16) and directly give it to 9V. Pin 1 and pin 9 are Enable pins for respective motors; for our connection, we need the motor to run as soon as it gets input from the IR sensor, so we'll connect the enable pin to high (short it with VCC). Pins 3 and 6 should go to one motor and pins 14 and 11 should go to another motor. Now, we have two pins for sensor output. This is used to run the motor in a forward or reverse direction.

Since our robot is going to move only in the forward direction, we can connect pin 7 and 15 to the ground and give the IR sensor output to pins 2 and 10. Both left and right motors should run in the same direction and the line following robot should move forward. If the robot is moving towards the opposite direction, swap the connection of the motor with the L293D output pins.

To sum up the connections, the robot moves forward when there's high input from the IR sensor. When there is a white surface under the robot, the IR sensor gives high output hence the motors turn forward. If both the IR sensors come across the black surface, it gives low output and hence the motor won't run. At this point, the robot stops moving forward. But if only one of the IR sensors comes across the black surface, that sensor gives low output whereas the other IR sensor, which will be on the white surface will give high output hence that side motor will still be turning and hence the bot makes the turn.

Phase 2: Assembling the Line Follower Robot

Once we have understood the connection of all the components, we can start assembling our line following robot. To make this robot, first, we need a robot chassis. Here we used a simple readymade robot chassis. Then, we soldered the IR circuit and controller circuit to the stripboard and mounted the motors to the chassis.

To power the robot, we used 9V batteries to drive both the motors and the IR circuit. If a single 9V battery won't output enough power; hence a parallel combination of 9V batteries has to be used. The L293D and IC 324 both can take input voltage up to 9V, hence it is used here. If one is using higher than 9V to power the circuit, check the datasheet of L293D and IC 358 for input voltage (because higher voltages might damage the IC). Connect the switch, resistor and LED to the output as shown in Fig. 7.

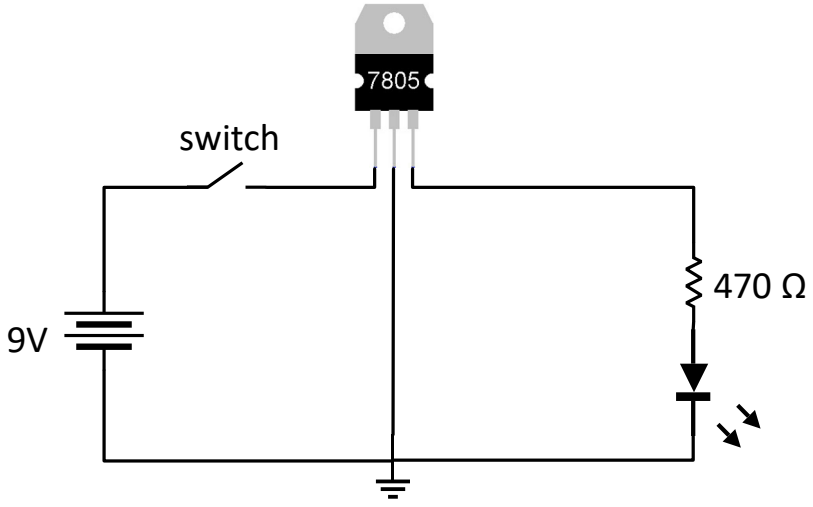

Fig. 7: Power supply connection

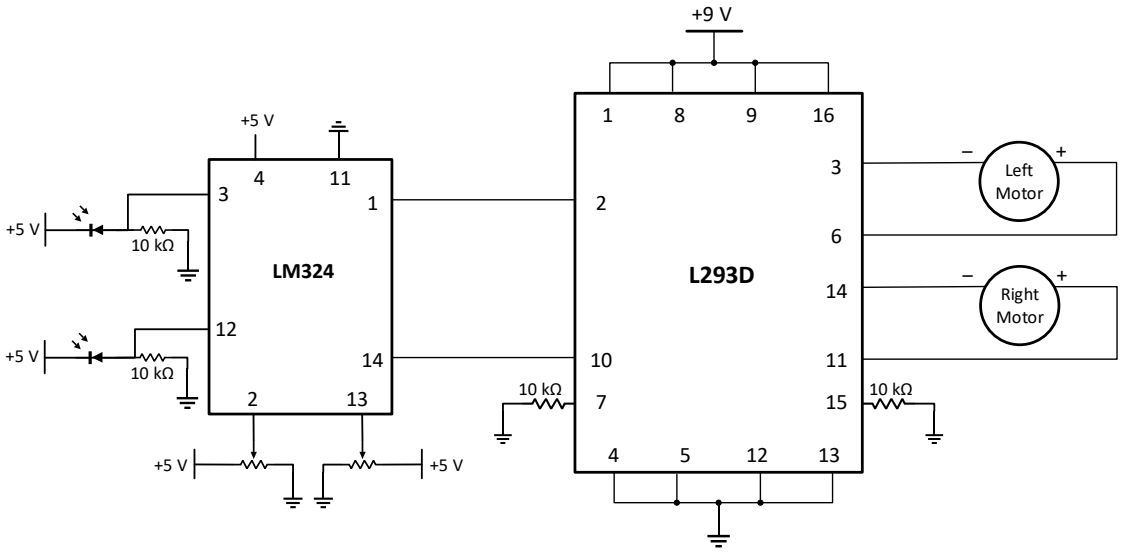

Fig. 8: Final system assembly

Phase 3: Testing and Calibration

We have assembled the robot as in Fig. 8 and as it doesn't require any code, so it's time to see it in action. For that all we need to do is place the robot on top of the black line and see it in action.