

**SLG46537**  
**Line Follower Control Circuit for Robots**

The application note gives step-by-step guidelines for creating a line follower control circuit for robots based on TCRT5000 reflective optical sensor.

The application note comes complete with design files which can be found in the Reference section.

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## 1. Terms and Definitions

|     |                        |
|-----|------------------------|
| IR  | Infrared               |
| LED | Light-Emitting Diode   |
| LUT | Look-up Table          |
| PWM | Pulse Width Modulation |

## 2. References

For related documents and software, please visit:

[GreenPAK Programmable Mixed-Signal Products | Renesas](#)

Download our free Go Configure Software Hub [1] to open the .gp files [2] and view the proposed circuit design. Use the GreenPAK development tools [3] to freeze the design into your own customized IC in a matter of minutes. Renesas provides a complete library of application notes [4] featuring design examples as well as explanations of features and blocks within the Renesas IC.

[1] [Go Configure Software Hub](#), Software Download and User Guide, Renesas Electronics

[2] [AN-1143 Line Follower Control Circuit for Robots.gp](#), GreenPAK Design File, Renesas Electronics

[3] [GreenPAK Development Tools](#), GreenPAK Development Tools Webpage, Renesas Electronics

[4] [Application Notes](#), GreenPAK Application Notes Webpage, Renesas Electronics

[5] [SLG46537 Datasheet](#), Renesas Electronics

### 3. Introduction

The GreenPAK chips have easy to program look-up tables (LUTs) which enable us to easily design a simple yet efficient controller for a line following robot.

### 4. Theory

We will explore both the classic approach using only predefined Logic Gates NAND, AND, OR, NOR and NOT, as well as taking full advantage of the programmable LUTs the GreenPAK has.

A line follower is a robot that can follow a track of black lines on a white background, as illustrated below in [Figure 1](#).

Black and white has the most contrast properties and allows us to work with the TCRT5000. The detailed schematic of the TCRT5000 is presented just below in [Figure 2](#).

The TCRT5000 is a Ref elective optical sensor, which means that it is composed of two parts: an IR LED and an IR receiver. The output is a digital signal HIGH for white and LOW for Black.

Each TCRT5000 has an output that we are going to call IN 1, IN 2 and IN 3.

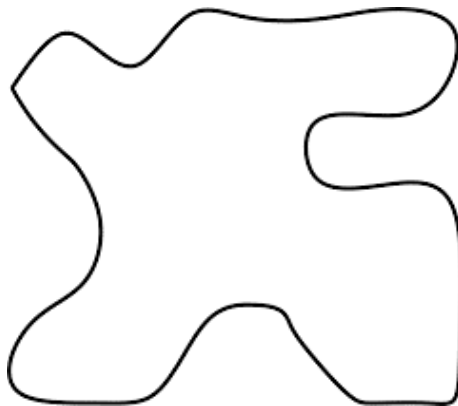


Figure 1. Track of black lines

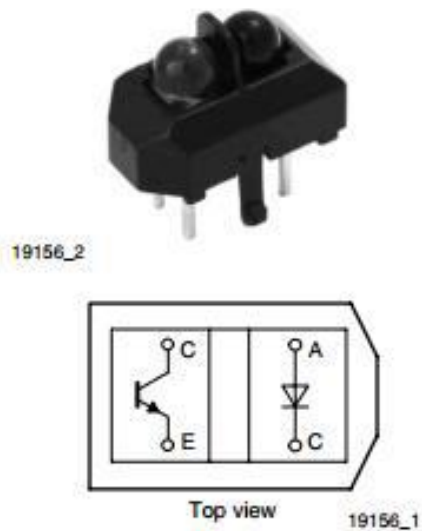


Figure 2. The schematic of the TCRT5000

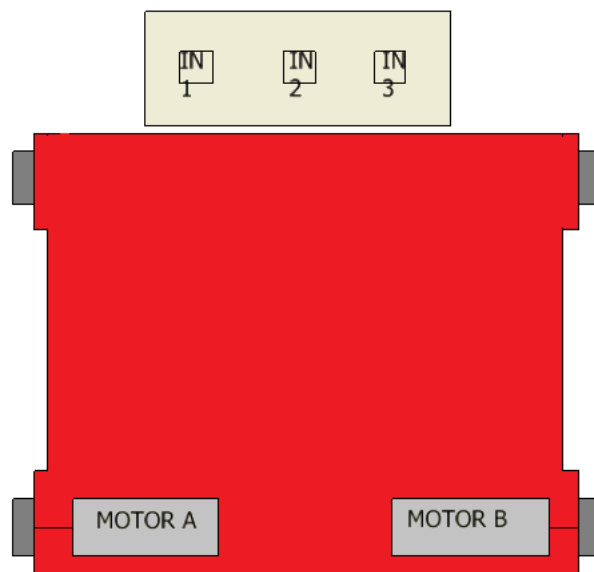
## 5. Design

The logic we are going to be implementing is shown in [Table 1](#):

**Table 1. Logic data**

| IN 1 | IN 2 | IN 3 | A MOTOR | B MOTOR |
|------|------|------|---------|---------|
| 0    | 0    | 0    | X       | X       |
| 0    | 0    | 1    | 0       | 1       |
| 0    | 1    | 0    | X       | X       |
| 0    | 1    | 1    | 0       | 1       |
| 1    | 0    | 0    | 1       | 0       |
| 1    | 0    | 1    | 1       | 1       |
| 1    | 1    | 0    | 1       | 0       |
| 1    | 1    | 1    | X       | X       |

Motor at 1 means that the motor is spinning, and at 0 means that it is stopped. In order to keep a simple design, we will only drive two motors. The motors are placed as shown in [Figure 3](#). We could design the sensor array with any quantity of sensors we like, but it can be just three TCRT 5000 arranged as below. An ideal distance between the TCRT 5000s would be the width of the black line it is going to follow.



**Figure 3. Motor schematic**

## 6. Classic Design Sequence

Following the normal process using the table shown before, we are to simply obtain the logical equations using Karnaugh's Maps for each motor.

The Karnaugh's map for the A motor is represented in [Table 2](#).

Table 2. The Karnaugh's map for the A motor

| Row IN 1 Columns IN2, IN3 | 00 | 01 | 11 | 10 |
|---------------------------|----|----|----|----|
| 0                         | X  | 0  | 0  | X  |
| 1                         | 1  | 1  | X  | 1  |

X state means that the combination is not expected to appear under normal circumstances, which means that it does not matter if the motor is either spinning or stopped

So the logic equation for the A motor is:

$$AMotor=IN1$$

The B Motor map is described by Table 3.

Table 3. The B Motor map

| Row IN 1 Columns IN2, IN3 | 00 | 01 | 11 | 10 |
|---------------------------|----|----|----|----|
| 0                         | X  | 1  | 1  | X  |
| 1                         | 0  | 1  | 0  | 0  |

This gives us the logic equation for the B Motor:

$$BMotor = IN1' + IN2'IN3$$

Usually, in order to use only one or two types of logic gates, we do some Boolean algebra until we get the following equivalent equation.

$$BMotor = IN1IN2'IN3''$$

This line follower is developed using simple logic, which means that going in reverse is not implemented.

In case the three sensors are outside the black line, IN 1, IN 2 and IN 3 will all be reading a HIGH, which for this configuration makes the car spin, until the black line can be found again.

On the other hand, when the three sensors are reading a LOW, the car stops moving altogether.

These equations are the logic for the basic line follower, and if we were to program it exactly in the same form, we obtain the configuration shown in Figure 4.

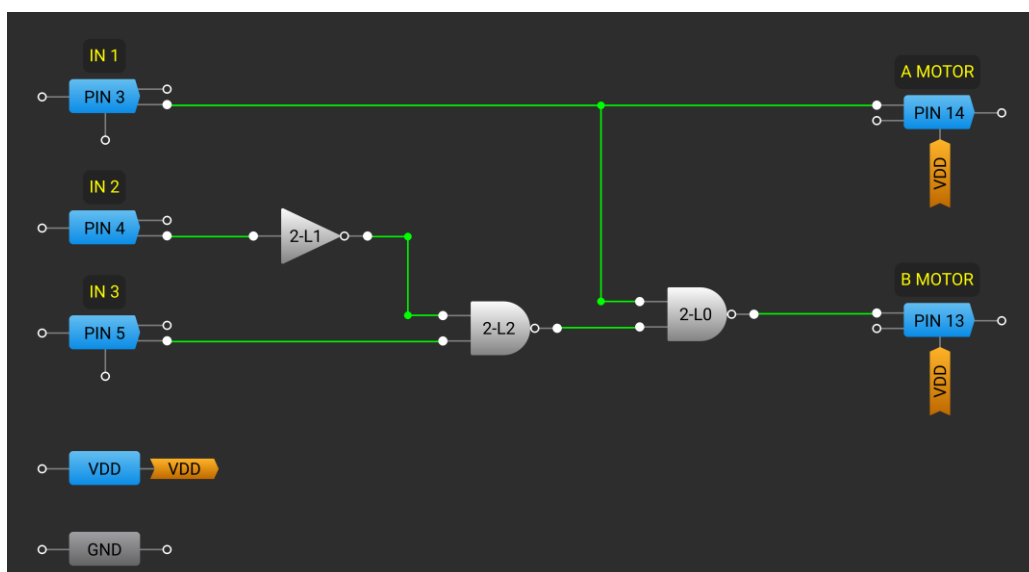


Figure 4. GreenPAK Designer configuration

## 7. Using GreenPAK for Design Optimization

GreenPAK has the advantage that the designs can be implemented using premade logic gates. But what makes it so favored by engineers is their capability to actually implement completely arbitrary Logic tables using their programmable LUTs.

Figure 5 illustrates that using the LUT table is far easier than implementing predetermined logic gates

Using the completely programmable feature of the LUT we can considerably reduce the use of resources inside the GreenPAK, and simplify even further the Line follower design.

In Figure 6 we can see that just one LUT table can do all the processing done by the other 3 Logic Gates shown in the first GreenPAK Design.

| IN3 | IN2 | IN1 | IN0 | OUT |
|-----|-----|-----|-----|-----|
| 0   | 0   | 0   | 0   | 0   |
| 0   | 0   | 0   | 1   | 1   |
| 0   | 0   | 1   | 0   | 0   |
| 0   | 0   | 1   | 1   | 1   |
| 0   | 1   | 0   | 0   | 0   |
| 0   | 1   | 0   | 1   | 1   |
| 0   | 1   | 1   | 0   | 0   |
| 0   | 1   | 1   | 1   | 0   |

Figure 5. LUT properties

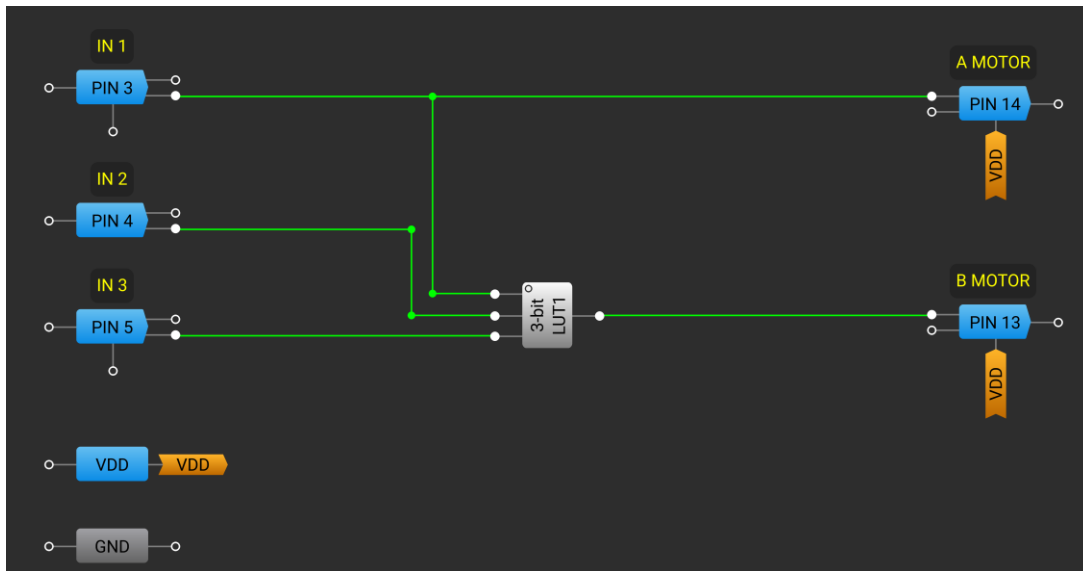


Figure 6. 3 Logic Gates in GreenPAK Design

## 8. Considerations

To power up the GreenPAK, we can connect it to the 5v Pin of the LN298N and power the same using a 12 volt battery. This can be seen in Figure 7.

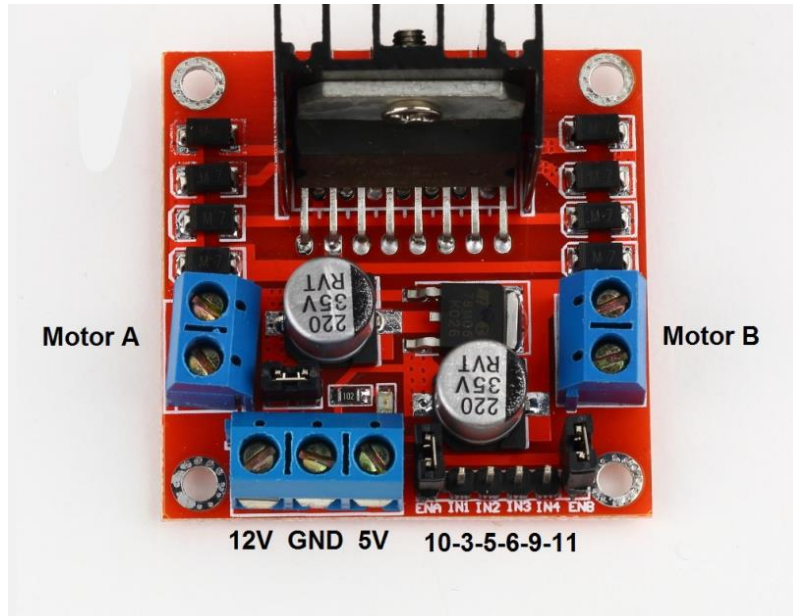


Figure 7. The LN298N

Using this setup, we can add more features to this basic design, implementing PWM to regulate the speed in which the line follower is moving, and enable us to implement a reverse condition if needed.

## 9. Conclusion

This app note shows a simple design that can always be modified to add new features.

GreenPAKs are a very promising tool for IoT development and as a tool for teaching future electronic engineers. Their low power consumption, small design and user friendly developing software makes them an interesting and handy technology to become mainstream in study plans for colleges around the world.

## 10. Revision History

| Revision | Date             | Description   |
|----------|------------------|---|
| 1.00     | November 4, 2016 | Initial release.  |
| 2.00     | April 30, 2026   | The part number has been changed from SLG46531V to SLG46537V. |

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