# DESIGN ELECTRO-MECHANICAL LINE TRACKING ROBOT

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"I treat as valid this report is doing by myself except summary and quotation in every part that I had clear source"

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My mum and dad, friends and all which involved

## ABSTRACT

The objective this Line Tracking Robot is used to follows a line that drawn on the floor. The robot will detect a black line on a white surface and track the line. To make sure robot can detect a black line, a sensor will be used like an IR (Infra-red) LED and phototransistor. IR light used for a variety purposes and one of its applications is as IR sensor that consists of an IR LED and phototransistor reflecting light from a surface. When the surface is white, the IR light from the LED reflects efficiently, turning the phototransistor. A black surface tends to adsorb IR light and very little is reflected, keeping the phototransistor turned off. This line following robot is expected to follow a black line on the surface. This robot also can detect line again if it out from the track with refers to IR LED and phototransistor function. This robot will used two motors for control rear wheels and a single front wheel is free. At the bottom of robot, IR sensors will be used for detect black tracking line. The IC used in this project is the LM393N. The function of this comparator is to compare a logic signal 0 or 1 from sensor whether robot will forward, turn left or turn right. The movement of robot is depends to signal which given by sensor namely 0 (low) and 1 (high).

# ABSTRAK

Objektif 'Line-Tracking Robot' adalah digunakan bertujuan supaya robot ini dapat mengikut garisan pada lantai atau selain daripadanya. Robot akan mengesan garisan gelap (hitam) pada permukaan cerah (putih) dan akan mengikuti jejak garisan tersebut. Untuk memastikan robot boleh mengesan garisan gelap (hitam) tersebut, penderia akan digunakan iaitu Diod Pemancar Cahaya (LED) Infra-merah dan juga Foto-transistor Infra-merah. Cahaya Infra-merah digunakan untuk pelbagai kegunaan dan salah satu kegunaannya ialah sebagai penderia Infra-merah yang berupa diod pemancar cahaya dan fototransistor bertindak sebagai pemantul cahaya pada permukaan. Bila pada permukaan putih, cahaya infra-merah akan memantul dengan efisen, permukaan gelap (hitam) akan cenderung untuk menyerap cahaya daripada infra-merah dan sangat sedikit cahaya memantul dan menyimpan foto-transistor dalam keadaan OFF dan ini menyebabkan 'Line-Tracking Robot' akan mengikut garisan gelap (hitam) pada permukaan. Selain itu, robot ini juga boleh mengesan semula garisan jika ia terpesong atau terkeluar daripada landasan dengan merujuk kepada fungsi Diod Pemancar Cahaya (LED) Infra-merah dan juga Foto-transistor Infra-merah. Robot ini akan menggunakan dua motor untuk mengawal roda atau tayar belakang dan pada roda atau tayar hadapan, robot akan menggunakan roda 'swivel'. Pada bahagian bawah robot, empat penderia infra-merah digunakan untuk mengesan garisan gelap (hitam). Litar bersepadu yang akan digunakan dalam projek ini ialah jenis LM393N iaitu Pembanding Dwi Voltan Kuasa Rendah keluaran STMicroelectronics. Fungsi pembanding ini adalah untuk membandingkan isyarat logic iaitu 0 atau 1 daripada penderia sama ada robot akan bergerak kehadapan, kekiri atau kekanan. Pergerakan robot bergantung kepada signal yang diberi oleh sensor iaitu 0 (rendah) dan 1 (tinggi).

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## LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| PSM | - | Projek Sarjana Muda |
| IC | - | Integrated Circuit |
| IR | - | Infrared |
| DC | - | Direct Current |
| LED | - | Light Emitting Diode |
| RPM | - | Rotation per Minute |
| Ni-MH | - | Nickel-Metal Hydride Battery |
| OP-Amp | - | Operational Amplifier |
| CPU | - | Central Processing Unit |
| I/O | - | Input/Output |
| PWM | - | Pulse Width Modulation |
| RC | - | Remote Control |
| MHz | - | Megahertz |
| RISC | - | Reduced Instruction Set Code |
| TTL | - | Transistor-Transistor Logic |
| CMOS | - | Complementary Metal-Oxide Semiconductor |
| PVC | - | Polyvinyl chloride |
| VCO | - | Voltage Control Oscillator |
| $V_t$ | - | Voltage terminal |
| $T_{st}$ | - | Starting torque |
| $T_x$ | - | Transmitter |
| $R_x$ | - | Receiver |

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# CHAPTER 1

## INTRODUCTION

The Line Tracking Robot is one of the self-operating robot that follows a line that drawn on the floor. The robot will detect a black line on a white surface and track the line. To make sure robot can detect a black line, a sensor will be used like an IR (Infra-red) LED and phototransistor. IR light used for a variety purposes and one of its applications are as IR sensor that consists of an IR LED and phototransistor reflecting light from a surface. When the surface is white, the IR light from the LED reflects efficiently, turning the phototransistor. A black surface tends to adsorb IR light and very little is reflected, keeping the phototransistor turned off. This line following robot is expected to follow a black line on the surface. This robot also can detect line again if it out from the track with refers to IR LED and phototransistor function. This robot will used two motors for control rear wheels and a single front wheel is free. At the bottom of robot, IR sensors will be used for detect black tracking line. The advantages of this robot is it non-programming, easy to maintenance, low cost and low power consumption.

## 1.1 Objectives

The objectives of this project are:

i. To study about Line-Tracking Robot characteristics and how this robot function.
ii. To study about functional and application of IR LED and phototransistor in line-tracking robot.
iii. To build a robot that will have its own mind so that it can navigate itself without the interference from the human.

## 1.2 Scopes of Work

For Line Tracking Robot project, the scopes consist of electrical and hardware (mechanical). For electrical part involved the circuit using like sensor and comparator circuit; and also motor controller circuit for robot movement. Meanwhile, for hardware part involved the mechanical equipment like main body of robot, motor for robot movement, wheel (front and rear) and also sensor device. The connection or combination between electrical and hardware is very significant because both of this part will determine whether the robot can be functioning or not. So, scope of works for this project will include both electrical and hardware (mechanical).

### 1.2.1 Mechanical Part

#### 1.2.1.1 Twin – Motor Gearbox

The Twin Motor Gear Box uses a two motor system to provide power and speed to turn the hex shaft. The gear box is made from high quality plastic. This motor will be mounted at the robot body and it function as rear wheel controller. The reason why this motor has been choose because:

i. It is versatile and easy to construct.
ii. The gear is of poly-acetyl resin, which permits efficient power transmission with less mechanical noise than metal gears.
iii. Have two gear ratios, 58:1 and 203:1 can be selected by altering the gears.
iv. Voltage rate for 3V DC but typically work fine up to 6 volts, 15100 RPM

Function of Twin - Motor Gearbox : To drive or control rear wheels.

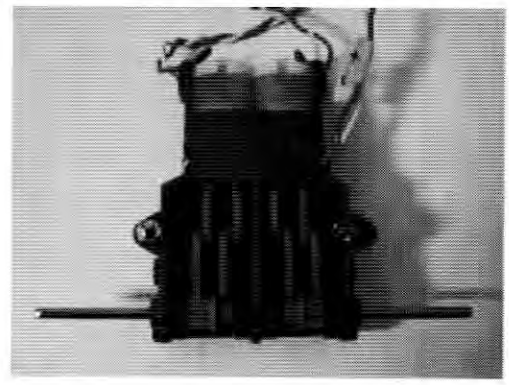


Figure 1.1: Twin – Motor Gearbox

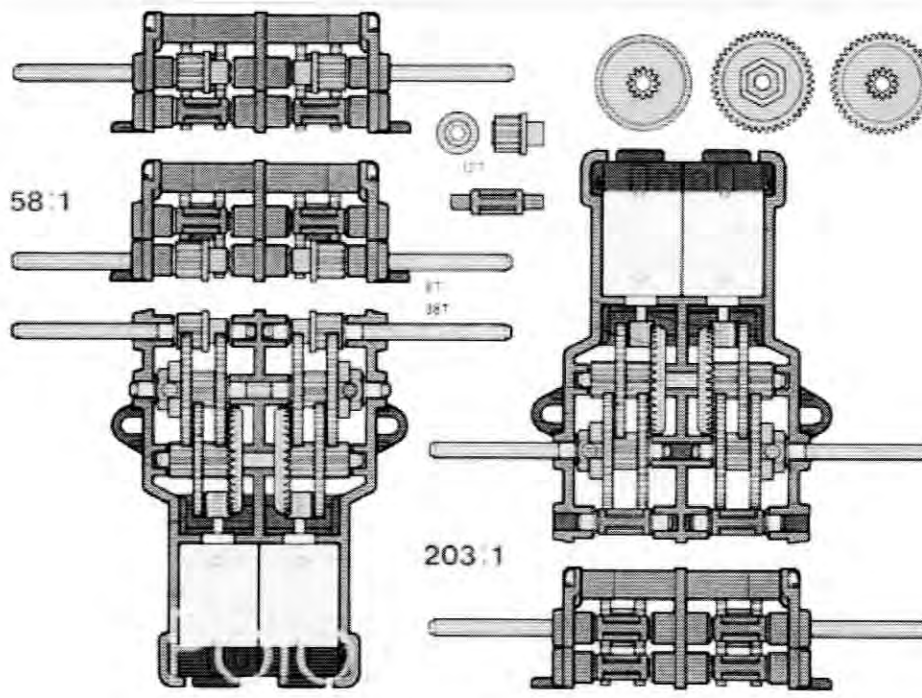
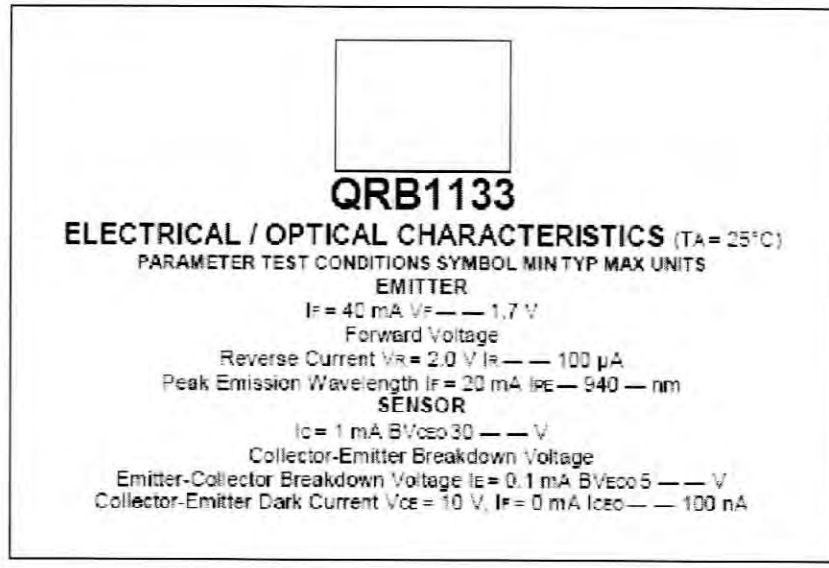



Figure 1.2: Twin – Motor Gearbox Motor Dimension

### 1.2.1.2 Line Sensor

For line sensing system, the QRB1133 Phototransistor Sensors from SHARP Company will be used. These sensors consist of two components, an infrared emitting diode and an NPN silicon phototransistor. The NPN phototransistor receives light waves that are reflected from the surface of the floor by the emitting diode. With a white surface the magnitude of reflection is different than that of a black surface; therefore a distinction can be made between two different color surfaces. Once that distinction has been made, a High voltage is sent through the circuit and to micro-controller.



**QRB1133**

**ELECTRICAL / OPTICAL CHARACTERISTICS** ($T_A$ = 25°C)

| PARAMETER | TEST CONDITIONS | SYMBOL | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| **EMITTER** | | | | | | |
| Forward Voltage | $I_F$ = 40 mA | $V_F$ | — | — | 1.7 | V |
| Reverse Current | $V_R$ = 2.0 V | $I_R$ | — | — | 100 | µA |
| Peak Emission Wavelength | $I_F$ = 20 mA | $\lambda_{PE}$ | — | 940 | — | nm |
| **SENSOR** | | | | | | |
| Collector-Emitter Breakdown Voltage | $I_C$ = 1 mA | $BV_{CEO}$ | 30 | — | — | V |
| Emitter-Collector Breakdown Voltage | $I_E$ = 0.1 mA | $BV_{ECO}$ | 5 | — | — | V |
| Collector-Emitter Dark Current | $V_{CE}$ = 10 V, $I_F$ = 0 mA | $I_{CEO}$ | — | — | 100 | nA |

Figure 1.3: Characteristics of QRB 1133 Phototransistor Sensor

### 1.2.1.3 Battery

**a) 9V/150mAh Rechargeable Ni-MH Battery**

This 9V battery is the latest in rechargeable technology and manufactures by Radio-Shack. The material to make a rechargeable Ni-MH battery is from chemistry and this battery is mercury free.


Figure 1.4: 9V/150mAh Rechargeable Ni-MH Battery

Table 1.1: Technical Specification of 9V Rechargeable Ni-MH Battery

| | |
|---|---|
| **Dimensions** | |
| Product Length | 0.689 |
| Product Height | 1.909 |
| Product Width | 1.043 INCHES |
| Product Weight | 0.3 ounces |
| **Battery Features** | |
| Size | 9 Volt |
| Capacity | 150 mAh |
| Voltage | 9 Volts |
| Rechargeable | Yes |
| Equivalent to | Radio-Shack 9V |

### 1.2.2 Electrical Hardware Part

#### 1.2.2.1 Motor Controller Circuit

The function of motor controller circuit is to:

i. Drive the motor direction

ii. Control the motor speed

There are three ways to vary the speed of DC motors:

i. Use a gearbox.

ii. By applying the supply voltage to the motor for a variable amount of time, eliminating the series dropping effect.

iii. Use a series resistor. Measure the current drawn by the motor and then calculate the value of a series resistor needed to drop the voltage applied to the motor.

### 1.2.2.2 Infrared sensors and comparator circuit

The LM393N Dual Comparator IC used as brain for line tracking robot so that it can be distinguish between black and white surfaces. The IC used in this robot contains 2 OP-Amp's used as comparators. The package has 8 pins: 4 inputs, 2 outputs and 2 more pins for $+V_{CC}$ and $-V_{CC}$.

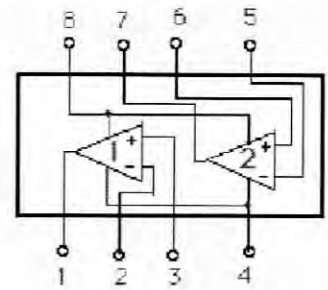



Figure 1.5: IC LM393N Containing two comparators

## 1.3 Report Organization

This report is divided into several chapters. They are:

i. Introduction
ii. Literature Review
iii. Project Methodology
iv. Component Description
v. Design and explanation of circuit
vi. Output Result
vii. Discussion and Conclusion

The first chapter is introduction that introduce about the project title. Beside that, the objectives and scopes of the project have been comprised.

The second chapter is the literature review about the project title. In literature review, it includes some research on the existing implementation of the Line Tracking Robot. Moreover, explore on different areas including the invention of line tracking robot and application of this robot.

The third section is about the project methodology. In this chapter, the methods and the project flow has been explained in clearly.

The fourth chapter is about the components description from the project. In this chapter, the functional of each component which used has been explained clearly.

The last chapter is the discussion and conclusion for the project. From this chapter, it includes the conclusion and also the further improvement that can be made in future.