Microprocessor Systems and Interfacing

Designing Line Detection Circuit for Interfacing with a Microcontroller

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ABSTRACT:

This report presents the design and implementation of a line detection sensor module for a line follower robot. The project involved selecting appropriate sensors, designing a digital output circuit for interfacing with a microcontroller, and finalizing the physical placement of sensors to detect lines and junctions effectively.

Objective:

To develop a custom-built line sensor module for a line follower robot capable of detecting a

2.5 cm wide black line and various junctions, using fundamental components rather than ready-made sensor modules.

Sub-task 1: Sensor Circuit Design

Working Principle:

IR LEDs emit infrared light onto the ground. The reflected light is detected by photodiodes. White surfaces reflect more IR light, while black lines absorb it. This difference is translated into voltage levels which can be fed to a microcontroller.

Component Selection:

- IR LED (x2)
- Photodiode (x2)
- LM358 Dual Op-Amp IC (x1)
- 10kΩ Resistors (x2)
- 100Ω resistors (x2)
- 350Ω Resistors (x2)
- Breadboard/PCB and jumper wires

Interface Type: Digital

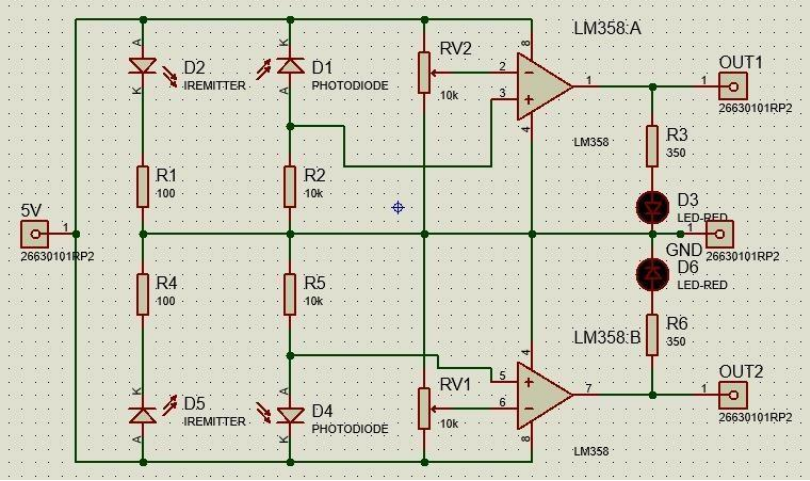
Reason: Digital interface was selected for its faster response time and easier integration with microcontroller digital I/O pins. Although it is slightly costlier

due to the requirement of comparators, it eliminates the need for ADC conversion, reducing processing complexity.

Circuit Operation:

Each IR LED and photodiode pair forms a reflective sensor. The photodiodes output is connected to a voltage divider that feeds into a comparator circuit (LM358). The comparator outputs high or low output depending on the surface reflectivity.

Schematic Diagram:



Test Results:

Tests confirmed that white surfaces produced logic high and black surfaces produced logic low. Circuit was validated using a breadboard prototype.

Sub-task 2: Sensor Placement and Junction Detection Research Work:

Following steps were followed to complete this sub-task:

- *A literature survey was conducted on various sensor placement techniques used in line follower robots.*
- *Different configurations were compared based on their ability to detect line positions and junction types.*
- *A horizontal linear placement of 2 sensors was finalized due to its balance between simplicity and effectiveness. However, 3 sensors may be used in the final version of the LFR for accurate function*
- *Supporting calculations were done to determine the optimal spacing for detecting a 2.5 cm black line with turning capabilities.*

Sensor Arrangement:

A linear array of 2 sensors was used. The sensors are placed equidistantly (~3 cm apart), forming a total width of approximately 6 cm. This covers the 2.5 cm black line and allows detection of turns and junctions.

Position Estimation:

The robot continuously reads the binary output of the 2 sensors. Depending on the active pattern, it adjusts its movement using differential motor control.

Cost Analysis:

Component	Quantity	Unit Price (PKR)	Total (PKR)
IR LEDs	12	15	180
Photodiodes	12	15	180
LM358 IC	4	40	160
POTs	4	20	80
Total			**600 PKR**

CONCLUSION:

This assignment successfully demonstrates the design of a line detection module using basic electronic components. A fast-response digital output system was developed, and a physical sensor layout was devised to reliably detect straight paths and junctions. The system is cost-effective and ready for integration with the main line follower robot.

CRITICAL ANALYSIS:

Instead of using ready-made modules we appreciated the task of developing it by ourselves which went more valuable and a source of practical knowledge. A black surface absorbs light whilst white surface reflects light. In case of a black surface/line, the IR waves are absorbed by it and the photodiode doesn't detect any waves reflected, resulting in logic low (about 50-90 mV when check via DMM). On the other hand, a white surface reflects most of the IR waves which are then detected by the photodiode, resulting in a logic high (1.83V to 1.87V when checked via DMM). The LM358 OpAmp is connected to a POT and the photodiode's output, resulting in the required output. This phenomenon is helpful in LFR robots which must follow a Black line track to reach their objectives.