Digital Logic Circuits (Spring 2012-13)
Project Report

Group 4:

Line Follower Robot

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Group Members:

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Project Objective & Introduction:

Our project is a simple line follower robot which detects a black line drawn on the floor and follows it. The objective of this project was to practically apply the theory that we have learned in the class in order to strengthen and develop the basic idea of Digital Logic Circuits and their design by implementing logic circuits in the real world.

Project Specifications:

Component	Quantity
Infra-Red Emitter	4
Infra-Red Receiver	4
Dual Comparator (LM393)	2
LED	4
ROM (27C512)	1
Voltage Regulator (7805)	1
Capacitors	4
Diodes	As Needed
Transistors (TIP 122)	2
555 Timer	1
Counter (74193)	2
Comparator (7485)	2
DC Motors	2
Battery (12 V)	1
Potentiometer (Variable Resistor)	1
Resistors	20
Capacitors	2

Project Deliverables:

The line follower robot is able to follow a black line with the aid of 4 sensors attached at the front. The robot's motion is smooth and without jittering.

Project Modules and Design Overview:

Sensors

Sensors are the eyes of the robot which are made using an Infrared(IR) emitter-detector pair. In the sensor circuit, two dual LM393 comparators are used and each is fed with the outputs of two of the IR sensors and a threshold potential difference. Comparators compare the output of the sensors with threshold voltage fed to them. If the sensor detects a black line, its output exceeds the threshold value and the comparators respond with a logic '1'. A variable resistor is also used to vary the threshold voltage which changes the range of the comparators (range means from what distance can the sensors detect a black line). The output form this sensor circuit is a 4 bit binary number. Each bit represents the state of each sensor (whether it is on the black line or not). This 4 bit binary number is fed to a pre-programmed ROM (27C512). Depending on this output, the ROM gives an 8 bit number at its output pins (described in detail in the next module). This 8 bit number is then fed into the Pulse Width Modulation (PWM) circuit which then varies the robot direction accordingly.

PWM

To control the speed and motion of the robot a PWM circuit is designed. The input from the 4 sensors is fed to a ROM which is pre-programmed. Depending upon the input the ROM sends an output to two comparators one for each motor. The other inputs to the comparators come from two counters which count from 0-15 and then back start back from 0. As long as the output from the PWM is greater than the values received from the counter, the comparator gives a logic '1' at its A>B output. When the value of the counter exceeds the inputs from the ROM a logic '0' appears at the A>B output and in this way the PWM is generated. This PWM is then fed to the base of two transistors - which act as voltage operated switches (one for each motor). The emitter of each transistor is grounded while the collector of each transistor is connected to the negative terminal of the motor. When PWM/logic '1' comes at the base a connection between the collector and emitter is established and current begins to flow which drives the motor. When a logic '0' comes at the base of the transistors the emitter and the base are disconnected and the motor stops. In this way the speed and the motion of the robot is controlled by saving appropriate values in the ROM. For example, if the sensors send a value of '0110', this means that the two sensors in the middle are on the line and both motors should receive equal PWM. The value

saved at 0110 is FF (11111111 in binary). Thus 1111 is sent to both comparators and full voltage is supplied to the motors. The values stored in the Rom are as follows:

** S stands for full speed*

Sensors Output	Speed Left	Speed Right	Motor Left	Motor Right	ROM Input (HEX)
0000	S	0	1111	0000	F0
0001	S	0	1111	0000	F0
0010	S	1/2S	1111	1000	F8
0011	S	1/2S	1111	1000	F8
0100	1/2s	S	1000	1111	8F
0101	S	3/4S	1111	1011	FB
0110	S	S	1111	1111	FF
0111	S	1/2S	1111	1000	F8
1000	0	S	0000	1111	0F
1001	S	S	1111	1111	FF
1010	3/4S	S	1011	1111	BF
1011	S	1/2S	1111	1000	F8
1100	1/2S	S	1000	1111	8F
1101	1/2S	S	1000	1111	8F
1110	1/2S	S	1000	1111	8F
1111	0	0	0000	0000	00

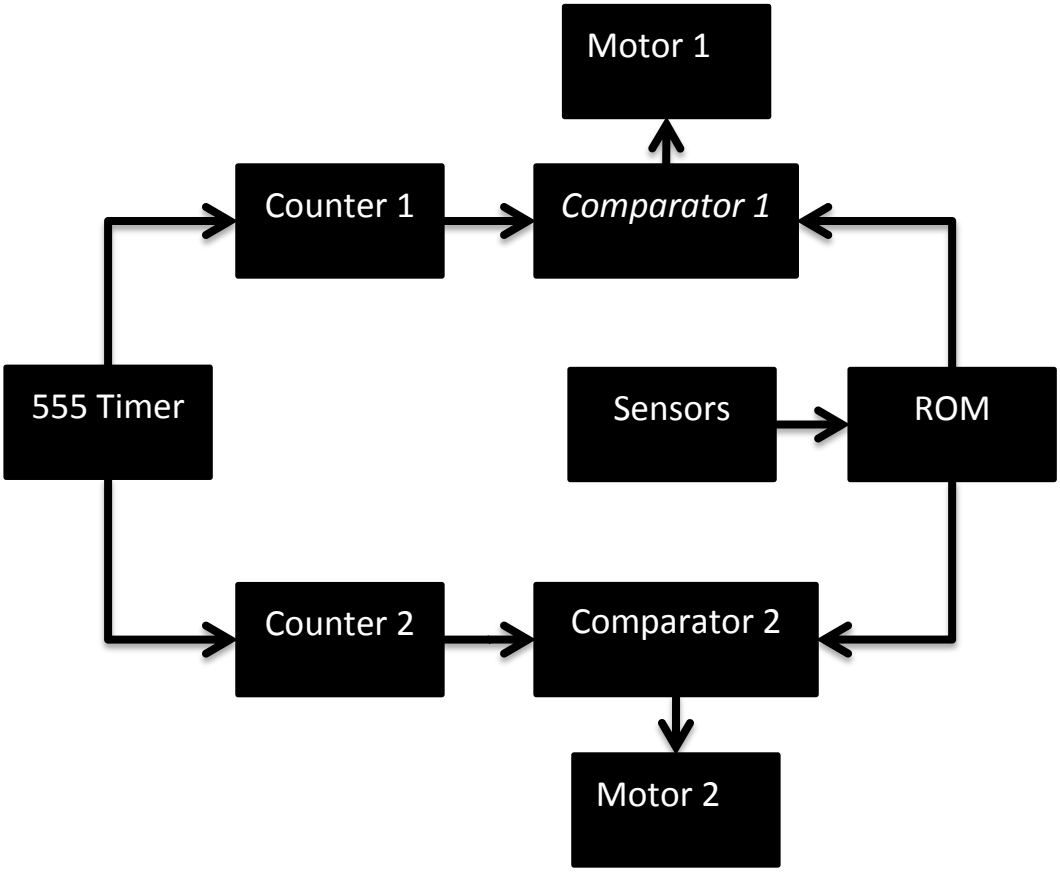
PCB

The next step in the robot making process was to implement the design of PWM and sensors on an etched PCB. Separate PCBs was made for the PWM and the sensors (following the hierarchical design pattern, consisting of two independent reusable blocks), these were connected together with the aid of 8-bit busses. PCBs were designed in a way that would allow upto 6 sensors to be connected to the robot. After the PCB was made a number of rigorous tests were carried out on them to avoid any flaws in the design which may hamper the robot making process.

Assembly

The final step in the robot making process was to assemble all parts together in one body to make the final robot body. A simple ice-cream box was selected and all the parts were fitted into it, holes were drawn for the wheels and IR sensors to come out of the box. The final product was then tested to see whether it meets the requirements or not. The robot was then finally decorated to give it an elegant look and LED's were protruded out from its body to give a handsome outlook to the final product. The switching of the LED's in the front corresponds to the output of the IR sensors.

Block Diagram(s):



Technical Issues Faced and Solution:

Some of the issues faced were as follows.

Logical Issues

The major logical issue that we faced was how make the PWM which is used to control the speed of the motors. This issue was finally resolved by saving appropriate values corresponding to the input of the IR sensors in a ROM which are the compared to the values from a counter and finally a PWM is generated.

Another issue was the supply of power to the ICs because they operate at 5V DC and we are using a 12V DC power supply. The solution to this problem came by using a voltage regulator which takes in 12V but gives a constant 5V at its output which is given to the ICs.

Mechanical Issues

The first mechanical problem was the design of the robots body i-e whether it should be a 3-wheeler or a 4-wheeler. We finally decided to go with a 3 wheel design because the speed and direction are controlled by only two motors as compared to controlling 4 motors in a 4 wheel design.

The second mechanical problem that we faced was the connection of the DC motor. Because of the unequal hole and pin size of the wheel and motor we had to design a special clamp to hold the two together.