Chapter 1: Introduction of Light Sensing Robot

- The light sensing robot moves to the direction of light. If the light falls on the left side, then it will move towards the left side and same for right side. If the light on both sides is same then it will go straight.
- The model contains sensors (Light Dependant Resistors), comparators, drivers, motors, light sources and power source.
- Normally LDR (Light Dependant Resistor) has very high dark resistance, but when it is illuminated with light, resistance drops.
- The voltage across this resistor is fed to the comparator, which compares this voltage with a reference voltage and gives output according to that. If the output voltage of LDR is more than the reference voltage, the comparator will give output of 5 V.
- The core of project is the micro controller. The micro controller has the function of instructing the drivers to drive the appropriate motor after reading the direction of light falling on the sensors. In this project, AT89C51 micro controller is used, which has 4K bytes of flash programmable and erasable read only memory.
- The output current of micro controller is 10 to 15 mA which is not enough to drive the motors, so a driver IC (L293D) is used. The L293D is designed to provide bidirectional drive currents of up to 1.2 A at voltages from 4.5 V to 36 V. Thus the driver IC drives the motors and the robot moves.
- The basic block diagram of the light sensing robot is shown in figure 1.1.

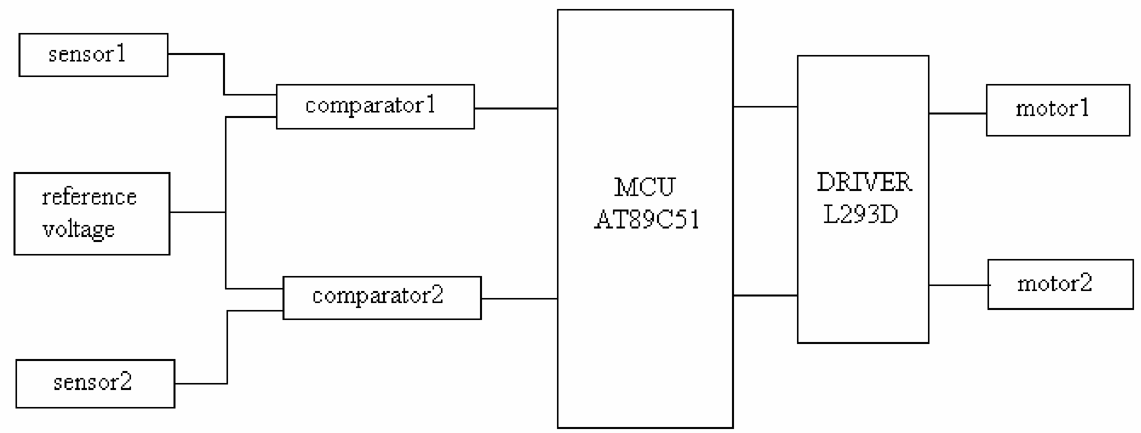


Figure 1.1 Block Diagram

Components

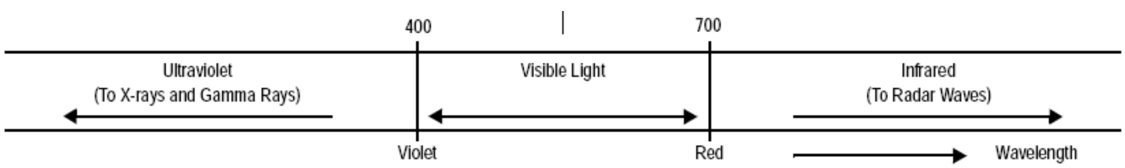
The model contains:

- Sensors (Light Dependant Resistors)
- Comparators (LM324)
- Micro controller (AT89C51)
- Drivers (L293D)
- Motors
- Light sources (Torch)
- Power source

* * * * *

Chapter 2: Light Dependant Resistor

- Light is produced by the release of energy from the atoms of a material when they are excited by heat, chemical reaction or other means. Light travels through space in the form of an electromagnetic wave.
- A consequence of this wave-like nature is that each colour can be completely defined by specifying its unique wavelength. The wavelength is defined as the distance a wave travels in one cycle.
- The spectral response of LDR is specified by lots of relative response versus wavelength (colour) for various material types as shown in figure 2.2.



Violet	Below 450 nm
Blue	450 - 500 nm
Green	500 - 570 nm
Yellow	570 - 590 nm
Orange	590 - 610 nm
Red	610 - 700 nm

Figure 2.1 Different wavelengths of colours

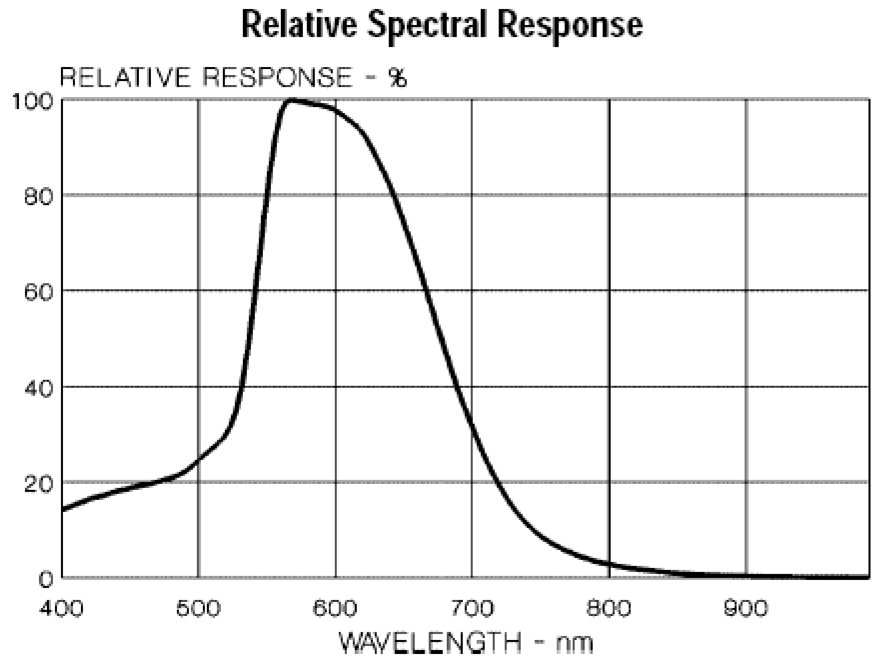


Figure 2.2 Relative Spectral Response

- From the relative spectral response, it can be seen that for yellow colour (570-590nm) the relative response is maximum.
- Normally LDR (Light Dependant Resistor) has very high resistance, but when it is illuminated with light, resistance drops.

Applications:

- Programmed electronic shutter and stroboscope light control for compact camera.
- Auto dimmer for digital display, CRT and room illumination.
- Sensor for automatic light on/off.
- Sensor for electronic toy and teaching aid material.

* * * * *

Chapter 3: Comparator

- A comparator compares a signal voltage on one input of an op-amp with a known voltage called the reference voltage on the other input.
- It is an open loop op-amp, with two analog inputs and a digital output. The output may be (+) or (-) saturation voltage, depending on which input is the larger.
- LM324 IC has four operational amplifiers, out of which, 2 are used as comparators. The pin diagram of LM324 is given in figure 3.1.

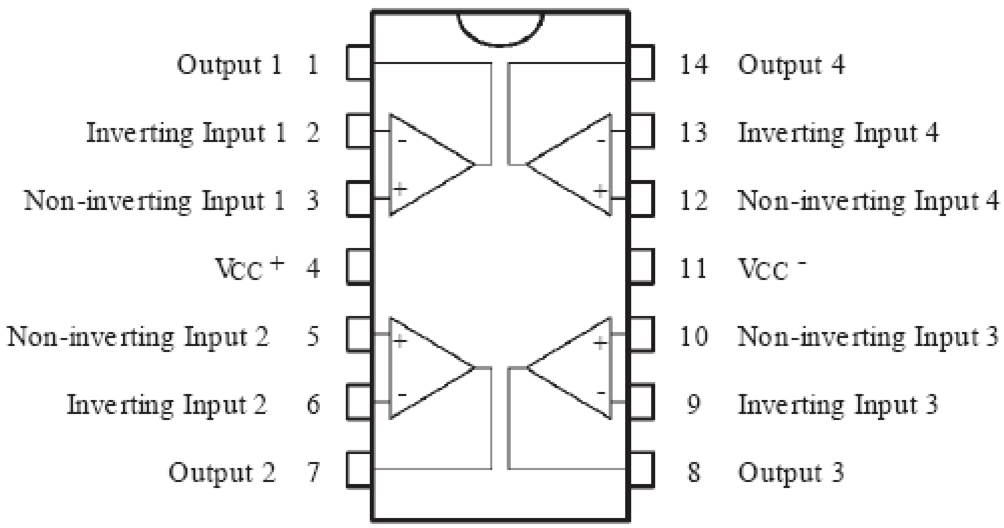


Figure 3.1 Pin Diagram of LM324

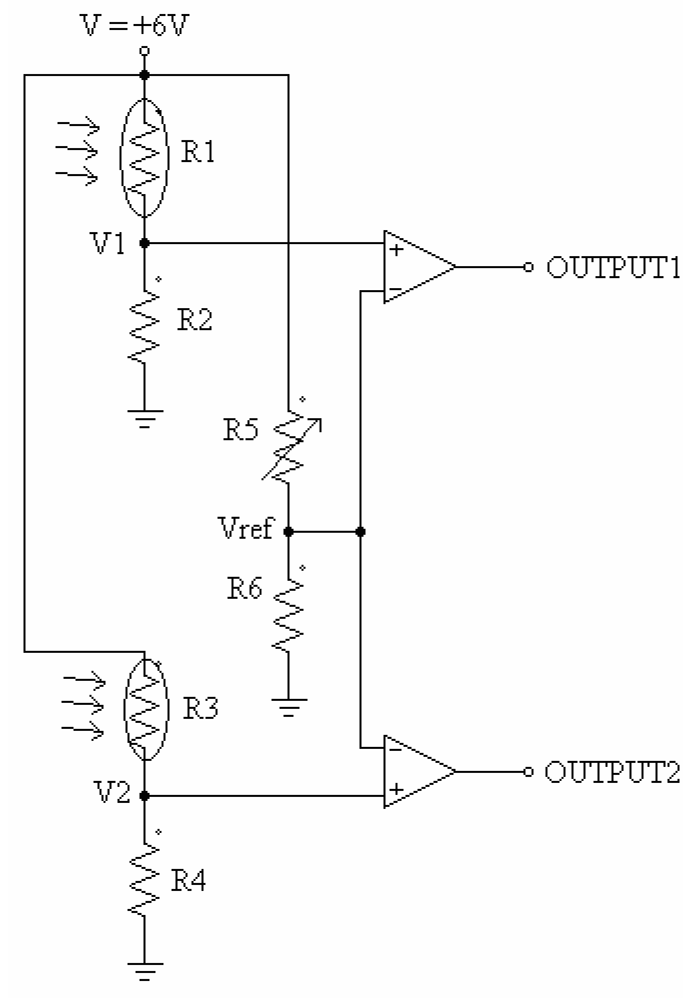


Figure 3.2 Circuit Diagram of Comparator

V1 = (R2/(R2+R1))*V

V2 = (R4/(R4+R3))*V

Vref = (R6/(R5+R6))*V

Where,

R1 = R3 = LDR
R2 = R4 = Fixed Resistor
R5 = Variable Resistor
R6 = Fixed Resistor

- First of all, as shown in figure 3.2, voltages V1 and V2 are measured considering the ambient light. According to that, the reference voltage Vref is set little more than V1 (or V2) by changing the variable resistor R5.
- Now, when the torch light falls on LDR1 (R1), its resistance decreases which increases the voltage V1 more than the reference voltage, hence the op-amp gives output of 5V.
- This same phenomenon occurs for LDR2 (R3). These outputs are fed to the micro controller's input port.
- The calculations of different resistors used in comparator are given in appendix A.

* * * * *

Chapter 4: Microcontroller AT89C51

Features:

- 4K bytes of in-system reprogrammable flash memory
- Fully static operation: 0 Hz to 24 MHz
- 128*8-bit internal RAM
- 32 programmable I/O lines
- Two 16-bit Timer/Counters
- Six interrupt sources
- Programmable serial channel

Description:

- The AT89C51 is a low power, high performance CMOS 8-bit microcomputer with 4K bytes of flash programmable and erasable read only memory (PEROM).
- The on-chip flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer.
- The pin diagram of AT89C51 is shown in figure 4.1.

Pin Diagram

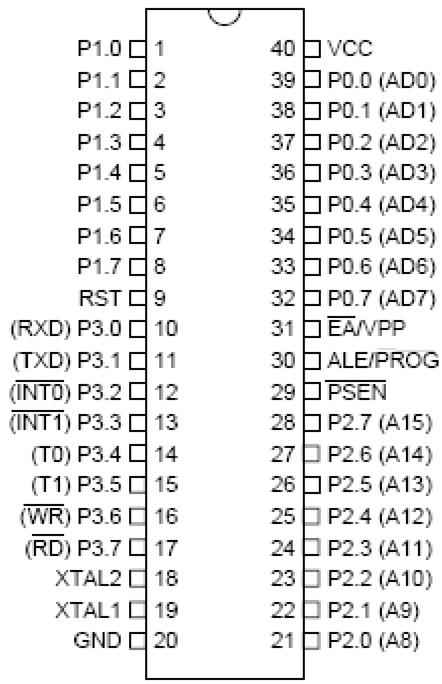


Figure 4.1 Pin Diagram of AT89C51

Pin Description

- **Vcc**

  Supply voltage.

- **GND**

  Ground.

- **Port 0**

  Port 0 is an 8-bit open-drain bi-directional I/O port. As an output port, each pin can sink eight TTL inputs. When 1s are written to port 0 pins, the pins can be used as high impedance inputs.

  Port 0 may also be configured to be the multiplexed low-order address/data bus during accesses to external program and data memory. In this mode P0 has internal pull-ups.

  Port 0 also receives the code bytes during Flash programming and outputs the code bytes during program verification. External □ull-ups are required during program verification.

- **Port 1**

  Port 1 is an 8-bit bi-directional I/O port with internal pull-ups. The Port 1 output buffers can sink/source four TTL inputs.

  When 1s are written to Port 1 pins they are pulled high by the internal pull-ups and can be used as inputs.

  As inputs, Port 1 pins that are externally being pulled low will source current (IIL) because of the internal pull-ups. Port 1 also receives the low-order address bytes during Flash programming and verification.

- **Port 2**

  Port 2 is an 8-bit bi-directional I/O port with internal pull-ups. The Port 2 output buffers can sink/source four TTL inputs.

  When 1s are written to Port 2 pins they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 2 pins that are externally being pulled low will source current (IIL) because of the internal pull-ups.

  Port 2 also receives the high-order address bits and some control signals during Flash programming and verification.

- **Port 3**

  Port 3 is an 8-bit bi-directional I/O port with internal pull-ups. The Port 3 output buffers can sink/source four TTL inputs.

  When 1s are written to Port 3 pins they are pulled high by the internal pull-ups and can be used as inputs.

  As inputs, Port 3 pins that are externally being pulled low will source current (IIL) because of the pull-ups.

  Port 3 also receives some control signals for Flash programming and verification. It also serves the functions of various special features of the AT89C51 as listed below:

Table 4.1 Alternate Functions of Port 3

Port Pin	Alternate Functions
P3.0	RXD (serial input port)
P3.1	TXD (serial output port)
P3.2	$\overline{INT0}$ (external interrupt 0)
P3.3	$\overline{INT1}$ (external interrupt 1)
P3.4	T0 (timer 0 external input)
P3.5	T1 (timer 1 external input)
P3.6	$\overline{WR}$ (external data memory write strobe)
P3.7	$\overline{RD}$ (external data memory read strobe)

- **RST**

  Reset input. A high on this pin for two machine cycles while the oscillator is running resets the device.

- **ALE/$\overline{PROG}$**

  Address Latch Enable output pulse for latching the low byte of the address during accesses to external memory. This pin is also the program pulse input (PROG) during Flash programming.

  In normal operation ALE is emitted at a constant rate of 1/6 the oscillator frequency and may be used for external timing or clocking purposes.

- **$\overline{PSEN}$**

  Program Store Enable is the read strobe to external program memory.

  When the AT89C51 is executing code from external program memory, $\overline{PSEN}$ is activated twice each machine cycle, except that two $\overline{PSEN}$ activations are skipped during each access to external data memory.

- **$\overline{EA}$/VPP**

  External Access Enable. EA must be strapped to GND in order to enable the device to fetch code from external program memory locations starting at 0000H up to FFFFH. Note, however, that if lock bit 1 is programmed, EA will be internally latched on reset.

- **XTAL1**

  Input to the inverting oscillator amplifier and input to the internal clock operating circuit.

- **XTAL2**

  Output from the inverting oscillator amplifier.

* * * * *

Chapter 5: Microcontroller Programming

Flow chart

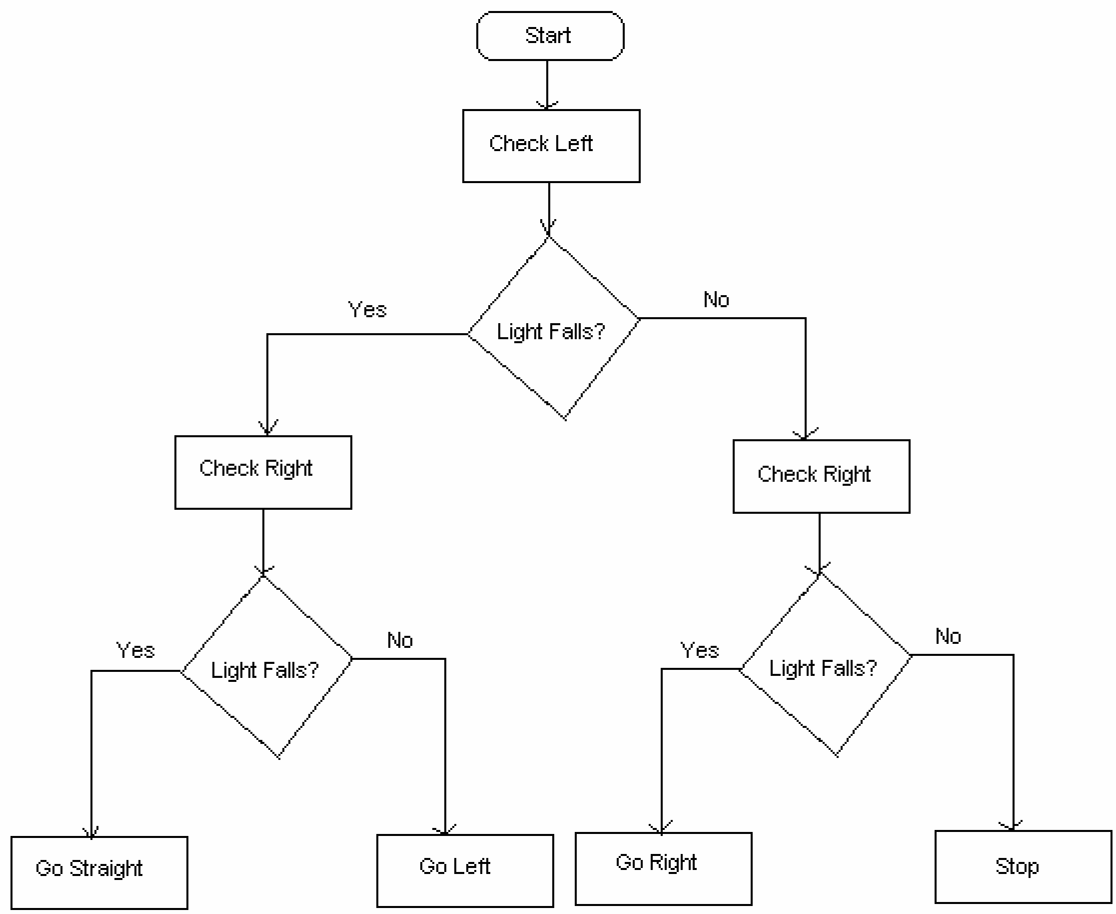


Figure 5.1 Flow chart

Program

All the instructions used in this program are explained in detail in appendix B.

- org 0
- clr a ; clears the accumulator (loads the accumulator with 00h)
- mov p2,a ; declares port 2 as output port
- mov a,p1 ; loads the byte of port 1(input port) into the accumulator
- anl a,#01h ; logically ANDs the byte of accumulator with 01h and stores the result in accumulator
- mov r2,a ; loads the byte of accumulator into R2
- cjne r2,#01h,rt ; compares the byte of R2 with 01h and jumps to 'rt' if they are not equal
- setb p2.0 ; sets the bit 0 of port 2 to high
- sjmp rt ; jumps to 'rt'
- rt: clr a ; clears accumulator, the label is 'rt'
- mov a,p1 ; loads the byte of port 1(input port) into the accumulator
- anl a,#02h ; logically ANDs the byte of accumulator with 02h and stores the result in accumulator
- mov r0,a ; loads the byte of accumulator into R0
- cjne r0,#02h,st ; compares the byte of R0 with 02h and jumps to 'st' if they are not equal
- setb p2.1 ; sets the bit 1 of port 2 to high
- sjmp st ; jumps to 'st'
- st: nop ; no operation, the label is 'st'
- end ; end of program

Hex File of the program

:03000000020800F3

:0C080000787FE4F6D8FD75810702000047

:10000000E4F5A0E5905401FABA0104D2A08000E41E

:0D001000E5905402F8B80204D2A18000006F

:00000001FF

* * * * *

Chapter 6: Driver L293D

Features

- 600 mA output current capability per channel
- 1.2 A peak output current per channel
- Enable facility
- Over temperature protection
- Logical 0 input voltage up to 1.5 V
- Internal clamp diodes

Description:

- The device is a high voltage, high peak current four channel driver designed to accept standard TTL logic levels and drive inductive loads and switching power transistors.
- To simplify use as two bridges each pair of channels is equipped with an enable input. A separate supply input is provided for the logic, allowing operation at a lower voltage and internal clamp diodes are included.
- The pin diagram of L293D is shown in figure 6.1.

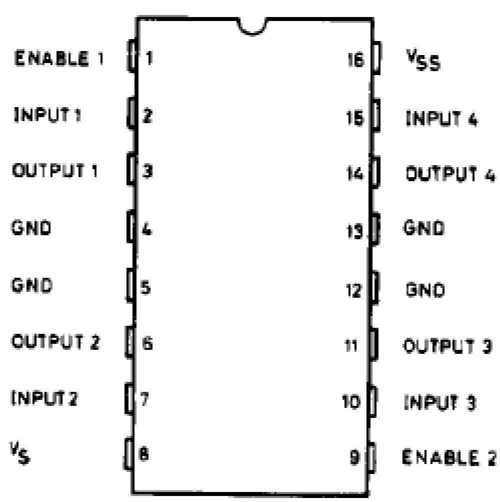


Figure 6.1 Pin Diagram of L293D

Block Diagram

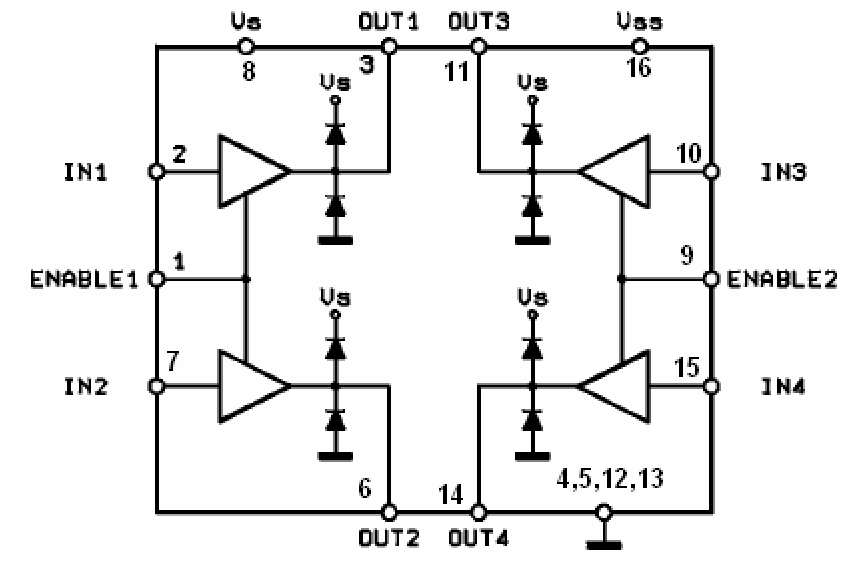


Figure 6.2 Block Diagram of L293D

- When an enable input is high, the associated drivers are enabled and their outputs are active and in phase with their inputs. External high-speed output clamp diodes should be used for inductive transient suppression
- When the enable input is low, those drivers are disabled and their outputs are off and in a high impedance state.

Truth Table

INPUTS‡		OUTPUT
A	EN	Y
H	H	H
L	H	L
X	L	Z

H = high-level, L = low level,
X = irrelevant, Z = high-impedance (off)
‡ In the thermal shutdown mode, the output is in the high-impedance state regardless of the input levels.

Absolute Maximum Ratings of L293D

Table 6.1 Maximum Ratings of L293D

Symbol	Parameter	Value	Unit
V_S	Supply Voltage	36	V
V_{SS}	Logic Supply Voltage	36	V
V_I	Input Voltage	7	V
V_{en}	Enable Voltage	7	V
I_o	Peak Output Current (100 μs non repetitive)	1.2	A
P_{tot}	Total Power Dissipation at T_{pins} = 90 °C	4	W
T_{stg}, T_j	Storage and Junction Temperature	– 40 to 150	°C

* * * * *

Chapter 7: Circuit Description

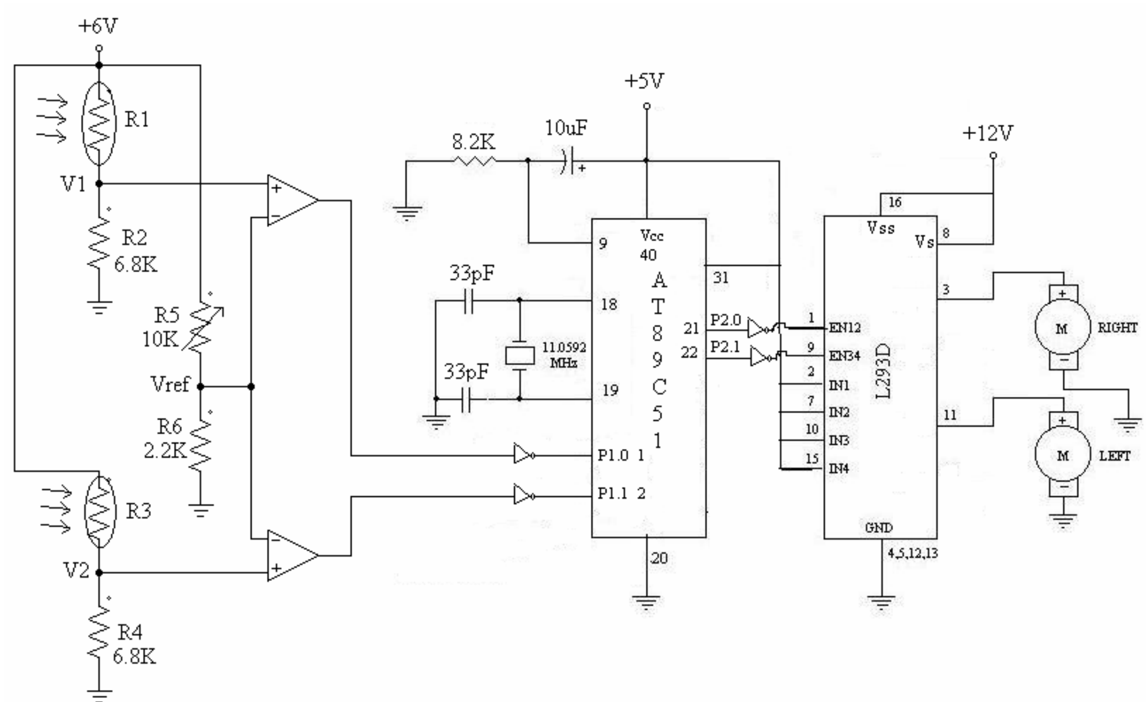


Figure 7.1 Circuit Diagram

- As shown in figure 7.1, the voltages V1 and V2 (across R2 and R4 respectively) are given at the non-inverting terminals of the op-amps. The reference voltage is given to the inverting terminals of the op-amps.
- When ambient light is there, the voltages V1 and V2 are measured using the multimeter. According to that, the reference voltage is set slightly higher than the measured value, by varying the variable resistor R5. In this situation, the digital outputs of the op-amps will be low.
- When the torch light falls on the LDRs, their resistances decrease and hence the voltages V1 and V2 increase, becoming more than the reference voltage. So the digital outputs of the op-amps will become high.
- The output terminals of the op-amps are connected through NOT gate to the input port 1 of the AT89C51 microcontroller.
- The microcontroller needs +5V at Vcc terminal to be operated. Here, +6V power source is available, so positive voltage regulator L7805 IC is used in order to get fixed 5 V supply (refer appendix D for L7805).

- The microcontroller programming is done in such a way that when the input port pins 1.0 and 1.1 are at high, the output port pins 2.0 and 2.1 become high respectively. Similarly when pins 1.0 and 1.1 are at low, pins 2.0 and 2.1 become low respectively.
- The output signals of pins 2.0 and 2.1 are given to the pins 1 and 9 (Enable pins) of the driver IC L293D through NOT gates (refer appendix C).
- The supply voltage Vs and the logic supply voltage Vss are at +12V in order to drive the 12V, 150 RPM DC motors.
- On the whole, when the torch light falls on any LDR, the motor related to that LDR will start and hence the robot moves accordingly. When the torch light is removed from any LDR, the corresponding motor will stop.

* * * * *

Chapter 8: Conclusion

The main sensors used in this project are light dependant resistors. The resistance of LDR decreases when it comes in contact with light. This characteristic of LDR is used in the comparator circuit in order to give signal to the microcontroller (AT89C51) for controlling the motors through the driver IC (L293D). In this robot, two rear wheels are responsible for moving the robot forward and turning it right or left. For providing the support to the robot on the front side, a caster wheel is used. The connections around the micro controller are standard in most of 8051 based projects, they are the crystal resonator along with the two decoupling capacitors and the debouncing circuit attached to the reset pin. Using the L293D motor driver, makes controlling a motor simple. It totally isolates the TTL logic inputs from the high current outputs. Each couple of channels of L293D can be enabled and disabled using Enable pins. When disabled a channel provide very high impedance (resistance) to the motor, exactly as if the motor wasn't connected to the driver IC at all. In conclusion, we can say that the robot can be compared to a “moth” that has affinity towards light and moves in its direction.

REFERENCES

Books

- The 8051 Microcontroller and Embedded Systems, by Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay
- Op-Amps and Linear Integrated Circuits, by Ramakant A. Gayakwad

Datasheets

- Datasheet of op-amp (LM324): http://www.alldatasheet.com/datasheet-pdf/pdf/182095/STMICROELECTRONICS/LM324N.html
- Datasheet of driver IC: http://www.alldatasheet.com/datasheet-pdf/pdf/22432/STMICROELECTRONICS/L293D.html
- LDR: http://www.alldatasheet.com/datasheet-pdf/pdf/84379/PERKINELMER/VT43N1.html
- Datasheet of microcontroller: http://pdf1.alldatasheet.com/datasheet-pdf/view/56215/ATMEL/AT89C51.html
- Datasheet of positive voltage regulator: http://www.alldatasheet.com/datasheet-pdf/pdf/22615/STMICROELECTRONICS/L7805.html
- Datasheet of Hex inverters (NOT gates): http://www.alldatasheet.com/datasheet-pdf/pdf/27874/TI/SN74HC04.html

Websites

- Simulation of the microcontroller program: www.keil.com

Appendix A: Calculations for the comparator circuit

- Dark resistance of both LDRs is 120KΩ.
- Refer figure 3.2. Consider for some ambient light, R1=R3=8.5KΩ and for torch light, R1=R3=1.5KΩ.

$$V1 = (R2/(R2+R1))*V$$

$$V2 = (R4/(R4+R3))*V$$

$$Vref = (R6/(R5+R6))*V$$

- From the calculations for different lights, we get,
  R2=R4=6.8KΩ
  R5=10KΩ (Variable Resistor)
  R6=2.2KΩ

* * * * *

Appendix B: Instructions used in the microcontroller programming

- **ANL destination-byte, source byte**

  This performs a logical AND on the operands, bit by bit, storing the result in the destination.

  This is a 2 byte, 1 cycle instruction and no flag is affected by this instruction.

A	B	A AND B
0	0	0
0	1	0
1	0	0
1	1	1

- **CJNE destination-byte, source-byte, target**

  The magnitudes of the source byte and destination byte are compared. If they are not equal, it jumps to the target address.

  This is a 3 byte, 2 cycle instruction and affects the CY flag.

- **CLR A**

  This instruction clears register A. All bits of the accumulator are set to zero.

  This is a 1 byte, 1cycle instruction and does not affect any flag.

- **MOV destination byte, source byte**

  This copies a byte from the source location to the destination.

  This is a 1 byte, 1 cycle instruction and does not affect any flag.

- **NOP**

  This performs no operation and execution continues with the next instruction. It is sometimes used for timing delays to waste clock cycles. This instruction only updates the PC (program counter) to point to the next instruction following NOP.

  This is a 1 byte, 1 cycle instruction and does not affect any flag.

- **SETB bit**

  This instruction sets high the indicated bit. The bit can be the carry or any directly addressable bit of a port, register or RAM location. This is a 2 byte instruction.

- **SJMP**

  This is a 2-byte instruction. The first byte is the opcode and the second byte is the signed number displacement, which is added to the PC (program counter) of the instruction following the SJMP to get the target address. Therefore, in this jump the target address must be within -128 to +127 bytes of the PC (program counter) of the instruction after the SJMP since a single byte of address can take values of +127 to -128. It is a 2 byte, 2 cycle instruction.

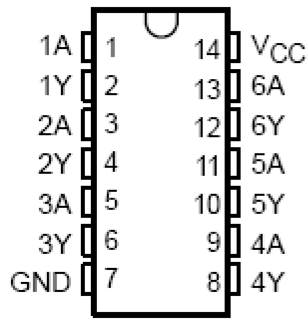
* * * * *

Appendix C: SN74HC04 HEX Inverter

Features

- Wide operating voltage range of 2V to 6V.
- Low input current of 1μA Max
- Low power consumption

Pin Diagram



This 74HC04 device contain six independent inverters and perform the Boolean function Y= $\overline{A}$ in positive logic.

Function Table

INPUT A	OUTPUT Y
H	L
L	H

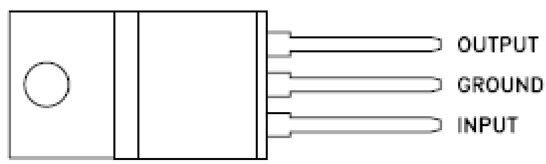
* * * * *

Appendix D: L7805 Positive Voltage Regulator

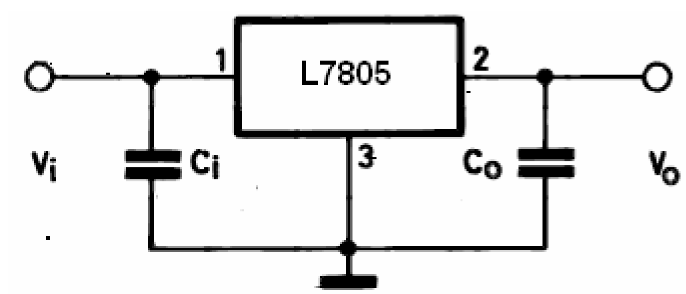
Features

- This regulator can provide local on-card regulation, eliminating the distribution problems associated with single point regulation.
- It employs internal current limiting, thermal shut-down and safe area protection, making it essentially indestructible.
- If adequate heat sinking is provided, it can deliver over 1A output current.
- Although designed primarily as fixed voltage regulator, this device can be used with external components to obtain adjustable voltage and currents.

Pin Diagram

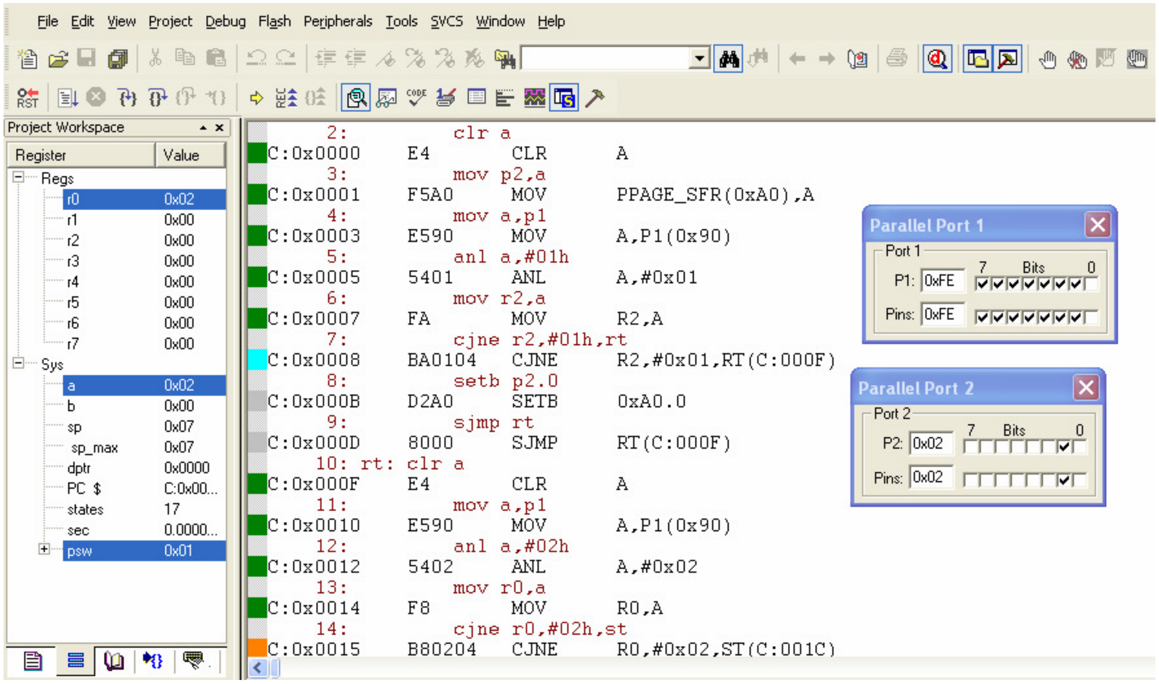


Connection Diagram



* * * * *

Appendix E: Simulation of the program on “keil uVision 3”



- As shown above, the software “keil uVision 3” has been used to simulate the program in computer. Here, the programming is done in assembly language. The programmer has to write the program in simple assembly language. The software generates hex code for each instruction and it also creates hex file for the program.
- To implement the program on hardware, the programmer has to load the hex file into the microcontroller through “Universal Programmer”.

* * * * *

Appendix F: Cost of Project

Component	Quantity	Cost (in Rs.)
LDR	2	20
ST LM324 (op-amp)	1	10
Resistances (fixed and Variable)	5	15
Capacitors	5	10
Crystal	1	15
AT89C51 (microcontroller)	1	60
ST L293D (Driver IC)	1	100
SN74HC04	1	15
ST L7805	1	10
6V Rechargeable Battery	1	180
12V Rechargeable Battery	1	400
12V, 150 RPM DC Motor	2	360
Aluminium Sheet	1	150
Rear Wheel (10 cm dia.)	2	40
Caster Wheel	1	15
Printed Circuit Board	1	80
Total Cost		1480

* * * * *