LINE FOLLOWER USING MICROCONTROLLER

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CERTIFICATE

This is to certify that the work entitled **"LINE FOLLOWER USING MICROCONTROLLER"** submitted by SAMEER BATTA (041013) and YASH SAXENA(041152) in partial fulfillment for the award of degree of Bachelor Of Technology in Electronics and Communication Engineering Of Jaypee University Of Information Technology has been carried out under my supervision. This work has not been submitted partially or wholly to any other university or institute for the award of this or any other degree or diploma.

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ABSTRACT

The line follower is one of the self operating robot that follows a line drawn on the floor.The primitive way of transporting raw materials or finished products from one place to another within any industry involves the use of labour and is a very time consuming job. But now with the advancements in technology,automized systems are replacing the primitive methods and this latest transport system, if implemented, will eliminate the human efforts. One such way to automize the primitive systems is the use of a line follower.. Imagine the amount of time that would be saved if this is possible.

This automated vehicle can also be utilized efficiently in library systems. Here its application is to carry books from the main counter to the bookracks and vice-versa. So we aim to modernize our library systems.

Sensors are used to sense the line on which the line follower has to move. A microcontroller is used to run the motors of the robot. Unlike a microprocessor, a microcontroller has on-chip RAM, ROM, I/O Ports and timer which makes the whole system very cost-effective.

CHAPTER 1

INTRODUCTION

1.1 Definition

The line follower is a machine that can follow a path. The path can be a black line on a white surface or vice-versa. This automated machine replaces the primitive system of transportation in industries or libraries or any other working environment.

The robot is placed at a pre-assigned starting point. Once started the robot navigates along a black line. It can traverse straight lines, gentle and sharp rounded corners as shown

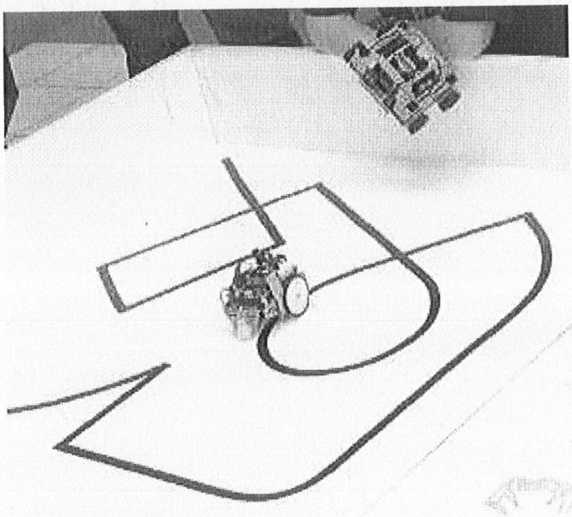


Fig. 1: *Line Follower track*

Sensing a line and making a robot to stay on course, while constantly correcting wrong moves using feedback mechanism forms a simple yet effective closed loop system. As a programmer one gets an opportunity to 'teach' the robot how to follow a line and thus giving it a human like property of responding to stimuli.

1.2 Transportation Scenario

The primitive transport system involved human intervention when transferring goods from Location A to Location B. But now with the use of this automated vehicle called line follower, the human efforts can be minimized to a minimum of just loading raw materials into the vehicle at location A and unloading them at location B. Also it saves time.

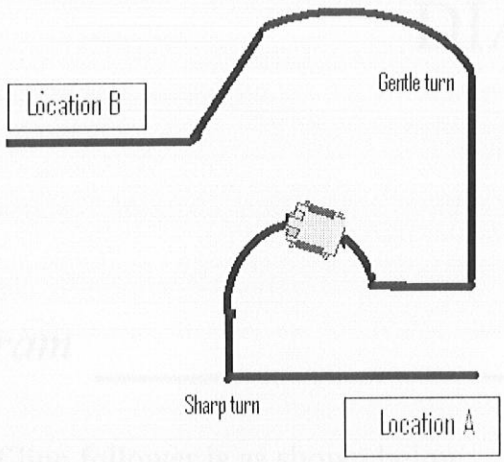


Fig. 2: Line follower moving from loc.A to loc.B.

CHAPTER 2

BLOCK DIAGRAM, COMPONENTS AND CIRCUIT DIAGRAM

2.1 Block Diagram

The block diagram of line follower is as shown below:

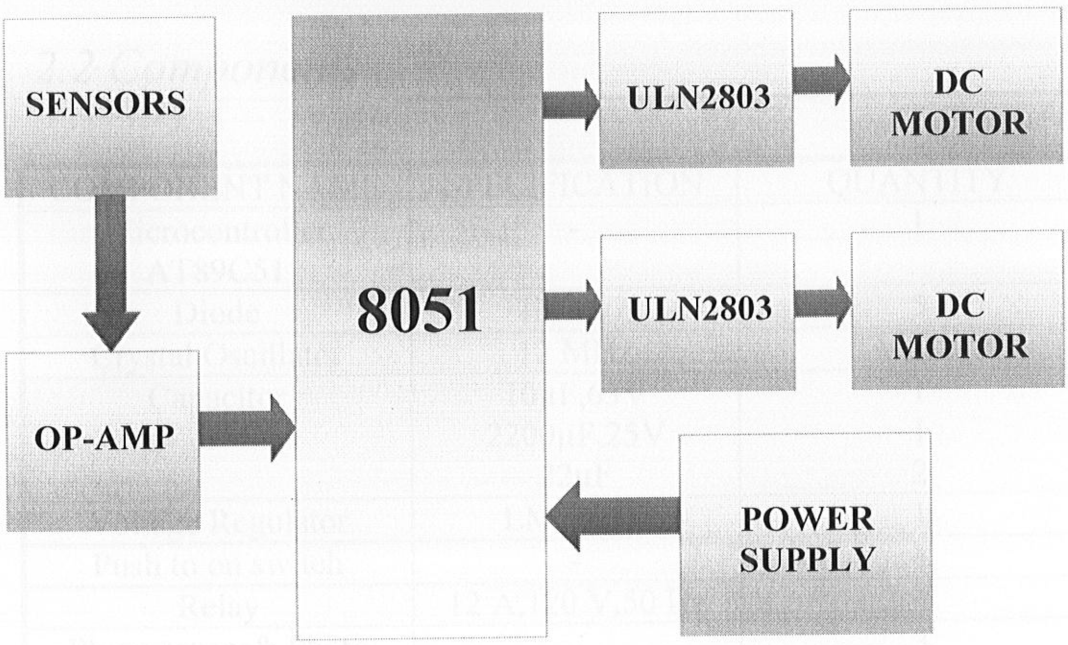


Fig. 3: Block diagram of line follower

Here the sensors sense the path i.e. the black line on the white surface or vice-versa.

The output of two sensors is fed into the op-amp in the form of 0s and 1s.

The comparator compares the output from both the sensors and gives its output to the 8051 microcontroller which is programmed to rotate the motors according to the following outputs:

- When both the sensors are on white surface, both the motors rotate clockwise.
- When both sensors are on the black surface, both the motors rotate anti- clockwise.
- When right hand side sensor comes on the black track, the right motor rotates anti-clockwise.
- When left hand side sensor comes on the black track, the left motor rotates anti-clockwise.

Circuit includes power supply units to feed power into the microcontroller and the motors.

As the output current of microcontroller is small as compared to that which is required to drive the motor, so ULN (a current amplifier) is used.

ULN amplifies the current from the microcontroller and supplies it further to the dc motors to drive them.

2.2 Components

COMPONENT NAME	SPECIFICATION	QUANTITY
Microcontroller AT89C51	-	1
Diode	IN4007	5
Crystal Oscillator	12 MHz	1
Capacitor	10μF,63V 2200μF,25V 22μF	1 1 2
Voltage Regulator	LM7805C	1
Push to on switch	-	1
Relay	12 A,120 V,50 Hz	4
Photo sensor& Photo	-	3

L.E.D		
Preset	100 KΩ	3
Battery	9 V 6 V	1 1
L.E.D	3 V,1mm.Red 3 V,1mm.Green 3 V,1mm.Yellow	1 1 1
Resistors	5.6 KΩ 4.7 KΩ 1 KΩ 3.3 KΩ	1 2 4 1
Toggle switch	-	2
SIP	-	1
Op-amp LM324N	-	1
ULN 2803	-	1
DC Motor	100rpm	2

2.3 Circuit Diagram

Firstly, the sensors sense the color of the line on the path on which the line follower is moving and it then gives its output to the comparator, which further on comparing the output from the sensors, gives its output into the port1 of the microcontroller . If it is any white or non-black line, then the motor rotates clockwise and the line follower gets the command to move forward. On the other hand, if one of the sensors senses a black line, then that respective motor will move anticlockwise and the line follower will take a turn in that direction. The sensors sense the track about five to seven lakh times per second. The switching is so fast that the observer sees an effect as if the motor is running continuously.

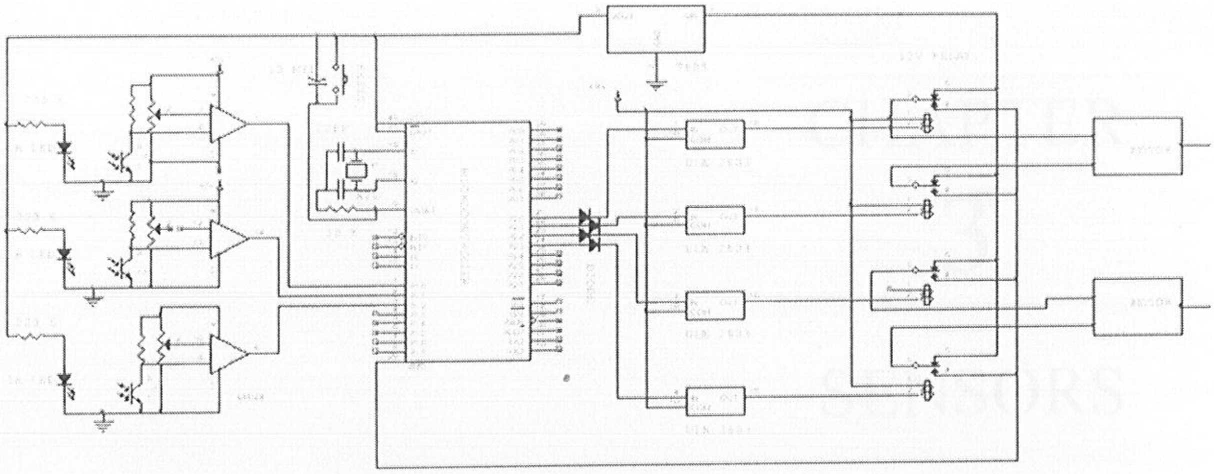


Fig.3: Circuit Diagram

CHAPTER 3

SENSORS

3.1 Definition

A type of photo sensor has been used. A photo sensor is an electronic control devices that adjusts the light output of a lighting system based on detected illuminance.

Infra Red sensors are used. These are passive devices that do not send out and receive signals. Instead, they passively wait until infrared energy from an object strikes the detector and it measures this energy.

The Infrared emitter detector circuit is very useful if one plans to make a line following robot, or a robot with basic object or obstacle detection. Infrared emitter detector pair sensors are fairly easy to implement, although they involve some level of testing and calibration to get right. They can be used for obstacle detection, motion detection, transmitters, encoders, and color detection (such as for line following).

3.2 Requirement in the project

The sensor used in our circuit consists of an IR LED used as an optical transmitter and a photo sensor as an optical detector. Three such sensors are used in our circuit. Two of them are mounted at the bottom of the PCB to sense the track position. One of them is for stopping the robot if any obstacle comes in front of it.

When the supply to the robot is turned ON, light is emitted by the IR LED.

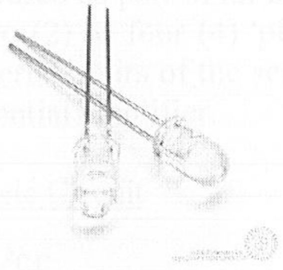


Fig. 5: IR LED

This light falls on the surface below the robot, it gets reflected back to the photo detector. When the light falls continuously on the photo detector, the output of the comparator LM324 is 1 and the output becomes 0 as soon as the light stops falling on it.

When the surface below the robot is white, the output is 1 and for black surface the output is 0. The output of the comparators used for sensing the track is given to pins P1.0 and P1.1 of the controller 89C51. The other comparator is connected to pin P2.0 which is used for stopping the robot.

3.3 Construction and Working

Infrared (IR) radiation is part of the electromagnetic spectrum which includes radio waves, microwaves, visible light, and ultraviolet light, as well as gamma rays and X-rays.

The IR range falls between the visible portion of the spectrum and radio waves. IR wavelengths are usually expressed in microns, with the IR spectrum extending from 0.7 to 1000 microns.

The actual sensor on the chip is made from natural or artificial pyroelectric materials, usually in the form of a thin film, out of gallium nitride (GaN), caesium nitrate (CsNO3), polyvinyl fluorides, derivatives of phenylpyrazine, and The actual sensor on the chip is made from natural or artificial pyroelectric materials, usually in the form of a thin film, out of gallium nitride (GaN), caesium nitrate (CsNO3), polyvinyl fluorides, derivatives of phenylpyrazine, and cobalt phthalocyanine. Lithium tantalate (LiTaO3) is a crystal exhibiting both piezoelectric and pyroelectric properties.

The sensor is often manufactured as part of an integrated circuit and may be comprised of one (1), two (2) or four (4) 'pixels' comprised of equal areas of the pyroelectric material. Pairs of the sensor pixels may be wired as opposite inputs to a differential amplifier.

Infrared Emitter Detector Basic Circuit

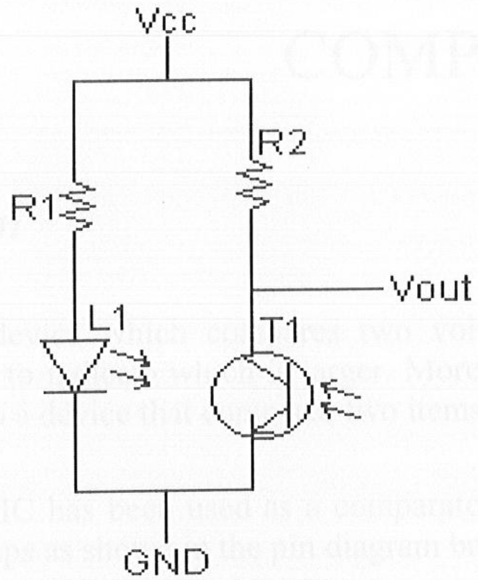


Fig. 6: Basic circuit

R1 is to prevent the emitter (clear) LED from melting itself. Choose a R1 value so that Vcc^2/R1 < Power specification.

R2 should be larger then the maximum resistance of the detector. Measure the resistance of the detector (black) when it is pointing into a dark area and then choose the next larger resister. This means Vout is close to zero when there is no signal.

CHAPTER 4

COMPARATOR

4.1 Definition

Comparator is a device which compares two voltages or currents and switches its output to indicate which is larger. More generally, the term is also used to refer to a device that compares two items of data.

LM324N Op amp IC has been used as a comparator. It is a 14 pin IC. It consists of 4 op-amps as shown in the pin diagram below:

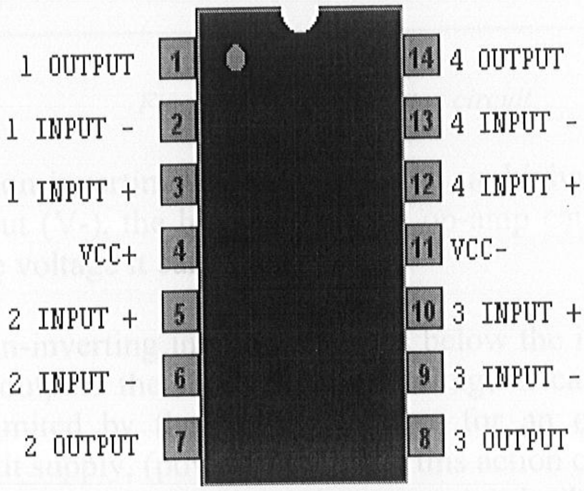


Fig. 7: pin diagram

Output of both sensors is fed as input into the comparator. It compares its two inputs and accordingly gives the output. The output of comparator is given in the microcontroller. According to the output of the comparator, the microcontroller decides the motion of the line follower. Hence, comparator tells the line follower which path it should choose.

4.3 Construction and Working

A standard op-amp without negative feedback can be used as a comparator, as indicated in the following diagram.

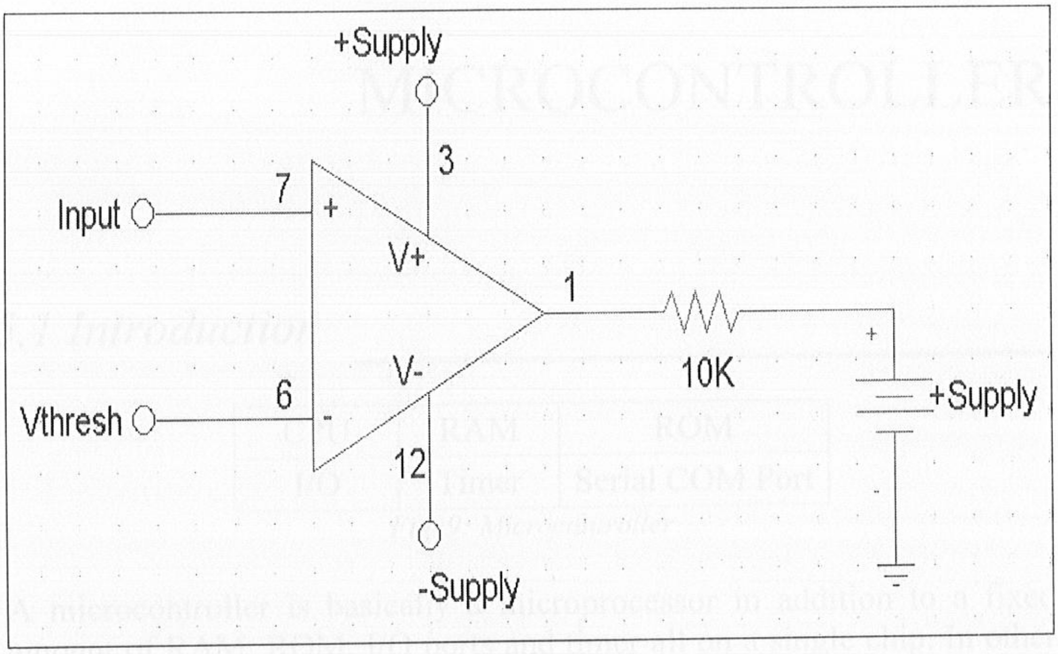


Fig. 8: Basic comparator circuit.

When the non-inverting input (V+) is at a higher voltage than the inverting input (V-), the high gain of the op-amp causes it to output the most positive voltage it can.

When the non-inverting input (V+) drops below the inverting input (V-), the op-amp outputs the most negative voltage it can. Since the output voltage is limited by the supply voltage, for an op-amp that uses a balanced, split supply, (powered by $\pm V_S$) this action can be written:
$Vout = V_S \times sgn(V+ - V-)$ where sgn (x) is the signum function. Generally, the positive and negative supplies VS will not match absolute value:
Vout <= VS+ when (V+ > V-) else VS- when (V+ < V-).
Equality of input values is very difficult to achieve in practice.

CHAPTER 5

MICROCONTROLLER

5.1 Introduction

CPU	RAM	ROM
I/O	Timer	Serial COM Port

Fig. 9: Microcontroller

A microcontroller is basically a microprocessor in addition to a fixed amount of RAM, ROM, I/O ports and timer all on a single chip. In other words, the processor, the RAM, ROM, I/O ports, and timer all are embedded together on one chip. Therefore the designer cannot add any external memory, I/O, or timer to it.

5.2 Requirement in the Project

Microcontroller is the major component of our project. Output from the comparator is fed into the microcontroller and it hence decides on the basis of this output the motion of line follower. The microcontroller is supplied power from a 6V battery. Output from the microcontroller is given to the motor drive circuitry i.e. ULN.

5.3 Microcontroller vs. Microprocessor

By microprocessor is meant the general- purpose microprocessors such as Intel's x86 family. These microprocessors contain no RAM, no ROM, and no I/O ports on the chip itself. Whereas a microcontroller has a fixed amount of RAM, ROM and I/O ports in the chip itself.

Thus a system designer using a general- purpose microprocessor such as Pentium must add RAM, ROM, I/O ports, and timers externally to make them functional.

The addition of these external components makes these systems bulkier and much more expensive. But they have the advantage of versatility such that the designer can decide on the amount of RAM, ROM, and I/O ports as per his/her requirement.

In case of a microcontroller the fixed amount of on-chip ROM, RAM, and the number of I/O ports makes them ideal for many applications in which coat and space are critical. Thus microcontrollers are the preferred choice for many embedded systems.

5.4 Atmel's AT89C51

In our project, we have used the microcontroller AT89C51, a version of popular 8051, manufactured by ATMEL Corporation. The first two letters in the name is for the manufacturer.

The AT89C51 is a low power, high performance CMOS 8-bit microcontroller with 4K bytes of Flash Programmable and Erasable Read Only Memory (PEROM).The device is manufactured using Atmel's high density nonvolatile memory technology. By combining a versatile 8-bit CPU with flash memory on a single chip, the Atmel's AT89C51 is a powerful microcontroller which provides a highly flexible and cost effective solution to many embedded control applications.

5.5 Features

The various features of AT89C51 are given below:

Feature	Value
ROM	4K Bytes
RAM	128 Bytes

Timers	2
I/O pins	32
Serial ports	1
Interrupt Sources	6

Fig. 10: Features of AT89C51

5.6 Block diagram

The block diagram of AT89C51 is shown below:

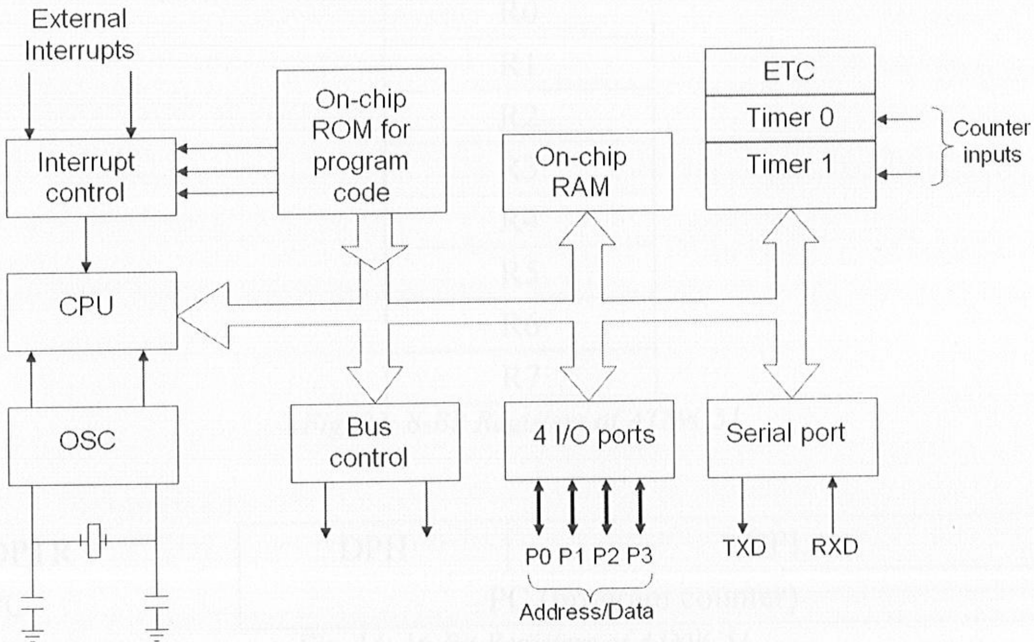


Fig. 11: Block Diagram of AT89C51

5.7 Register Set

In the microcontroller, registers are used to store information temporarily. That information could be a byte of data to be processed, or an address pointing to the data to be fetched. In the AT89C51, there is only one data type: 8 bits.

The 8 bits of a register are shown below from the MSB (D7) to the LSB (D0).

D7	D6	D5	D4	D3	D2	D1	D0

Fig. 12: 8-Bits of the Register

With an 8-bit data type, any data larger than 8 bits has to be broken into 8-bit chunks before it is processed.

The most commonly used registers of the 8051 are A (accumulator), B, R0, R1, R2, R3, R4, R5, R6, R7, DPTR (data pointer) and PC (program counter).

A
B
R0
R1
R2
R3
R4
R5
R6
R7

Fig. 23: 8-Bit Registers of AT89C51

DPTR	DPH	DPL
PC	PC (program counter)	

Fig. 14: 16-Bit Registers of AT89C51

A (accumulator)

It is used for all arithmetic and logical instructions.

R0-R7

These eight 8-Bit registers are used for temporary storage of data.

DPTR (data pointer)

This register is made up of two 8-bit registers, DPH and DPL, which are used to furnish memory addresses for internal and external data access. The DPTR is under the control of program instructions. DPTR does not have a single internal address. Instead, DPH and DPL are assigned individual addresses.

PC (program counter)

This is a 16-bit register and it points to the address of the next instruction to be executed. As the CPU fetches the op-code from the program in ROM, the program counter is incremented to point to the next instruction. Since the PC is 16-bits wide so it can access program addresses 0000 to FFFFH i.e. a total of 64 Kbytes of code.

5.8 PSW Register and Flag Bits

8051 has a flag register to indicate various arithmetic conditions. The flag register in the 8051 is called the processor status word register. It is an 8-bit register. Although this register is 8-bit wide, only 6 bits of it are used by the microcontroller. The two unused bits are user definable flags. Four of the flags are conditional flags which indicate some conditions that result after an instruction is executed. The four conditional flags are CY (carry), AC (auxiliary carry), P (parity) and OV (overflow). The bits of the PSW register are shown below:

CY	AC	F0	RS1	RS0	OV	-	P

Fig. 15: Bits of PSW Register

CY, the carry flag

This flag is set whenever there is a carry out from the D7 bit. This flag bit is affected after an 8-bit addition or subtraction. It can also be set to 1 or 0 directly by an instruction such as 'SETB C' and 'CLR C' where 'SETB C' stands for "set bit carry" and 'CLR C' for 'clear carry'.

AC, the auxiliary carry flag

If there is a carry from D3 to D4 during an ADD or SUB operation, this bit is set; otherwise it is cleared. This flag is used by instructions that perform BCD (binary coded decimal) arithmetic.

P, the parity flag

The parity flag reflects the number of 1s in the A (accumulator) register only. If the A register contains an odd number of 1s, then P=1. Therefore, P=0 if A has an even number of 1s.

OV, the overflow flag

This flag is set whenever the result of a signed number operation is too large, causing the high-order bit to overflow into the sign bit. In general, the carry flag is used to detect errors in unsigned arithmetic operations while the overflow flag is only used to detect errors in signed arithmetic operations.

5.9 Pin Diagram

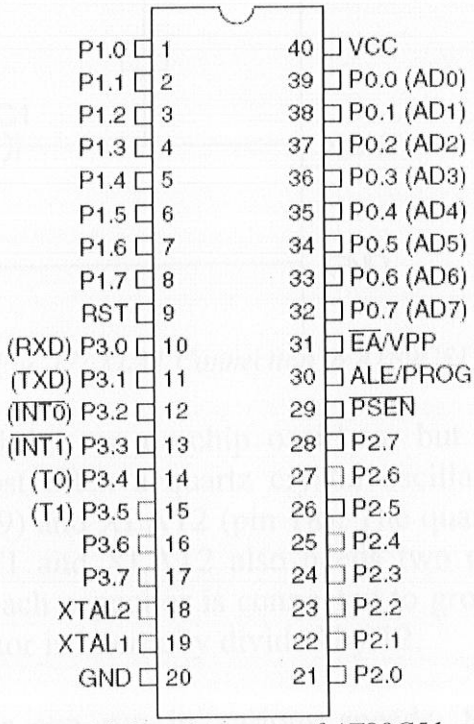


Fig. 16: Pin Diagram of AT89C51

5.10 Pin Description

Of all the 40 pins, a total of 32 pins are set aside for the four ports P0, P1, P2, and P3, where each port takes 8 pins. The rest of the pins are designated as V_{cc}, GND, XTAL1, XTAL2, RST, EA and PSEN. The functions of various pins are described below:

5.10.1 Power Supply

V_{cc}

Pin 40 provides supply voltage to the chip. The voltage source is +5 V.

GND

Pin 20 is ground.

5.10.2 External Clock

XLAT1 and XLAT2

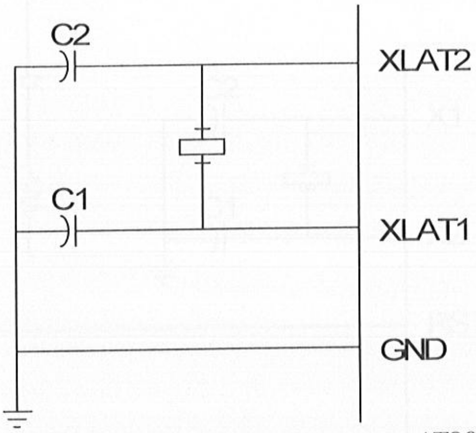


Fig. 17: XLAT Connection to AT89C51

The AT89C51 has an on-chip oscillator but requires a external clock to run it. Most often a quartz crystal oscillator is connected to inputs XLAT (pin 19) and XLAT2 (pin 18). The quartz crystal oscillator connected to XLAT1 and XLAT2 also needs two capacitors of 30 pF value. One side of each capacitor is connected to ground. The frequency of the crystal oscillator is internally divided by 12.

This microcontroller can run in various speeds. Speed refers to the maximum oscillator frequency connected to XLAT. For example, a 12 MHz chip must be connected to a crystal oscillator with 12 MHz frequency or less.

If a frequency source other than crystal oscillator, such as a TTL oscillator, is used then it will be connected to XLAT1; XLAT2 is left unconnected.

5.10.3 Reset

RST

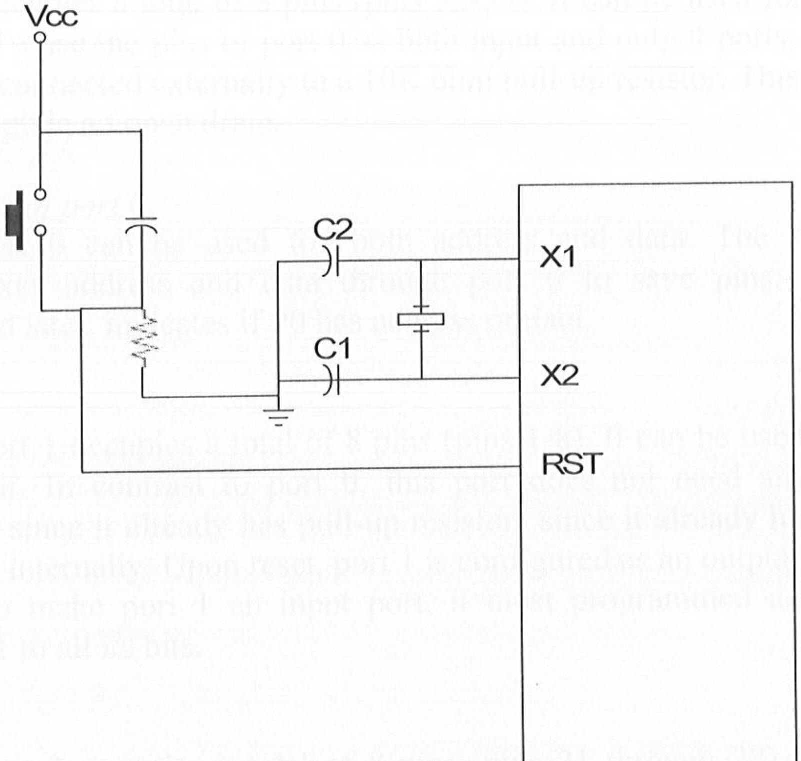


Fig. 18: Power-On Reset with Push to On Switch

Pin 9 is the RESET pin. It is an input and is active high (normally low). Upon applying a high pulse to this pin the microcontroller will reset and terminate all activities. This is often referred to a power-on reset. Activating a power-on reset will cause all values in the registers to be lost.

The value of the PC (program counter) is 0 upon reset, forcing the CPU to fetch the first opcode from ROM memory location 0000H.

In order for the RESET input to be effective, it must have a minimum duration of 2 machine cycles before it is allowed to go low.

5.10.4 I/O Port Pins

The four ports P0, P1, P2, and P3 each use 8 Pins, making them 8-bit ports. All the ports upon RESET are configured as output, reedy to be used as output ports. To use any of these ports as an input port, it must be programmed.

Port 0

Port 0 occupies a total of 8 pins (pins 32-39). It can be used for input or output. To use the pins of port 0 as both input and output ports, each pin must be connected externally to a 10K ohm pull-up resistor. This is due to fact that p0 ia an open drain.

Dual role of port 0

Port 0 can be used foe both address and data. The AT89C51 multiplexes address and data through port 0 to save pins. ALE, as described later, indicates if P0 has address or data.

Port 1

Port 1 occupies a total of 8 pins (pins 1-8). It can be used as input or output. In contrast to port 0, this port does not need any pull-up resistors since it already has pull-up resistors since it already has pull-up resistors internally. Upon reset, port 1 is configured as an output port.

To make port 1 an input port, it must programmed as such by writing 1 to all its bits.

Port 2

Port 2 occupies a total of 8 pins (pins 21 through 28). It can be used as input or output. Just like P1, port 2 does not need any pull-up resistors since it already has pull-up resistors. Upon reset, port 2 is configured as an output port.

To make port 2 as an input, it must programmed as such by writing 1 to all its bits

Port 3

Port 3 occupies a total of 8 pins (pins 10 through 17). It can be used as input of output/ P3 does not need any pull-up resistors, the same as P1 and P2 did not. Although port 3 is configured as an output port upon reset, this is not the way it is most commonly used. Port 3 has the additional function of providing some extremely important signals such as interrupts.

P3.0 and P3.1 are used for the RxD and TxD serial communication signals. Bits P3.2 and P3.3 are set aside for external interrupts. Bits P3.4 and P3.5 are used for timers 0 and 1. P3.6 and P3.7 are used for I/O.

5.10.5 Other Pins

$\overline{EA}$

The AT89C51 comes with on-chip ROM to store programs. In this case, the EA (pin 31) is connected to V_{cc}. EA stands for 'external accesses. There are times when the on-chip ROM is no longer working due to repeated burning and erasing by the PROM burner. In those cases we can connect the EA pin to GND and connect the chip to external ROM containing the program code. This input pin cannot be left unconnected.

$\overline{PSEN}$

Pin 29 is PSEN. This is an output pin. PSEN stands for 'program store enable'. This pin must be connected to the OE (output enable) pin of external ROM in case when we have used one. Thus with the help of PSEN the AT89C51 fetches the opcode from an external ROM in case EA pin is grounded.

ALE

Pin 30 is ALE (address latch enable). This is an output pin and is active high. When ALE is 0 (low) the AT89C51 uses P0 for data path and when ALE 1 (high), it is used for the address path. As a result, to extract the addresses from the P0 pins we connect P0 to a 74LS373 latch. This extracting of addresses from P0 is called address/data demultiplexing.

CHAPTER 6

LED

6.1 Definition

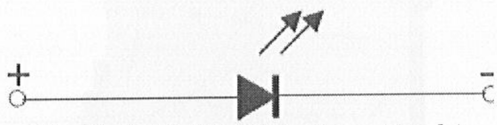


Fig 19: LED (Light Emitting Diode)

LED stands for Light Emitting Diode. LED is basically a semiconductor p-n junction diode which when energized gives off visible light. The process of giving off light by applying an electrical source of energy is called electroluminescence.

6.2 Requirement in the project

Three different LEDs (red, green, yellow) have been used for displaying the output of each sensor pair individually.

Sensors have been used in negative logic configuration. So whenever there is an obstacle or the sensors sense white or any non black surface then it gives output as 1.

6.3 Working

In a forward biased p-n junction there is, within the structure and primarily close to the junction, a recombination of holes and electrons.

This recombination requires that the energy possessed by the unbound free electrons will be given off as heat and some in the form of photons. In silicon and germanium the greater percentage is given up in the form of heat and the emitted light is insignificant.

But in case of an LED made up of gallium arsenide phosphide (GaAsP) or gallium phosphide (GaP), the number of photons of light energy emitted is sufficient to create a very visible light source.

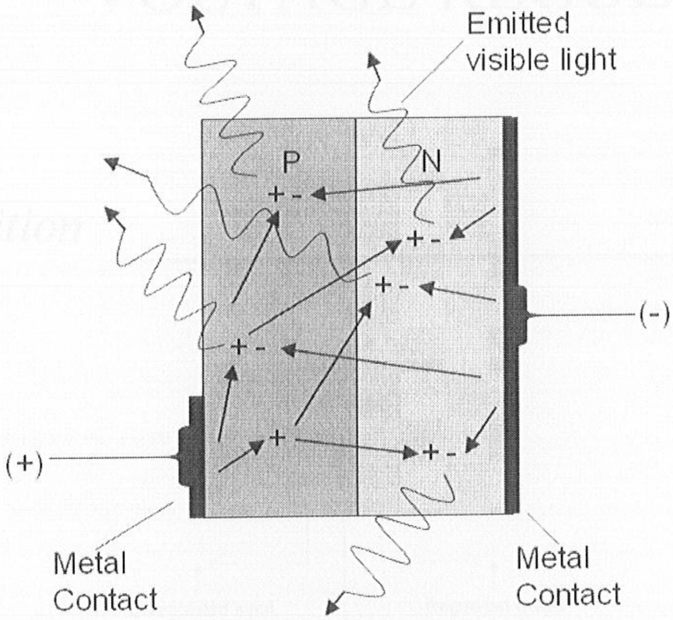


Fig 20: Process of electroluminescence in LED

As shown in the above diagram, the conducting surface connected to the p-material is much smaller, to permit the emergence of the maximum no. of photons of light energy. The recombination of the injected carriers due to the forward biased junction results in emitted light at the site of recombination.

CHAPTER 7

VOLTAGE REGULATOR

7.1 Definition

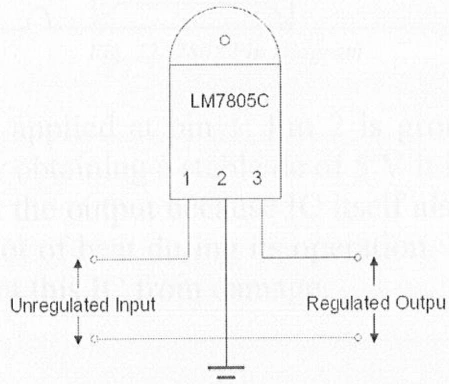


Fig. 21: Voltage Regulator 7805

Voltage regulator is a device which is used to regulate the input voltage to a desired fixed dc value. The regulation is usually obtained from an IC voltage regulator unit, which takes a dc voltage and provides a somewhat lower dc voltage, which remains the same even if the input dc voltage varies or the output load connected to the dc voltage changes. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC.

7.2 Requirement in the project

The output from the battery is not a perfect dc. It still contains some ac components as opposed to our requirement of a perfect fixed dc.

To compensate for this factor, we have a used a voltage regulator IC 7805. It gives a fixed dc value of 5 V. Also the output of 7805 remains same in case of any variations in the load.

7.3 IC 7805

The 78XX series is for positive voltage regulators. '5' at the end indicates the output dc voltage. This voltage regulator requires a minimum of 6.3 V. Thus if a signal having variations above 6.3 V is applied at the input of 7805 will produce 5 V fixed dc at the output.

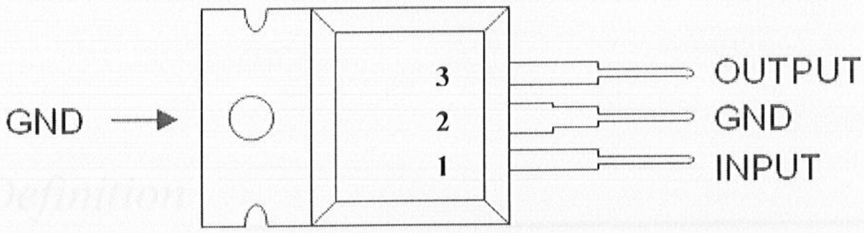


Fig. 22: 7805 Pin Diagram

The input voltage is applied at pin 1. Pin 2 is grounded. The output is taken from Pin 3. For obtaining a stable dc of 5 V it is necessary to have a minimum of 6.3 V at the output because IC itself also has a voltage drop. This IC generates a lot of heat during its operation. Therefore a heat sink is also there to prevent this IC from damage.

CHAPTER 8

DC MOTOR

8.1 Definition

An electric motor converts electrical energy to mechanical energy.DC motors are fairly simpler to understand. They are also simple to make and only require a battery or dc supply to make them run.

The rotational speed of a DC motor is proportional to the voltage applied to it, and the torque is proportional to the current. Speed control can be achieved by variable battery tappings, variable supply voltage, resistors or electronic controls. The direction of a wound field DC motor can be changed by reversing either the field or armature connections but not both.

8.2 Requirement in the project

The output of microcontroller is fed into the motor drive circuitry. Here we have used gear headed dc motors in order to reduce the speed so that torque gets enhanced .

Wheels of line follower automatically move as the motor rotates in synchronism with the output from the microcontroller.

8.3 Construction and Working

DC motors consist of rotor-mounted windings (armature) and stationary windings (field poles). In all DC motors, except permanent magnet motors, current must be conducted to the armature windings by passing current through carbon brushes that slide over a set of copper surfaces called a commutator, which is mounted on the rotor.

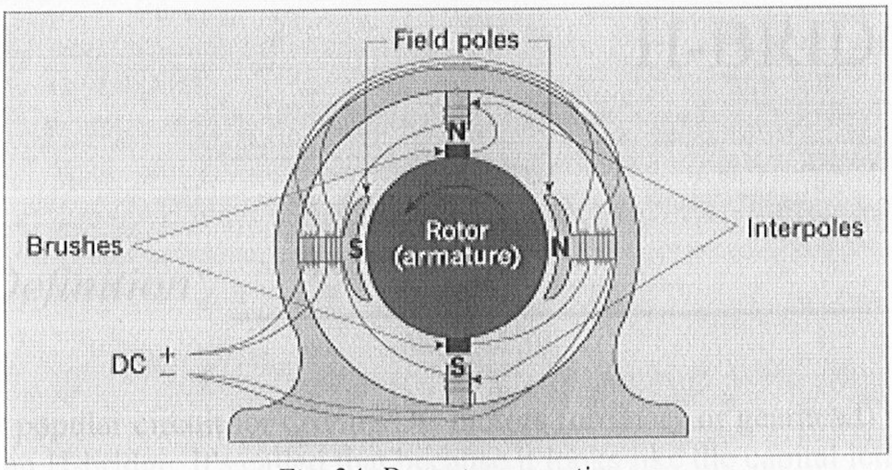


Fig. 24: Dc motor operation

The commutator bars are soldered to armature coils. The brush/commutator combination makes a sliding switch that energizes particular portions of the armature, based on the position of the rotor. This process creates north and south magnetic poles on the rotor that are attracted to or repelled by north and south poles on the stator, which are formed by passing direct current through the field windings. It's this magnetic attraction and repulsion that causes the rotor to rotate.

CHAPTER 9

H-BRIDGE

9.1 Definition

A very popular circuit for driving DC motors (ordinary or gearhead) is called an H-bridge. It's called that because it looks like the capital letter 'H' on classic schematics. The great ability of an H-bridge circuit is that the motor can be driven forward or backward at any speed, optionally using a completely independent power source.

9.2 Requirement in the project

H-Bridge acts as an interface between microcontroller and motor. It is formed using relays.

9.3 Construction and Working

An H-bridge design can be really simple for added protection and isolation. An H-bridge can be implemented with various kinds of components (common bipolar transistors, FET transistors, MOSFET transistors, power MOSFETs, or even chips).

Physical motion of some form helps differentiate a robot from a computer. It would be nice if a motor could be attached directly to a chip that controls the movement. But, most chips can't pass enough current or voltage to spin a motor. Also, motors tend to be electrically noisy (spikes) and can slam power back into the control lines when the motor direction or the speed of the motor changes.

Specialized circuits (motor drivers) have been developed to supply motors with power and to isolate the other ICs from electrical problems. These circuits can be designed such that they can be completely separate boards, reusable from project to project.

H-bridge which is sometimes called a "full bridge" is so named because it has four switching elements at the "corners" of the H and the motor forms the cross bar. The basic bridge is shown in the figure below:

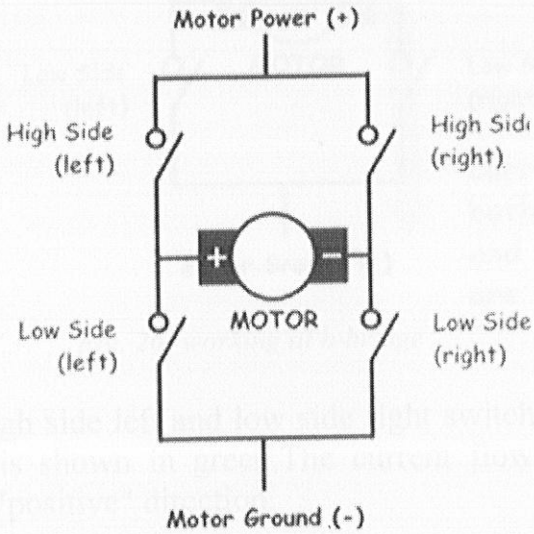


Fig. 25: H-bridge

Of course the letter H doesn't have the top and bottom joined together, but hopefully the picture is clear.The key fact to note is that there are, in theory, four switching elements within the bridge. These four elements are often called, high side left, high side right, low side right, and low side left (when traversing in clockwise order). The switches are turned on in pairs, either high left and lower right, or lower left and high right, but never both switches on the same "side" of the bridge.

If both switches on one side of a bridge are turned on, it creates a short circuit between the battery plus and battery minus terminals. This phenomenon is called shoot through in the Switch-Mode Power Supply (SMPS) literature.

If the bridge is sufficiently powerful it will absorb that load and the batteries used will simply drain quickly. Usually however the switches melt. To power the motor, we turn on two switches that are diagonally opposed.

In the picture shown below,

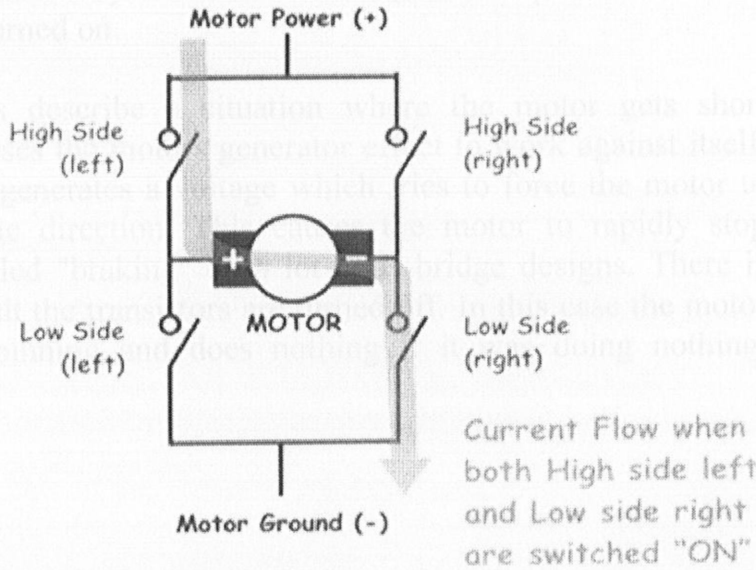


Fig. 26: working of h-bridge

imagine that the high side left and low side right switches are turned on. The current flow is shown in green.The current flows and the motor begins to turn in a "positive" direction.

If now high side right and low side left switched are turned on, current flows in the other direction through the motor and the motor turns in the opposite direction.

If each switch can be controlled independently then such a bridge is called a "four quadrant device" (4QD).

High Side Left	High Side Right	Lower Left	Lower Right	Quadrant Description
On	Off	Off	On	Motor goes Clockwise

Off	On	On	Off	Motor goes Counter-clockwise
On	On	Off	Off	Motor "brakes" and decelerates
Off	Off	On	On	Motor "brakes" and decelerates

We have now built a small truth table that tells the state of each switch, which further tells what the bridge will do. As each switch has one of two states, and there are four switches, there are 16 possible states.

However, since any state that turns both switches on one side 'on' is "bad". There are in fact only four useful states (the four quadrants) where the transistors are turned on.

The last two rows describe a situation where the motor gets short circuited which causes the motors generator effect to work against itself. The turning motor generates a voltage which tries to force the motor to turn in the opposite direction. This causes the motor to rapidly stop spinning and is called "braking" on a lot of H-bridge designs. There is also a state where all the transistors are turned off. In this case the motor coasts if it was spinning and does nothing if it was doing nothing.

CHAPTER 10

CURRENT AMPLIFIER

11.1Definition

IC ULN2803 is used as current amplifier. It is a motor driver IC. It has continuous load current ratings of 500 mA for each of the drivers.The series ULN28xxA/LW and ULQ28xxA/LW high-voltage, high-current Darlington arrays are ideally suited for interfacing between low-level logic circuitry and multiple peripheral power loads.

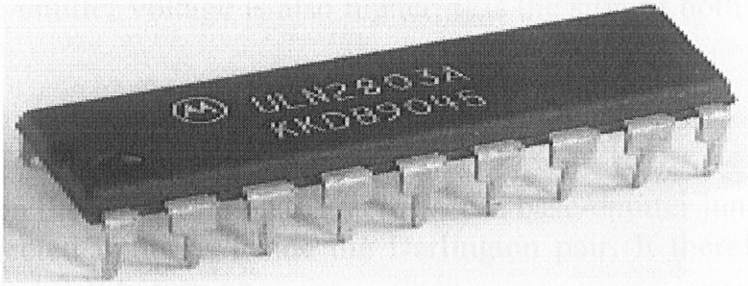
Typical power loads totaling over 260 W (350 mA x 8, 95 V) can be controlled at an appropriate duty cycle depending on ambient temperature and number of drivers turned on simultaneously.

Typical loads include relays, solenoids, stepping motors, magnetic print hammers, multiplexed LED and incandescent displays, and heaters. All devices feature open-collector outputs with integral clamp diodes.It has series input resistors selected for operation directly with 5 V TTL or CMOS. These devices will handle numerous interface needs —particularly those beyond the capabilities of standard logic buffers. It has series input resistors for operation directly from 6 V to 15 V CMOS or PMOS logic outputs.

11.2 Requirement in the project

Output current of the microcontroller is 25mA while that required to drive the motor circuitry is more than 100mA so current amplifier is used.

ULN2803 is an 8-bit 50V 500mA TTL-input NPN Darlington driver. It provides sufficient current to drive the motor. It gives an inverted output.



It is an 18 pin IC, out of which two pins are of VCC and GND. The 8 input pins are joined in pairs to amplify the current as stepper motor is a current operated device and also to increase the current bearing capacity of ULN up to 1A. The remaining 8 output pins are connected to the motors.

The Darlington transistor is a semiconductor device which combines two bipolar transistors in tandem (often called a "Darlington pair") in a single device so that the current amplified by the first is amplified further by the second transistor. This gives it high current gain (written β or h_{FE}), and takes up less space than using two discrete transistors in the same configuration. The use of two separate transistors in an actual circuit is still very common, even though integrated packaged devices are available.

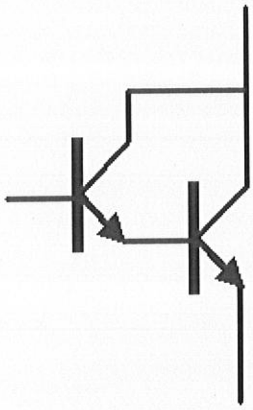


Fig. Darlington transistors

A Darlington pair behaves like a single transistor with a very high current gain. This is beneficial as many commonly-used transistors with high gains have a low current threshold. The total gain of the Darlington is the product of the gains of the individual transistors:

$$\beta_{\text{Darlington}} = \beta_1 \times \beta_2$$

The base-emitter voltage is also higher; it is the sum of both base-emitter voltages:

$$VBE = VBE_1 + VBE_2$$

To turn on there must be ~0.6 V across both base-emitter junctions which are connected in series inside the Darlington pair. It therefore requires more than 1.2 V to turn on.

CHAPTER 11

OTHER COMPONENTS

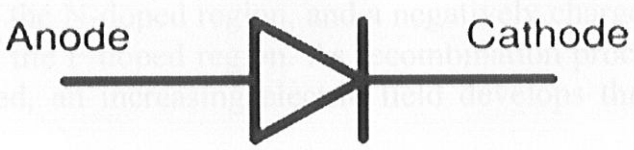
12.1 Diode

A diode is a component that restricts the direction of flow of charge carriers. Essentially, it allows an electric current to flow in one direction, but blocks it in the opposite direction. Thus, the diode can be thought of as an electronic version of a check valve. Circuits that require current flow in only one direction will typically include one or more diodes in the circuit design.

Today the most common diodes are made from semiconductor materials such as silicon or germanium.
http://en.wikipedia.org/wiki/Image:Diode_symbol.svg

Most modern diodes are based on semiconductor p-n junctions. In a p-n diode, conventional current flows from the p-type side (the anode) to the n-type side (the cathode), but not in the opposite direction. Another type of semiconductor diode, the Schottky diode, is formed from the contact between a metal and a semiconductor rather than by a p-n junction.

Fig. Diode schematic symbol



A semiconductor diode's current-voltage, or I-V, characteristic curve is shown below.

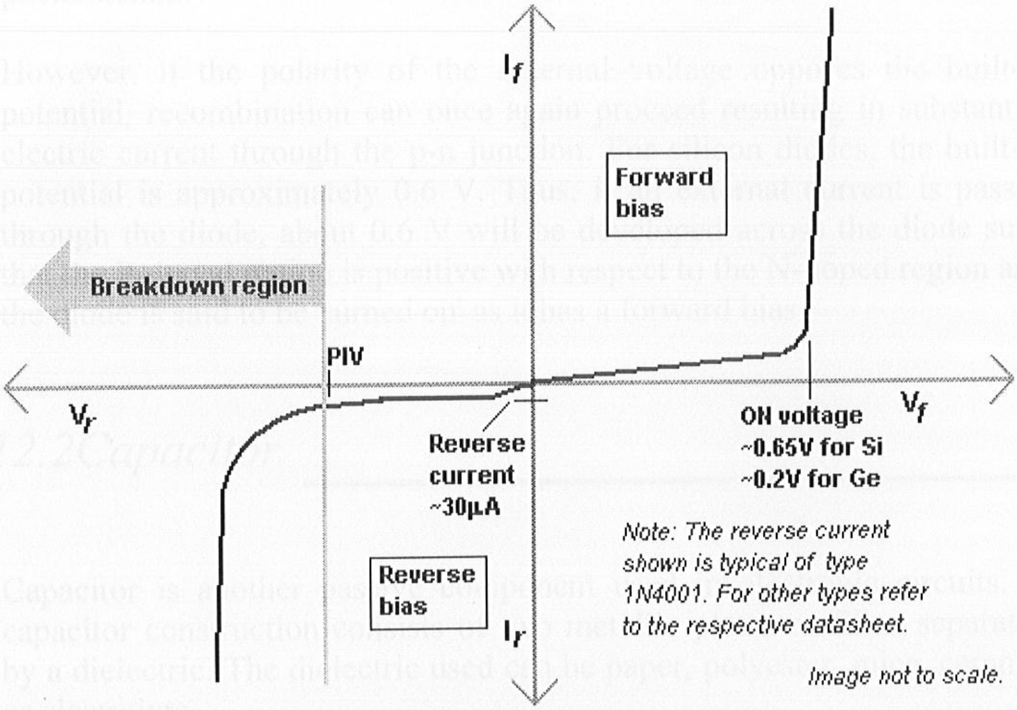


Fig. VI Characteristics of a diode

When a p-n junction is first created, conduction band (mobile) electrons from the N-doped region diffuse into the P-doped region where there is a large population of holes (places for electrons in which no electron is present) with which the electrons "recombine".

When a mobile electron recombines with a hole, the hole vanishes and the electron is no longer mobile. Thus, two charge carriers have vanished. The region around the p-n junction becomes depleted of charge carriers and thus behaves as an insulator.

However, the depletion width cannot grow without limit. For each electron-hole pair that recombines, a positively-charged dopant ion is left behind in the N-doped region, and a negatively charged dopant ion is left behind in the P-doped region. As recombination proceeds and more ions are created, an increasing electric field develops through the depletion zone which acts to slow and then finally stop recombination. At this point, there is a 'built-in' potential across the depletion zone.

If an external voltage is placed across the diode with the same polarity as the built-in potential, the depletion zone continues to act as an insulator preventing a significant electric current. This is the reverse bias phenomenon.

However, if the polarity of the external voltage opposes the built-in potential, recombination can once again proceed resulting in substantial electric current through the p-n junction. For silicon diodes, the built-in potential is approximately 0.6 V. Thus, if an external current is passed through the diode, about 0.6 V will be developed across the diode such that the P-doped region is positive with respect to the N-doped region and the diode is said to be 'turned on' as it has a forward bias.

12.2Capacitor

Capacitor is another passive component used in electronic circuits. A capacitor construction consists of two metallic plates or films separated by a dielectric. The dielectric used can be paper, polyester, mica, ceramic or electrolyte.

It is the dielectric used in the capacitors on basis of which the capacitors are categorized. Therefore, capacitor can be of following types:

- Paper Capacitor
- Polyester Capacitor
- Mica Capacitor
- Ceramic Capacitor
- Electrolytic Capacitor

The capacity ranges of these capacitors vary from type to type. Ceramic capacitors have usually very low capacitance with few pico farad rating. The electrolytic capacitors are high capacity ones, with capacity up to few thousand micro farads.

The capacitors are also rated for maximum value of voltage which they can withstand. This maximum operating voltage is decided on basis of the breakdown voltage of the dielectric used between the plates. Breakdown voltage of a capacitor is the voltage at which the dielectric used ceases to be a dielectric, and starts conducting. This gives rise to short – circuiting of the plates, and hence, the capacitor. The two types of capacitors used in our circuit are:

12.3 Resistors

A resistor is a passive component. It introduces resistance i.e. opposition to the flow of current in a circuit. Resistors are used in electronic circuits for setting biases, voltage division, controlling gain, fixing time constants, matching and loading circuits, heat generation and related applications.

Resistance is basic property of the conducting material as given

$$R = \frac{\rho L}{A}$$

Where R is resistance

L is length of conductor

A is area of cross-section of the conductor

ρ is specific resistivity of the material

Thus, resistance depends upon physical dimensions of the resistor and resistivity of the conducting material used.

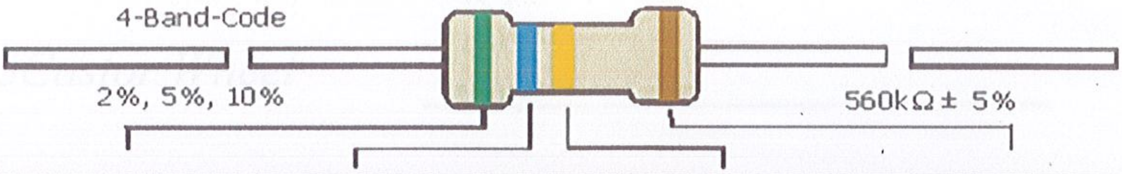
Many applications of the resistors require fixed resistance, while sometimes, variable resistance is required which can be varied according to need. Depending on these, two types of resistors are available.

- Fixed resistors
- Variable resistors

Fixed resistors are those, for which the value of resistance is fixed, i.e., it can not be varied except the change creeping in due to age or environmental factors. Carbon composition resistors and wire- wound resistors are examples of fixed resistors.

Variable resistors, on the other hand are those resistors, value of which can be varied by physically moving some control or supplying external energy. Presets and potentiometers are the examples of physically variable resistors.

The color coding diagram of resistor is as follows:



COLOR	1st BAND	2nd BAND	3rd BAND	MULTIPLIER	TOLERANCE
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	±0.5% (D)
Blue	6	6	6	1MΩ	±0.25% (C)
Violet	7	7	7	10MΩ	±0.10% (B)
Grey	8	8	8		±0.05%
White	9	9	9		
Gold				0.1	± 5% (J)
Silver				0.01	± 10% (K)

Fig. Color Coding Scheme

12.4Crystal Oscillator

A crystal is used as a reference input to generate clock pulses. They provide a stable, accurate and appropriate reference input. The equivalent circuit of a crystal is as shown:

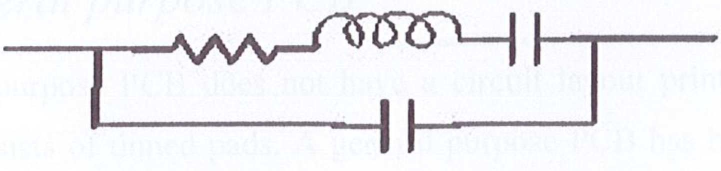


Fig. Equivalent circuit of a crystal

We have used a 12 MHz crystal in our circuit to provide external clock reference to the microcontroller. It is as shown below:

12.5Castor Wheel

Caster Wheel is also known as ball bearing. It is the free wheel as shown. The term ball bearing to mechanical engineers usually means a bearing assembly which uses spherical bearing balls as the rolling elements. Ball bearings typically support both axial and radial loads and can tolerate some misalignment of the inner and outer races. Also, balls are relatively easy to make cheaply compared to other kinds of rolling elements. Ball bearings tend to have lower load capacity for their size than other kinds of rolling-element bearings due to the smaller contact area that spherical shapes provide.

12.6 Wheels

The line follower wheel has a radially directed, circumferential groove shaped to fit over a raised track portion, and the cross sectional shape of the wheel groove and the track over which it fits are such that the uppermost portion of the track contacts the radially innermost portion of the wheel groove.

12.7Batteries

Two batteries are used to supply power in the circuit. Out of them, one battery is of 9V. The other one is of 6V

12.8General purpose PCB

A general purpose PCB does not have a circuit layout printed on it. It simply consists of tinned pads. A general purpose PCB has been used in our circuit.

CHAPTER 12

SOURCE CODE

```
Mov p2,000h
Mov p1,0ffh

Start:  mov a,p1
        cjne a,00000011b,xxx1
        mov p2,00001010b
        call delay
        mov p2,000h

xxx1:   cjne a,00000001b,xxx2
        mov p2,00000001b
        call delay
        mov p2,000h

xxx2:   cjne a,00000010,xxx3
        mov p2,0000110b
        call delay
        mov p2,000h

xxx3:   cjne a,00000000b,xxx4
        mov p2,00000101b
        call delay
        mov p2,000h

xxx4:   jmp start

delay:  h1:  mov r4,10
        h2:  mov r3,10
        h3:  djnz r3,h3
             djnz r4,h2
             djnz r5,h1
             ret
```

CHAPTER 13

CONCLUSION

In a nutshell, the purpose of working on this project was to become more familiar with the undergoing developments in the field of electronics. The sole reason behind choosing this project is to study ROBOTICS as a ROBOT is such a word which fascinates everybody.

The project that we have made is not only to understand the fundamentals of ROBOTICS.

A line follower has a wide range of ***Applications-***

It is mostly used in various kinds of industries to carry goods from one place to another following a certain dedicated path.

It can be used at harbors to carry the unloaded goods to the godowns for storage.

The main feature of our project is that it stops as soon as the line ends or any obstacle comes in its way.