SWARM ROBOTICS

BRIEF DESCRIPTION OF ELECTRONIC COMPONENTS

IN

SWARM ROBOTS

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SENSORS:

A Sensor is basically defined as a convertor which can sense and measure a physical quantity and then converts them into a signal so that it can be analyzed by an instrument. Infrared sensor is a particular type of a sensor which detects the intensity difference between white and black colour.

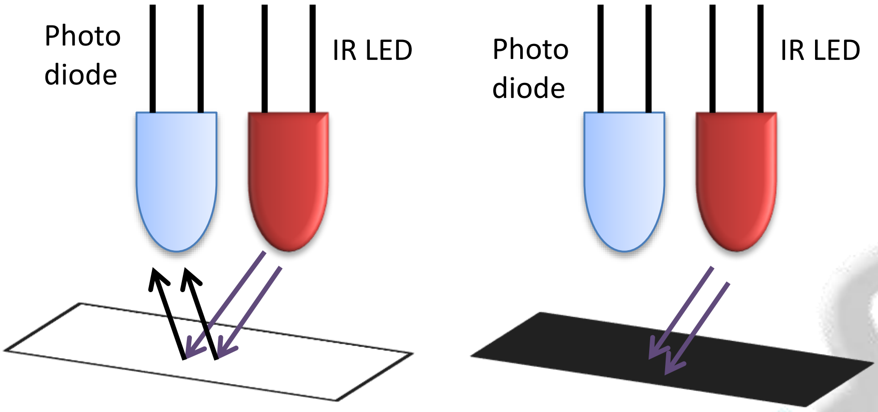


Fig.1. Light Reflected off white surface Fig2. Light absorbed by the black surface

IR reflective sensors have an emitter (IR LED-TX) and a receiver (Photo diode). If white surface is present beneath the IR LED, IR rays are reflected and are sensed by the receiver (refer fig1). While in the case of black surface, the light gets absorbed and hence receiver does not sense any IR rays (refer fig2).

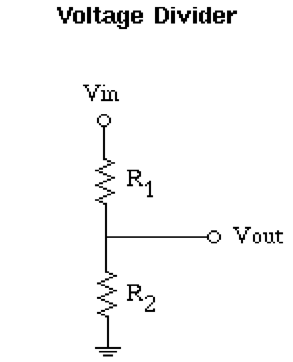
The photo diode is characterized by a property that its electrical resistance decreases when it is illuminated with IR light (i.e. it comes down, say from 150kΩ to 10kΩ). For sensing this change in the resistance we use voltage divider circuit

NOTE:

Voltage Divider is defined as the linear circuit that produces an output voltage which is a fraction of the input voltage.

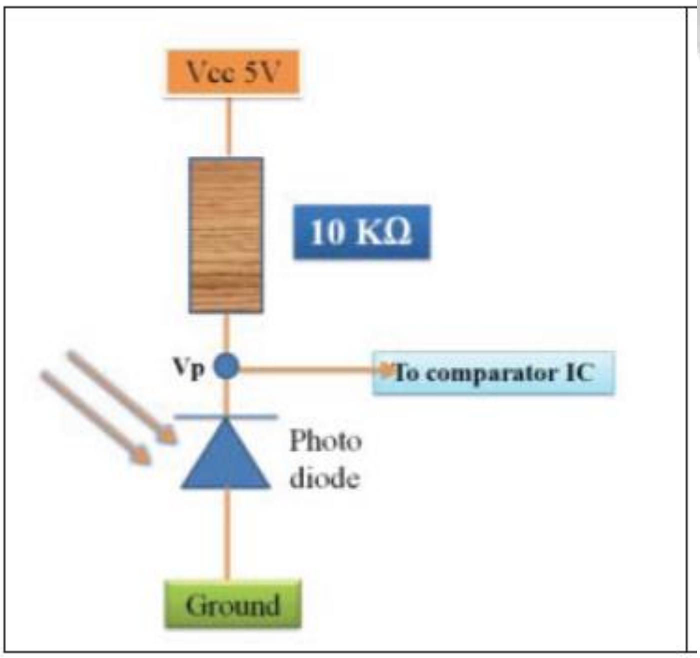
The two resistor voltage divider is used to supply a voltage different from that of a supply voltage or from available battery. The output voltage depends on the resistance value of the load it drives. We use this two resistor voltage divider in sensors to convert the variation of resistance (with change in light intensity) of the photo diode into a corresponding change in voltage.

CALCULATION OF OUTPUT VOLTAGE FROM VOLTAGE DIVIDER:



$$V_{out} = \frac{R_2}{R_1 + R_2} V_{in}$$

ILLUSTRATION OF THE SENSOR WORKING MECHANISM:



Let us consider R_s to be the resistance of the receiver (Photo Diode),

As discussed earlier the R_s value varies for different intensities falling on the photo diode, let us assume the values of R_s to be ->

R_s=150Ω without light (black surface)

R_s=10kΩ with light (on white surface)

V_{cc}- Supply voltage

Let V_p be the output voltage that will be obtained across the voltage divider circuit,

On black surface-

V_p= [R_s/ (R_s+R)*V_{cc}] = [150/ (150+10)]*5V=4.68V

On white surface-

V_p= [R_s/ (R_s+R)*V_{cc}] = [10/ (10+10)]*5V=2.5V

This voltage change needs to be captured in the digital format for it to be given as an input to the microcontroller and, therefore, the output from the sensors needs to be converted from analog to digital. For this operation we use comparators.

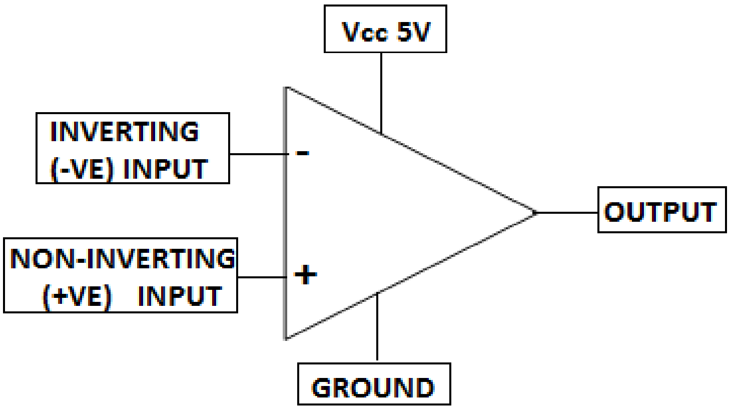
COMPARATOR:

It is an operational amplifier, which compares two input voltages and generates a high/low (binary) output.

Comparators are also used as Null detectors, Zero Crossing Detectors, Relaxation Oscillators, Level Shifters, in addition to its application as an Analog to Digital Converter (ADC).

When a comparator performs the function of deciding if an input voltage is above or below a given threshold, it is essentially performing a 1-bit quantization. This function is used in nearly all Analog to Digital Converters (ADC) and hence we use them to generate digital data from sensors' analog voltage input.

In a circuit diagram it is normally represented by a triangle having Inverting (-) and Non-Inverting (+) inputs, V_{cc}, Ground and Output.



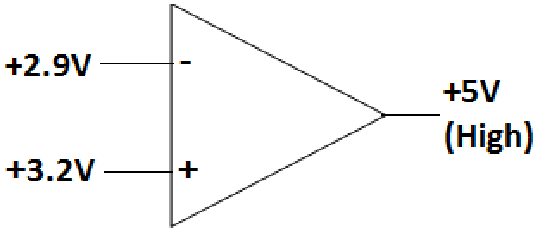
OPERATION OF A COMPARATOR:

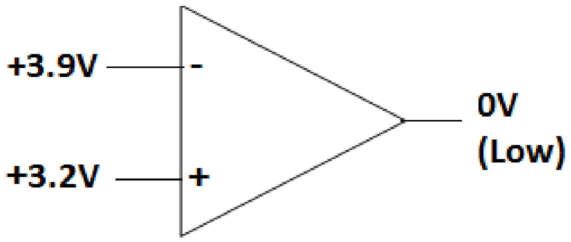
CASE1:

Assume

V_{ref} (from Potentiometer) is connected to **Non-Inverting Input**

V_{in} (sensors' voltage) is connected to **Inverting input** then the output will be as follows:





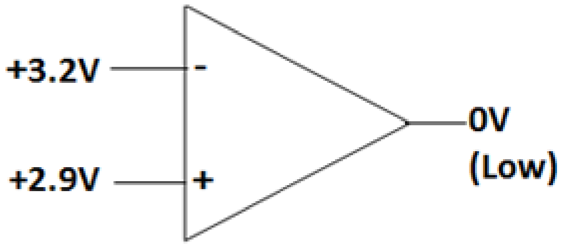
V_{in}<V_{ref}, output will be **high;** **V_{in}>V_{ref}**, output will be **low.**

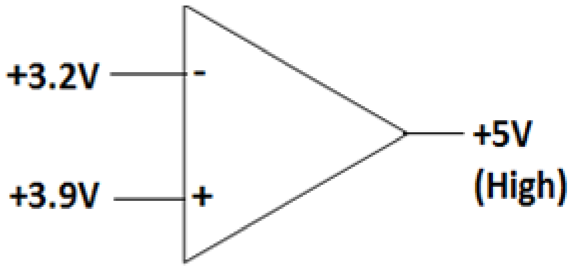
CASE2:

Assume

V_{ref} (from Potentiometer) is connected to **Inverting Input**

V_{in} (sensors' voltage) is connected to **Non- Inverting input** then the output will be as follows:





V_{in}<V_{ref}, output will be **low;** **V_{in}>V_{ref}**, output will be **high.**

NOTE:

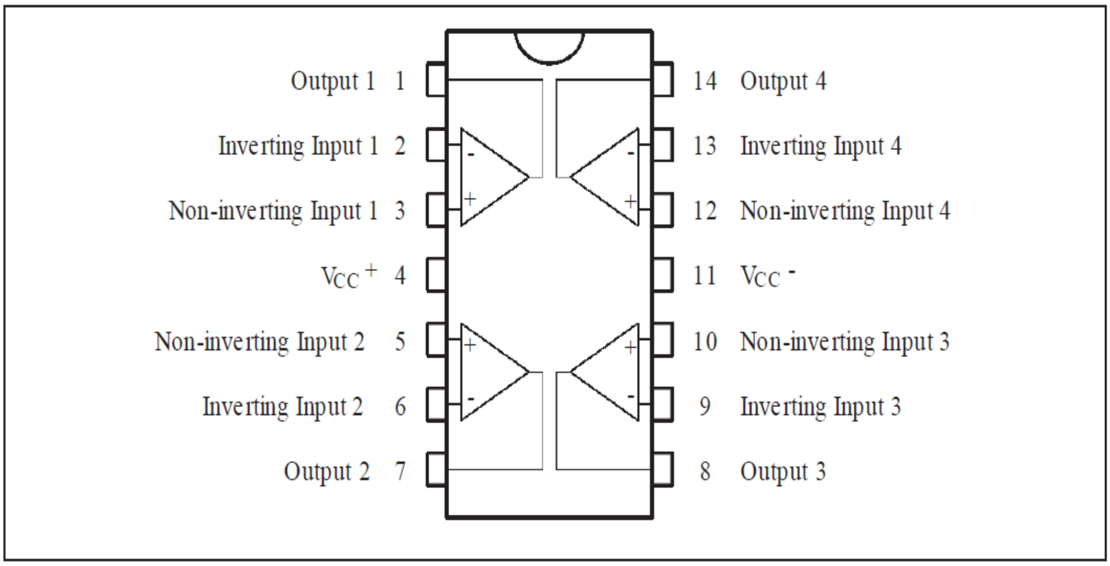
From the above observation it is very clear that when sensor Input is connected to the Inverting Input terminal then output changes inversely i.e. for inputs lower than the reference

value, higher outputs are obtained and vice versa. When sensor input is connected to Non-Inverting input terminal then output would be same i.e. for inputs lower than reference value, lower outputs are obtained and vice versa. Hence the corresponding names for the input terminals.

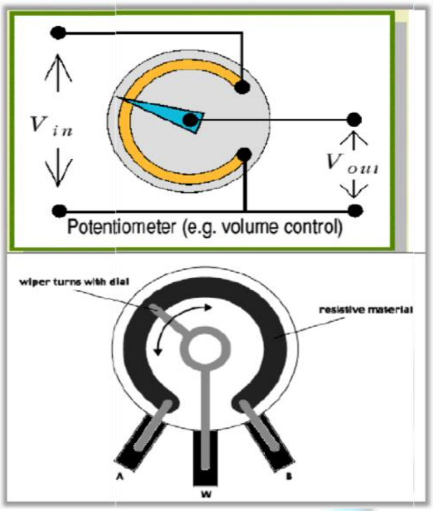
We can set the reference voltage by using the potentiometer, and for comparator circuitry operation LM324 IC is used which has got four Op-Amps in it.

LM324:

PIN CONNECTIONS (top view)



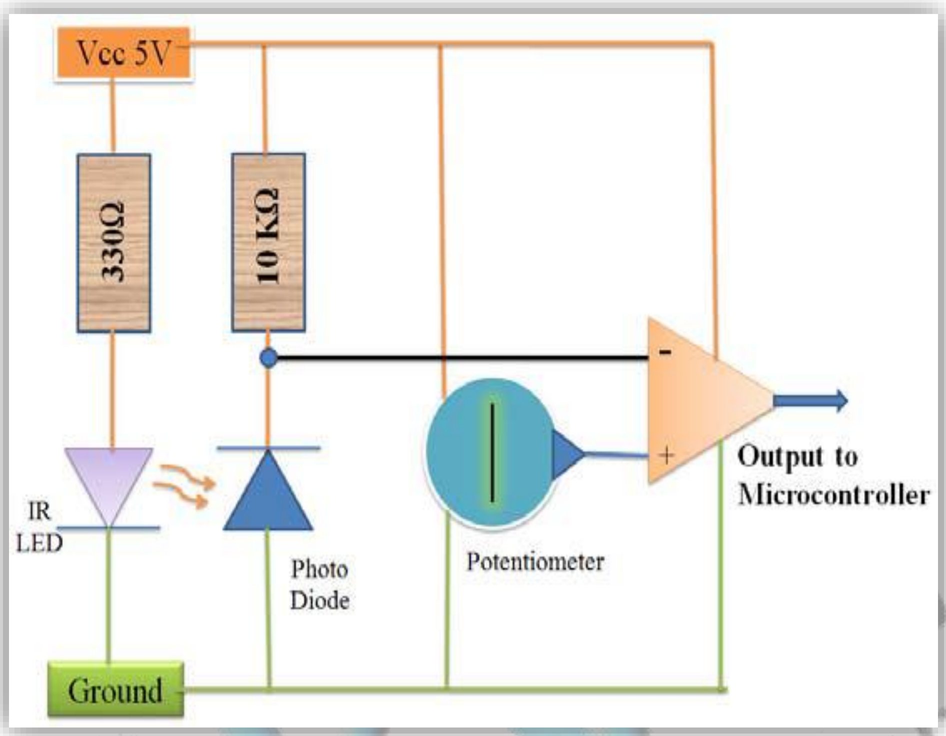
POTENTIOMETERS (VARIABLE RESISTOR):



A potentiometer is a three-terminal resistor with a sliding contact that forms an adjustable voltage divider. If only two terminals are used, one end and the wiper, it acts as a variable resistor or rheostat.

Potentiometers are used for setting up the reference voltage (V_{ref}).

OVERVIEW OF SENSOR CONNECTION:



After digitalizing the sensors' data, it is sent to micro controller for further processing and execution.

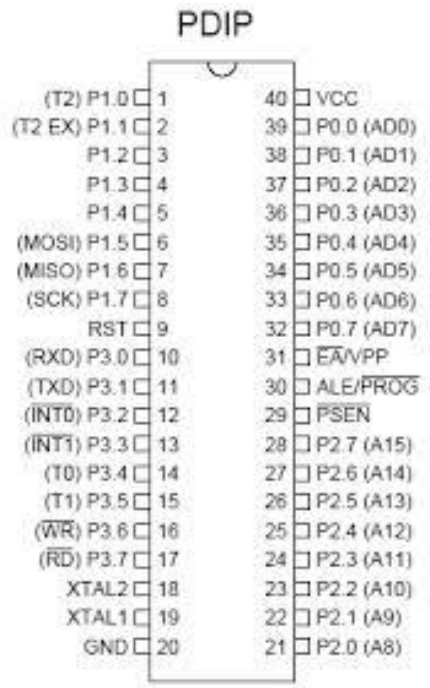
MICRO CONTROLLER:

The Skyfi Labs Development Board use AT89S52 microcontroller which comes under 8051 family. It is equipped with a 8kB flash memory and 256 bytes of data RAM.

FEATURES OF AT89S52:

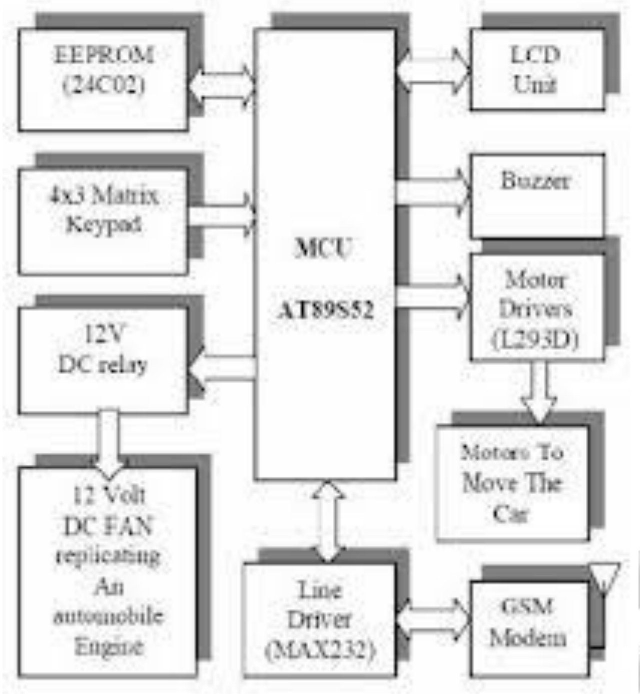
- 4.0V to 5.5V Operating Range.
- Fully Static Operation: 0 Hz to 33 MHz.
- Three-level Program Memory Lock.
- 256 x 8-bit Internal RAM.
- 32 Programmable I/O Lines.
- Three 16-bit Timer/Counters.
- Eight Interrupt Sources.
- Full Duplex UART Serial Channel.
- Low-power Idle and Power-down Modes.
- Interrupt Recovery from Power-down Mode.
- Watchdog Timer.
- Dual Data Pointer.
- Power-off Flag.
- Fast Programming Time.
- Flexible ISP Programming.

PIN DIAGRAM OF AT89S52:



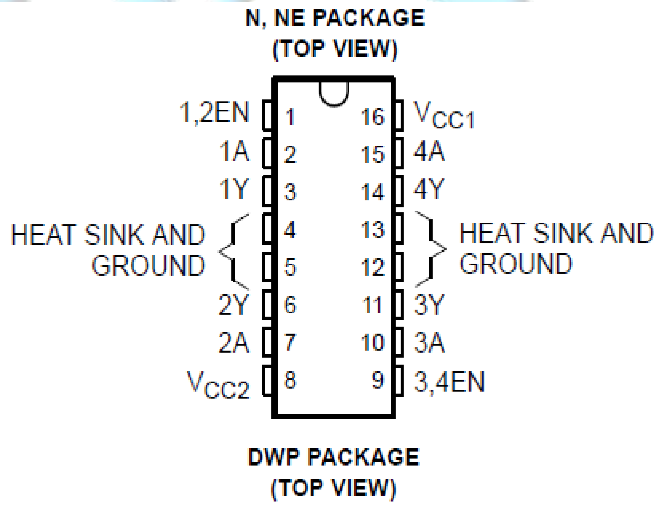
In Skyfi Labs' development board, the Port1 Lower has been used for input (connected to comparator) and Port2 Lower for output (connected to motor driver).

BLOCK DIAGRAM:

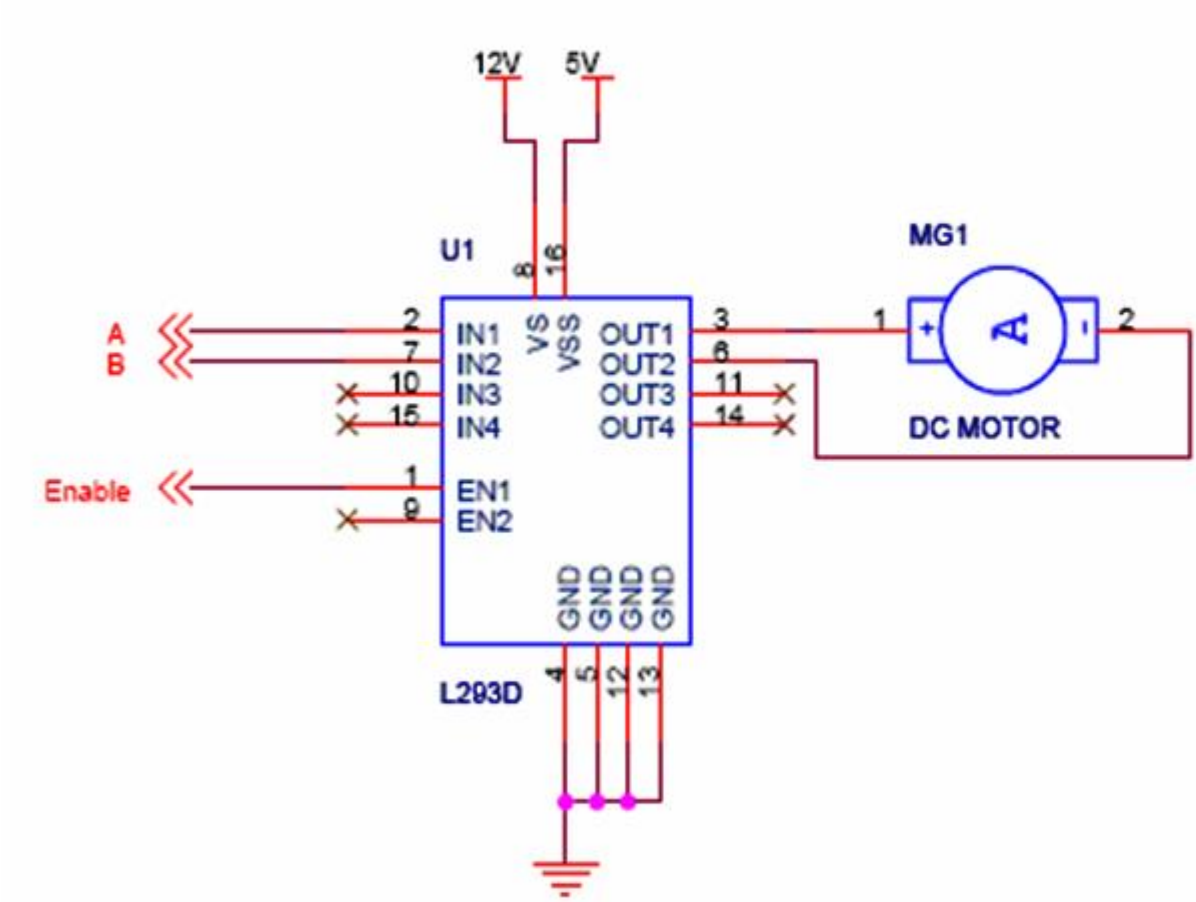


MOTOR DRIVER:

- The L293 and L293D are quadruple high-current half-H drivers.
- The L293 is designed to provide bidirectional drive currents of up to 1A at voltages from 4.5V to 3.6V



OPERATION OF MOTOR DRIVER (L293D):



TRUTH TABLE:

A	B	DESCRIPTION
0	**0**	Motor stops or Breaks
0	**1**	Motor Runs Anti-Clockwise
1	**0**	Motor runs Clockwise
1	**1**	Motor stops or breaks

For the above table, the Enable has to be set 1. Motor power is mentioned as 12V, but the power supply can be connected according to the rating of the motors used.

NOTE:

- The above operation of a Motor Driver demonstrates its working with only one DC motor connected to it. Note that in our robot the PCB is used to drive two motors and the settings need to be done accordingly.

DC MOTORS:

DC Motors convert electrical energy (voltage) to mechanical energy (produce rotational motion). The Dc motor works on the principle of Lorentz force which states that when a wire

carrying current is placed in a region having magnetic field, than the wire experiences a force. This Lorentz force provides a torque to the coil to rotate..

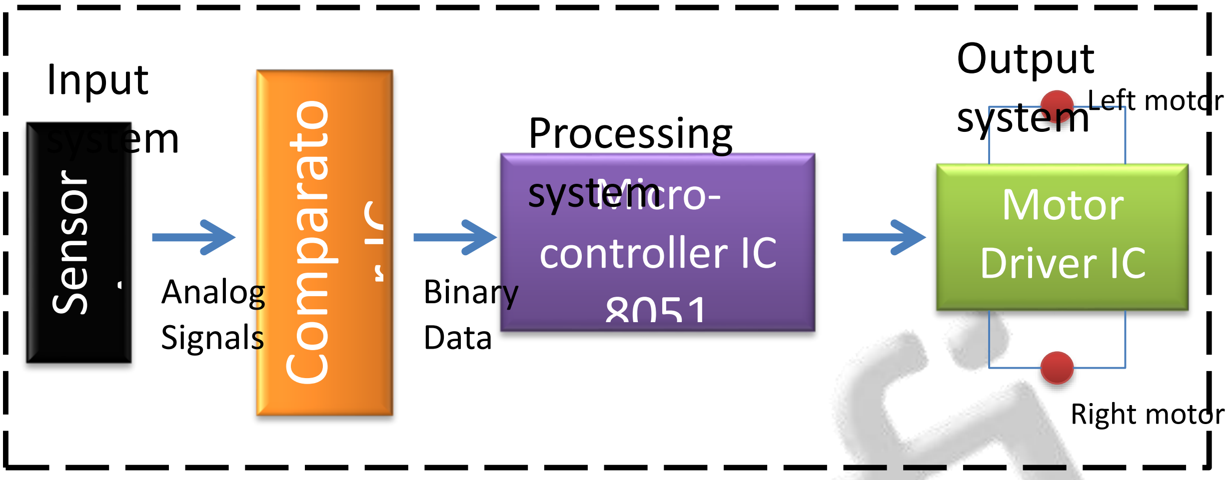
Figure of DC Motor

Speed of motor depends upon its RPM rating and we can vary the speed of motor by changing the voltage across the motor terminals. Gears are used to increase the torque of D.C Motor on the expense of its speed.

SPECIFICATIONS OF THE MOTORS USED IN WORKSHOP:

60 RPM-12V DC Geared Motor.

OVERVIEW:



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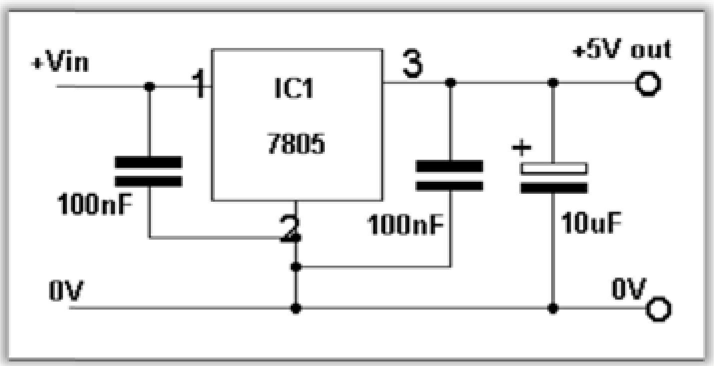
VOLTAGE REGULATOR:

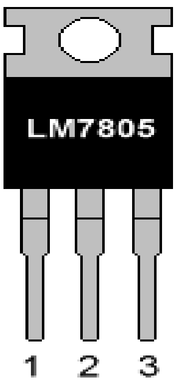
7805 is a **Voltage Regulator** Integrated Circuit. It is a member of 78xx series of fixed linear voltage regulator ICs.

BLOCK DIAGRAM:



The **voltage regulator IC** maintains the output voltage at a constant value. The xx in 78xx indicates the fixed output voltage to which it is designed to provide. 7805 provides +5V regulated power supply.

PIN DIAGRAM OF 7805:



PIN CONFIGURATION OF 7805:

Pin No	NAME	FUNCTION
1	Input	Input Voltage; (5V-18V)
2	Ground	Ground (0V)
3	Output	Output Voltage; (4.8V-5.2V)

RF MODULE

RF module operates at Radio frequency i.e. between 3 kHz & 300 GHz. In this RF system, the digital data is represented as variations in the amplitude of carrier wave. This kind of modulation is known as Amplitude Shift Keying (ASK).

Why only RF?

Transmission through RF is far better than IR (infrared) because of many reasons.

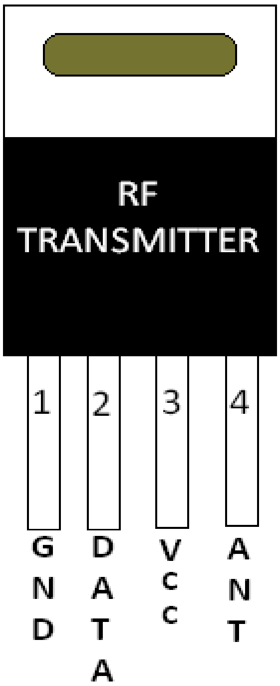
I. Signals through RF can travel through larger distances making it suitable for long range applications.
II. While IR mostly operates in line-of-sight mode, RF signals can travel even when there is an obstruction between transmitter & receiver.
III. RF transmission is more strong and reliable than IR transmission
IV. RF communication uses a specific frequency unlike IR signals which are affected by other IR emitting sources.

RF module consists of an RF Transmitter and an RF Receiver, where the transmitter/receiver (Tx/Rx) pair operates at a frequency of 434MHz.

RF TRANSMITTER

An RF Transmitter receivers serial data and transmits it wireless through RF, through its antenna connected at Pin4.

PIN DIAGRAM-RF TRANSMITTER:



PIN FUNCTIONALITY-RF TRANSMITTER:

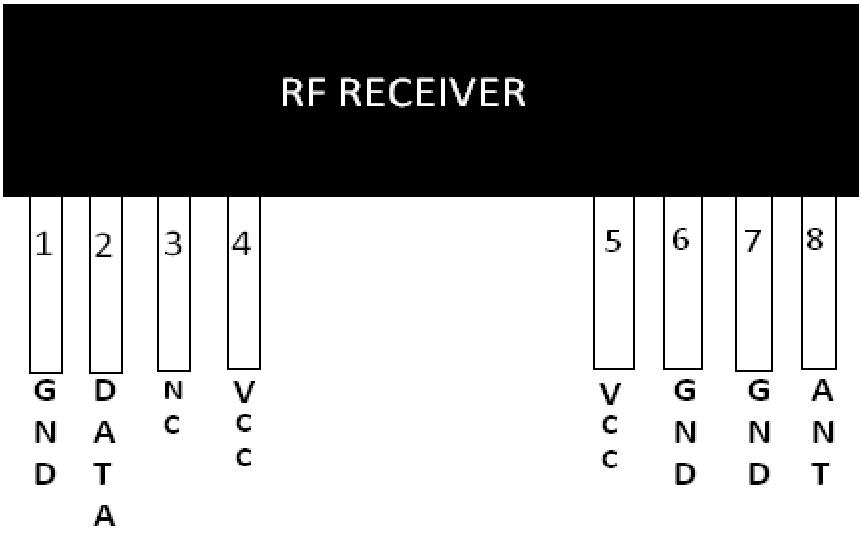
PIN	NAME	FUNCTION
1	GROUND	Ground (0V)
2	DATA	Serial Date input pin
3	VCC	Supply Voltage (5V)
4	ANT	Antenna Output pin

The transmission occurs at the rate of 1 Kbps – 10Kbps.

RF RECEIVER

The transmitted data is received by an RF receiver operating at the same frequency as that of the transmitter i.e. 434MHz.

PIN DIAGRAM-RF RECEIVER:



PIN FUNCTIONALITY-RF RECEIVER:

PIN	NAME	FUNCTION
1	GROUND	Ground (0V)
2	DATA	Serial Date output pin
3	NC	Linear Out pin; Not Connected
4	V_{CC}	Supply Voltage (5V)
5	V_{CC}	Supply Voltage (5V)
6	GROUND	Ground (0V)
7	GROUND	Ground (0V)
8	ANT	Antenna Input pin

HT12E

It is an **Encoder IC** of 2^{12} series of encoders. They are paired with 2^{12} series of decoders for use in remote control system applications.

- ❖ The chosen pair of encoder/decoder should have same number of addresses and data format.

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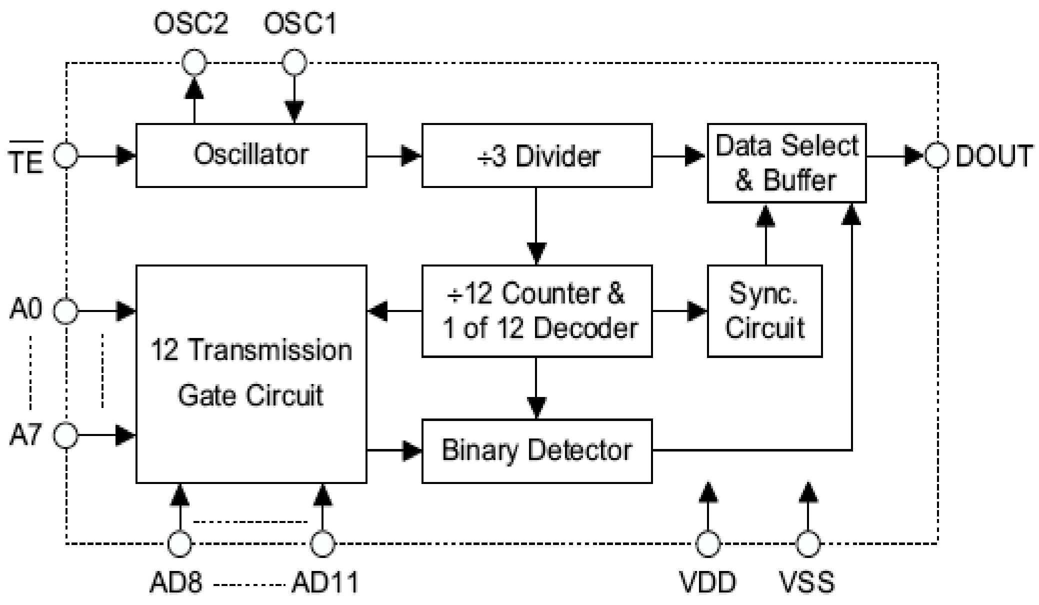
BLOCK DIAGRAM:



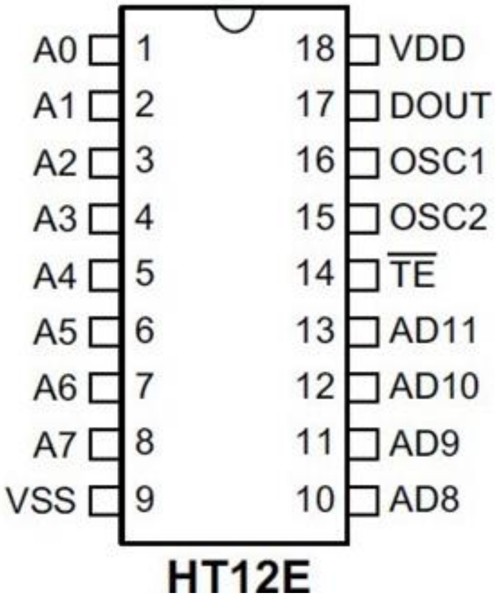
WORKING:

HT12E converts the parallel inputs into serial output. It encodes the 12 bit parallel data into serial for transmission through an RF transmitter. These 12 bits are divided into 8 address bits and 4 data bits. HT12E has a transmission enable pin which is active low. When a trigger signal is received on TE pin, the programmed addresses/data are transmitted together with the header bits via an RF transmission medium. HT12E begins a 4-word transmission cycle upon receipt of a transmission enable. This cycle is repeated as long as TE is kept low.

NOTE:

- As soon as TE returns to high, the encoder output completes its final cycle and then stops.

PIN DIAGRAM OF HT12E:



PIN DESCRIPTION OF HT12E:

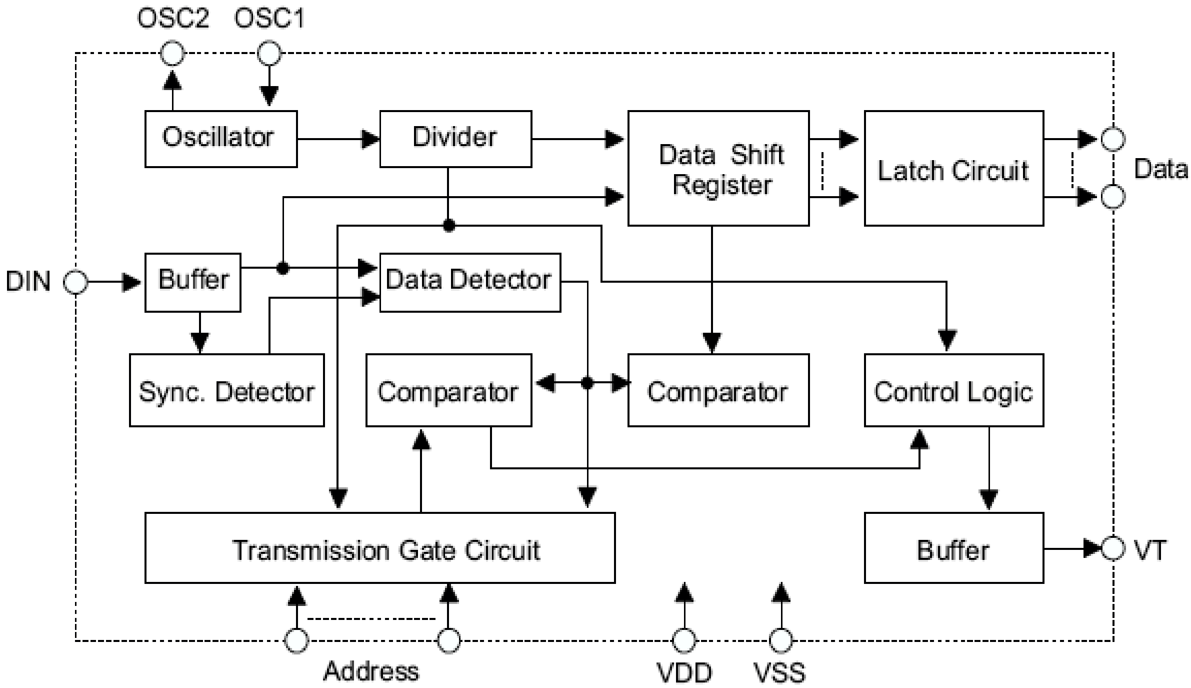
S.NO	FUNCTION	NAME
1	8-Bit Address Pins For Input	A0
2		A1
3		A2
4		A3
5		A4
6		A5
7		A6
8		A7
9	Ground (0V)	GROUND
10	4-Bit Data/Address Pins For Input	AD8
11		AD9
12		AD10
13		AD11
14	TRANSMISSION ENABLE; ACTIVE LOW	TE
15	OSCILLATOR INPUT	OSC 2
16	OSCILLATOR OUTPUT	OSC1
17	SERIAL DATA OUTPUT	OUTPUT
18	SUPPLY VOLTAGE; 5V (2.4V-12V)	VCC

HT12D:

It is a **Decoder IC** that belongs to 2^{12} series of decoders and is paired with 2^{12} series of encoders.

- ❖ The chosen pair of encoder/decoder should have same number of addresses and data format.

BLOCK DIAGRAM:



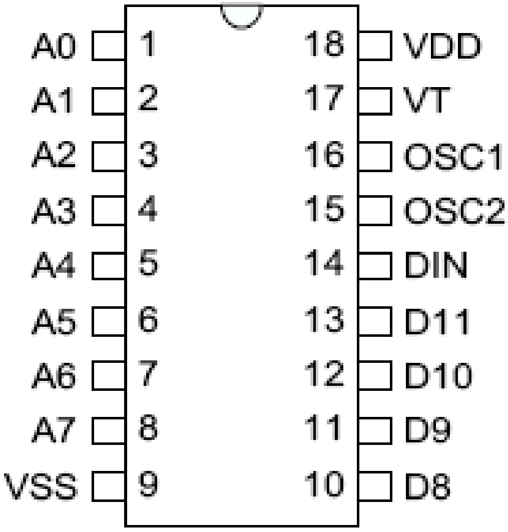
WORKING:

HT12D converts the serial input into parallel outputs. It decodes the serial addresses and data received by, say, an RF receiver, into parallel data and sends them to output data pins. The serial input data is compared with the local addresses three times continuously. The input data code is decoded when no error or unmatched codes are found. A valid transmission in indicated by a high signal at VT pin.
HT12D is capable of decoding 12 bits, of which 8 are address bits and 4 are data bits.

NOTE:

- ❖ The data on 4 bit latch type output pins remain unchanged until new is received.

PIN DIAGRAM OF HT12D:



PIN DESCRIPTION OF HT12D:

S.NO	FUNCTION	NAME
1	8-Bit Address Pins For Input	A0
2		A1
3		A2
4		A3
5		A4
6		A5
7		A6
8		A7
9	Ground (0V)	GROUND
10	4-Bit Data/Address Pins For Input	D8
11		D9
12		D10
13		D11
14	SERIAL DATA INPUT	INPUT
15	OSCILLATOR OUTPUT	OSC 2
16	OSCILLATOR INPUT	OSC1
17	VALID TRANSMISSION;ACTIVE HIGH	VT
18	SUPPLY VOLTAGE; 5V (2.4V-12V)	VCC

