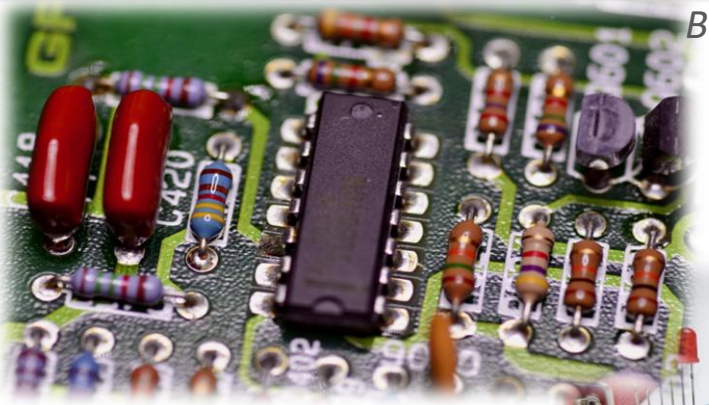
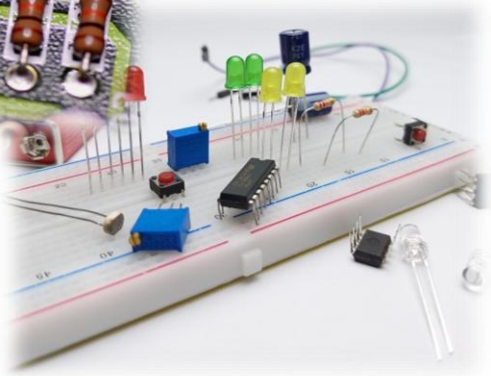
Persilience presents

Beyond Circuits

Basics & Principles





by
Agrim Sharma

Persilience

Beyond Circuits- Basics & Principles

Disclaimer:

This booklet is for educational purposes only. The content is intended to support understanding and practical learning. While care has been taken for accuracy, the author and publisher are not responsible for any outcomes from applying the information.

WARNING: Electricity can be dangerous. **Do not work with mains power.**

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Contents

Basic Terms & Principles

•**Anode:** Negative(-ve) side of a circuit/component.
•**Cathode:** Positive(+ve) side of a circuit/component.
•**VCC:** Voltage at Common Collector refers to the terminal where +ve voltage[1] is collected in components like transistors, ICs, microcontrollers, etc.
•**Ground:** Refers to the common reference point of conventionally 0v for a circuit/component.
•**Terminal:** Connections or wires through which two circuits or components are joint, allowing safe flow of current. For e.g., terminals of a battery.
•**Polarity:** It refers to the dependence of a circuit or component on correct +ve and –ve terminal connections for proper operation; components like LEDs require correct polarity to work, whereas components like DC motors generally function even if the terminals are reversed (only the direction changes).
• **Ampere:** Rate of flow of charges (or current) in an electric circuit. Measured in amps(A) or milliamps(mA). 1A = 1000mA. Usually referred to as *"current".*
•**Voltage:** Potential difference in an electric circuit. The *"push"* created by flowing charges. Measured in volts(V). Usually referred to as *"volt".*
•**Amp-hour:** Refers to the capacity of a battery to store charge for certain current delivery. Measured in amp per hour(Ah) or milliamp per hour(mAh). For e.g., a 1 mAh lasts 1 hour if 1 mA is supplied by it continuously.

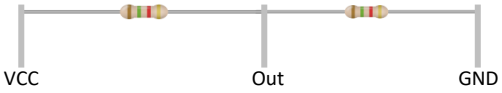
[1]*Voltage across components is VCC - Ground. Since Ground is almost always 0v, voltage across the component becomes the voltage supplied to VCC.*

•**Power:** It means total power or energy per unit time. Measured in watts(W). 1 Watt = 1V×1A.
•**Energy:** It means total energy or power used in certain amount of time[2]. Measured in Watt-hour(Wh). 1 Wh = 1V×1A×1h.
•**Resistance:** Opposition or *"friction"* to the current in a circuit/component/wire. Measured in Ohms (Ω).
•**Ohm's law:** It states that voltage ∝ current. V=I×R. Here, V is voltage, I is current and R is resistance. Or, we can say V=A×Ω. 1 Ω = 1V/1A.
•**DC:** Direct current is a type of current in which the polarity remains constant—current flows in one direction, so the positive and negative terminals do not interchange.
•**AC:** Alternating current is a type of current in which the polarity reverses continuously, usually at a fixed frequency. Because of this reversal, most devices designed for AC operation do not have a fixed polarity requirement.
•**PCB:** Printed Circuit Board. This is a type of circuit in which copper traces are joint on a fiberglass board to facilitate firm electronic connections.
•**Series:** In series, components are connected end to end in the same electric path. Failure of one component can effect other components directly. Each component get same current but voltage is divided amongst them.
•**Parallel:** In parallel circuit, components are connected separately to the same power source, ie, their electric paths are different. Failure of one component doesn't effect others. Each component get same voltage but current gets divided.

2 *1 unit of electricity is 1000 Watt-hour(1kWh).*

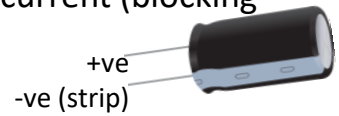
Everyday Electronics

Resistor: A resistor is a passive electronic component[1] used to limit current in a circuit. It is made from resistive materials such as carbon film or metal alloys (e.g., Nichrome) on an insulating core like ceramic. Resistors convert electrical energy into heat and follow Ohm's law(their values are in Ω, e.g., 10 Ω), with resistance depending on material, length, and thickness. They are commonly used to protect components (e.g., LEDs) and to form voltage dividers.



Voltage divider circuit. Resistors don't have a polarity, VCC and GND may be swapped.

Capacitor: A capacitor is a passive component that is used to store electrical charge. They are made up of two conducting plates separated by a thin insulating film. Providing current to the capacitor induces a charge on the conductors(electrical field) and when they are connected to a load[2], they discharge almost instantly. They may or may not have polarity depending upon the type. They are used to *"smooth"* out voltage and filter current (blocking DC while allowing AC to pass). Their value is in Farads(F). 1µF = 1000nF = 1,000,000pF



[1]*Components that store, absorb or dissipate electrical charge but not amplify or generate electricity.*

[2]*Electricity consuming component that converts electricity into other forms of energy like heat, light, sound, etc.*

Inductor: An inductor is a passive component that consists of a coil wound around a magnet or ferromagnetic core. They store charge as a magnetic field. Their function is similar to a capacitor but they resist[3] changes in current, unlike capacitor which filters voltage. They are used in buck boost convertors[4], power circuits, etc. They don't have a polarity and almost act like a short circuit with stable DC supply. Their value is in Henry(H). 1H=1V/(1A/s).

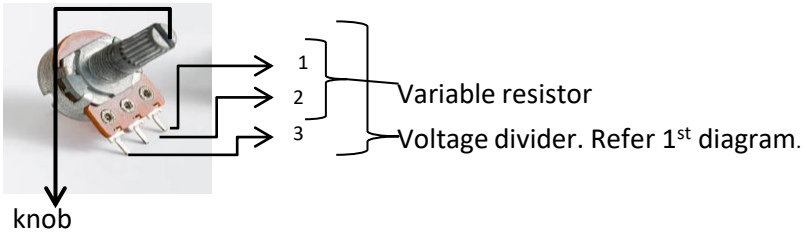
Inductor

Pushbutton: A push button is a type of switch that has a spring for momentary connection of an open circuit. It is used in circuits for inputs. It is found in various places like keyboard, control panels, mouse buttons, etc.

All the terminals are connected with opposite ones when pressed.

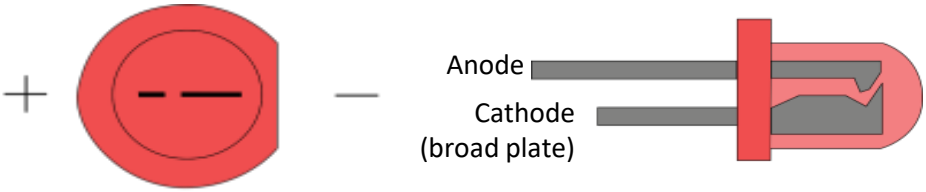
Potentiometer: A potentiometer is a passive component that can act both as a variable resistor & voltage divider. It has a wiper that is rotated by a knob. As wiper wipes across a resistive path, the corresponding resistance value is achieved between VCC[5] and out. If GND is connected, we get a voltage divider. Its value is measured in Ω.

[3]*Not to be confused with resistance. Here, resistance means that it makes current(or volt in the case of capacitor) stable, ie, fluctuations are smoothed out.*
[4]*You will learn more about them in the last chapter.*
[5]*Similar to a resistor, potentiometers don't have polarity. In the diagram given on the next page, pin 1 is considered VCC and pin 3 is considered GND. Pin 2 is the out pin.*



Voltage divider[6] circuit is used to divide voltage by a specific value, whereas, resistor limits current and voltage drops (Ohm's law). Potentiometers change resistance value by varying the length of resistive path between VCC and out. Voltage dividers are used for reference signals as in Arduino or to measure high voltages(e.g., 9v battery from a 3v LED). Voltage dividers fail under current hungry loads.

LED: Light Emitting Diode is a component that converts electricity into light. It has a polarity and a current rating. Excessive current[7] can fail it, hence, we use a resistor of appropriate value to protect the LED. These are used in LED lamps, torches, indicators, decorations led strips, etc.



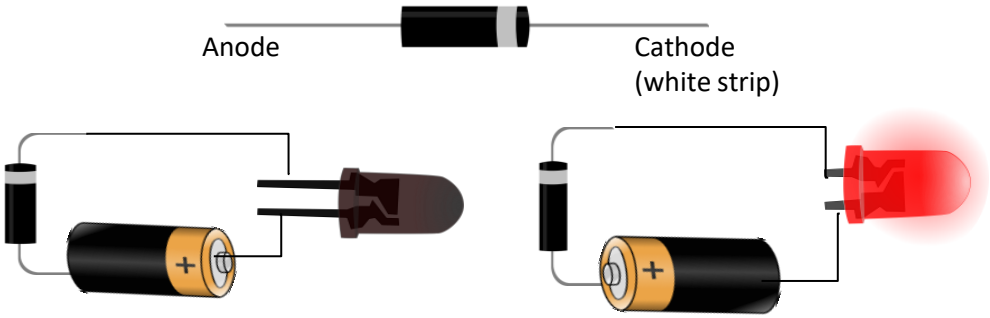
[6]*Potentiometer can act as a variable resistor. The Ω rating of pot does not affect its functions as a voltage divider; its for the maximum resistance provided by it when used as variable resistor.*

[7]*Although LEDs are current-driven devices, voltage still plays an indirect role. A higher supply voltage can force excessive current through the LED (by Ohm's law) if no current-limiting component (such as a resistor) is used. Thus, voltage matters because it determines the current flowing through the LED.*

Semiconductor Based

A semiconductor is a material whose electrical conductivity lies between that of a conductor and an insulator. It allows limited current to flow, and its conductivity can be controlled by modifying the material. Every semiconductor component (including LEDs, diodes, transistors, etc.) consists of 2 types of semiconductors: P-type(positive, less electrons or “holes”) and N-type(negative, more electrons).

Diode: A diode is a polarised[1] passive component that is used to block the reverse flow of electric current in a circuit. It allows the current to flow in one direction (forward bias) easily but not the other direction (reverse bias). Due to this property, diodes are used in various places like protecting other polarised components, converting AC to DC (also called a rectifier), in protection circuits, etc.



LED does not glow in the first circuit even when battery is connected the correct way, because diode is blocking the current in the opposite direction.

[1] *Means that the component has polarity.*

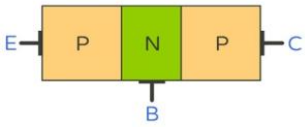
Zener Diode: Zener diode is similar to a diode but it allows current to flow in reverse polarity, but, it must be more that that of zener volt rating(V_z), else, it will block it. It is used in protection circuits, reference voltage and signal voltage for sensors or measurement instruments. Like a voltage divider, it fails under current heavy loads.

Anode Cathode (strip)

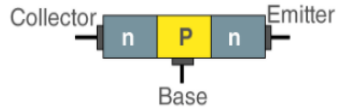
Suppose V_z is 3v and input is 5v. The volt across the zener diode will be clammed to V_z, which is 3v. However, if input is less than V_z, the zener will act as a diode and block it. Zener is used in reverse bias.

Transistor: A transistor is like an electric switch, but instead of pressing it, you control it with electricity. It's one of the most important electronic components and is used in logic circuits, amplifiers, and many other devices. A transistor has three pins- Collector/Source (current in), Emitter/Drain (current out) & Base/Gate (control). When you give a small current to the Base/Gate, the transistor "turns on", allowing a larger current to flow from Collector to Emitter (or Drain to Source in FETs). Depending upon their types[2], transistors are:
N-type(or NPN): Current flows when a positive voltage is applied to the Base/Gate.
P-type(or PNP): Current flows when a negative voltage is applied to the Base/Gate.

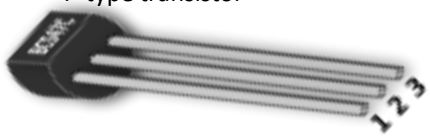
[2]*It is characterised by type of semiconductor used to make a transistor. Transistors are made using both P-type and N-type materials. An NPN transistor has N-P-N layers, while a PNP transistor has P-N-P layers. The name shows the transistor's main behavior.*



P-type transistor

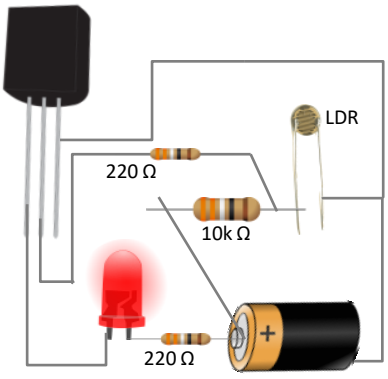


N-type transistor



BC547C: An NPN transistor Bi-polar junction transistor(BJT)

1. Collector
2. Base
3. Emitter

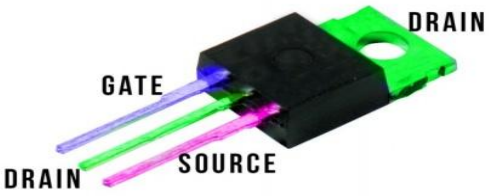


This circuit works by using a small control signal to operate a larger load. The transistor acts as the main electronic switch. The LDR[2] and resistor form a voltage divider that provides a control voltage to the base of the transistor. The voltage divider is arranged so that when the LDR resistance increases in darkness, the base voltage of the transistor also increases. This turns the transistor ON and allows current to flow from the collector to the emitter, causing the LED to glow in the dark.

Thus, a weak signal from the sensor controls the transistor, enabling automatic operation of the LED without any manual switching. (Resistors are used to protect LED and transistor)

MOSFET: Like transistor, MOSFET(Metal-Oxide-Semiconductor Field-Effect Transistor) are also automatic switches controlled by electricity. The key difference between a transistor and a MOSFET is that MOSFET's gate is controlled by voltage(gate voltage) and require near 0 current in ideal cases, whereas, transistors need low voltage and high current at base to operate. While transistors can work by low voltage(crucial for voltage amplification) but their high current demand makes them power hungry. MOSFETs, on the other hand, can work with low current, making them more power efficient and allow faster switching (on or off).

[2]*Light Dependent Resistor- you'll learn more about it in the Sensors chapter.*



These are used in audio amplifiers; can switch LEDs, motors, etc. efficiently; controlling high power circuits with low current.

They form the basic building blocks of ICs, CPUs , comparators, logic gate, memory chips. They enable fast switching, low power consumption, and miniaturization, which is why modern electronics like smartphones and computers are possible.

They are of following types:

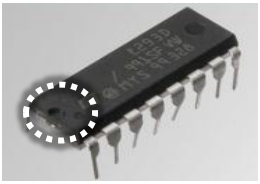
N-type (NMOS): Conduct when a positive voltage is applied to the gate.

P-type (PMOS): Conduct when a negative voltage is applied to the gate.

Complementary MOSFET (CMOS): Combines N-type and P-type for efficient logic circuits used in almost all digital ICs.

IC: An Integrated Circuit is a tiny circuit made on a semiconductor chip, containing components such as transistors, diodes & resistors. It performs a specific function. Different ICs have different pin-outs and use.

Motor Driver IC (L293D): A motor driver is an IC used to control DC motors[4] safely by handling higher current and voltage. The L293D motor driver contains internal transistor stages arranged as H-bridges[5], allowing 2 DC motors to run independently in both directions.

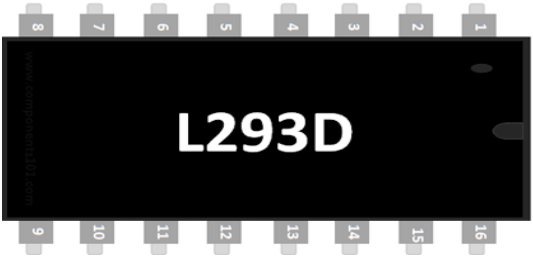


Alignment notch. It helps to orient an IC correctly.

[4]*You'll learn more about DC motors in the next chapter.*

[5]*An H-Bridge is an electronic circuit that allows a DC motor to rotate in both directions by controlling the direction of current flow through the motor.*

continuous rating. It operates on 5V logic and can drive motors between voltages of 4.5V-36V. Its pinout is:



1. **Enable-** Enables motor at pin 3 and 6(Motor A). Can control speed with PWM[6]. Must be HIGH(5V).
2. **Direction-** To control direction of Motor A.
3. **Out-** First terminal of Motor A.
4. **GND-** For power supplies and logic (by automatic transistor circuits or Arduino).
5. **GND-** For power supplies and logic.
6. **Out-** Second terminal of Motor A.
7. **Direction-** Works with pin 2 to control direction of Motor A.
8. **VIN-** Motor voltage (4.5V to 36V).
9. **Enable-** Enables motor at pin 10 and 15(Motor B).
10. **Out-** First terminal of Motor B.
11. **Direction-** To control the direction of Motor B.
12. **GND-** For power supplies and logic.
13. **GND-** For power supplies and logic.
14. **Direction-** Works with pin 11 to control the direction of Motor B.
15. **Out-** Second terminal of motor B.
16. **VCC-** 5v supply.

2 & 11	7 & 14	Motor direction (A & B)
1	0	Forward
0	1	Reverse
0	0	Stop
1	1	Stop

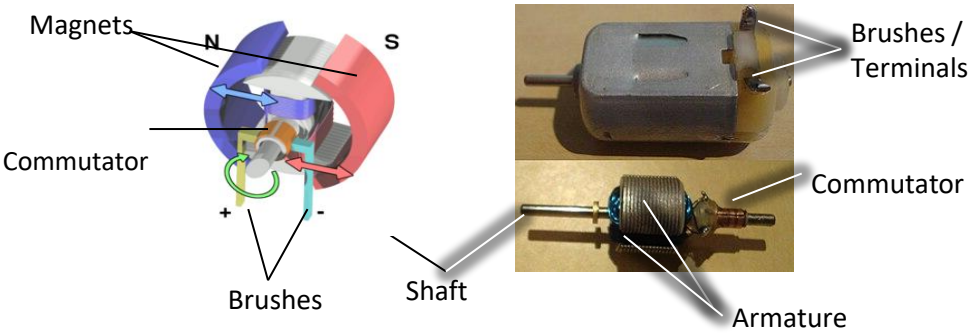
Truth table for direction control of motors. 1 means HIGH(5V) and 0 means LOW(0V or GND). This table shows how direction is controlled of motors by applying signal input to the direction pins of L293D.

[6] *Pulse Width Modulation, used by microcontrollers like Arduino to make fake analog signals. It means rapid switching between HIGH & LOW.*

Actuators

Motor: This is a electromechanical load which converts electricity into mechanical energy (rotation). It can be brushed(DC) or brushless(AC).

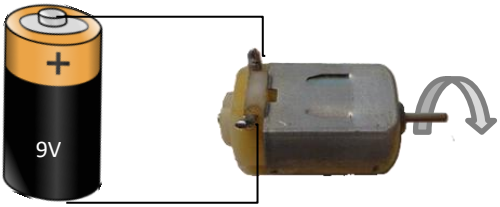
Brushed DC Motor: A brushed DC motor, in its simplest form, has an electromagnet(coil) and its terminals, along with permanent magnets to provide a rotational force called as torque. An armature is an electromagnet inside a DC motor. There are multiple armatures in a DC motor, arranged symmetrically. Armatures align themselves with permanent magnets on either sides[1] when a current is applied to them. The commutator[2] keeps the motor running (ie, to stop armatures from locking onto permanent magnets by switching current supply between them). Brushes, refer to physical external terminals which extend to meet the commutator inside the motor and they don't rotate. A metal rod or shaft is rotated by the torque produced.



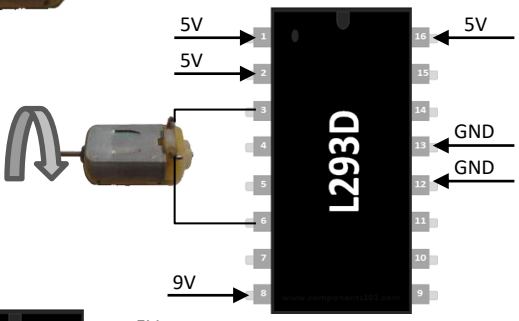
[1] *Think of regular permanent magnets. When opposite poles come close, the magnets rotate to align with unlike poles.*

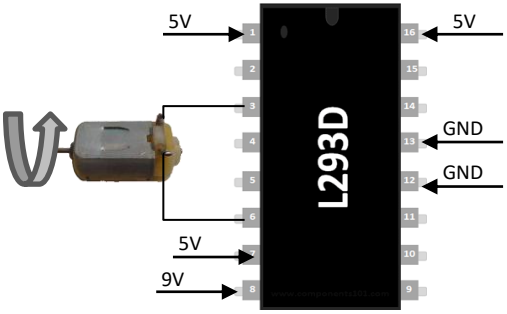
[2] *An internal commutator (mechanical switch) is used to connect and manage current flowing in different coils.*

The brushed DC motor's direction is affected by its polarity and rating ranges from 1A - 3A in toy motors. DC motors form the basis of many mechanical or moving parts, seen in toys, complex machines, electric pumps, drones, and maybe your next RC car!



Motor A connected to the L293D, running in a direction. It is being run from 9V and GND of every voltage source is connected to 12&13.





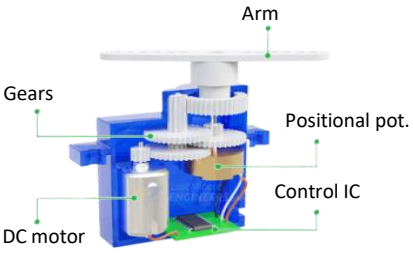
Same circuit as above but direction pin is changed from 2 to 7.

Piezo Buzzer: It is a component that converts electricity into vibration of piezo crystals when a DC voltage is applied to them, called piezo electric effect. This vibrates air molecules to produce sound. A plastic cover is used to amplify this sound. It is used in sirens, alarms, etc. A piezo can also be used as a sensor, but the buzzer is an actuator.

Polarity of a buzzer. Red- anode; black- cathode.

Servo Motor: It is a device which is able to rotate its mechanical arm by any angle between a fixed range (0° -180°). It has an internal DC motor with its shaft connected to a gear system to increase its torque. It has a control IC to compare signal angle and the angle of arm with the help of a potentiometer[3]. The hobby servo motor has following pinout:

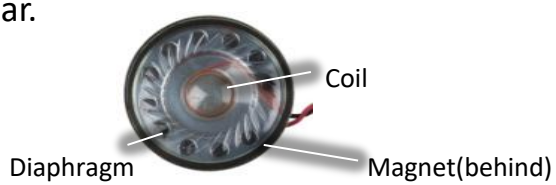
1. **GND-** To connect to the common GND of power supply and signal. It's typically brown in colour.
2. **VCC-** The positive power supply. It has a power rating of 4.8V-6V & current is drawn as per load on the arm. It's typically red in colour.
3. **Signal-** This pin is used to input angle PWM signal from Arduino. It has yellow coloured wire conventionally.



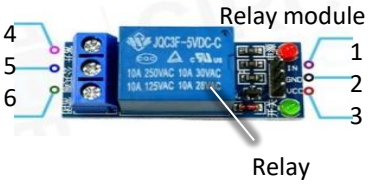
Speaker- A speaker consists of a permanent magnet and a coil (voice coil) attached to a paper or plastic diaphragm. When an electric current flows through the coil, it experiences a force due to the magnetic field of the permanent magnet. A DC voltage would only push

[3] *The servo compares the angle sent by the signal with the actual angle of the arm using a potentiometer. If there is a difference, the motor rotates until both angles match, keeping the arm at that position.*

the coil in one direction, causing a fixing it at that position. Therefore, speakers use an AC (audio) signal, which makes the coil move back and forth at the same frequency as the signal. This vibration of the diaphragm vibrates the surrounding air, producing sound. A single speaker will work even if its +ve and –ve terminals are swapped. But when using more than one speaker, the terminals must be connected correctly; otherwise, they push air in opposite directions, causing the sound to become weak or unclear.



Relay: A relay is an electromechanical switch that uses an electromagnet to move ferromagnetic contacts, thereby opening or closing an electrically isolated circuit. This allows a low-power control signal to switch a high-voltage or high-current load. Relays have slower switching speeds than transistors, provide physical (galvanic) isolation[4], and operate in binary states (ON/OFF). This relay module has following pinout:



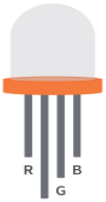
1. **IN-** Active LOW, ie, when GND is connected, the relay is switched.
2. **GND-** Common for VCC & IN.
3. **VCC-** 5V power supply.
4. **Normally Open(NO)-** This terminal is disconnected from common(COM) when IN is at 0V.
5. **Common(COM)-** This is the common terminal to NO & NC.
6. **Normally Closed-** This terminal is connected with COM when power is supplied to IN.

[4] *It means that since NC, NO and COM are physically disconnected from IN, VCC and GND, a small power supply can be used to automatically open high power circuits, ie, AC appliances, etc.*

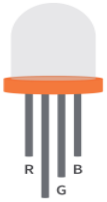
Bright Tech

RGB LED: This is a component that has LEDs of 3 colours, ie, Red, Green & Blue inside it. It is of two types by polarity, both having four pins:

1. Common Anode: It is made in a way that all the LEDs' anodes are joint to a single terminal which is called common anode. Cathodes, however, are made separated to light each colour individually.



-
Common Cathode

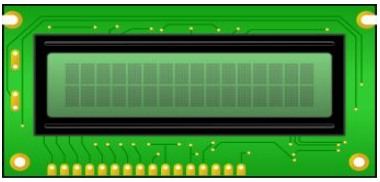


+
Common Anode

2. Common Cathode: In this type, instead of anode, cathodes of LEDs' are taken common. Anodes are made separated to light each colour individually.

LCD Display (Liquid Crystal Display): An LCD is a display device used to show basic information such as text, numbers, or simple symbols from a circuit to the user. It can be interfaced directly with a microcontroller (MCU) like Arduino using a parallel interface, but an I2C[2] backpack is commonly used to reduce the number of required pins. An LCD uses liquid crystals to control light from an LED backlight placed behind it, making characters or symbols visible. Displays come in various sizes, character types and lengths, columns, etc. Most common ones include 16x2[1] and 20x4 character displays. It is used to display simple messages, warnings, data, and status in many devices.

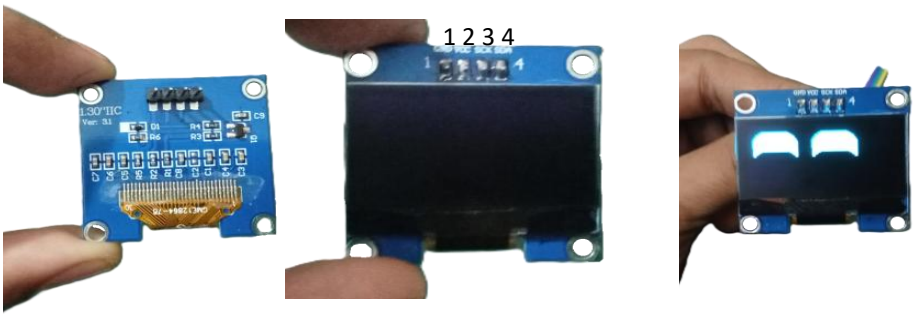
[1] *1st digit is the no. of characters places in each line/column. 2nd digit is the no. of columns in total.*
[2] *Inter-Integrated Circuit*



16x2 character LCD display. It has 16 pins in total, 5 of which are for power.

I2C backpack. It is connected to the 16 pins of this display. It reduces the pin count to GND, VCC, SDA(serial data) and SCL(serial clock).

OLED Display: An OLED(Organic LED) is a digital display used to show text and simple graphics using a microcontroller (MCU). It consists of a matrix of organic light-emitting pixels, where each pixel emits its own light and does not require a backlight. OLED displays commonly support communication protocols such as I2C or SPI. They have many creative uses, such as displaying robot eyes, Arduino-based retro games, or the interface of a minimalistic smartwatch.

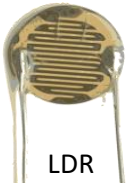


1.3” I2C 128x64 pixel OLED display. Pinout is- 1. GND 2. VCC 3. SCK 4. SDA
This display runs on 5V for logic and power; perfect for Arduino.

[3] *Both I2C and SPI are amongst the interfaces (like different devices speaking in different languages). SPI means Serial Peripheral Interface. MCUs like Arduino are used to interface the devices with their corresponding interface.*

Sensors

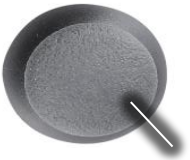
LDR: A Light Dependent Resistor is a resistor whose resistance decreases when light falls on its surface and increases in darkness. It is commonly used to sense light intensity by connecting it in a voltage divider circuit. Depending on whether the LDR is connected to VCC or GND in the voltage divider, the output voltage will increase either in light or darkness, allowing the circuit to detect brightness or darkness. Similar to a resistor, it as no polarity. It is used in automatic lamps, cameras, laser beam security circuits, solar trackers, etc.



LDR

Joystick: A joystick is used to detect the motion of the finger or the thumb in 2-dimensions. It is used in the remote controllers, RC car controllers, retro game pads, etc. They consist of two potentiometer arranged perpendicularly or in "+" pattern, reading changes in x-axis & y-axis. A joystick is in input device. It has 4 pins:

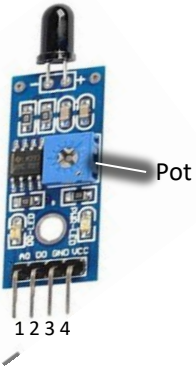
1. **VCC-** For voltage input.
2. **GND-** Common GND between the circuit or MCU.
3. **VRX-** Output of pot measuring x-axis.
4. **VRY-** Output of pot measuring y-axis.
5. **SW-** For accessing the inbuilt pushbutton. It is active LOW, ie, pressing it reads GND/0v in the circuit.



knob

IR Sensor: It is a sensor which is used to detect IR radiation and converts it into an electrical signal for use in electronic circuits. In its simplest form, it is just an IR photo transistor or IR photo resistor, whose conductivity changes when exposed to infrared light. It is used to detect heat, flame detection, obstacle, etc. This IR detection module has the pinout as follows:

1. **AO-** For analog output of phototransistor.
2. **DO-** For digital output. It is triggered when threshold set with adjustment pot is exceeded.
3. **GND-** Common GND for power and signal**.**
4. **VCC-** For 5V power input.



Pot- This is an adjustment potentiometer. It is used to set a threshold for the module. If IR signal is more than the threshold, the comparator IC on the module give output from DO.

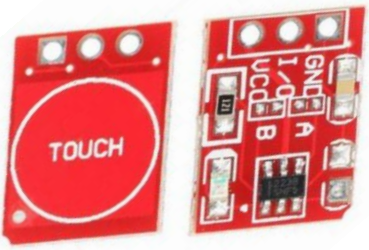
Ultrasonic Module: It uses ultrasonic waves to detect obstacles and distances. Unlike IR obstacle module[1], it can reliably detect objects at larger distances . It consists of an Ultrasonic piezoelectric emitter and ultrasonic piezoelectric detector. The module measures the time delay (echo time) between the transmitted pulse and the received reflected wave to determine the distance of an object.

[1]*IR photo transistor, when paired with an IR LED, acts as an obstacle sensor. The IR light reflects from the obstacle and is received by the IR photo transistor, and its intensity can be used to approximate the distance from obstacle. This is how the IR obstacle module works. It can get effected by ambient light.*

The pinout is as follows:

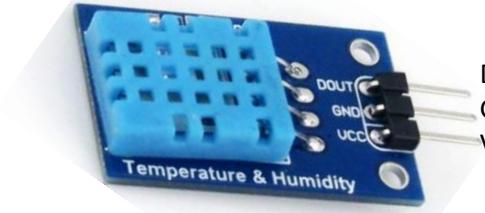
1. **VCC-** 5V
2. **Trig-** Input pin for transmitter.
3. **Echo-** Output of receiver.
4. **GND-** Common for power and signal.

Touch Sensor: It is used to sense touch or tap and converts it into electrical signals. It measure differences of capacitance between touch pad and the finger to sense touch. It is used for user input in various places.



IO pin is used to get digital HIGH output when touched

Humidity Sensor: A humidity sensor is a component that detects changes in humidity levels and converts them into electrical signals. It is used to measure weather, rain, moisture, etc.



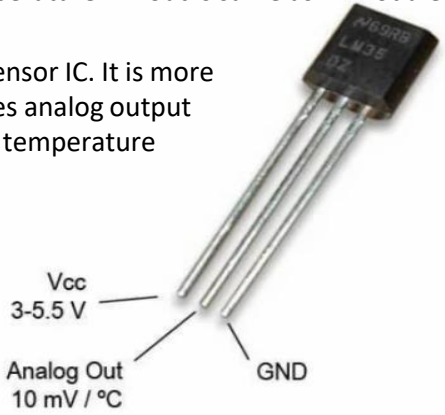
DOUT- Digital signals about humidity level.
GND- Common GND
VCC- 5V

Temperature Sensor- This component measures temperature and outputs corresponding electrical signals. It is used in various places like digital thermometers, to measure temperature of other components to regulate their “stress”, fridge, AC, etc.

It, along with the humidity sensor, can approximate weather conditions. Usually, they are used together in smart environment sensors and weather stations.

The thermistor module. It has a thermistor, a component whose resistive value changes with temperature. Pinout is same as IR module.

The LM35 is a digital temperature sensor IC. It is more accurate that thermistor. It only gives analog output where it changes by 10mV per °C of temperature change.



Sensor v/s Module

A sensor is the raw component that responds to a physical change such as light, heat, or sound by changing an electrical property.

A sensor module includes the sensor along with supporting components such as resistors, comparators, or amplifiers, making it easier to interface with a microcontroller or logic circuit.

Modules simplify interfacing by eliminating the need for external supporting components. However, a basic understanding of the underlying component is still important to know how the module works internally.

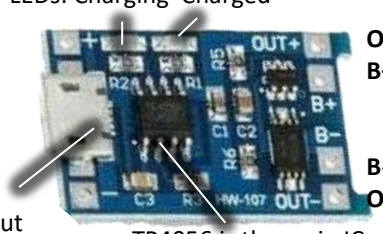
Power management & Supplies

Battery: Battery is an electrochemical device which stores electricity and provides power in electronic circuits. It converts stored chemical energy into electricity whenever connected in a circuit via internal electrochemical reactions. Depending upon the materials used to make a battery (electrode & electrolyte), a battery can vary in its type and be either rechargeable or non-rechargeable. Based on the chemistry, design and size, batteries can vary on their voltage rating, capacity(mAh or Ah) and current handling capabilities. A Lithium-Ion(Li-ion) is one of the most used and power efficient batteries used in electronics. Its nominal voltage can be 3.6V-3.7V and its capacity can vary between a few hundred mAh to thousands of mAh depending upon size and quality. A battery, obviously, has a polarity because it stores only DC power.

A 3.7v, 4.44Wh (~1200mAh) Li-ion battery.

Li-ion Battery Charging Module(TP4056): TP4056 is a DC linear Li-ion battery charging module which is used to safely charge a Li-ion battery completely and protects it from over/undercharge. It is used to make battery powered projects portable as it allows the battery to be charged from USB port. However, it can't boost the output voltage of the battery.

Indicator LEDs: Charging Charged



OUT+: Positive output of the battery.
B+: Anode of Li-ion Battery.

B-: Battery Cathode.
OUT-: Negative output of the battery.

USB input

TP4056 is the main IC which safely charges a battery completely.

Boost Converter(MT3608): The MT3608 is a DC-DC switching converter module used to boost and regulate the output voltage of a battery or other DC power source. It operates by rapidly switching an internal transistor and using external inductors, capacitors, and diodes to store and transfer energy, thereby increasing the output voltage to a desired level. The module provides a regulated DC output even when the input voltage varies.

boosted output.

DC input.

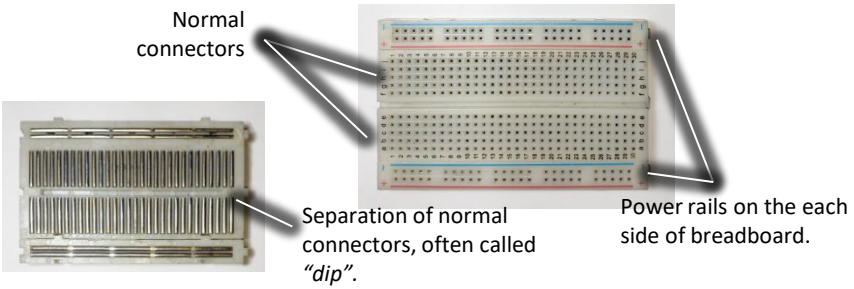
Adjustment Pot- To set the output(boosted) voltage of the battery.

Inductor

Breadboard: A breadboard is a reusable board with tiny holes that lets you plug in electronic parts and wires to quickly build, test, and change circuits without making them permanent. It facilitates firm connections of components in a circuit. It has following sections:

Horizontal connectors- Normal connectors are short groups of holes in the middle of the breadboard where components are placed; holes in each group are internally connected. These connections are arranged in small rows separated by a central gap for ICs or small MCUs.

Power rails- Power rails are the long continuous rows on the sides of a breadboard used to distribute power across the circuit.



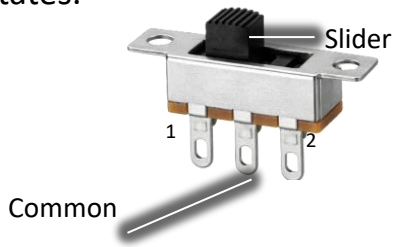
Breadboard- Internal Structure

Note that markings are not hard wired, just guides.

Voltage regulator: It is used to provide stable voltage output irrespective of power voltage(must be more than the output rating) or load fluctuations. The 7805 is a versatile and common linear voltage regulator IC that is capable of providing stable 5V output with 1A current. It provides thermal overload and short circuit protection.

1.Input- Voltage from 7V to 35V
2.GND
3.Output- 5V regulated @ 1A

Toggle switch: It is a simple mechanical switch that can toggle between ON/OFF. It is used to break or complete an electronic circuit. It is used to take user input or shut power in a circuit. It can be toggled with a mechanical slider or lever. A slide toggle switch may have 3 or more terminals, in that case, the other terminals connect to Common when slider is toggled to different states.



DO TRY THESE!

Imitate all the circuits mentioned in the booklet.

Touch controlled LED lamp: Using transistor, battery, LED and a toggle switch, create an LED lamp that turns ON/OFF when touched.

Colour changing light: A lamp that can provide the light of any color using RGB LED. Use 3 potentiometers to adjust brightness of each colour. Don't forget the power supply of appropriate voltage and resistors for protection!

Flame detector: A device that can save accidents! Using IR sensor, buzzer, battery and switch, create a flame detector. You can rotate the pot to adjust sensitivity.

Rain Sensor: Using humidity module, transistor, buzzer, LED, battery, switch, etc., create a device that can detect raindrops as they'll fall on the sensor's surface.

Basic thermometer: Using thermistor module, try to create a basic thermometer that can be used to measure approximate changes in temperature. You can calibrate the output by putting the sensor on an object of known temperature and rotating the pot.

Toy car: Using DC motors, L293D, toggle switch, a 5V power source[1], RGB LEDs, Buzzer, toy wheels, etc, create a simple car that can run in reverse with the input from toggle switch.

These components can be used to make many devices or toys, try to figure out what YOU can do with them!

[1]*You can use a LI-ion cell, boost its output via MT3608 to 7V and then regulate it using 7805 regulator.*

Further Learning

Due to the scope of this booklet, limited knowledge is provided about selective components, enough for general use, however, you can take the help of other resources to learn more about electronics and other electronic components. The components deleted from the main content of the book are:

1. Transformer
2. Op-amp(Operation Amplifier)
3. Optocoupler
4. 555 timer IC
5. IR demodulator IC, etc.

Pinout: Every component has different pinouts, and sometimes, same components can have different pinout depending upon the manufacturer. Try to search pinout of your component online or in datasheets.

Datasheet: Datasheet is the document that provides specific information about the components, such as power ratings, ideal working conditions, pinouts, etc.

Schematic: It refers to the simple diagram/structure of a device or circuit. Its main purpose is to represent logic and functioning, rather than appearance.

Almost every component has markings(like the color bands of a resistor) or its name printed(like on ICs, diodes, modules, etc.) on it. These markings are crucial on identifying the component and its general information. Datasheets are available to use these components online.

Various YouTube channels provide engaging and informative learning about electronics. Try searching about your component on YT.

The notch on ICs enable us to orient them in the correct way and a dot/dimple marks “pin 1”. Pin numbers are counted from top to bottom on the left side and bottom to top on the right side.

THE END… *Really?*

You have come a long way—from learning basic terms and LEDs to understanding one of the most valuable skills for a curious learner. You didn't just learn how to connect wires and components; you learned how things work, why they are made this way, and what happens when something breaks. Electronics can become a metaphor for curiosity—the urge to ask *"how does this work?"* You are now able to recreate some of the ideas behind modern *"wheels"* of technology.

Stay curious.

Way Forward: This is not an end, it is a new beginning. Your next intuition might be learning Arduino basics and coding. You can consider

Persilience

Coding Motion- Arduino Basics & Physical Computing

Persilience is focused on providing the simple explanations for concepts that often seem complex.

This book covers fundamental electronic components, including:

- The physics behind them
- Pinouts
- Where they are commonly found
- Practical use cases

If this book helped you, star the project on Github

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