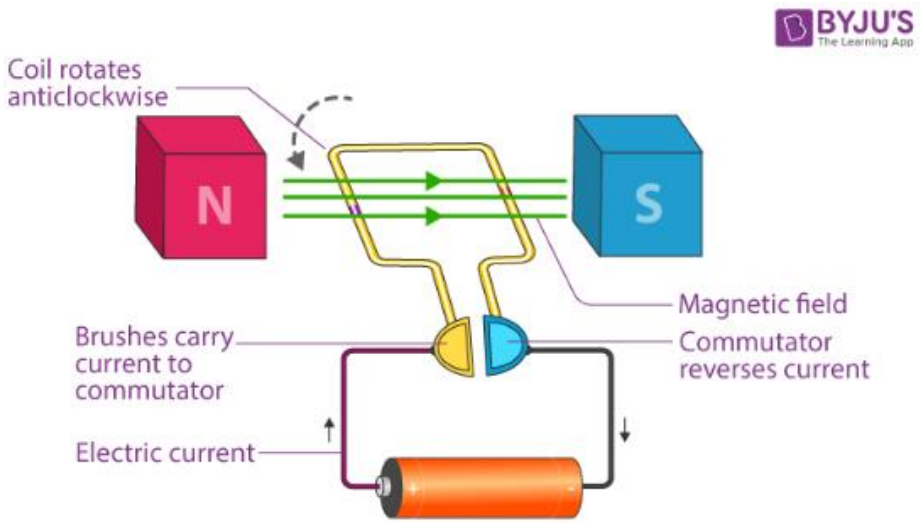
Name : Sarang Swami

TASK 4

MOTORS



DEFINTION: A motor is a device that changes a form of energy into mechanical energy to produce motion.

PARTS :

A simple motor has the following parts:

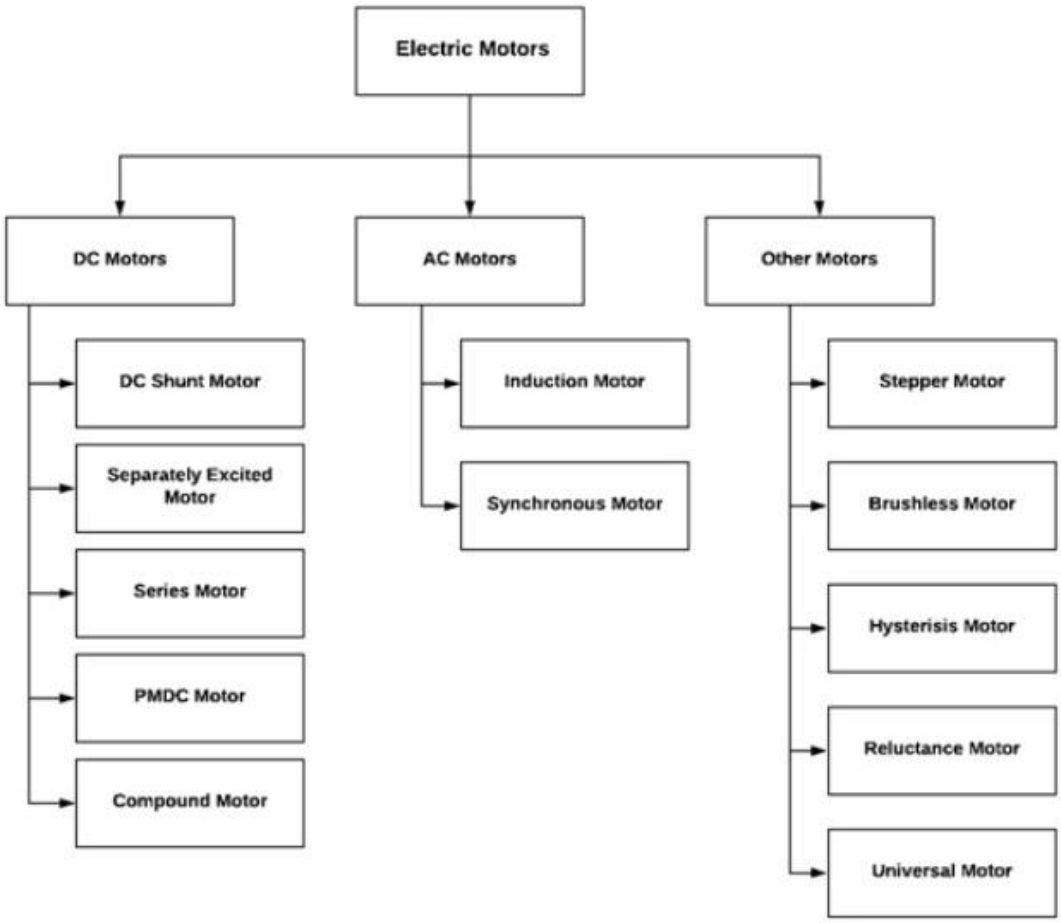
- A power supply – mostly DC for a simple motor
- Field Magnet – could be a permanent magnet or an electromagnet
- An Armature or rotor
- Commutator
- Brushes
- Axle

- ***Power Source***: A simple motor usually has a DC power source. It supplies power to the motor armature or field coils.
- ***Commutator***: It is the rotating interface of the armature coil with a stationary circuit.
- ***Field Magnet***: The magnetic field helps to produce a torque on the rotating armature coil by virtue of Fleming's left-hand rule.
- ***Armature Core***: Holds the armature coil in place and provides mechanical support.

- ***Armature Coil***: It helps the motor to run.
- ***Brushes***: It is a device that conducts current between stationary wires and moving parts, most commonly the rotating shaft.

WORKING : The working of an electric motor is based on the fact that a current-carrying conductor produces a magnetic field around it. The magnetic field of the magnets interferes with that produced due to electric current flowing in the conductor. Since the loop has become a magnet, one side of it will be attracted to the north pole of the magnet and the other to the south pole. This causes the loop to rotate continuously. This is the principle of working of electric motor.

TYPES :



A] DC MOTORS

1) ***DC Shunt Motor*** - DC shunt motor works on DC and the windings of this electric motor like the armature windings and field windings are linked in parallel which is known as a shunt. This kind of motor is also called as shunt wound DC motor, where the winding type is known as a shunt winding. Please refer to this link to know more about DC shunt motor working and applications.

2) ***Separately Excited Motor*** - In separately excited motor, the connection of stator and rotor can be done using a different power supply. So that the motor can be controlled from the shunt and the armatures winding can be strengthened to generate flux.

3) ***DC Series Motor*** - In DC series motor, rotor windings are connected in series. The operation principle of this electric motor mainly depends on a simple electromagnetic law. This law states that whenever a magnetic field can be formed around conductor & interacts with an external field to generate the rotational motion. These motors are mainly used in starter motors which are used in elevators and cars. Please refer to this link to know more about DC series motor working & its applications

4) ***PMDC Motor*** - The term PMDC stands for “Permanent Magnet DC motor”. It is one kind of DC motor which can be inbuilt with a permanent magnet to make the magnetic field necessary for the electric motor operation. Please refer to this link to know more about PMDC Motor: Construction, Working, and Applications

5) ***DC Compound Motor*** - Generally, DC compound motor is a hybrid component of DC series and shunt motors. In this type of motor, both the fields like series and shunt are present. In this type of electric motor, the stator and rotor can be connected to each other through a series & shunt windings compound. The series winding can be designed with few windings of wide copper wires, which gives a small resistance path. The shunt winding can be designed with multiple windings of copper wire to get the full i/p voltage.

B] **AC MOTORS** : -

1***). Synchronous Motor -***

The working of the synchronous motor mainly depends on the 3-phase supply. The stator in the electric motor generates the field current which rotates in a stable speed based on the AC frequency. As well as the rotor depends on the similar speed of the stator current. There is no air gap among the speed of stator current and rotor. When the rotation accuracy level is high, then these motors are applicable in automation, robotics, etc. Please refer to this link to know more about synchronous motor types and applications.

2***) Induction Motor -***The electric motor which runs asynchronous speed is known as induction motor, and an alternate name of this motor is the asynchronous motor. Induction motor mainly uses electromagnetic induction for changing the energy from electric to mechanical. Based on the rotor construction, these motors are classified into two types namely squirrel cage & phase wound.

DEFINITION : - A motor with only amortisseur windings is called an induction motor***.***

PARTS : -

1. **Stator** - The stator is made up of various stampings with slots to carry three-phase windings. It is wound for a distinct number of poles. The windings are geometrically divided 120 degrees separated. Two sorts of rotors are used in Induction motors: Squirrel cage rotor and Wound rotor. No DC field current is required to run the machine. Rotor voltage is induced in the rotor windings rather than being physically connected by wires.

2. **Rotor -** The rotor is the rotating part of the electromagnetic circuit. The most common type of rotor is the squirrel cage rotor. The rotor comprises a cylindrical laminated core with axially placed parallel slots for carrying the conductors. Each slot carries a copper, aluminum, or alloy bar. The rotor of three-phase induction motors frequently is likewise implied as an anchor. The purpose behind this name is the anchor shape of the rotors used within quite early electrical devices. In electrical equipment, the anchor's winding would be induced by the magnetic field, although the rotor takes this part in three-phase induction motors.

WORKING PRINCIPLE : - The induction motor works on the principle of induction where an electromagnetic field is induced into the rotor when the rotating magnetic field of the stator cuts the stationary rotor. The induction motor working principle is, the AC in the rotor of the motor is required to generate torque that is gained through electromagnetic induction which results from the stator winding's rotary magnetic field.

TYPES : -

1. ***Single-phase Induction Motor*** - The single-phase induction motor is not self-starting. When the motor is connected to a single-phase power supply, the main winding carries an alternating current. It is logical that the least expensive, most reduced upkeep sort engine ought to be utilized most regularly. These are of different types based on their way of starting since these are not self-starting. Those are split phase, shaded pole, and capacitor motors. Again capacitor motors are capacitor start, capacitor run, and permanent capacitor motors

2. ***Three-Phase Induction Motor*** - These motors are self-starting and use no capacitor, start winding, centrifugal switch, or another starting device. Three-phase AC induction motors are widely used in industrial and commercial applications. These are of two types, squirrel cage, and slip ring motors. Squirrel cage motors are widely used due to their rugged construction and simple design. Slip ring motors require external resistors to have high starting torque.

C] SPECIAL PURPOSE MOTORS :

1. ***Stepper Moto***r - The stepper motor can be used to offer step angle revolution, as an alternative to stable revolution. We know that for any rotor, the whole revolution angle is 180degrees. However, in a stepper motor, the complete revolution angle can be separated in

numerous steps like 10 degree X 18 steps. This means, in a total revolution cycle the rotor will go stepwise eighteen times, every time 10 degree. Stepper motors are applicable in plotters, circuit fabrication, process control tools, usual movement generators, etc. Please refer to this link to know more about stepper motor types and its applications

2. ***Brushless DC Motors*** - The brushless DC motors were first developed for achieving superior performance within a lesser space than brushed DC motors. These motors are lesser when compared with AC models. A controller is embedded into the electric motor to facilitate the process within the lack of a commutator and a slip ring. Please refer to this link to know more about Brushless DC Motor – Advantages, Applications & Control

3. ***Hysteresis Motor*** - The operation of the hysteresis motor is extremely unique. The rotor of this motor can be induced hysteresis and eddy current to generate the required task. The motor working can depend on the construction, 1-phase supply otherwise 3-phase supply. These motors give a very smooth process with stable speed, similar to other synchronous motors. The noise level of this motor is quite small, due to this reason they are applicable in numerous complicated applications wherever the soundproof motor is used such as sound player, audio recorder, etc.

4. ***Reluctance Motor*** - Basically, reluctance motor is a 1-phase synchronous motor & this motor construction is quite same with induction motor like cage type. The rotor in the motor is like squirrel cage type & the stator of the motor include sets of windings such as auxiliary and main winding. The auxiliary winding is very useful at the beginning time of the motor. As they offer a level operation at a stable speed. These motors are commonly used in synchronization applications which include signal generators, recorders, etc.

5. ***Universal Motor*** - This is a special kind of motor and this motor works on single AC supply otherwise DC supply. Universal motors are series wound where the field and armature windings are connected in series and thus generates high starting torque. These motors are mainly designed for operating at high-speed above 3500 rpm. They utilize AC supply at low-speed and DC supply of similar voltage. Please refer to this link to know more about Universal Motor

Servo Motor - A servo motor is a type of motor that can rotate with great precision. Normally this type of motor consists of a control circuit that provides feedback on the current position of the motor shaft, this feedback allows the servo motors to rotate with great precision. If you want to rotate an object at some specific angles or distance, then you use a servo motor. It is just made up of a simple motor which runs through a servo mechanism.

Servo Motor Working Mechanism

It consists of three parts:

1. Controlled device
2. Output sensor
3. Feedback system

It is a closed-loop system where it uses a positive feedback system to control motion and the final position of the shaft. Here the device is controlled by a feedback signal generated by comparing output signal and reference input signal.

Here reference input signal is compared to the reference output signal and the third signal is produced by the feedback system. And this third signal acts as an input signal to the control the device. This signal is present as long as the feedback signal is generated or there is a difference between the reference input signal and reference output signal. So the main task of servomechanism is to maintain the output of a system at the desired value at presence of noises.

Stepper Motor	Servo Motor
It operates in an open-loop	It operates in an closed-loop
It has no feedback system. So more prone to error.	It has an internal feedback system. So less prone to error.
Stepper motors are less costly as compared to servo motors.	Servo motors are costly as compared to stepper motors
Small Size	Not as small
Stepper motors provide a high amount of torque at low speeds	Servo motors provide lower torque in comparison with stepper motor
Stepper motors provide very low torque at higher speeds.	Servo motors provide very high torque at higher speeds.
No need of encoder.	Servo motors require an encoder and gearbox for more accurate control.
The speed of the stepper motor is lower than the servo motor	The speed of the servo motor is higher than the stepper motor
There will be no vibration or pulsation in stepper motors at standstill position	Servo motors tend to pulsate or vibrate in standstill position.

APPLICATIONS : Common Applications of Electric Motors

- ***HVAC -*** HVAC stands for Heating, Ventilation and Air Conditioning. It is the technology for providing thermal comfort in any indoor environment such as in an office, home, or vehicle, etc. HVAC works by providing fresh air from the outdoors. The outdoor air is air-conditioned in order to cool or heat the different areas of a building or vehicle. The conditioned air is blown into the ducts using a blower motor.

- ***Industrial Automation -*** Using motors we can eliminate the use of labor or human beings. We can perform the heavy tasks with high speed and without any interruption.

- ***Benefit in Climate Change -*** The electrical motor does not need fuel or any other maintenance required for any engine

- ***Agriculture -*** Different types of electric motors are used in agriculture to eliminate human involvement and increase productivity. They are used in every mechanical structure used in farming and agriculture.

- ***Compressor -*** An Air compressor is a mechanical device that increases the pressure of the gas by reducing its volume. An electric motor is used to pump the gas inside increasing its pressure which is then released through an outlet to do work.

- ***Blowe***r - A blower is an equipment that increases the speed of the air or gas. It is powered by an electrical motor that pulls in the air from one side and pushes it with high speed on the other side. It is used in the exhaust system or ventilation, dust cleaning or vacuum cleaning.

- ***Refrigeration & Air-conditioning -*** Air-Conditioning & Refrigeration means cooling of space. It basically works by compressing the refrigerant using a compressor that is powered by an electric motor. it is used for preserving food by maintaining the temperature below normal. It is also used to make ice from water.

- ***Pump*** - A pump is used for the flow of fluid. it does not generate pressure. A pump pushes out the air creating a vacuum which is then filled up by the fluid. They are powered by electric motors which increase efficiency and save time.

- ***Crusher*** - Crusher is a machine that is used to reduce large rocks into small rocks, sand or gravel. An electric motor is used to generate crushing power by splitting the rocks into smaller chunks.

- ***Lathe Machine -*** A lathe is a machine that is used in the metalworking industry. It rotates a workpiece about its axis of rotation. It is used for cutting, sanding, drilling and shaping any workpiece into your desired shape. It is used for designing components that are symmetrical about an axis.

- ***Drill -*** A drilling machine is a power tool used for making holes. It utilizes an electric motor that is either powered by a battery or using the mains. Different types and power of drills are used for drilling holes such as in plastic, wood, metal and concrete, etc.

- ***Power Tools -*** Power tools are portable hand equipment that is powered by a battery attached to them. They are designed for a variety of applications. Such as grinders, drills, sanders, etc. They save time and reduce effort. Most of the power tools used electric motors.

- ***Rolling Mill -*** Rolling mills are heavy tools that have steel rollers. Electric machines are used to rotate these rollers. It is used for changing the shape or thickness of any metal or a sheet of metal. It is also used to increase the hardness of the material.

- ***Paper Mill -*** Papermill makes paper, paperboards and other fiberboard using various kinds of machinery. There are rolling machines cutting and pressing machines powered by electrical motors.

- ***Conveyor -*** A conveyor is a mechanical system of rollers or belts that is used to transport or move product or material with minimal effort. It eliminates the use of labor and also used for feeding material from one machine into another. A conveyor system also increases the productivity of the industry.

- ***Washing Machine -*** As the name implies, it is used for washing clothes. There is an electrical machine that rotates the clothing inside the machine. It effortlessly cleans the clothes without using your hands.

- ***Drying Machine***

The drying machine quickly dries your clothes by rotating it with such speed so that the water droplets push out of the clothes. It helps to dry the clothes quicker than usual.

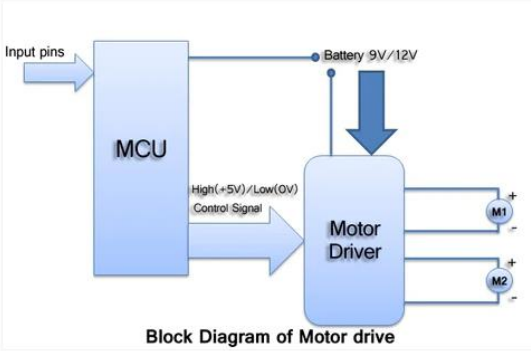
- ***Elevator***
- ***Escalator***
- ***Computer Disk Drives***
- ***Robots***
- ***Printer and Photocopiers***
- ***Positioning***
- ***Hoist***
- ***Winches***

MOTOR DRIVERS

DEFINITON : A motor driver is a device that controls the motion and direction of a motor by feeding it current. Motor drivers act as an interface between the motors and the control circuits. They take a low-current control signal and turn it into a higher-current signal that can drive a motor

WORKING :

- First, the microcontroller sends signals to the motor driver.
- Then, the signals received by the motor driver are interpreted and stepped up with the reference voltage i.e. provided for driving the motor.
- The motor has two voltage input pins. Pin 1 turns ON the motor by giving the voltage equal to the reference voltage, whereas pin 2 turns OFF the motor by giving 0V at the output pin.
- This entire process is controlled by the motor driver.
- We use motor drivers to give high power to the motor by using a small voltage signal from a microcontroller or a control system.
- If the microprocessor transmits a HIGH input to the motor driver, The driver will rotate the motor in one direction keeping the one pin as HIGH and one pin as LOW.
- And when the microcontroller transmits a LOW input to the motor driver, the motor driver makes the motor to rotate in other direction by making 2 motor pins as LOW and HIGH alternatively.



Block Diagram of Motor drive

BUILDING :

- The motor driver circuits can be made using readily available integrated ICs.
- Otherwise, you can also use transistor circuits to control the direction and the speed of the DC motor.
- If you want to control the speed of the DC motor, you can use a PWM signal from a microcontroller like Arduino and feed it to the base of the transistor.

Major components in motor drivers

1. ***Controller*** - The controller can be a microprocessor or a microcontroller.
2. ***Motor Driver IC or Motor Driver Circuits*** - They are current amplifiers that accept a low current signal from the controller and convert it into a high current signal that is used to drive the motor.
3. ***Motor*** – It is defined as an electric or mechanical device that can create a motion
4. ***Power Supply Unit*** – It provides the required power to the motor drive.

TYPES :

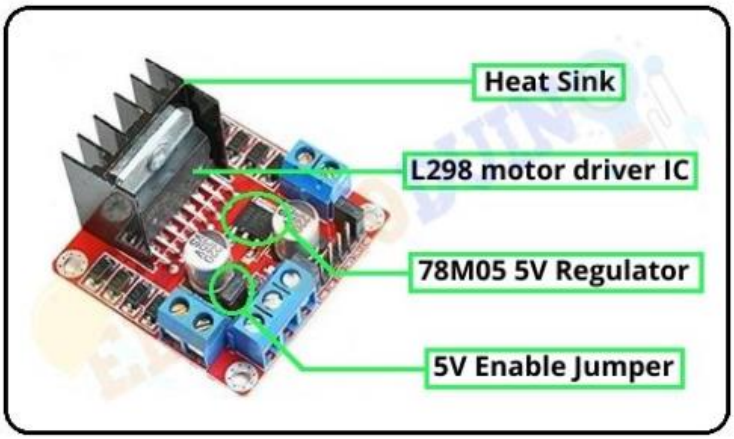
Different Types of Motor drivers

Motor driver	Description	Image
1. L293D IC	• Can be interfaced between the microcontroller and the motor. • Designed to control 2 DC motors simultaneously.	
2. BTS7960B motor driver board	• Can be interfaced with the microcontroller. • Controls the speed and the direction of the DC motor based on the PWM signal.	
3. TB6612FNG motor driver board	• Can control 2 DC motors at 1.2 A constantly. • 2 input signals (IN1 and IN2) can be used to control the motor in one of four function modes CW, CCW, short-brake, and stop.	
4. TB6560 motor driver board	• The TB6560 Driver Board 3A CNC Router Single 1 Axis Controller Stepper Motor driver board is for axis control with Input signal high-speed optocoupler isolation, the large heat sink to ensure good heat dissipation. • Stepper motor driver is Semi-flow mode adjustable, semi-flow current adjustable, with a variety of semi-flow model and semi-flow current setting functions.	
5. PCA9685 16 channel Servo motor driver board	• The PCA9685 16-Channel 12-bit PWM/Servo Driver will drive up to 16 servos over I2C with only 2 pins. • Can be interfaced with the microcontroller like Arduino and Raspberry Pi etc. • Can control 16-servo motors with just 2 I2C pins.	

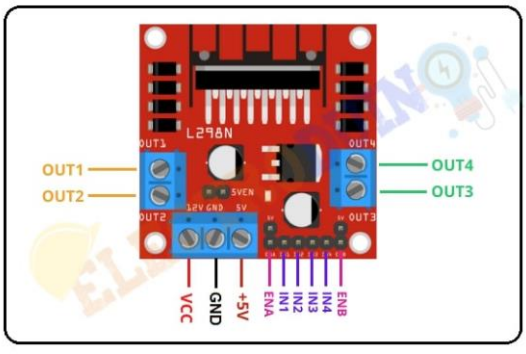
6. MACH3 Interface Board CNC 5 Axis	• Maximum support 5-axis stepper motor driver controllers • Compatible with MACH3, Linux CNC (EMC2), etc. parallel-control CNC software. • USB power supply and peripherals power phase are separate to protect computer security.	
7. TB6600 Stepper motor driver	• Can control the speed and direction of the stepper motors. • TB6600 stepper motor driver has a wide range of power input and 9~42VDC power supply. • You can set its micro-step and output current with a 6 DIP switch.	
8. PWM DC motor speed controller	• DC motor speed control using PWM signal. • Onboard Potentiometer to vary the duty cycle of the PWM signal. • Can handle loads of 9V-50V and up to 500W	
9. 2000W 220V AC motor speed control board	• SCR-based Speed control of AC motors. • Other AC loads like fans, bulbs, and heaters can also be controlled. • Can handle up to 2000W of loads.	
10. L298 Motor driver board	• Can control 2 DC motors with speed and direction. • Can be interfaced with the microcontroller like Arduino, Raspberry Pi, ESP32, etc., • A 12V input voltage can be given to driving the motors. And has a 5V onboard voltage regulator.	

11. A4988 Stepper motor driver	• The A4988 driver allows micro-stepping by allowing intermediate step locations. This is achieved by energizing the coils with intermediate current levels. • We can control the stepper motor with just 2 pins from our controller, one for controlling the rotation direction and the other for controlling the steps.	

1. ***L298N*** - L298N module is a high voltage, high current dual full-bridge motor driver module for controlling DC motor and stepper motor. It can control both the speed and rotation direction of two DC motors. This module consists of an L298 dual-channel H-Bridge motor driver IC. This module uses two techniques for the control speed and rotation direction of the DC motors. These are PWM – For controlling the speed and H-Bridge – For controlling rotation direction. These modules can control two DC motor or one stepper motor at the same time.



L298N Motor Driver Module Hardware Overview



L298N Motor Driver Module Pin Diagram/Pinout/Pin configuration

Pin No.	Pin Name	Description
Power Supply Pins		
1	**VCC**	VCC pin is used to supply power to the motor. Its input voltage is between 5 to 35V.
2	**GND**	GND is a ground pin. It needs to be connected to the power supply ground(negative).
3	**+5V**	+5V pin supplies power for the switching logic circuitry inside the L298N IC. If the 5V-EN jumper is in place, this pin acts as output and can be used to power up a microcontroller or other circuitry (sensor). If the 5V-EN jumper is removed, you need to connect it to the 5V power supply of the microcontroller.
Control Pins		
1	**IN1**	These pins are input pins of **Motor A**. These are used to control the rotating direction of Motor A. When one of them is HIGH and the other is LOW, Motor A will start rotating in a particular direction. If both the inputs are either HIGH or LOW the Motor A will stop.
2	**IN2**	
3	**IN3**	These pins are input pins of **Motor B**. These are used to control the rotating direction of Motor A. When one of them is HIGH and the other is LOW, Motor A will start rotating in a particular direction. If both the inputs are either HIGH or LOW the Motor A will stop.
4	**IN4**	

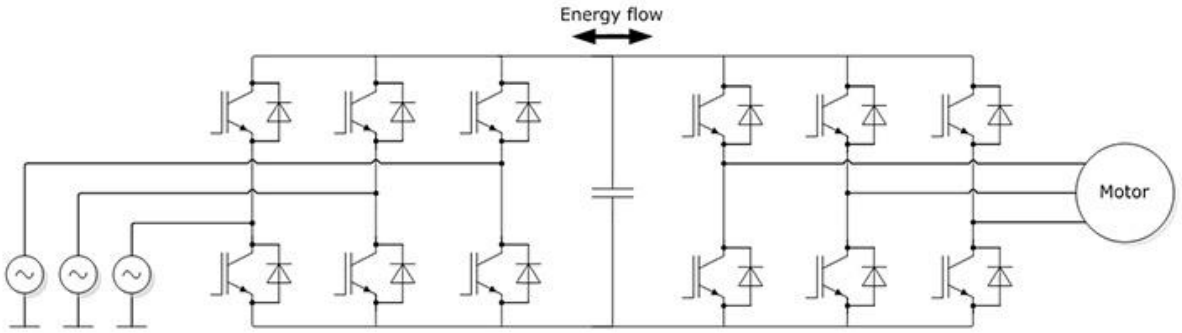
Speed Control Pins		
1	**ENA**	ENA pin is used to control the speed of **Motor A**. If a jumper is present on this pin, so the pin connected to +5 V and the motor will be enabled, then the Motor A rotates maximum speed. if we remove the jumper, we need to connect this pin to a PWM input of the microcontroller. In that way, we can control the speed of Motor A. If we connect this pin to Ground the Motor A will be disabled.
2	**ENB**	ENB pin is used to control the speed of **Motor B**. If a jumper is present on this pin, so the pin connected to +5 V and the motor will be enabled, then the Motor B rotates maximum speed. if we remove the jumper, we need to connect this pin to a PWM input of the microcontroller. In that way, we can control the speed of Motor B. If we connect this pin to Ground the Motor B will be disabled.

Output Pins		
1	**OUT1** & **OUT2**	This terminal block will provide the output for **Motor A**.
2	**OUT3** & **OUT4**	This terminal block will provide the output for **Motor B**.

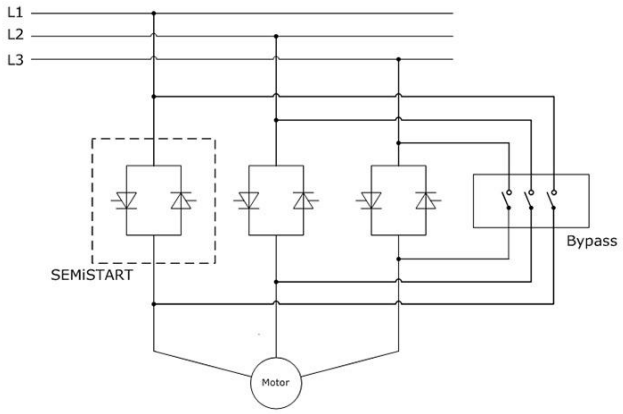
APPLICTIONS :

A] INDUSTRIAL

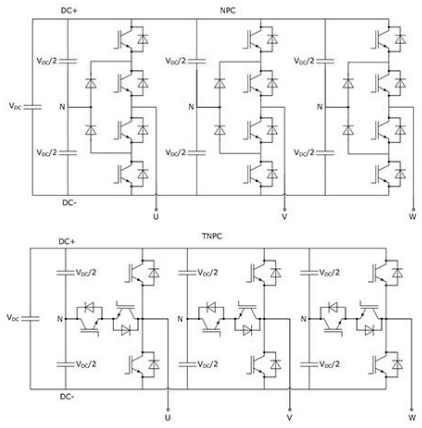
1. ***2-quadrant converter -*** 2-quadrant converters are not able to recover energy; braking energy must be converted into heat. These converters are primarily used in drives with low power output, including the majority of machine tool drives. CIB power modules (Converter Inverter Brake module) are preferred for use in converters with low to medium output, up to around 15 kW. CIB modules of this type contain all the power semiconductors for a converter, the mains rectifier, the brake chopper and the inverter.



2. ***4-quadrant converter -*** In order to be able to feed energy back to the grid, drive converters with higher output are often rated for 4-quadrant operation, which means they consist of two topologically identical converters at the grid side and the machine side. Ability to recover energy means that, in the event of a regenerative load, the connected machine can feed the generated energy back to the grid.



3. ***Thyristor controllers and soft starters -*** Variable speed control of asynchronous machines can also be achieved with anti-parallel thyristors in each supply phase. Today, this method is mainly applied to soft starters in order to limit starting current and starting torque. SEMIPACK thyristor modules and specific power modules that contain thyristors connected in anti-parallel for one or three phase



Block diagram of a 3-level IGBT inverter

Examples for controlled electric drives

1. ***Low-voltage drives -*** In terms of quantity, "general" low-voltage drives for universal applications are the largest area of use for frequency converters. These converters control motors in 2- and 4-quadrant operation and are available in a broad power range, from under 0.5 kW to beyond 1 MW. Typical applications include pumps, fans and motors for technological processes.

2. ***Servo drives*** - Highly dynamic servo drives are used in applications with high peak loads for controlling position, speed or torque. The power range is predominantly between 0.5 kW and 30 kW. These precision drives are frequently used to control 2-quadrant operation of motors in machine tools, industrial robots etc.

3. ***Elevator drives*** - When it comes to drives for elevators, there are demanding requirements in terms of smooth operation, accuracy of position, reliability and load cycle stability. Here, drives with outputs of 10 kW to 250 kW are used for 2 and 4-quadrant operation.

Medium-voltage drives

Medium-voltage drives with outputs of 500 kW to 5 MW are used extensively in heavy industry. In these topologies, many IGBT or inverter cells are connected in series, allowing for significantly higher system voltages than the blocking voltage of the power semiconductor. This means that it is possible to use cost-efficient IGBT modules with just 1,700 V reverse recovery voltage in medium-voltage networks with line voltages of 3,300 V and higher. Moreover, multilevel switching of the cells produces low network harmonics, so reducing on filters.

B] AUTOMOTIVE APPLICATION

fact, power electronics can be found at the heart of the electric powertrain in any battery electric and hybrid electric vehicle. They are needed to convert the direct current that comes from the car battery into the alternating current needed for the electric motor.

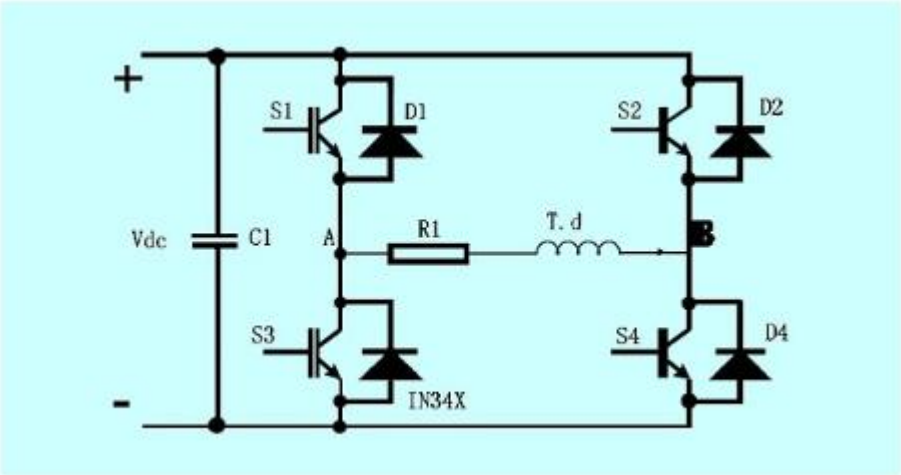
H- BRIDGE

DEFINITON : An H-bridge is an electronic circuit that switches the polarity of a voltage applied to a load. It's often used in robotics and other applications to allow DC motors to run forwards or backward .You normally use it with a microcontroller, such as an Arduino, to control motors. When you can control two motors to go either forward or backward.

H-bridge is a typical DC motor control circuit because its circuit shape resembles the letter H, so it is named with "H-bridge". 4 transistors form the 4 vertical legs of H, and the motor is the horizontal bar in H.

Working principle

The operating principle of a single-phase bridge inverter circuit as shown in the figure H-bridge inverter (single-phase)



- Switch T1, T4 on, T2, T3 off: u0 = Ud.
- Switch T1, T4 off, T2, T3 on: u0 = -Ud;
- When switching switches T1, T4 and T2, T3 alternately at frequency fS, an alternating voltage waveform (square wave alternating positive and negative) is obtained at the load resistor R with period Ts=1/fS. In this way, the DC voltage E is turned into AC voltage uo. uo contains all harmonics and can be filtered by a filter if a sinusoidal voltage is desired.
- The main circuit switches T1 to T4, which is actually an ideal model for various semiconductor switching devices. The common switching devices used in inverter circuits are fast thyristor, turn-offable thyristor (GTO), power transistor (GTR), power field-effect transistor (MOSFET), and insulated gate transistor (IGBT).
- In practice, there are losses in switching devices: conduction losses and commutation losses, and gate losses. The gate losses are negligible, while the conduction losses and phase change losses increase with the switching frequency.

Control method - The control of the H-bridge is mainly divided into approximate square wave control and pulse width modulation (PWM) and cascaded multi-level control.

1. ***Approximate square-wave control -*** The output waveform has one more zero level (3-level) than the alternating positive and negative square wave, and the harmonics are greatly

reduced.The advantage is that the switching frequency is lower, but the disadvantage is that the harmonic component is high and the cost of the filter is large.

2. ***Pulse width modulation -*** Pulse width modulation is divided into unipolar and bipolar PWM. As the switching frequency increases, the output voltage and current waveform tends to be sinusoidal and the harmonic components are reduced, but the high switching frequency brings a series of problems: large switching losses, high insulation pressure on the motor, heat generation, etc.

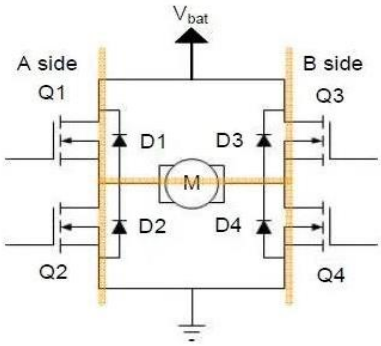
3. ***Cascaded multi-level control -*** The multi-level inverter is a cascaded H-bridge, which minimizes harmonic distortion at the same switching frequency, even without a filter, to obtain a good approximation of a sinusoidal output waveform.

Switching state

The following is a brief introduction to several switching states of the H-bridge, taking a DC motor as an example, where forward and backward are artificially specified directions, and the actual engineering can be divided according to the actual situation.

Forward

Usually, the H-bridge is used to drive inductive loads, here we drive a DC motor.



H-bridge circuit

Turn on Q1 and Q4. Turn off Q2 and Q3.At this point, assuming the motor is forward, this current passes through Q1, M, Q4 in turn, marked in the diagram using the yellow line segment, as shown below.

APPLICATION :

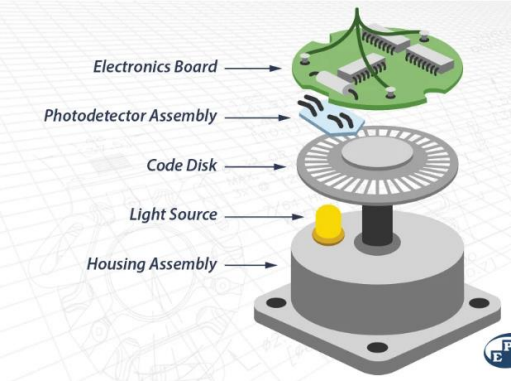
DC motor control - Controlling the speed and direction of DC motors.

Stepper motor control - Controlling stepper motors, which are commonly used in precision instruments like 3D printers and CNC machines

DC/AC, AC/AC, or DC/DC converters - Used in many other applications such as DC/AC, AC/AC, or DC/DC converters

Point-of-sales (PoS) units - Suitable for applications such as point-of-sales (PoS) units, small-scale domestic appliances, air conditioning systems, and electronic door locks.

ENCODER



DEFINTION - Encoders convert motion to an electrical signal that can be read by some type of control device in a motion control system, such as a counter or PLC. The encoder sends a feedback signal that can be used to determine position, count, speed, or direction. A control device can use this information to send a command for a particular function. For example:

WORKING : Encoders use different types of technologies to create a signal, including: mechanical, magnetic, resistive and optical – optical being the most common. In optical sensing, the encoder provides feedback based on the interruption of light.

The graphic below outlines the basic construction of an incremental rotary encoder using optical technology. A beam of light emitted from an LED passes through the Code Disk, which is patterned with opaque lines (much like the spokes on a bike wheel). As the encoder shaft rotates, the light beam from the LED is interrupted by the opaque lines on the Code Disk before being picked up by the Photodetector Assembly. This produces a pulse signal: light = on; no light = off. The signal is sent to the counter or controller, which will then send the signal to produce the desired function.

TYPES :

As a result of the dimension technique and also type of output signal, the complying with are distinguished

- incremental encoders (rotary-pulse transducers).
- absolute encoders (rotating encoders).

The difference between absolute and incremental encoders :

Encoders may produce either incremental or absolute signals. Incremental signals do not indicate specific position, only that the position has changed. Absolute encoders, on the other hand, use a different “word” for each position, meaning that an absolute encoder provides both the indication that the position has changed and an indication of the absolute position of the encoder.

Encoders are likewise divided right into rotating as well as linear. The previous are used to measure the angular position of an item, while the last (linear) determine its longitudinal motion, i.e. variation. Both rotating and also linear encoders can be incremental or absolute encoders.

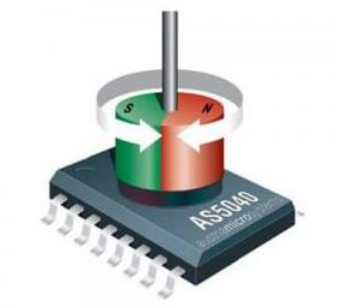
Rotary encoders principle of operation

Incremental encoder - An incremental encoder produces a digital output signal as the shaft rotates through a defined angle. The number of signals (pulses) per revolution figures out the resolution of the encoder. The higher the resolution, the smaller angular displacements can be gauged, which converts right into greater dimension accuracy.

Optical encoder- In an optical incremental encoder, its major part is a code disc connected to a shaft, on which there are clear and also opaque areas. Light created by an LED illuminates the disc as well

as goes through its transparent areas or is quit – in the case of nontransparent fields. A receiver (optoelectronic aspect) mounted on the back of the disc transforms the obtained light into an electrical signal. The kind of the encoder output signal relies on the adopted signal standard, usually it is an electronic (rectangular) signal.

Magnetic encoder -



In a magnetic incremental encoder, each angular setting is identified by an electromagnetic field vector. The encoder has a magnetic disc attached to the shaft to generate the needed electromagnetic field. Furthermore, the encoder is equipped with a Hall sensor. Such a sensor is typically in the form of an integrated circuit. It includes a plate made from semiconductor material which is positioned in an electromagnetic field. A voltage is then put on it, forcing electrons to flow in the right direction, that is, vertical to the electromagnetic field lines. By measuring the voltage at the electrodes, which are placed vertical to the field lines and the direction of the electrons, it is very easy to determine the toughness of the electromagnetic field in which the sensor is located. The electromagnetic field leads to a Hall voltage, which is converted to an electronic output signal.

Magnetic encoders do not require direct call between the sensor and revolving axis. Therefore, they have a longer service life because of less relocating parts entering into contact with each other.

Absolute encoder - The designs of absolute encoders and incremental encoders are virtually the exact same, the difference is just in the approach of measurement. With absolute encoders, the output signal is created in analogue kind by furnishing its disc with an one-of-a-kind code for each and every position. It guarantees that each angular setting of the shaft is assigned its own code value at the output. This is the so-called code signal.

APPLICATION

- In a cut-to-length application, an encoder with a measuring wheel tells the control device how much material has been fed, so the control device knows when to cut.
- In an observatory, the encoders tell actuators what position a moveable mirror is in by providing positioning feedback.
- On railroad-car lifting jacks, precision-motion feedback is provided by encoders, so the jacks lift in unison.
- In a precision servo label application system, the encoder signal is used by the PLC to control the timing and speed of bottle rotation.
- In a printing application, feedback from the encoder activates a print head to create a mark at a specific location.
- With a large crane, encoders mounted to a motor shaft provide positioning feedback so the crane knows when to pick up or release its load.
- In an application where bottles or jars are being filled, feedback tells the filling machines the position of the containers.

- In an elevator, encoders tell the controller when the car has reached the correct floor, in the correct position. That is, encoder motion feedback to the elevator's controller ensures that elevator doors open level with the floor. Without encoders, you might find yourself climbing in or out of an elevator, rather than simply walking out onto a level floor.
- On automated assembly lines, encoders give motion feedback to robots. On an automotive assembly line, this might mean ensuring the robotic welding arms have the correct information to weld in the correct locations.
- In any application, the process is the same: a count is generated by the encoder and sent to the controller, which then sends a signal to the machine to perform a function.

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