Basics of Electronics

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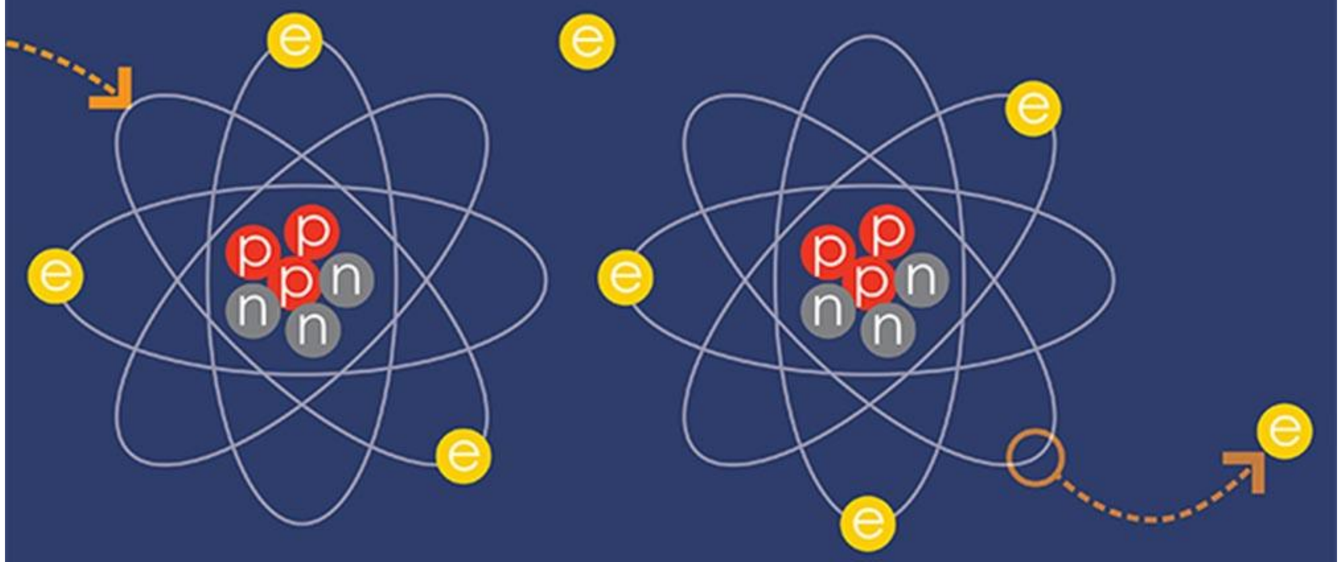
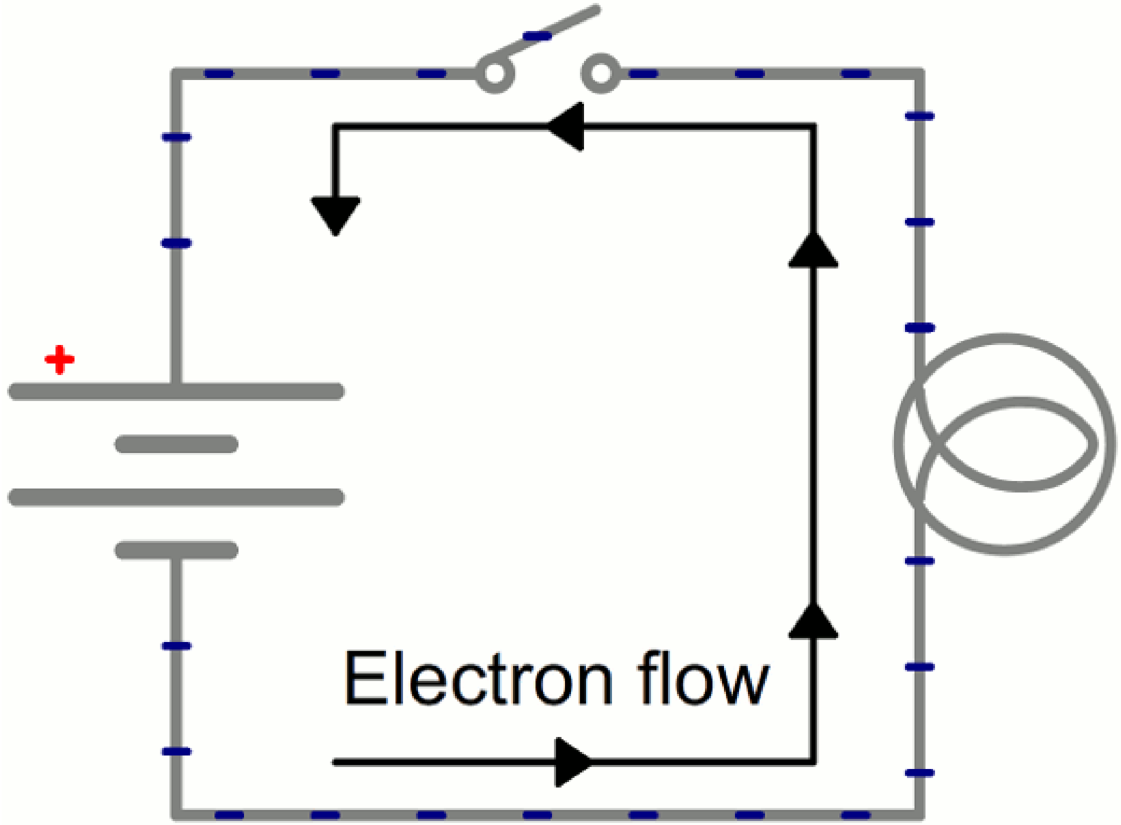
What is electricity?

Electricity is simply the flow of electrons from one place to another. Electrons are tiny particles that orbit the core of an atom, and they can be made to hop from one atom to the next.

Electrons move very easily through metal wire, but the flow of electrons is limited by the size of the wire. Increasing the wire size allows for more electrons to flow through it and for electricity to be delivered safely to homes and businesses.

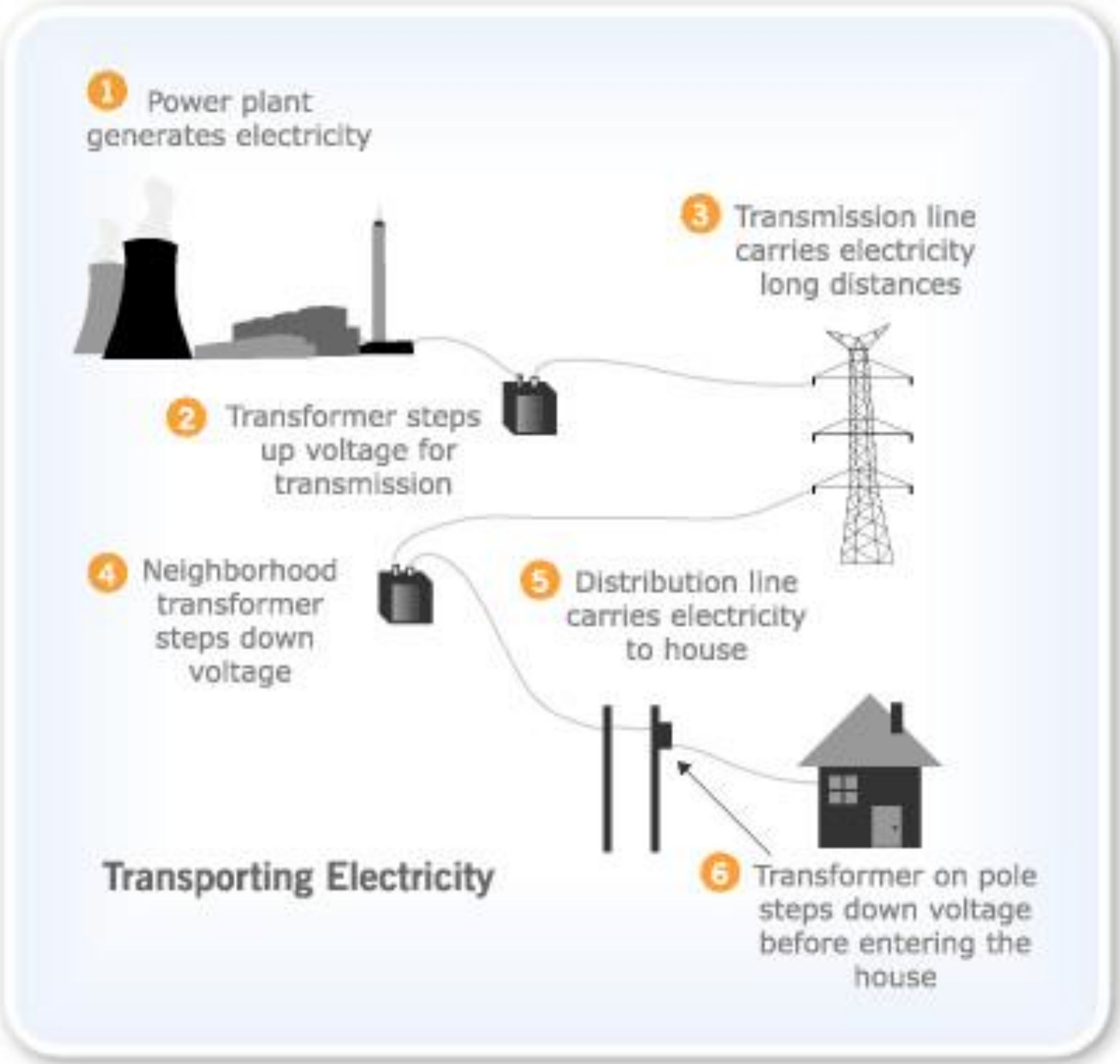


What is Electricity?



How Electricity Flows from Power Stations to Us?

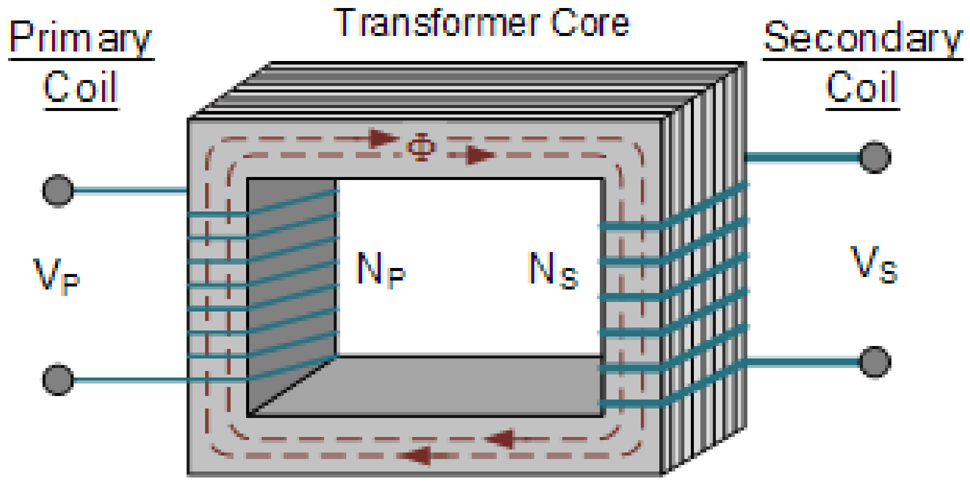
The spinning turbines make the electricity, which flows into power lines and to our houses. Electricity moves through the wires very fast. In just one second, electricity can travel around the world seven times. From the power station where the electricity is made the electricity flows to large transmission lines held up by huge towers. The transmission lines carry large amounts of electricity to substations in cities and towns. Distribution lines carry small amounts of electricity from the substations to houses and businesses.


1 Power plant generates electricity
2 Transformer steps up voltage for transmission
3 Transmission line carries electricity long distances
4 Neighborhood transformer steps down voltage
5 Distribution line carries electricity to house
6 Transformer on pole steps down voltage before entering the house
Transporting Electricity

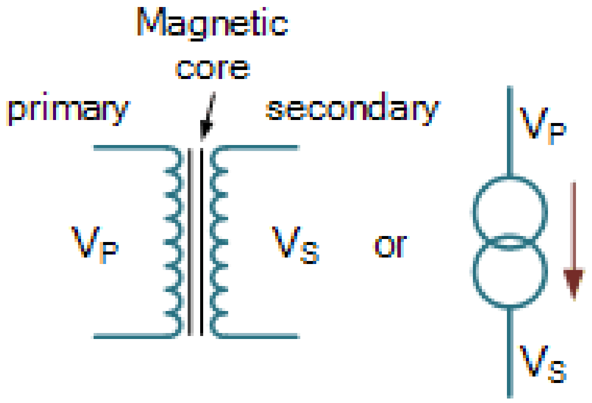
Transformers in AC

- One of the main reasons that we use alternating AC voltages and currents in our homes and workplace's is that AC supplies can be easily generated at a convenient voltage, transformed (hence the name transformer) into much higher voltages and then distributed around the country using a national grid of pylons and cables over very long distances.
- A transformer is an electrical device that transfers energy from one circuit to another by magnetic coupling with no moving parts. A transformer comprises two or more coupled windings, or a single tapped winding and, in most cases, a magnetic core to concentrate magnetic flux.
- An alternating current (AC) in one winding creates a time-varying magnetic flux in the core, which induces a voltage in the other windings. Transformers are used to convert between high and low voltages, to change impedance, and to provide electrical isolation between circuits.

Transformer



Transformer Construction



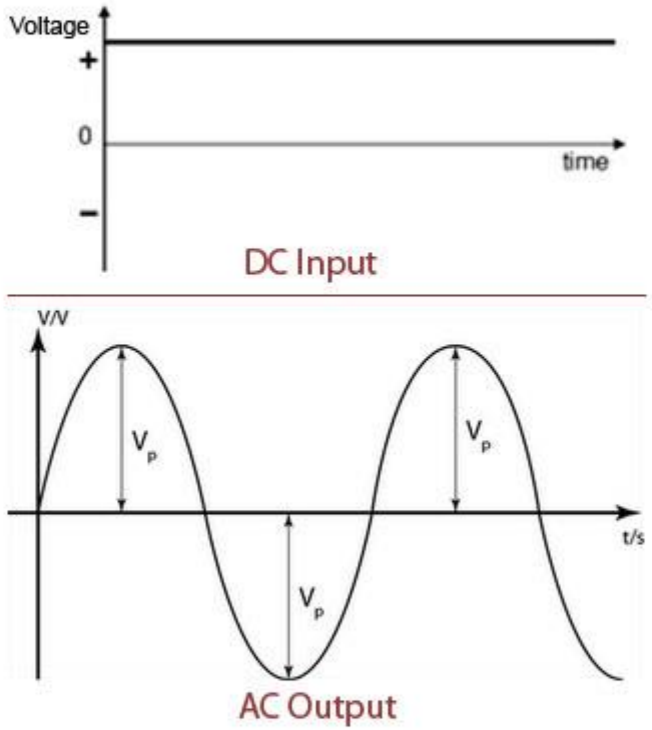
Transformer Symbols

•Where:

- V_P - is the Primary Voltage
- V_S - is the Secondary Voltage
- N_P - is the Number of Primary Windings
- N_S - is the Number of Secondary Windings
- Φ (phi) - is the Flux Linkage

Inverter

- Inverting direct current (DC) into alternating current (AC) by changing the frequency of the electrical supply.



Converters

- Converters convert direct current (DC) into different amplitude direct current (DC) while keeping the power same assuming no loss. (in reality due to component losses the output power will be less than input power) appx. POUT < PIN. eg. 490W < 510. The difference 20W is lost on components as heat.

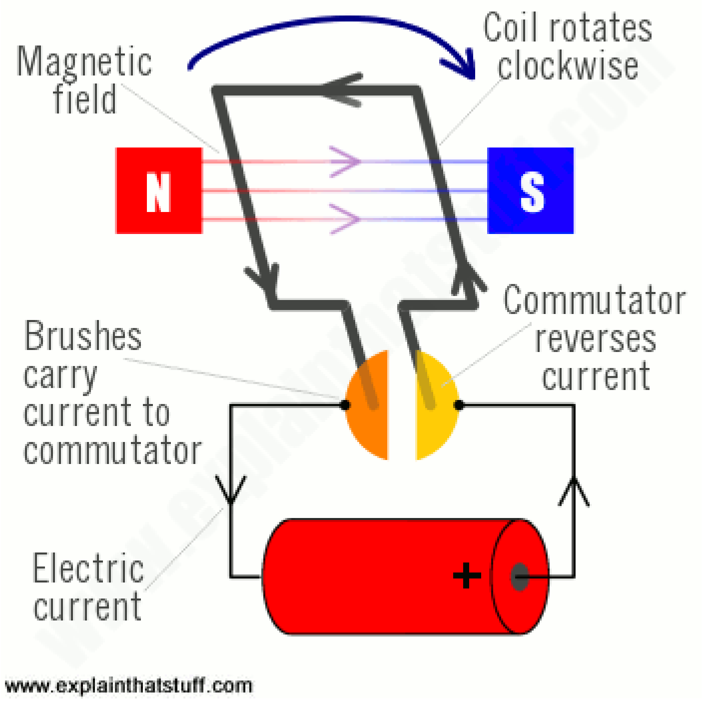
Step-up & Step-down

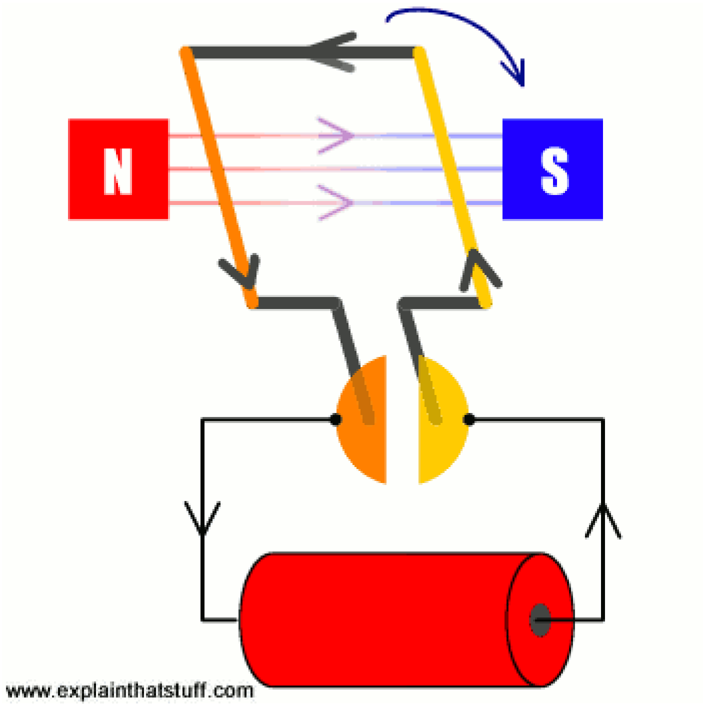
- DC-to-dc *switching converters* are used to change one dc voltage to another efficiently. High efficiency dc-to-dc converters come in three basic topologies: *step-down* (buck), *step-up* (boost), and *step-down/step-up* (buck/boost). The buck converter is used to generate a lower dc output voltage, the *boost* converter is used to generate a higher dc output voltage, and the buck/boost converter is used to generate an output voltage less than, greater than, or equal to the input voltage.

Motors

- The basic idea of an electric motor is really simple: you put electricity into it at one end and an axle (metal rod) rotates at the other end giving you the power to drive a machine of some kind. How does this work in practice? Exactly how do your convert electricity into movement? To find the answer to that, we have to go back in time almost 200 years.
- Suppose you take a length of ordinary wire, make it into a big loop, and lay it between the poles of a powerful, permanent horseshoe magnet. Now if you connect the two ends of the wire to a battery, the wire will jump up briefly. It's amazing when you see this for the first time. It's just like magic! But there's a perfectly *scientific* explanation. When an electric current starts to creep along a wire, it creates a magnetic field all around it. If you place the wire near a permanent magnet, this temporary magnetic field interacts with the permanent magnet's field. You'll know that two magnets placed near one another either attract or repel. In the same way, the temporary magnetism around the wire attracts or repels the permanent magnetism from the magnet, and that's what causes the wire to jump.

Motors


Magnetic field
Coil rotates clockwise
N
S
Brushes carry current to commutator
Commutator reverses current
Electric current
+
www.explainthatstuff.com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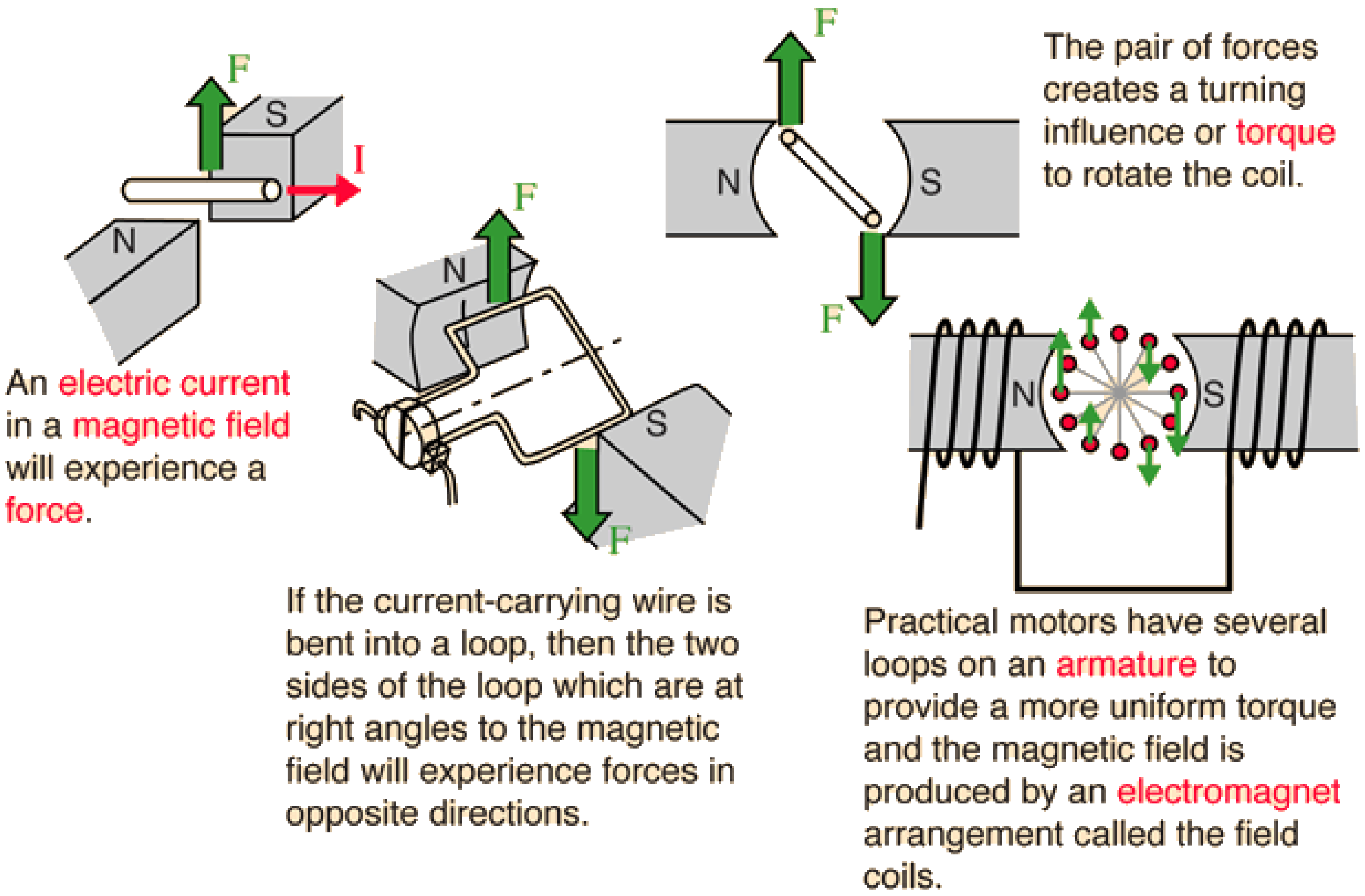
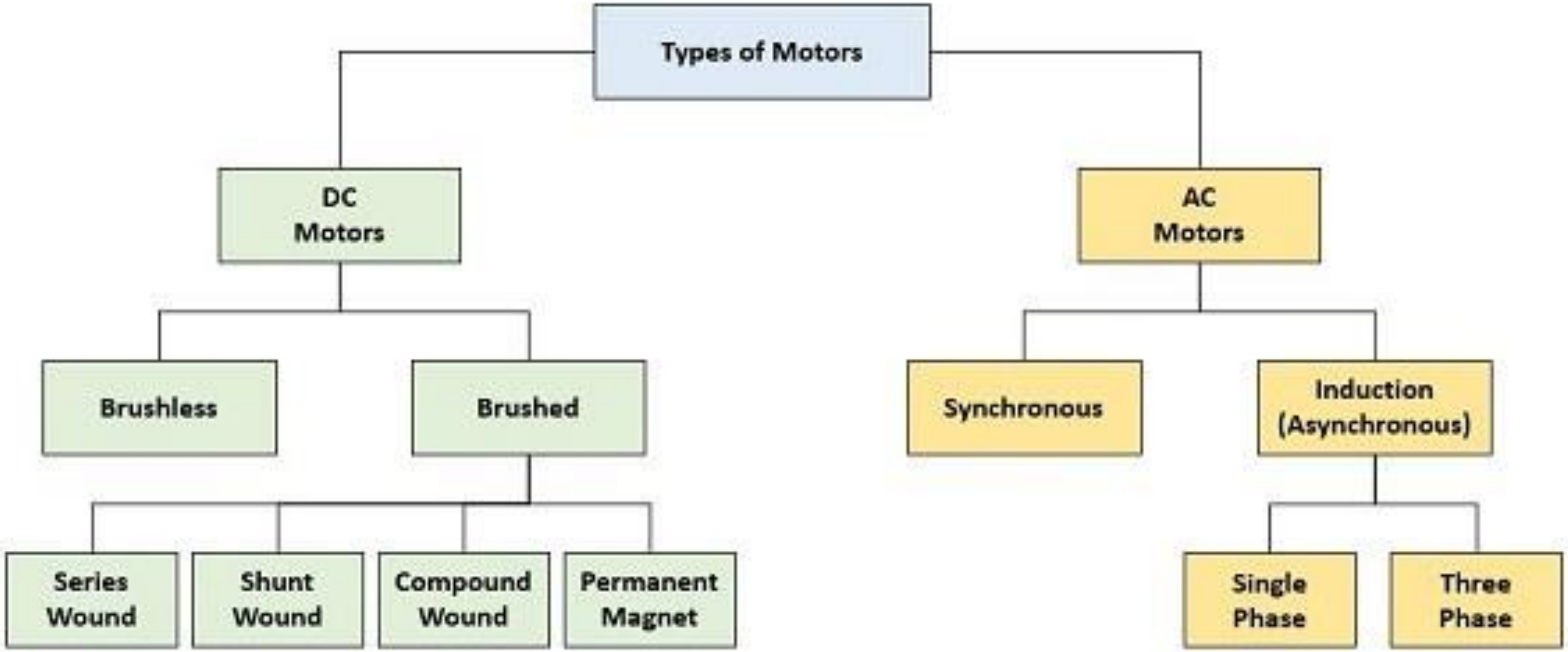
Motors


F
S
I
N
An electric current in a magnetic field will experience a force.
F
N
S
F
If the current-carrying wire is bent into a loop, then the two sides of the loop which are at right angles to the magnetic field will experience forces in opposite directions.
F
N
S
F
The pair of forces creates a turning influence or torque to rotate the coil.
N
S
Practical motors have several loops on an armature to provide a more uniform torque and the magnetic field is produced by an electromagnet arrangement called the field coils.

Types of Motors



AC Motors

AC motors are highly flexible in many features including speed control (VSD - Variable Speed Drives) and have a much larger installed base compared to DC motors, some of the key advantages are:

- Low power demand on start
- Controlled acceleration
- Adjustable operational speed
- Controlled starting current
- Adjustable torque limit
- Reduced power line disturbances

Types of AC motor : **Synchronous**

In this type of motor, the rotation of the rotor is synchronized with the frequency of the supply current and the speed remains constant under varying loads, so is ideal for driving equipment at a constant speed and are used in high precision positioning devices like robots, instrumentation, machines and process control

Types of AC motor :
Induction (Asynchronous)

This type of motor uses electromagnetic induction from the magnetic field of the stator winding to produce an electric current in the rotor and hence Torque. These are the most common type of AC motor and important in industry due to their load capacity with Single-Phase induction motors being used mainly for smaller loads, like used in house hold appliances whereas Three-Phase induction motors are used more in industrial applications including like compressors, pumps, conveyor systems and lifting gear.

DC Motors

DC motors were the first type of motor widely used and the systems (motors and drive) initial costs tend to be typically less than AC systems for low power units, but with higher power the overall maintenance costs increase and would need to be taken into consideration. The DC Motors speed can be controlled by varying the supply voltage and are available in a wide range of voltages, however the most popular type are 12 & 24V, with some of the advantages being:

- Easy installation
- Speed control over a wide range
- Quick Starting, Stopping, Reversing and Acceleration
- High Starting Torque
- Linear speed-torque curve

- DC motors are widely used and can be used from small tools and appliances, through to electric vehicles, lifts & hoists

Types of DC motor : **Brushed**

These are the more traditional type of motor and are typically used in cost-sensitive applications, where the control system is relatively simple, such as in consumer applications and more basic industrial equipment, these type of motors can be broken down as:

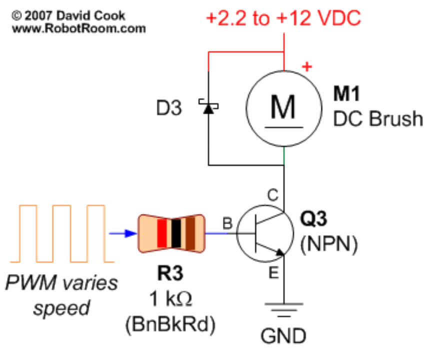
- **Series Wound** – This is where the field winding is connected in series with rotor winding and speed control is by varying the supply voltage, however this type offers poor speed control and as the torque to the motor increase, then the speed falls. Applications include automotive, hoists, lifts and cranes as it has a high starting torque.
- **Shunt Wound** – This type has one voltage supply and the field winding is connected in parallel with the rotor winding and can deliver increased torque, without a reduction in speed by increasing the motor current. It has medium level of starting torque with constant speed, so suitable for applications include lathes, vacuum cleaners, conveyors & grinders.
- **Compound Wound** – This is a cumulative of Series and Shunt, where the polarity of the shunt winding is such that it adds to the series fields. This type has a high starting torque and run smoothly if the load varies slightly and is used for driving compressors, variable-head centrifugal pumps, rotary presses, circular saws, shearing machines, elevators and continuous conveyors
- **Permanent Magnet** – As the name suggests rather than electromagnet a permanent magnet is used and are used in applications where precise control and low torque, such as in robotics, servo systems.

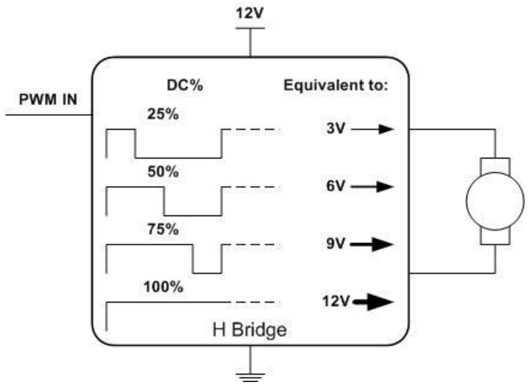
Types of DC motor : **Brushless**

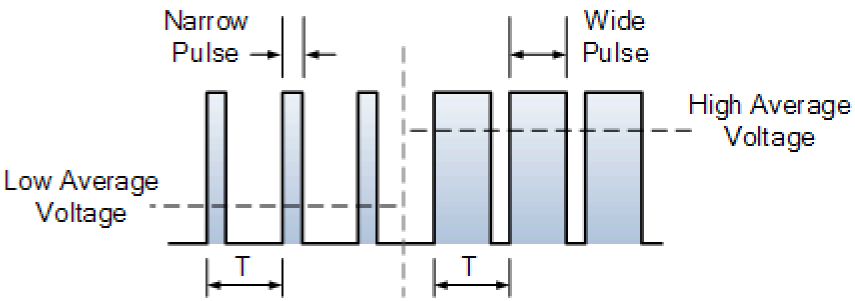
Brushless motors alleviate some of the issues associated with the more common brushed motors (short life span for high use applications) and are mechanically much simpler in design (not having brushes). The motor controller uses Hall Effect sensors to detect the rotors position and using this the controller can accurately control the motor via current in the rotor coils) to regulate the speed. The advantages of this technology is the long life, little maintenance and high efficiency (85-90%), whereas the disadvantages are higher initial costs and more complicated controllers. These types of motors are generally used in speed and positional control with applications such as fans, pumps and compressors, where reliability and ruggedness are required.

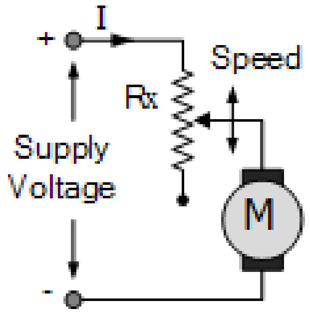
An example of brushless design are in Stepper Motors, which are primarily used in open-loop position control, with uses from printers through to industrial applications such as high speed pick and place equipment.

Speed Control; Pulse Width Modulation









The power applied to the motor can be controlled by varying the width of these applied pulses and thereby varying the average DC voltage applied to the motors terminals. By changing or modulating the timing of these pulses the speed of the motor can be controlled, ie, the longer the pulse is “ON”, the faster the motor will rotate and likewise, the shorter the pulse is “ON” the slower the motor will rotate.

In other words, the wider the pulse width, the more average voltage applied to the motor terminals, the stronger the magnetic flux inside the armature windings and the faster the motor will rotate .