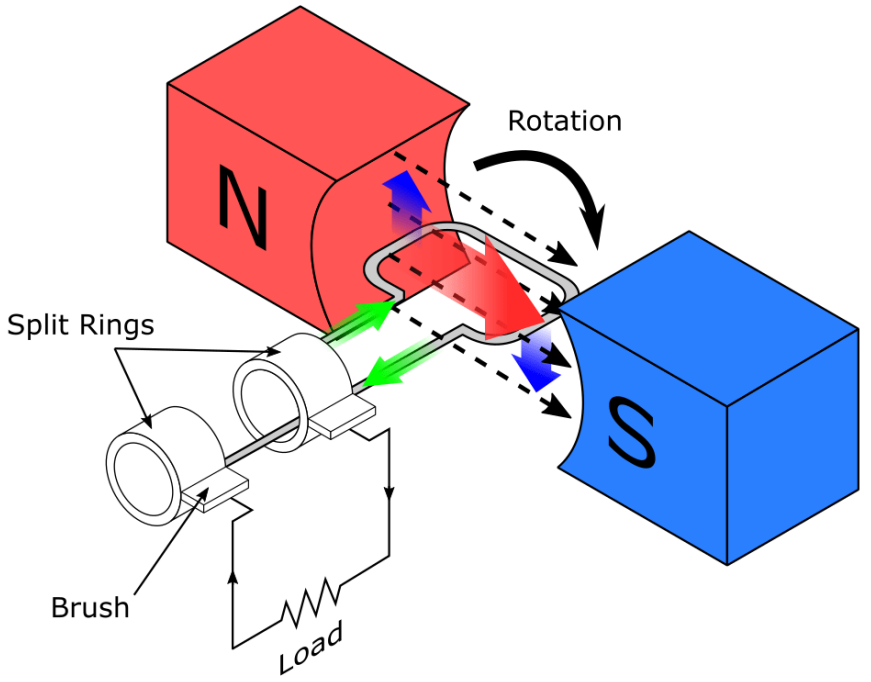
# AC Generation

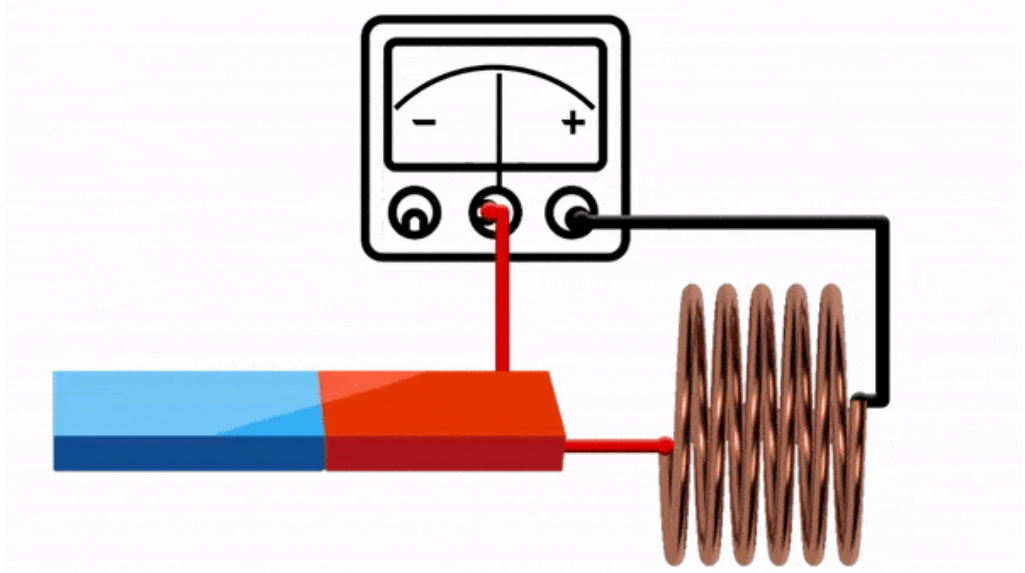
# What is an AC generator

- An AC generator converts mechanical motion into oscillating single or 3 phase electrical energy
- AC generators are widely used because AC power is more efficient to transmit over long distances, as its voltage can be easily stepped up or down using transformers
- They are also widely used as they are simpler to build using slip rings instead of a commutator



# Faraday's Law of Electromagnetic Induction

- The induced EMF (voltage) in a circuit is proportional to the rate of change of magnetic flux through the circuit.
- This means that moving a magnet near a coil induces an EMF; if the coil is part of a closed circuit, this produces an electric current.



# Faraday's Law of Electromagnetic Induction

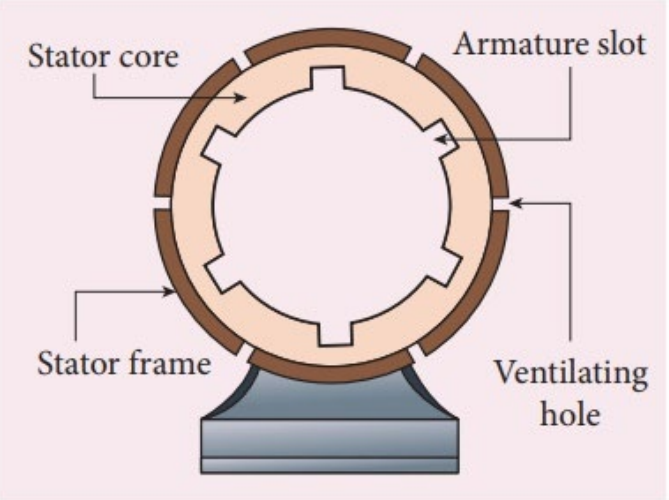
- Faraday's law follows this equation:

$$e = -N\frac{d\Phi}{dt}$$

- Where:
  - $e$ = induced EMF (volts)
  - $N$ = number of turns in the coil
  - $\Phi$ = magnetic flux (webers)
  - $\frac{d\Phi}{dt}$ = rate of change of flux

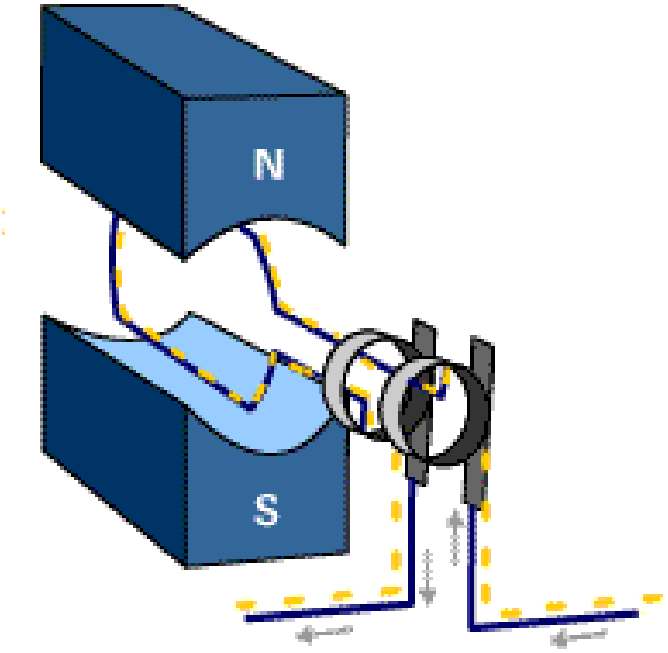
# Construction - Stator

- **Definition:**
  - The stationary part of an AC generator.
- **Function:**
  - Holds the armature windings where AC is induced.
  - Provides the path for magnetic flux.
- **Features:**
  - Laminated steel core (reduces eddy current losses).
  - Copper windings.
  - Outer frame for support and cooling.
- **Important Point:**
  - In most AC generators, the stator produces the electrical output, while the rotor carries the magnetic field.



# Construction - Rotor

- **Definition:**
  - The rotating part of an AC generator.
- **Function:**
  - Produces the magnetic field (either by permanent magnets or an electromagnet).
  - Rotates within the stator to induce AC voltage in the windings.
- **Features:**
  - Shaft connected to the prime mover (e.g., turbine or engine).
  - Field windings or permanent magnets mounted on the rotor core.
  - Slip rings and brushes supply current to field windings (if electromagnet).

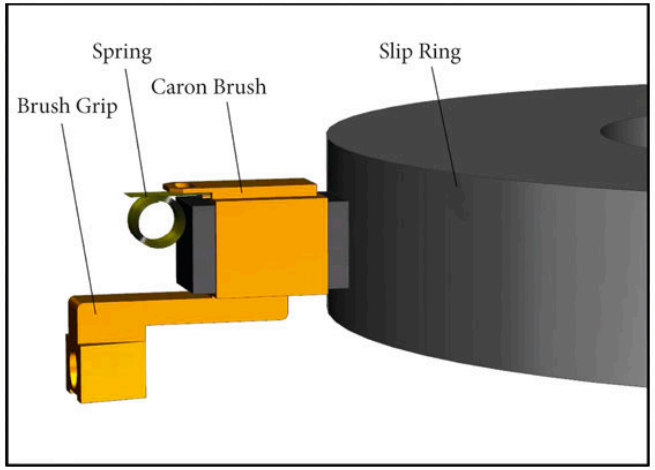


# Slip Rings & Brushes

- **Definition:**
  - Slip rings: circular conductors on the rotor shaft.
  - Brushes: carbon or graphite blocks pressing against slip rings.

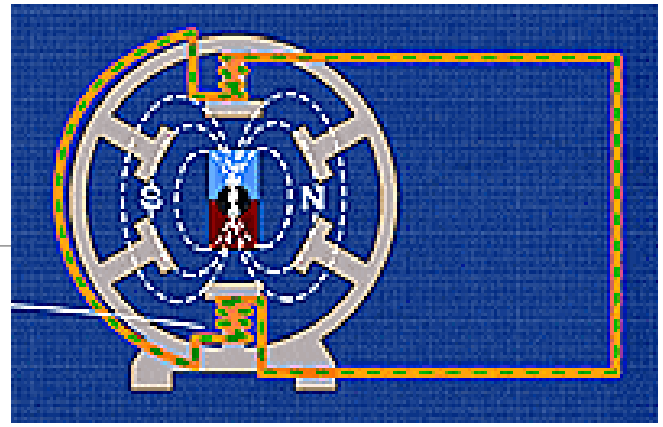
- **Function:**
  - Together, they transfer AC voltage from the rotating coil to the external circuit.
  - Maintain continuous contact while the rotor spins.

- **Features:**
  - Slip rings made of copper or brass.
  - Brushes made of carbon/graphite (good conductor + self-lubricating).
  - Designed for low friction and long service life.



# Two Generator Setups

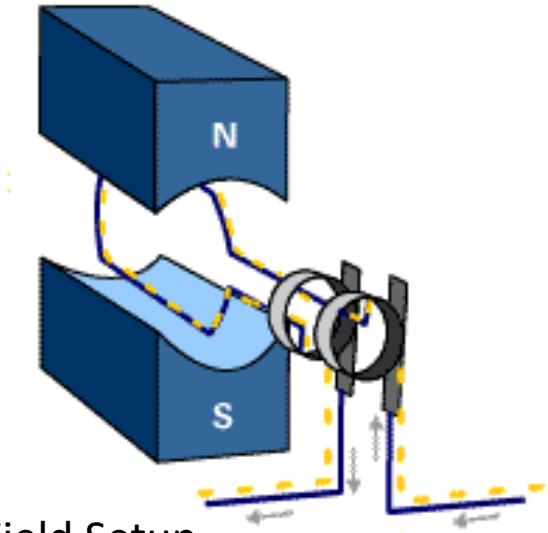
- **Rotor Field Setup:**
  - Rotor carries the field windings (or magnets).
  - Stator holds the armature windings where AC is induced.
  - Most common in large power stations.



Rotor Field Setup

- **Stator Field Setup:**
  - Stator carries the field windings.
  - Rotor holds the armature windings where AC is induced.
  - Used in some small machines.

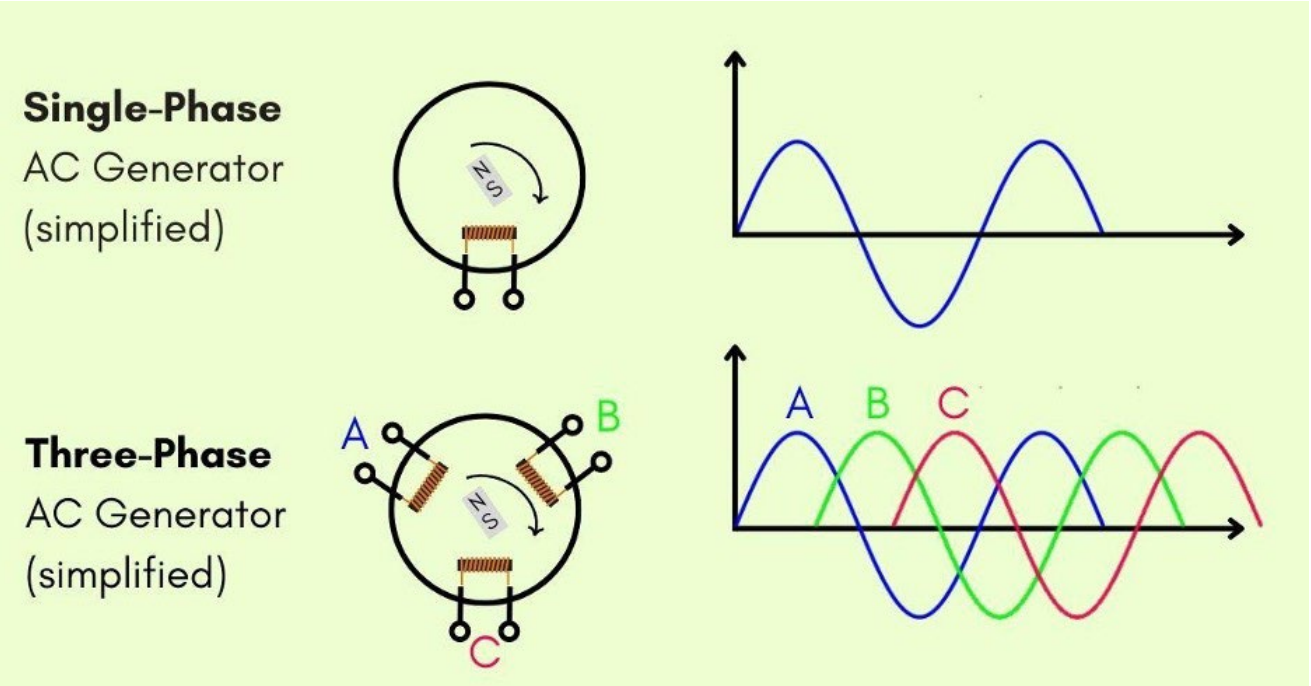
- **Key Difference:**
  - Where the AC is induced → either in the rotor coils or in the stator coils.



Stator Field Setup

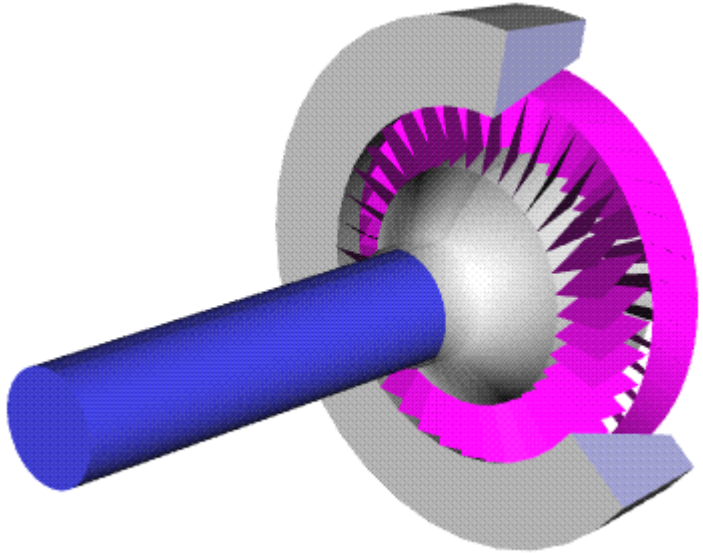
# Single vs Poly Phase AC Generation

- The number of phases you get from an AC generator is dependant on the number of coils the generator uses
- They most commonly are single or three phase



# Rotational to Electricity

- AC power is generated when the magnet in the system is rotated
- Often this rotation happens due to a turbine spinning
- The turbine will be turned by many different sources including wind, water, gas and steam
- Steam is the most used as it’s easy to generate by boiling water



# How an AC Generator Works (Step by Step)

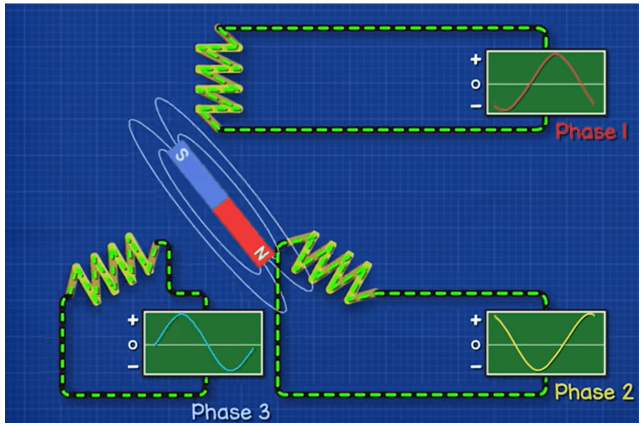
- **Magnetic Field Created**
  - The rotor (field) produces a magnetic field — either from permanent magnets or an electromagnet.
  - Field lines pass through the stator windings.

- **Coil Rotation Begins**
  - The rotor is turned by a prime mover such as a turbine or engine.
  - As it spins, the magnetic flux through the stator coils continually changes.

- **Electromagnetic Induction Occurs**
  - According to Faraday's Law, a changing magnetic flux induces an EMF (voltage) in the coils.
  - The direction of induced current alternates as the magnetic poles pass the windings.

- **AC Voltage Generated**
  - The induced EMF follows a sinusoidal waveform, alternating between positive and negative values.
  - Frequency depends on the rotational speed and number of magnetic poles.

- **Current Delivered to Load**
  - Slip rings and brushes maintain contact between the rotating coil and external circuit.
  - The alternating current flows out to supply electrical power.



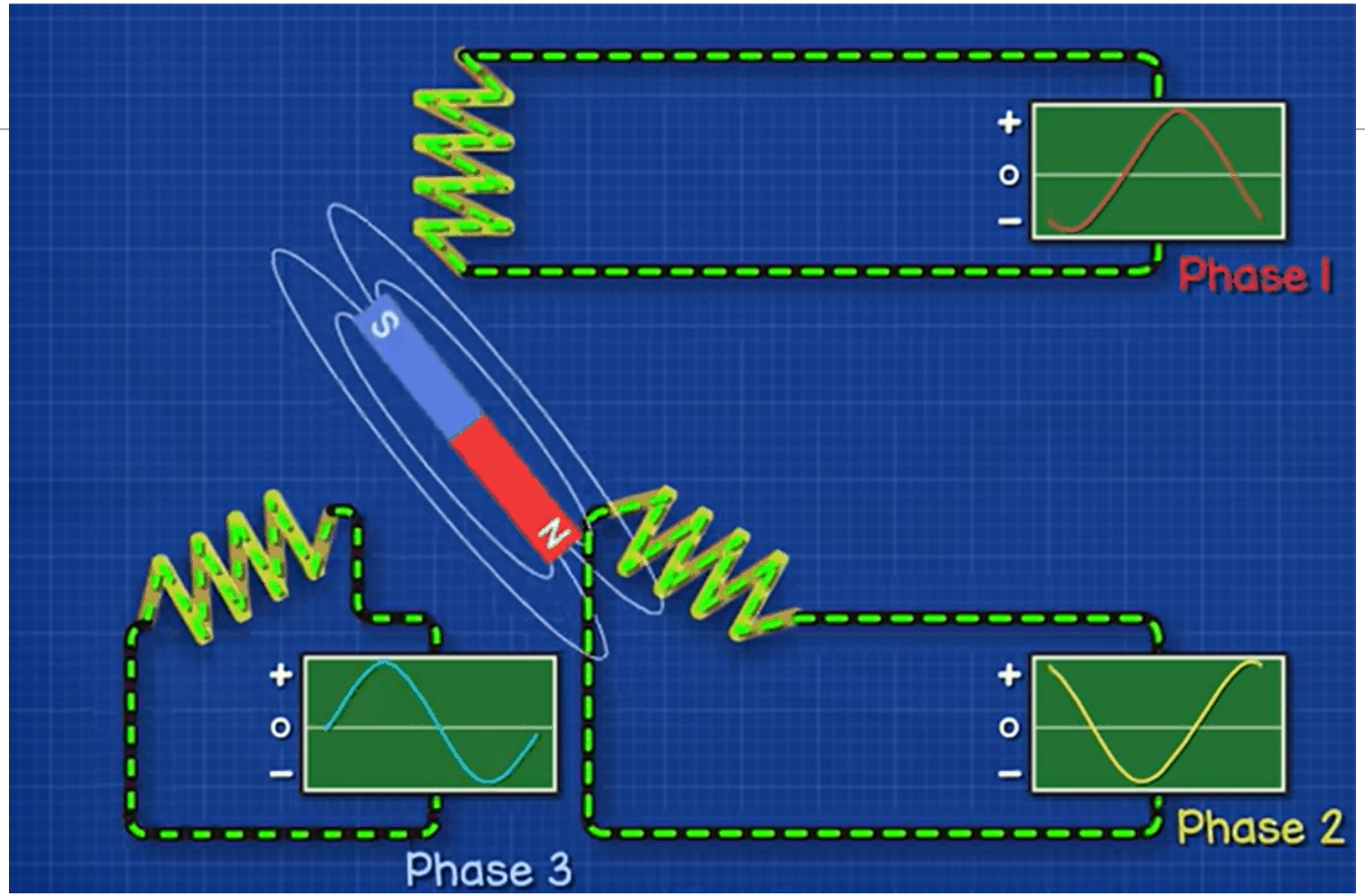
# Frequency of output

- The frequency (f) is how many cycles occur per second, measured in Hertz (Hz).

- Determined by the generator's speed and number of poles:

$$f = \frac{N \times P}{120}$$

(where $N$ = RPM, $P$ = poles)


+
o
−
Phase 1
S
N
Phase 3
Phase 2