

# EE2029: Introduction to Electrical Energy System

## How do Generators Work?

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# Learning Outcomes

- Electromagnetic induction
- A simple generator
- Main components of a generator
- Types of rotor

# Electromagnetic Induction

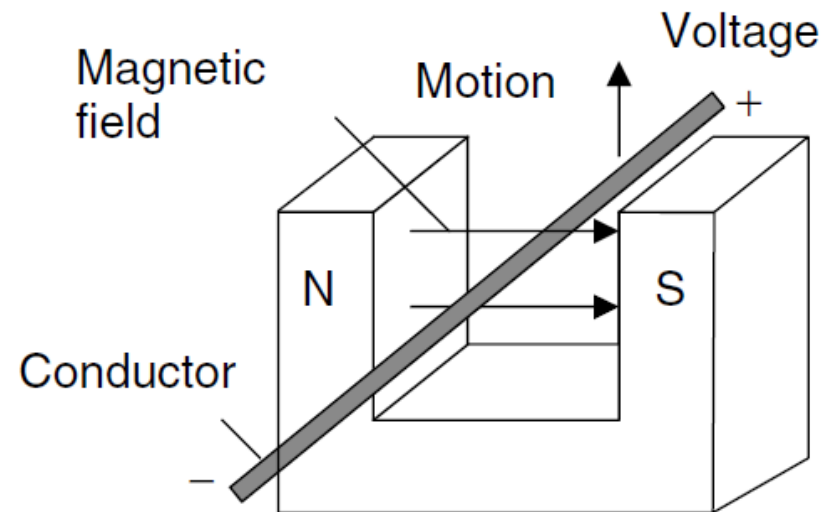
- **Moving** a conductor through a magnetic field.
- Induced electromotive force (EMF), voltage generated by the magnetic force across wire.
- Faraday's law:



Michael Faraday,  
English chemist and physicist, 1791-1867.

Electricity  
rocks!

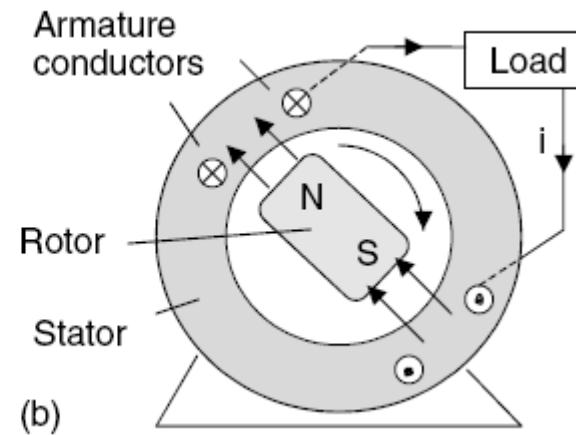
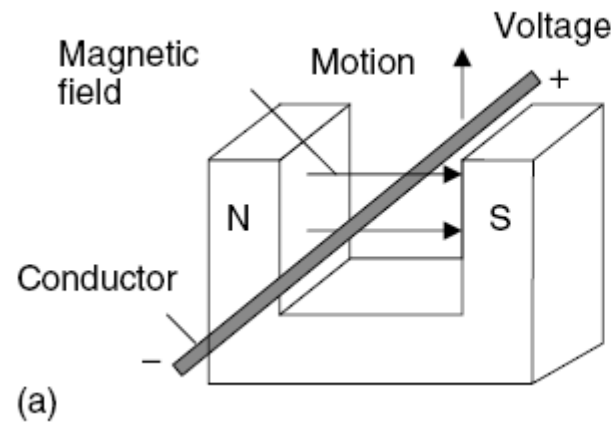
$$e = N \frac{d\phi}{dt}$$



# A Simple Generator

- Need **mechanical force** to move the **magnetic field** to generate “*Relative motion*” between a conductor and a magnetic field.
- Key concept:

Mechanical Input → Electrical Output



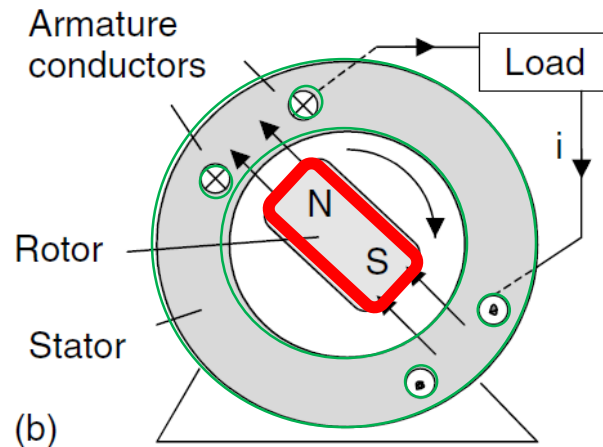
# Main Components of a Generator

## Rotor

- Moving part that is usually made of electromagnet materials.

## Stator

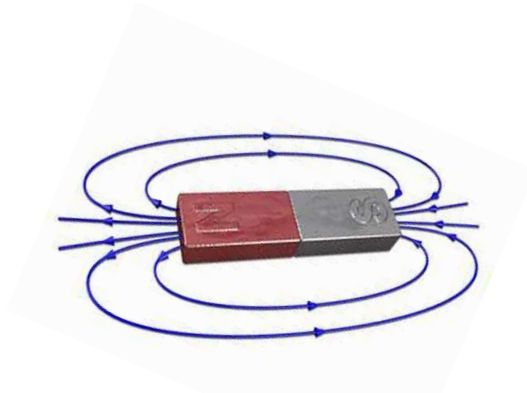
- Stationary part that contains a set of conductors called 'armature winding'.



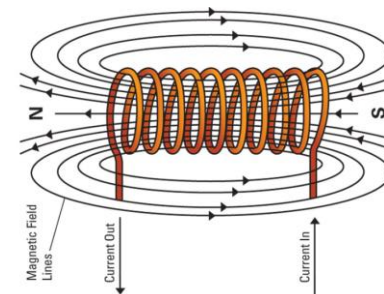
- indicates the positive current is directed out of plane of the paper.
- × indicates the positive current is directed into the plane of the paper.

# Constant Magnetic Fields at Rotor

- We can produce constant magnetic fields at the rotor by two methods.
  1. Using permanent magnet. This is only suitable for small generators.
  2. Create magnetic fields using DC current supplied through coil. The DC power source is called 'exciter'. The coil is called 'field winding'.

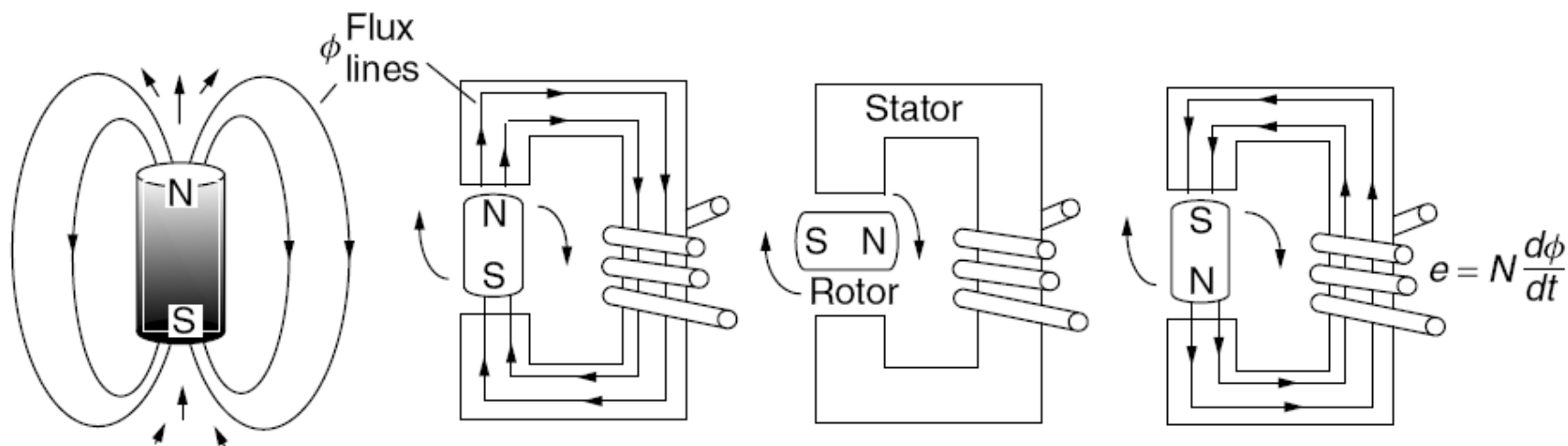


Source:  
<http://www.magnet.fsu.edu/education/tutorials/magnetminute/permanent.html>

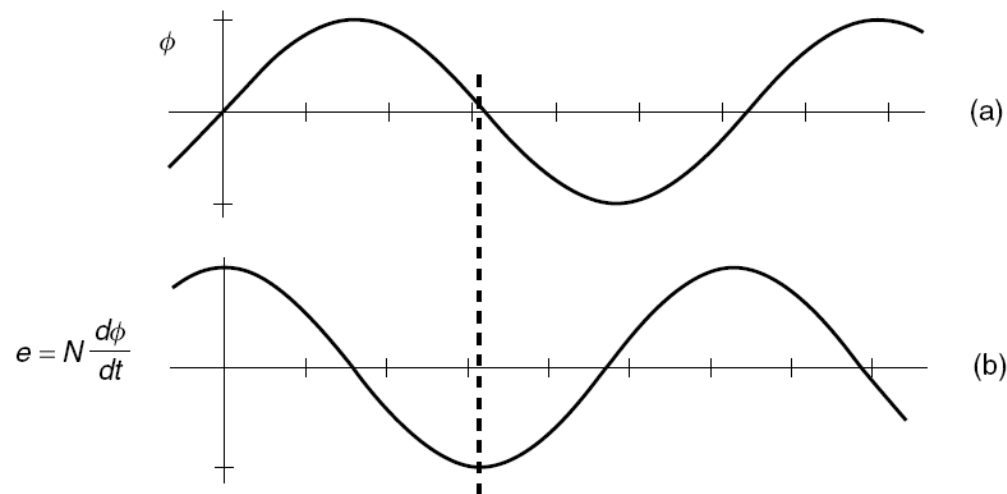


Source:  
<http://www.lanl.gov/news/index.php/fuseaction/1663.article/d/20085/id/13276>

# Electromagnetic Induction at Stator

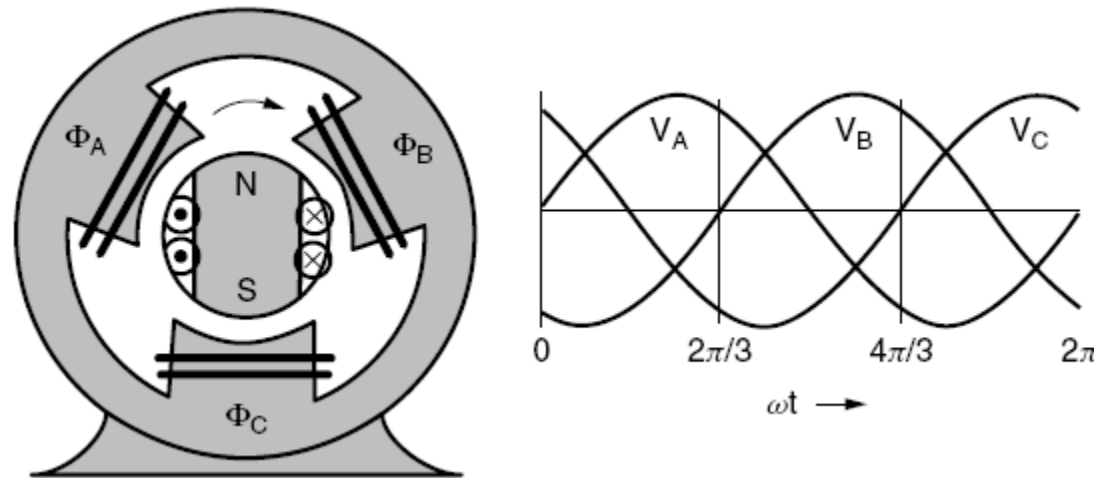


$$e = N \frac{d\phi}{dt}$$



# Positive VS Negative Sequence

- Positive and negative sequences can be achieved by **how we label the conductors** at the stator.



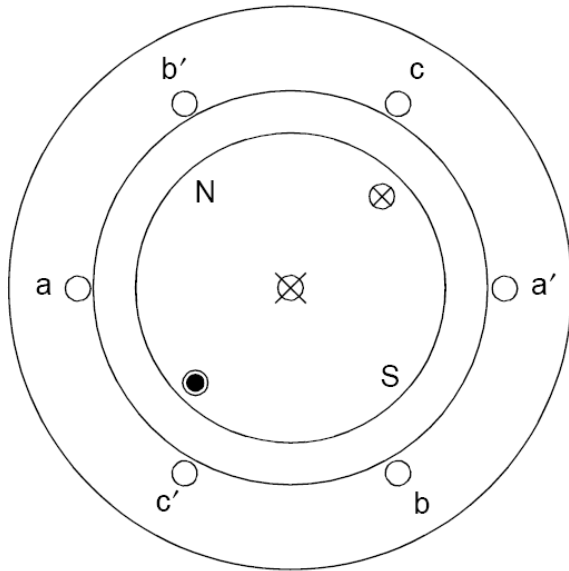
*By swapping b to c, the voltage source will produce negative sequence.*



# Types of Rotor

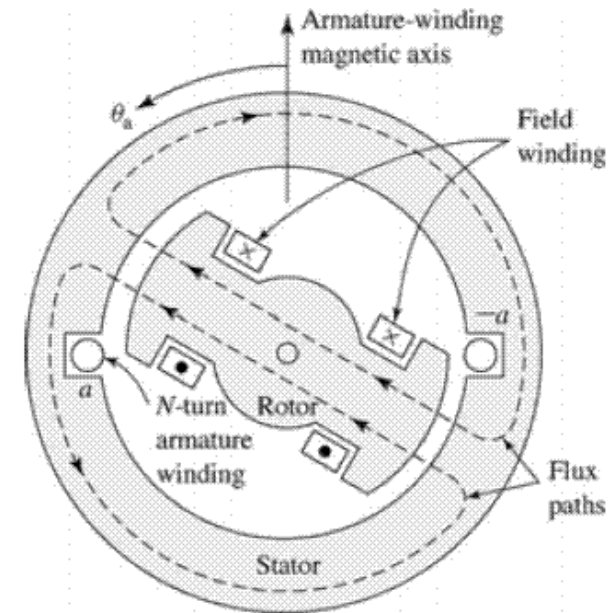
## Cylindrical (Round) Rotor

- High speed application such as steam turbine at 3600 or 1800 rpm



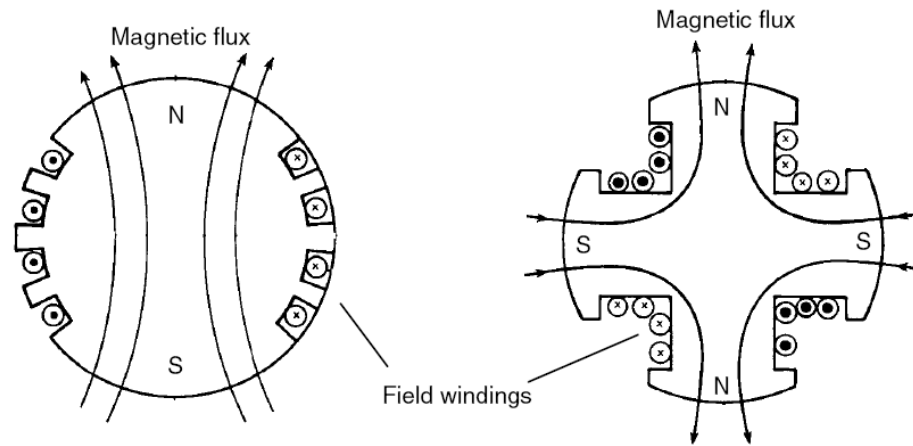
## Salient Rotor

- Low speed hydro turbines at a few hundred rpm.



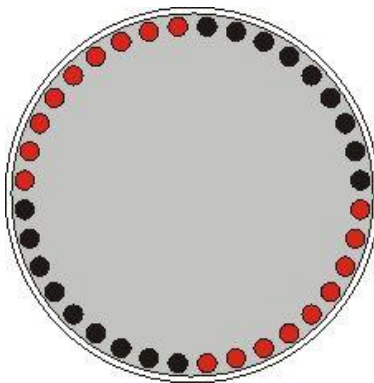
Source: <http://cnx.org/content/m28323/latest/?collection=col10767/latest>

# Multi-Pole Rotor

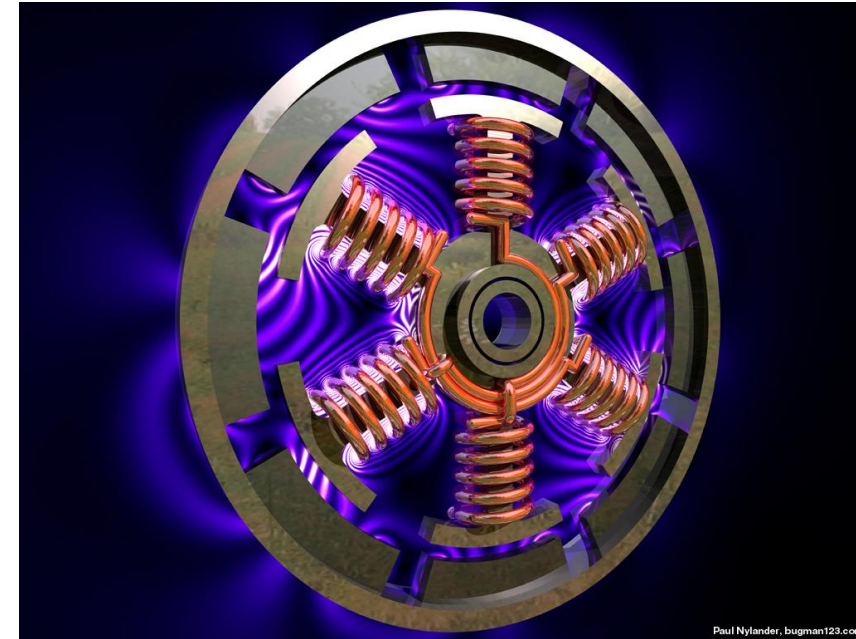


2-pole round rotor

4-pole salient-pole rotor



4-pole round rotor



6-pole salient-pole rotor

Source:  
<http://www.bugman123.com/Engineering/Motor-large.jpg>

# Summary