

Automotive Alternators

Team 9

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Agenda

History: DC vs AC

DC/AC Field Theory

Electromagnetic Induction

**Parts of a Wye-Connected
Automotive Alternator**

Power Generation Process

Different Types of Alternators

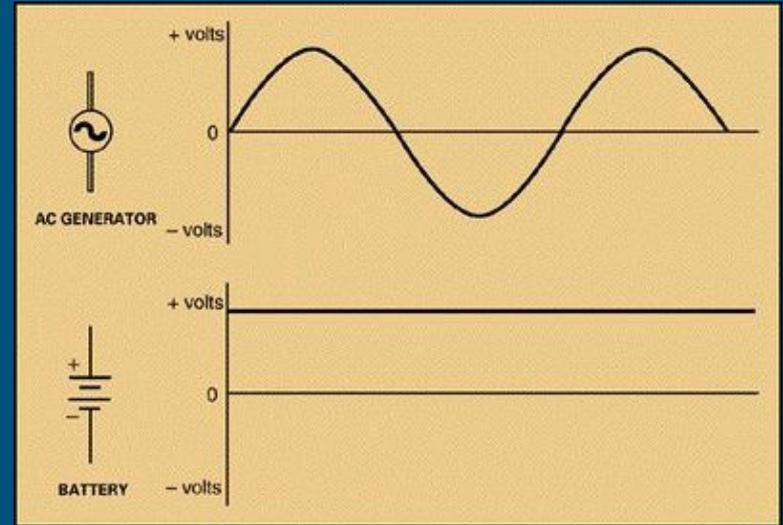
**Importance of Automotive
Alternators**

War of Currents: DC vs. AC

- Late 1880's: Thomas Edison vs. Nikola Tesla

- DC not easily converted

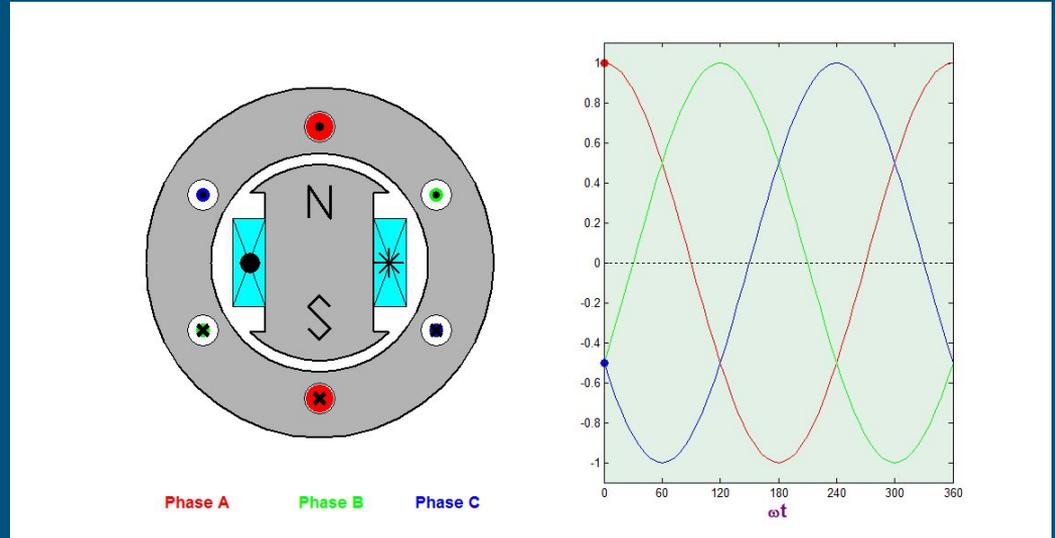
- Solution: Alternating Current



- Can easily be converted to different voltages using transformer

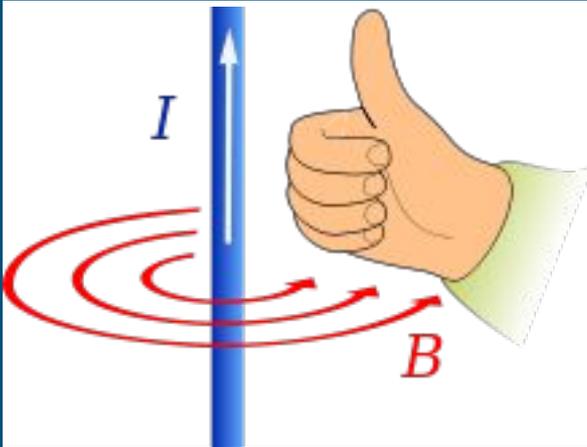
Usage of AC and DC

- Electric Vehicles and computers run on DC power
- Discovery of AC led to creation of generators

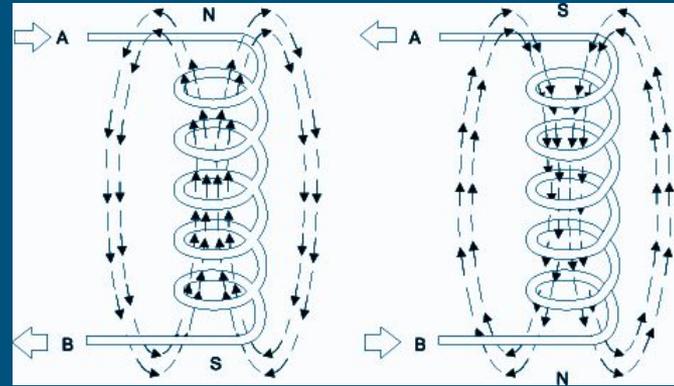


DC Field Theory

- A DC current through a wire produces a magnetic field



$$B = \frac{\mu_0 I}{2\pi r}$$



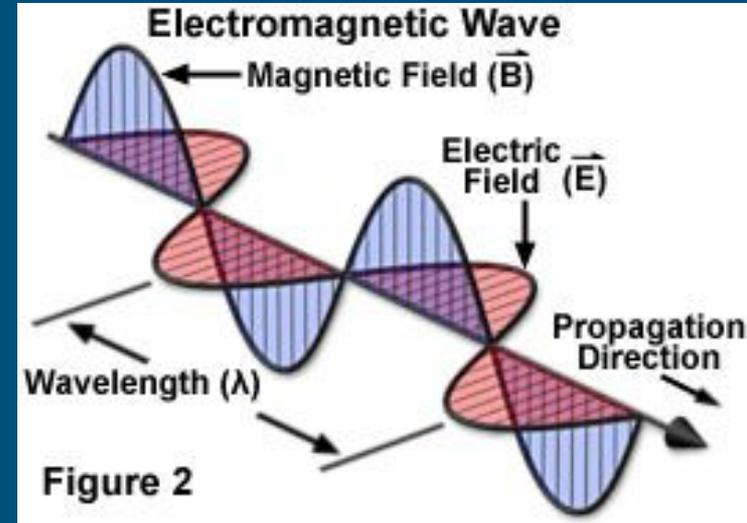
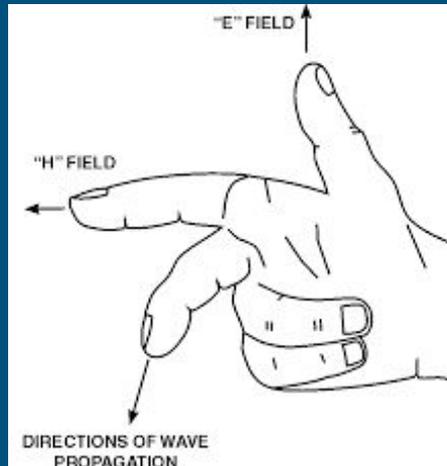
$$\vec{B} = \mu_0 \frac{N}{L} I$$

AC field Theory

- Maxwell Faraday equation
- Ampere Maxwell Law
- Direction of propagation using the right hand rule

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}(t)}{\partial t}$$

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \epsilon_0 \frac{\partial \mathbf{E}}{\partial t}$$

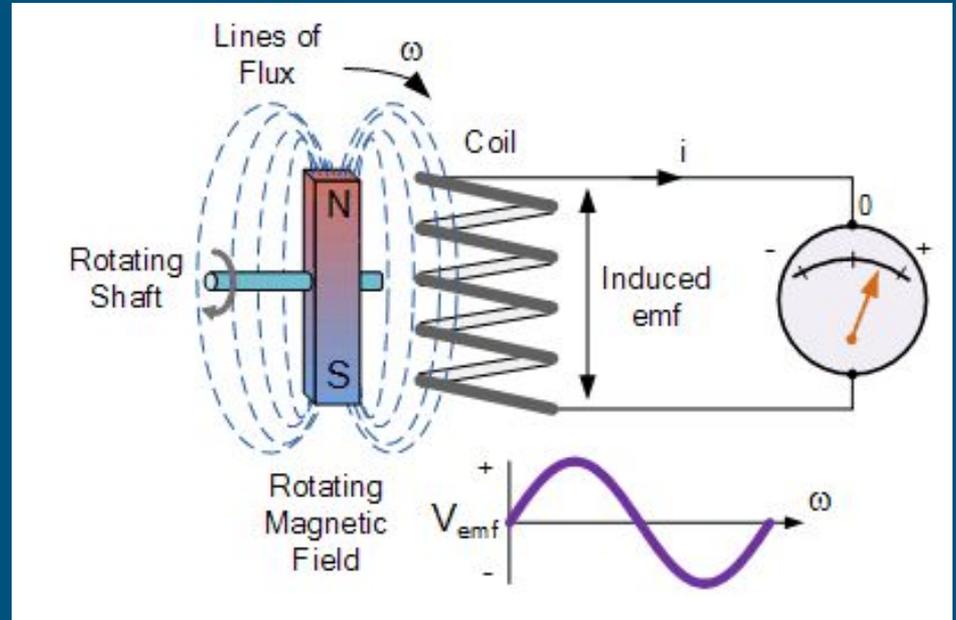


<http://www.olympusmicro.com/primer/lightandcolor/electromagintro.html>

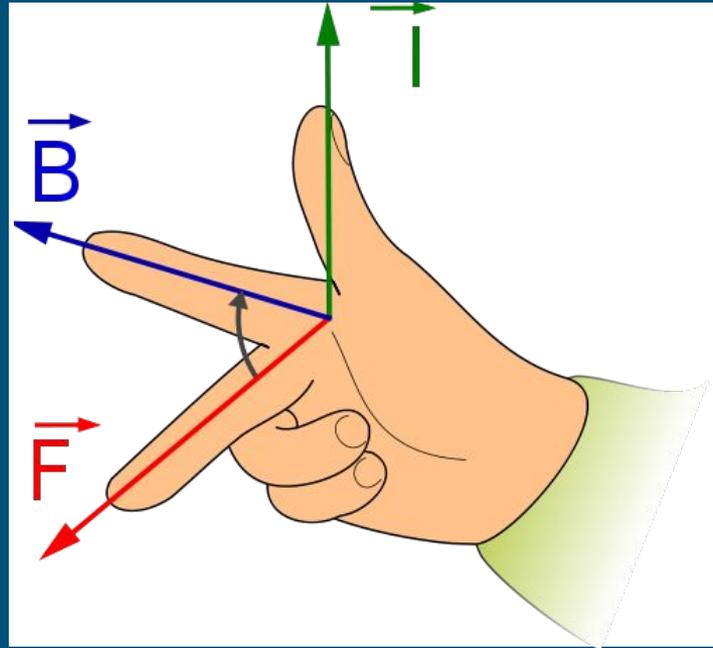
Electromagnetic Induction

- Faraday's law
- A time varying magnetic field induces a current in a coil of wire

$$\mathcal{E} = -N \frac{d\Phi_B}{dt}$$

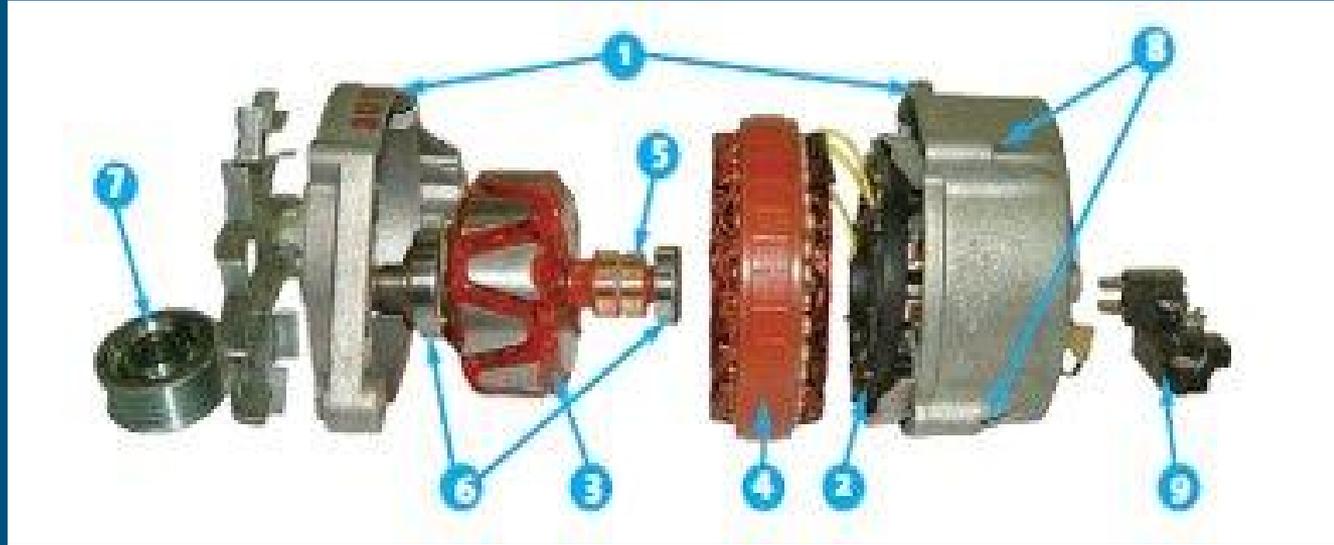


Right Hand Rule for Current, Force, and Magnetic Field



Parts of a Wye-Connected Alternator

1. Aluminum shield
2. Diode rectifier
3. Claw-pole rotor
4. Stator windings
5. Rotor slip rings
6. Roller bearings
7. Pulley
8. Mounting points
9. Voltage regulator



Rotor and Stator

Rotor

- Coil of wire wrapped around iron core
- Field current (DC) produces a magnetic field around core
- Driven by alternator pulley attached to the engine



<http://www.kava-auto.com/product/533-motorola-alternator-parts-motorola-8lha--8lhp-alternators-rotor-28-505--e0fd/>

Stator

- Set of coils fixed to the shell of the alternator
- Magnetic field from rotor produces current in windings
- Placed 120 degrees apart, producing 3 separate phases



<http://store.alternatorparts.com/cs144-series-alternator-stator.aspx>

Diode Rectifier and Voltage Regulator

Diode Rectifier

- AC current needs to be converted to DC in order to be used
- Diode rectification produces pulsed DC voltage
- Critical automotive components have internal filtering circuits



http://starterok.com/rectifier-alternator_cargo_138389.html

Voltage Regulator

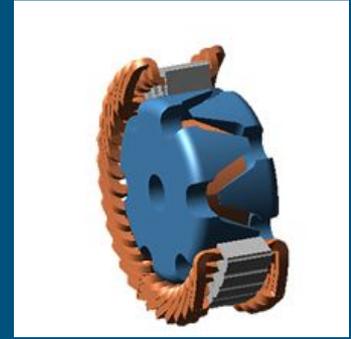
- Two inputs, one output
- Inputs: field current supply and battery voltage input
- Output: field current to the rotor



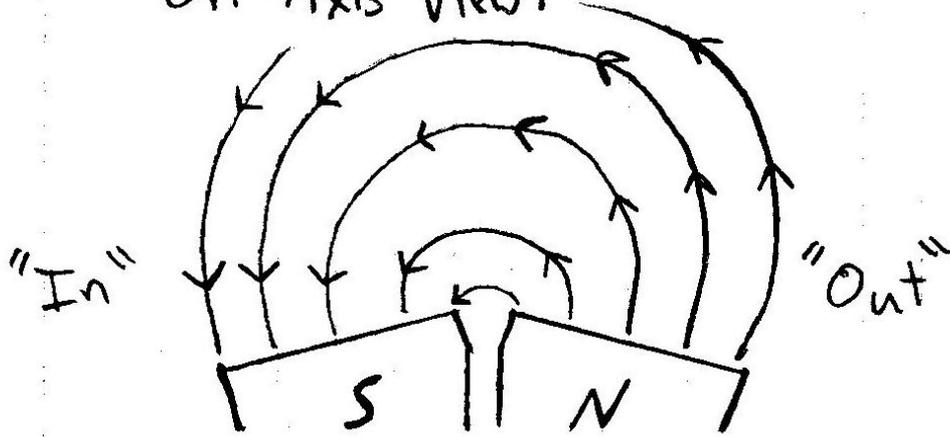
http://starterok.com/voltage-regulator-alternator_cargo_333255.html

Claw Pole Rotor

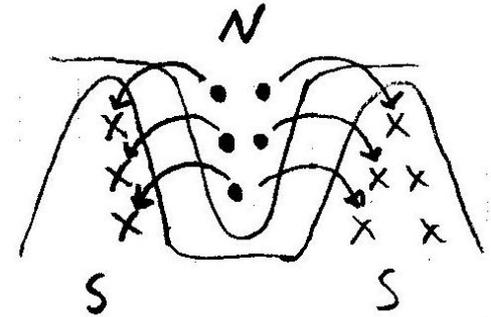
- Helps generate and orient magnetic field lines



- On-Axis View:

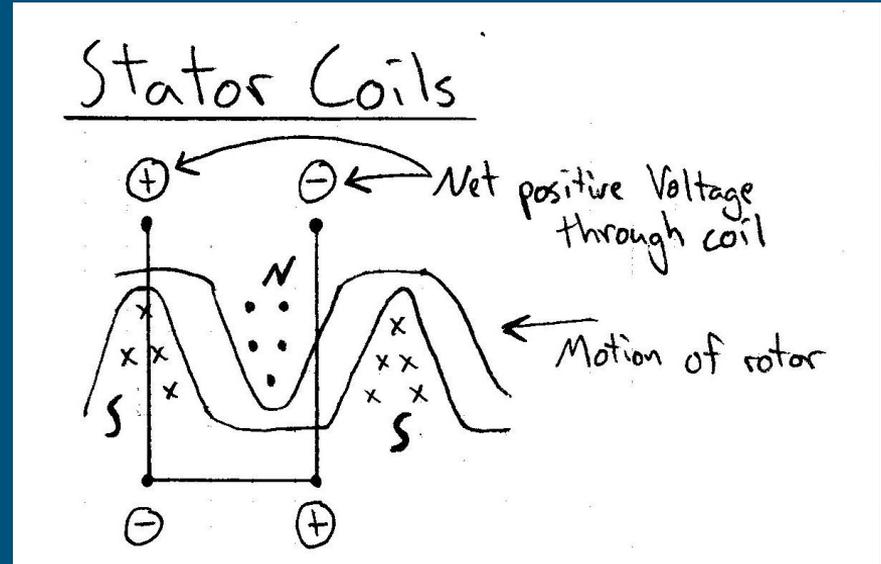


- Top View:



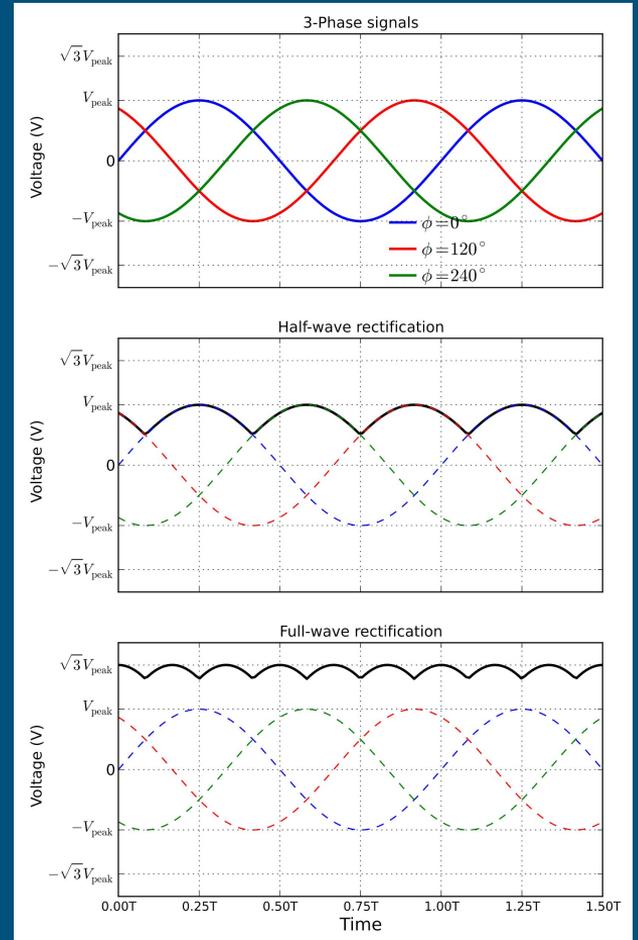
Stator Coils

- Introduce stator coils to the claw-pole rotor field
- As rotor turns, the polarity flips
- Alternating Current!



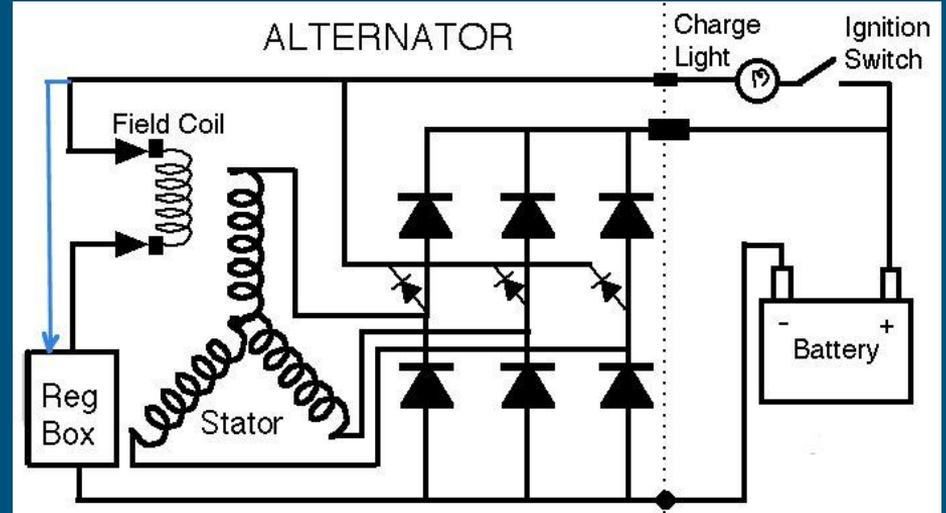
Rectification of AC voltage

- 3 sets of coils offset by 120 degrees creates 3 phase power.
- rectified by a simple diode circuit
- Ripple is reduced without need for large capacitors



Circuit Overview

- 3 stator coils and field coil
- 3 or 6 diodes for half or full wave rectification
- Some applications have additional filtering



Classification by Excitation - Field Coils

- Transformation and Rectification
 - Small residual magnetism in iron core of rotor
 - The alternator generates a stronger voltage that builds up
 - After build-up the field is supplied by rectified voltage from stator with brushes
- Direct Connected DC Generator
 - Smaller generator to excite the field coils
 - Brushes to excite the rotor
 - Variation: direct current from a battery for excitation, i.e. automotive alternator

Classification by Excitation - Magnets

- Magnetos
 - Two alternators end - to - end
 - Main alternator and Exciter
 - Exciter has a stationary field coil and rotating armature (power coils)
 - Main alternator has a rotating field coil and stationary armature (magnets)
 - No brushes or slip rings

Classification by Phases

- Single to Polyphase
 - 3 Phase automotive alternator

Classification by Rotating Part

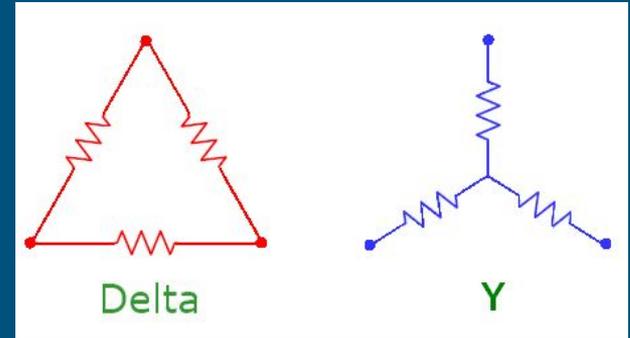
- Field in Stator
- Field in Rotor
 - Field in rotor uses less power, slip ring / brushes are less costly

Classification by Application

- Electric Generators
 - Power stations
- Automotive Alternators
- Locomotive Alternators
 - Power for electric traction motors
- Radio Alternators

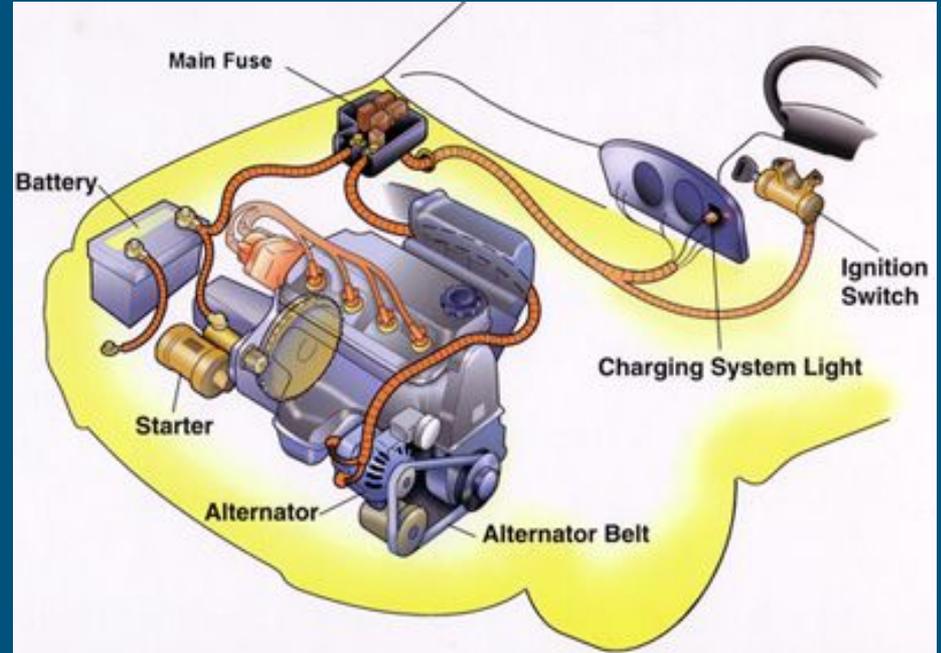
Automotive Alternator Types

- Delta Configuration of the Stator
 - Lower voltage, higher current
 - Typical for gasoline engines
 - Higher reliability
 - Line current greater than the phase current by 1.73
- Wye (Y) Configuration of the Stator
 - Higher voltage, lower current
 - Ideal for diesel engines due to lower RPM
 - Can be found in newer automotive alternators
 - Series doubles resistance
 - Line voltage greater than phase voltage by 1.73



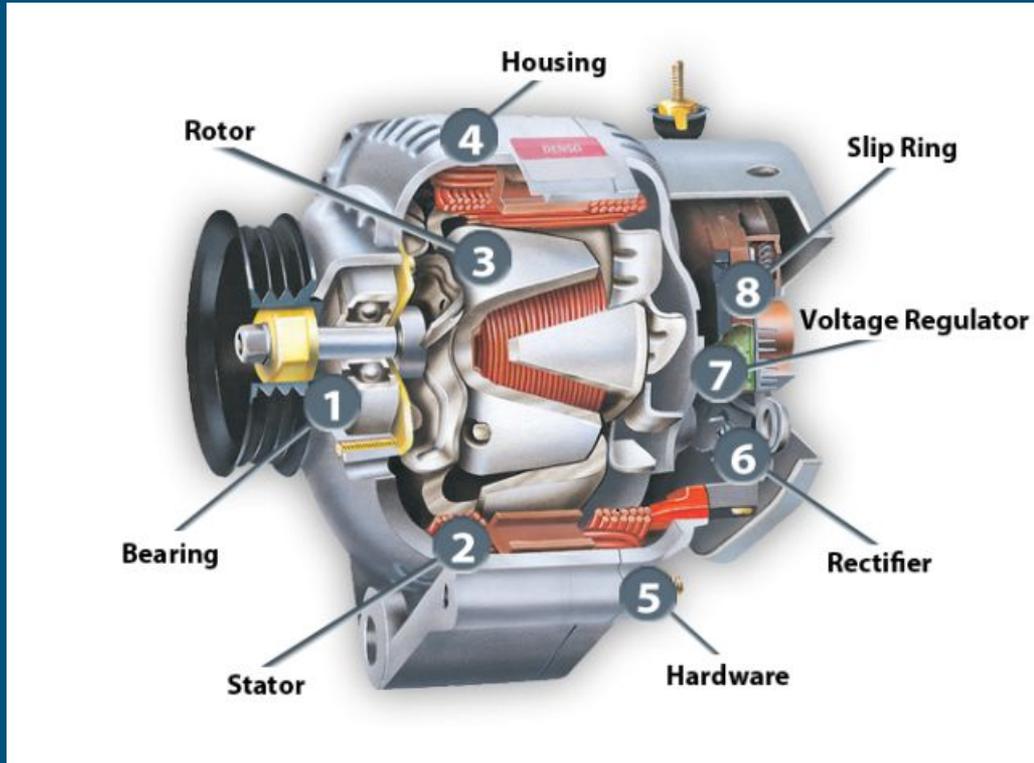
Importance of Automotive Alternators

- Converts mechanical energy to electrical energy
- Uses current generated to power vehicle's electrical components
- Excellent balance between efficiency and cost



Versatility of Alternators

- Customizable
- Reversible
- Dependable



Questions?
