Automotive Electrical Systems

Batteries, Charging and Starting Systems

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Automotive Electrical Systems

Battery Operation

- Batteries convert chemical energy into electrical energy
- During discharge the battery's plate composition is changed
- During charging the alternator returns the battery plates to their original composition

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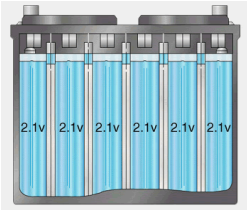
Battery Construction

- Positive plates
  - Lead peroxide - PbO_2
- Negative plates
  - Sponge lead - Pb
- Electrolyte
  - 36% sulfuric acid - H_2SO_4
  - 64% water - H_2O
- Cells are connected in series



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Battery State Of Charge

Specific Gravity	State of Charge	Battery Voltage
1.265	100%	12.65 volts
1.235	75%	12.4 volts
1.200	50%	12.2 volts
1.165	25%	12.0 volts
1.135	Discharged	11.7 volts

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Battery Rating Systems

- Cold-Cranking Amps
  - number of amps a battery can deliver for 30 seconds at 0° F without the cell voltage falling below 1.2 volts
- Cranking Amps
  - number of amps a battery can deliver for 30 seconds at 32° F without the cell voltage falling below 1.2 volts
- Reserve Capacity
  - Length of time a fully charged battery can deliver 25 amps at 80° F
- Ampere-Hour Rating
  - current the battery can deliver for for 20 hours without the cell voltage dropping below 1.75 volts at 80° F

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Battery Load Test

- Open Terminal Voltage above 12.4 volts
- Load test the battery for 15 seconds at:
  - ½ the cold cranking amp rating
- The battery's voltage should not fall below 9.6 volts

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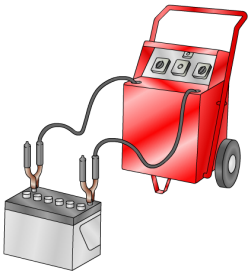
Three Minute Charge Test

- Charge the battery at a rate of 30 to 40 amps for three minutes
- If the terminal voltage remains below 15.5 volts charge the battery and re-conduct the load test
- If the terminal voltage exceeds15.5 volts the battery should be replaced



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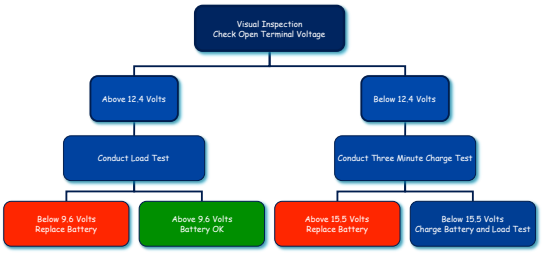
Battery Diagnosis



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Parasitic Draw

- A parasitic draw discharges the battery while the vehicle is parked
- Common causes of excessive parasitic draw include malfunctioning hood, trunk, glove box and courtesy lamp circuits
- Parasitic draw is diagnosed by monitoring current flow from the battery with the ignition and all non-ignition switched circuits turned off
- A maximum of 50 mA of current flow is a common parasitic draw specification

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Charging System

- Alternator
- Drive belt
- Voltage regulator
- Indicator lamp or gauge
- Battery
- Wiring and circuit protection

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Charging System Operation

- Alternators use magnetic induction to produce AC voltage
- Diodes convert the AC voltage into DC voltage
- The voltage regulator controls alternator output by regulating the field current

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Alternator Components

- Rotor & brushes
- Stator
- Diode rectifier
- Voltage regulator
- Generator housing

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Alternator Circuits

- B+ Output
  - connection to battery and vehicle electrical system for alternator output
- I Circuit
  - ignition circuit
  - used to turn on the voltage regulator
  - Powered when the ignition switch is in the run position
- A Circuit
  - provides power for rotor
  - current flow controlled by voltage regulator
- S Circuit
  - stator circuit
  - ½ alternator output to voltage regulator

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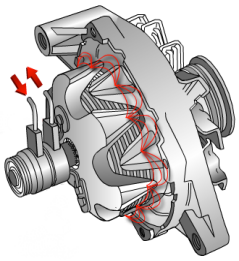
Rotor Operation

- The rotor is the electromagnet rotated to induce a voltage output in the alternator's stator windings
  - Brushes
  - Slip rings
  - Field windings
  - Pole pieces



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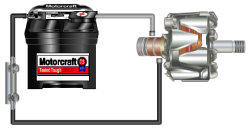
Voltage Regulator Operation

- The voltage regulator monitor's stator output on the S circuit and controls alternator output by modulating the rotor's field current flow through the A circuit
- The rotor's current flow may be regulated on the power or ground side



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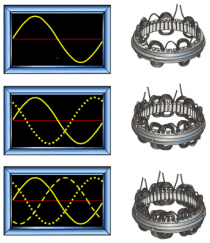
Stator Operation

- The rotor induces an AC voltage output from the stator
- The stator's output is controlled by varying the strength of the rotor's magnetic field
- Diodes are used to rectify the stator's AC output into DC voltage



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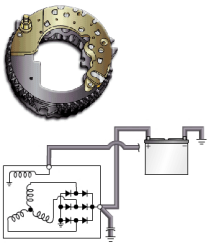
Rectifier Operation

- The rectifier bridge uses diodes to convert the AC sine waves generated by each set of stator windings into phased DC voltage output



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Charging System Inspection

- Undercharging
  - dead battery, slow cranking, indicator lamp on
- Overcharging
  - battery boiling, high voltage, excessive bulb failures, indicator lamp on
- Check battery condition
- Check belt tension
- Check wiring, connections and grounds
- Check alternator input terminals for proper signals

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Check Alternator Operation

- Hook up VAT 40/60 or equivalent to monitor alternator output and battery voltage
- Check alternator's output and battery voltage at idle and 2000 RPM with all electrical loads turned off
- Check the alternator's output and battery voltage at idle and 2000 RPM with approximately a 40 amp electrical load applied
- Check the alternator for maximum rated current output by applying a load with the VAT 40/60 or equivalent while operating the engine at 2000 RPM
- Compare the readings to vehicle specifications

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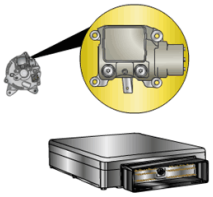
Isolating Charging Concerns

- Some vehicles allow full or increased battery power to be applied to the field
  - if the alternator is defective there will be no change in alternator output
  - If output increases the field control system is at fault



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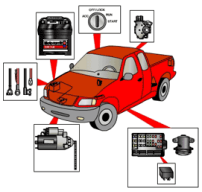
Starting System Components

- Starter
- Battery
- Cables and Wires
- Ignition switch
- Starter relay
- Starter solenoid
- Manual Lever Position (MLP) switch
- Starter Clutch Pedal Position (SCPP) switch



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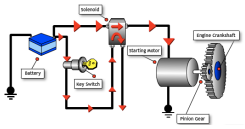
Starting System Operation

- The battery provides power to the ignition switch and starter relay
- Closing the ignition switch provides power through the neutral or clutch safety switch to the starter relay
  - MLP versus CES
- The starter relay energizes the starter solenoid and motor



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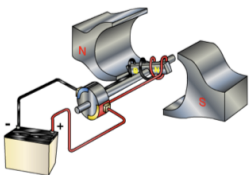
Motor Operation

- The magnetic pole in the armature is attracted and rotates toward the opposite magnetic pole of the field
- The commutator rotates with the armature reversing the armature's current flow/magnetic field and the like magnetic poles now move the armature away from the field



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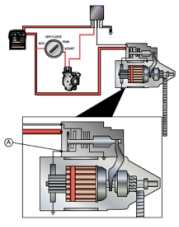
Solenoid Actuated Starter

- The battery provides power to the ignition switch and starter relay
- Closing the ignition switch provides power through the MLP to the starter relay
- The starter relay delivers power to the starter solenoid
- The solenoid moves the starter drive into position and energizes the starter motor



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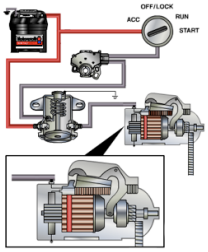
Moveable Pole Shoe Starter

- The moveable pole shoe starting system uses a fender mounted relay to send current to the starter motor
- A moveable pole shoe is used to engage the starter drive with the flywheel and complete the circuit allowing current to flow to the field coils and armature



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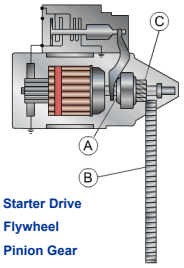
Starter Motor

- Armature
- Field coils or field magnets
- Brushes
- Solenoid
- Drive assembly
- Frame or housing



A – Starter Drive
B – Flywheel
C – Pinion Gear

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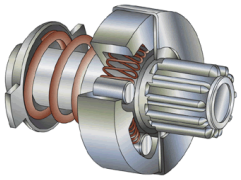
Starter Drive Gear

- The starter drive has an overrunning clutch that engages the pinion gear with the flywheel as the starter motor turns
- The overrunning clutch freewheels when the engine takes over and protects the starter motor from damage



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Starter Draw and Performance Test

- Connect an inductive ammeter to measure current flow from battery during cranking
- Connect a tachometer to measure cranking speed
- Disable the fuel injection system and ignition system
- Crank the engine for 15 seconds and monitor current flow and engine cranking speed
- Listen for any abnormal sounds during engagement operation and disengagement
- Compare your results to the vehicle's specifications

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Engine Does Not Crank

- Loose or corroded battery cable connections
- Undercharged battery
- Malfunctioning starter motor
- Malfunctioning ignition switch
- Malfunctioning starter relay or solenoid
- Malfunctioning transmission or clutch safety switch

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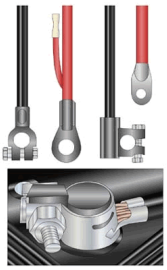
Engine Cranks Slowly

- Loose or corroded battery cable connections
- Undercharged battery
- Loose or corroded starter motor connections
- Malfunctioning starter motor
- Excessive engine rotational force required



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Unusual Starter Noise

- Starter motor improperly mounted
- Malfunctioning starter motor
- Damaged flywheel teeth and or starter drive