Light Duty
Starting & Charging Systems

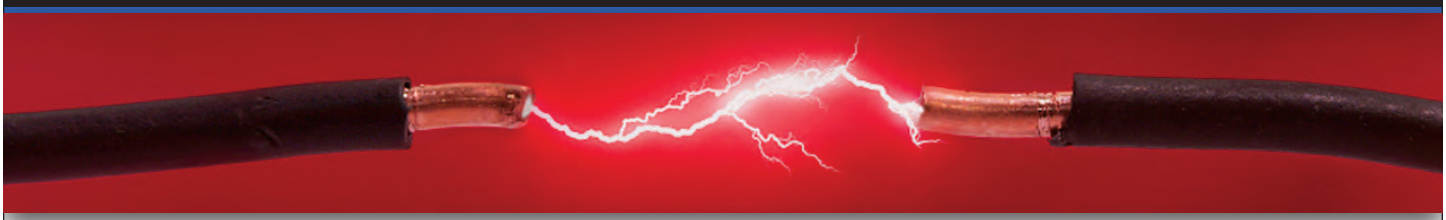


The battery, starter & alternator

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Starting & Charging Systems

The battery, starter & alternator



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Electricity 101: Voltage, Amperage & Ohms

Voltage	Voltage is the electrical pressure or force that causes current or electrons to flow through a conductor. Voltage can also be described as the difference in electrical pressure between two points in a circuit. This electrical force or pressure is measured in volts.
Amperage	Electrical current is the flow or movement of electrons in a conductor. Without pressure (voltage) the current will not flow. Electrical flow is measured in amperes (amps).
Ohms	An ohm is a force that reduces or stops the flow of current. It is also known as electrical resistance. Resistance is the opposition to current flow. Higher resistance = decreased current flow. Lower resistance = increased current flow.

Ohm's Law
It takes **one volt**
to push **one amp**
through **one ohm**

Electricity 101: Resistance

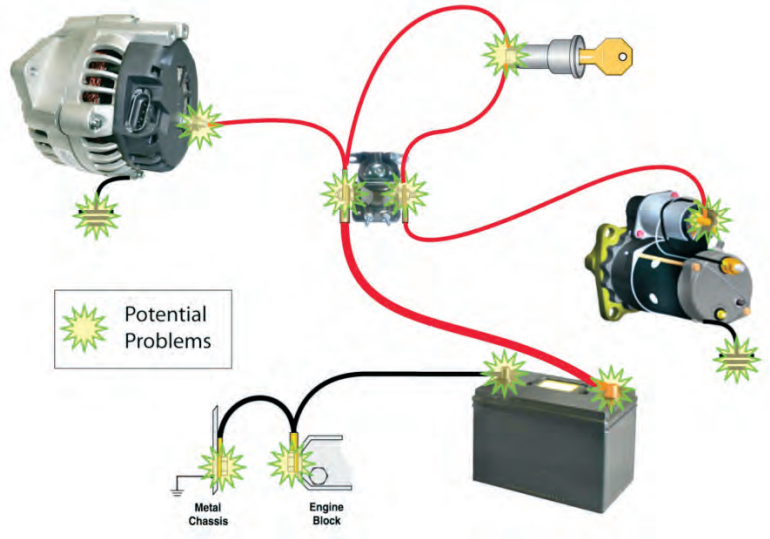
Resistance is the restriction that prevents amperage from moving through the conductor.

Types of resistance can be:
- Corrosion
- Frayed cables
- Loose connections
- Gauge of cable too small

The green star bursts in this diagram represent areas in a circuit where high resistance can occur.

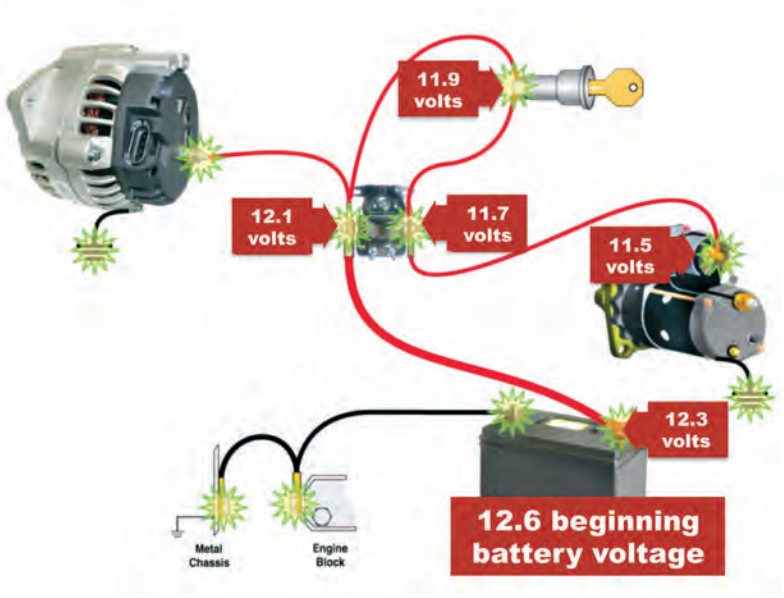
These connections start out clean and tight, however, over time corrosion build up can cause high resistance.

This can have a huge effect on performance.



With each point of high resistance, voltage is lost.

Low voltage reading at the starter can fail to start the vehicle and damage the starter.

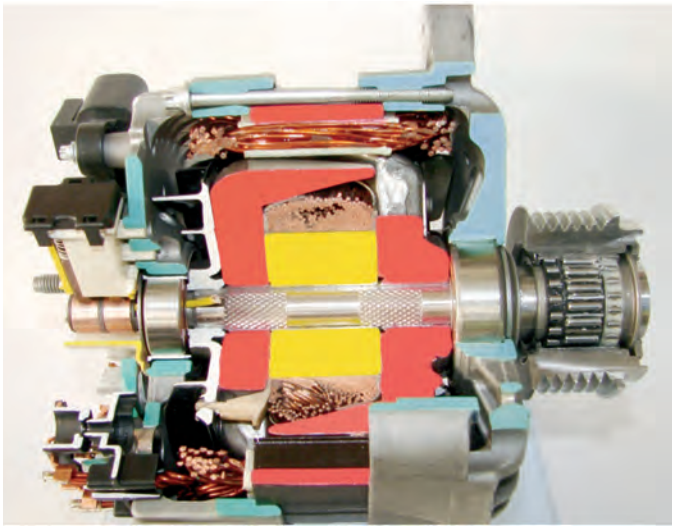


The Alternator: It's Function, The Stator & The Rotor

The alternator is part of a larger system comprised of the battery, starter, alternator, interconnecting wiring, electrical and mechanical switches.

The role of a alternator is to convert mechanical energy into electrical energy.

The alternator supplies current for the vehicle's electrical loads and replenishes battery voltage used by the starting motor during cranking.





A typical stator assembly consists of three separate windings mounted on a laminated iron frame.

Stator windings in the alternator generate three-phase AC voltage.

Positive and negative diodes change the AC voltage into DC voltage. DC voltage allows the current to flow to the battery terminals.



The rotor coil is an electromagnet which produces alternate north and south poles.

As the rotor turns, the north and south poles cross each loop in the stator windings and voltage is induced in the windings.

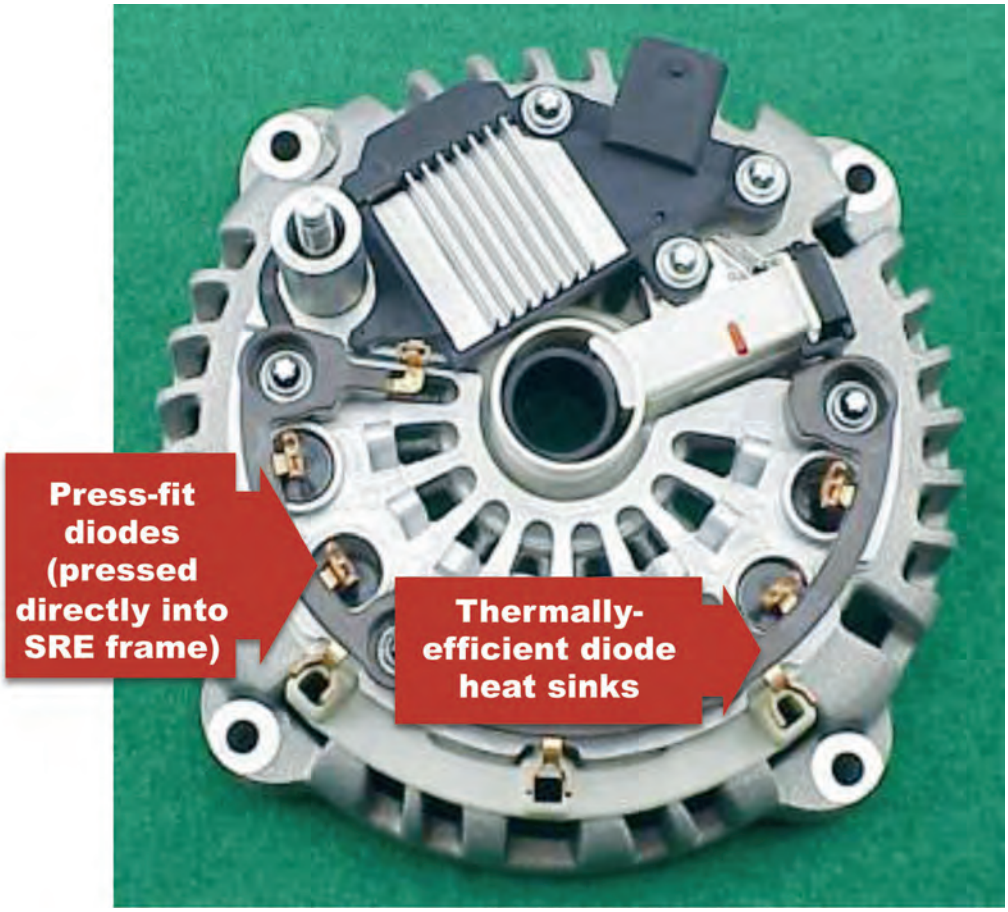
The amount of voltage generated in the stator is dependent upon the speed of the turning rotor – the greater the speed, the greater the voltage. This action creates a current flow into the stator.

The Alternator: The Rectifier

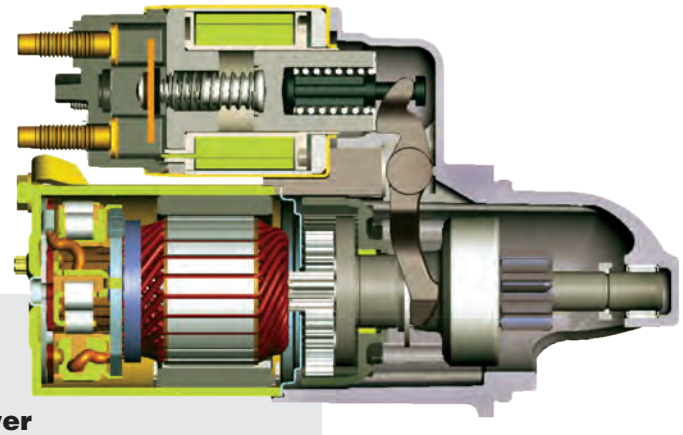
Since the vehicle needs DC power, most rectifier bridges contain six diodes that convert AC current into DC current.

Three of the diodes are connected to ground and the other three are mounted to an insulator (+).

Since AC continually alternates between positive and negative, the diodes regulate the positive and negative output.



The Starter: The Components & Starting Motors



Sealed solenoid cover
Eliminates water intrusion
Reduced contact icing occurrences

Terminals with lead-in
Reduced cross threading during vehicle assembly

Sealing gasket in Housing/Solenoid interface
Prevents water intrusion

One piece plunger/contact assembly
Reduced contact welding occurrences

Abutment spring located inside plunger
Improved life of plunger assembly

One piece plunger/contact assembly
Reduced contact welding occurrences

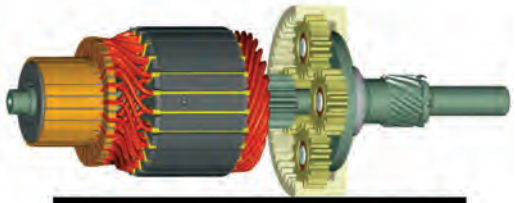
Abutment spring located inside plunger
Improved life of plunger assembly

Long life, lead free brushes
Extended motor life
Environmentally friendly
Copper/graphite mix tailored to starter type

High grade ferrite or neodymium magnets
Improved performance
Exceptional torque transmission

High strength molded commutator
Reduced failure from high speeds or temperature

Precision machined and balanced armature
Reduced air gap for increased performance
Improved sound quality
Reduced vibration





There are two types of starting motors used: conventional and gear reduction. Both are rated by power output in kilowatts (KW). The greater the output, the greater the cranking power.

The gear-reduction starter (PMGR) motor has a compact, high-speed motor and a set of reduction gears. While the motor is smaller and weighs less than a conventional starting motor, it operates at higher speed. The reduction gears transfer this torque to the pinion gear at ¼ the motor speed. The pinion gear still rotates faster than the gear on the convictional starter and with much greater torque.

The Starter: The Solenoid, Armature & The Motor Drive



The solenoid switch is basically two windings mounted around a hollow cylinder.

The cylinder contains a moveable core (or plunger) and a push rod and contact disk in line with the plunger.

When the windings are energized (when the ignition is turned to crank the engine), the plunger pulls the shift lever and moves the motor drive to mesh with the ring gear. The contact disk is pushed into firm contact with the solenoid battery and motor terminals. With the motor windings connected directly to the battery, cranking takes place.

The armature assembly consists of a stack of iron laminations located over a steel shaft, a commutator assembly, and the armature windings.



The winding ends are soldered or welded to the commutator bars which are electrically insulated from each other and from the iron shaft.

With a battery connected to the brushes, the direction of current flow under the north pole is the same in all conductors, and the current flow under the south pole is the same in all conductors. This arrangement provides maximum torque and causes the armature to rotate.

The motor drive mechanism is assembled onto the armature shaft and is the component part through which power is transmitted from the armature to the engine during the starting cycle.

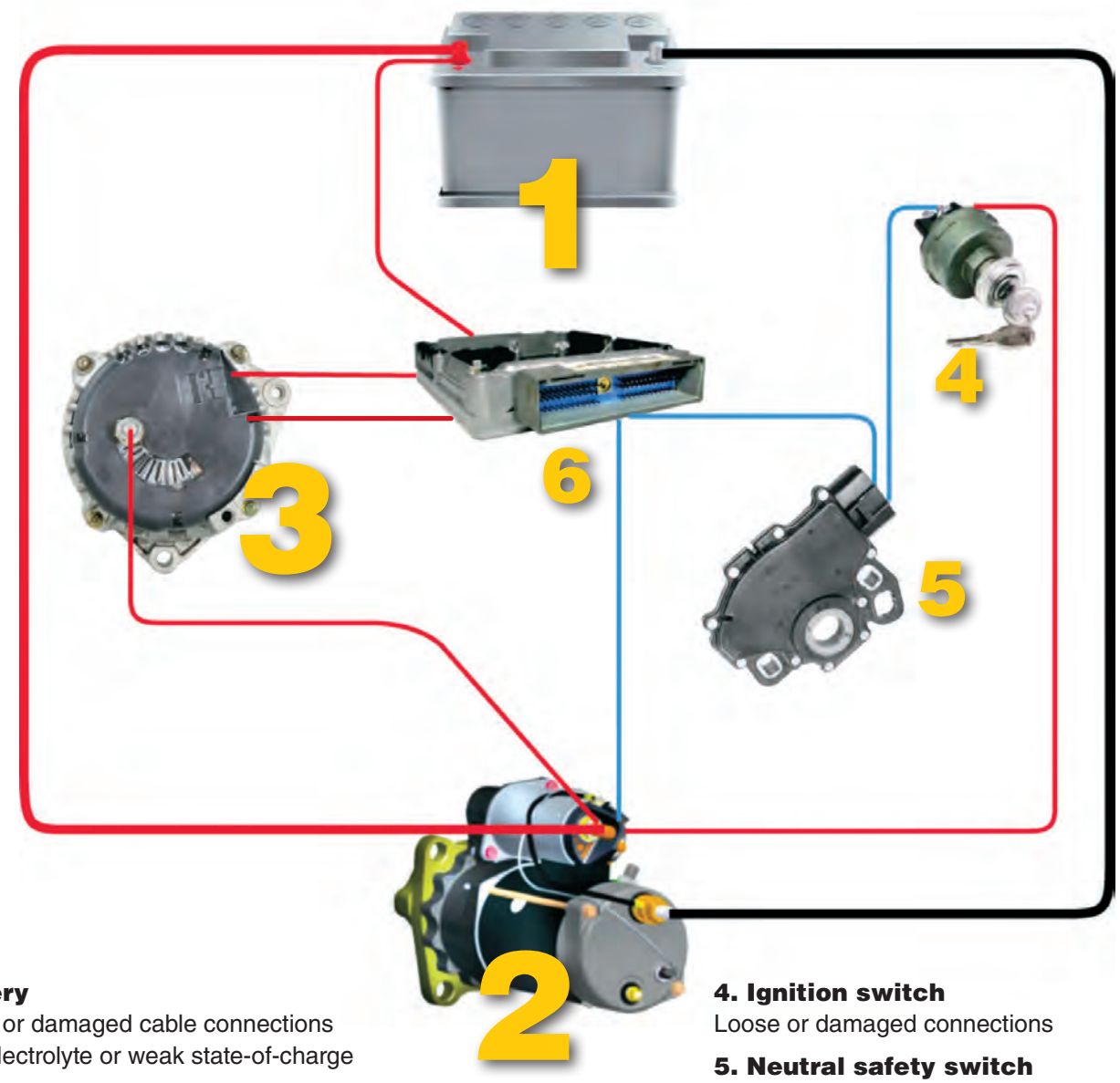


All drives, regardless of type, contain a pinion which is made to move along the shaft and engage the engine ring gear for cranking purposes.

When the engine has started, the ring gear drives the armature at speeds which could cause the windings to be thrown from their slots. Drive mechanisms are designed to disengage the pinion from the ring gear to provide an overrun feature when the engine spins the pinion faster than the armature. This design feature protects the armature from being driven to damaging speeds.

Troubleshooting: Electrical System

The system can have problems in the below 6 areas. We will review the 3 major component issues: battery, starter and alternator.



1. Battery
- Loose or damaged cable connections
- Low Electrolyte or weak state-of-charge

2. Starter
- Loose mounting
- Loose or damaged connections
- Solenoid control circuit has damaged or loose connections

3. Alternator
- Loose or damaged connections
- Loose mounting

4. Ignition switch
Loose or damaged connections

5. Neutral safety switch
Bad adjustment
Loose mounting
Loose or damaged connections

6. PCM
Check for charging system codes

Troubleshooting: Battery

1

Primary Causes of Battery Malfunction

The battery is the primary cause of electrical system malfunctions.

After the initial visual test for loose connections, corrosion or belt wear, the next step is testing the battery.





Loose or corroded battery connection will result in low circuit voltage.

Corrosion build up (white substance) on the cable to battery connections will result in low circuit voltage (voltage drop). Corrosion build up can be caused by loose or stripped connecting screws.

Corrosion build up on the battery terminals will result in high resistance connections resulting in the alternator ability to sustain vehicle requirements resulting in discharged batteries and loss of vehicle electrical loads.

Voltage drop (excessive resistance) can create a slow crank (no start) situation resulting in high current draw and damaging the starting motor. Once the connection is unstable (loose) then voltage spikes will occur, these spikes can result in alternator bridge diode failure and or regulator failure

Battery Life Cycle

Batteries are perishable devices that wear out at some point in time. With use, they gradually deteriorate, and become less capable of performing their important job. Also new, good batteries can become discharged for various reasons.

2 Primary Causes of Starting System Malfunction

Battery Charge

A battery having a low or poor state of charge will place abnormal stresses on the starting system. When measuring the battery voltage, make sure the voltage is 12.5v or greater.

Excessive Heat

A starter motor can become damaged if it operates too long at high temperatures. Excessive heat is generally due to continuous engagement of the starter.

Damage to starting system components can occur when the starter motor is cranked for long periods (often due to cold weather starts, improperly tuned engine, etc.)

Starter should operate for 15 seconds maximum then allow to cool down for 2 minutes.

Excessive Vibration

If starting system components are poorly or loosely mounted to the vehicle's engine, the resulting vibration can damage sensitive internal components.

Corrosion, Dirt and Dust

Starting system components operate less efficiently when corrosion forms or dirt particles build up around wire and cable connection points.

Corroded and dirty connection points impair the flow of electrical current.

Defective Solenoid / Magnetic Switch

If the starter fails to engage or fails to stay engaged, the coils in the solenoid or magnetic switch may be defective, or the wiring to the switch is bad. You need to check the wiring to the solenoid / magnetic switch. If the wiring is ok then the coil may be defective and you will have to replace the solenoid or magnetic switch.

Troubleshooting: Starters



Milled Pinion

- Drive pinion damage is a result of a control circuit problem external to the motor
- Alignment problem (to shim or not to shim)
- The flex plate teeth are milled not allowing good pinion engagement
- The flex plate is weak and flexes during pinion engagement.
- Key switch, mag switch or external solenoid stuck.
- Starter engagement while engine is running





Impact Loading

- Impact loading as a result of engine fuel or ignition start problems.
- Engine rocks back at the same time pinion is engaged and starter is trying to crank.
- Heavy side load.
- Improper torque on mounting bolts.
- Malfunction indicator lamp indicates cam and/or crankshaft sensor performance.



Oil Contamination

- Petroleum is an insulator. Brushes that come into contact with oil will smear oil on the commutator causing the connection to become insulated, stopping circuit from completing and causing malfunction.
- Possible valve cover, rear main seal, and or intake gasket replacement

Troubleshooting: Starter

Symptom	Possible Cause	Action Needed
Engine will not crank	• Dead battery • Defective fusible link • Loose connections • Defective ignition switch • Defective solenoid/mag switch, relay, neutral start switch or clutch switch • Mechanical problem in engine • Problem in vehicle anti-theft system	• Check battery state-of-charge • Replace fusible link • Clean and tighten connections • Check switch operation, replace as needed • Check and replace as needed • Check engine • Check service manual for system tests
Engine cranks too slow	• Weak battery • Loose or corroded connections • Defective starter motor • Mechanical problem with engine	• Check battery state of charge • Clean and tighten connections • Test starter • Diagnose engine problem and repair
Starter keeps running	• Damaged pinion or ring gear • Defective starter or magnetic switch • Defective ignition switch or control circuit	• Check gears for wear or damage • Test starter, and magnetic switch • Check switch and circuit components
Starter spins, but engine will not crank	• Defective drive clutch • Defective starting motor	• Rotate pinion by hand, it should not go both ways • Test motor and verify drive extension
Starter does not engage or disengage properly	• Defective solenoid/mag switch • Damaged or worn pinion gear or ring gear	• Bench test starter, if passes check external switches and control circuit • Check teeth on both drive and ring gear

3

Primary Causes of Alternator System Malfunction

Excessive Heat

An alternator can become damaged if it operates too long at excessive temperatures. Damaging heat levels can be caused when the alternator becomes dirty externally or internally restricting the airflow not allow the ability to dissipate heat from internal electrical components.

Dirt and Dust

Charging system components operate less efficiently when buildups of dirt particles form around wire and cable connections points. Dirty connection points impair the flow of electrical current.

Vibration

If charging system components are poorly or loosely mounted to the vehicle's frame, the resulting vibration can damage sensitive internal components. A loosely mounted alternator will also diminish the performance of the important belt drives.

Belt Tension and Condition

A loose belt will slip on the pulley and fail to turn the alternator. If the belt is loose or broken the alternator will not provide electrical current needed to sustain the vehicle's demands.

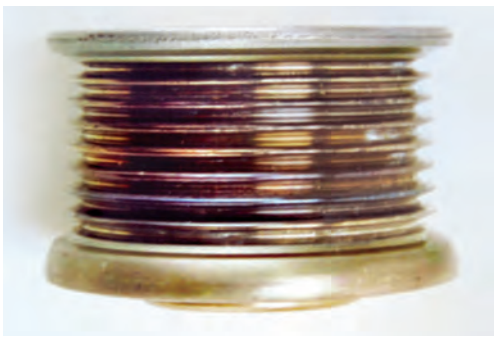
Other Items in the System

In addition to the above, some manufacturers utilize fuses in the charging system. Many newer vehicle charging systems receive a signal from the PCM/ECM /ECU activating the voltage regulator. If a electrical trouble code is present, the charging system will not operate until repair is completed and code is erased.

Troubleshooting: Alternators







Loose Electrical Connections

- Loose electrical connections. Broken, stripped and/or cross-threaded terminals.
- Evidence of a loose electrical connection can be arcing & burning. Arcing will show on washers, nut clamping surfaces and terminal threads.
- A loose connection many times will melt the insulator and loosen the stack-up allowing the output terminal to overheat.

Pulley Discoloration or Bluing

- Loose or worn belt
- Improper tension due to defective belt tensioner
- Belt misalignment
- Loose alternator mounting

Troubleshooting: Alternators

Symptom	Possible Cause	Action Needed
No output from alternator. Battery condition good. (Dashboard indicator light illuminates when key on engine off)	• Drive belt broken or loose • No voltage signal to field through regulator plug • Voltage not present at alternator B+ terminal	• Replace or tighten belt • Check regulator plug for corrosion or melting (replace pigtail if necessary) • Check fusible links and wire going to B+ terminal
Dash board charging indicator does not light while key on engine off	• Blown fuse or fusible link • Light bulb burnt out	• Check and replace fuses as needed • Replace charging indicator light bulb
Low voltage output from alternator	• Corroded or loose connections • Drive belt slipping • Belt tensioner weak	• Clean and tighten connections and perform voltage drop test • Use test gage on belt to determine if replacement is needed • Check tensioner alignment marks for weakness
Lights dim at idle while all accessories are off	• Cables corroded • Improper body ground • Drive belt slipping or tensioner is weak • Improper engine rpm's at idle • Weak or defective battery	• Clean and tighten connections and perform volt drop testing • Clean and tighten body ground • Check belt and tensioner for excessive wear • Refer to manufacture specifications and repair as needed • Test battery and replace as needed

Troubleshooting: Other Possible Issues

Damaged Connections
Vibration, corrosion or temperature change can cause wiring and connections to deteriorate causing an increase in resistance to current flow.

Improper Wiring
Insufficient voltage or amperage resulting from improper wiring or connections can cause malfunctions within the cranking and charging systems.

Faulty Cranking Circuit
The cranking circuit consists of the large cables that carry the high starter current. Excessive loss here causes slow cranking speeds, especially in cold weather. Inability to start from slow cranking will lead to starter premature failure if continuously cranked for more than 15 seconds. Deeply discharged or worn out batteries can cause the same problem.

Faulty Solenoid Circuit
Consists of the wiring from the battery through a key, push button and/or a magnetic switch to the “SW” terminal of the starter solenoid and back to the battery. Excessive loss here can cause the solenoid to shift in and out (chatter) resulting in a no-start condition. This could cause the contact disc and terminal heads of the starter solenoid to stick.

Faulty Control Circuit
(If mag switch or external solenoid is used) This consists of wiring from the battery through a key switch and / or starter button to the coil of the magnetic / solenoid switch to the starter. Excessive voltage loss here can result in a “no-start” complaint.

Faulty Charging Circuit
This consists of the wiring between the alternator and the battery and the return back to the alternator. Excessive loss here can result in the battery not receiving adequate charge, resulting in a deeply discharged battery.

Other Items in the System
There could also be safety switches in the system (Transmission Neutral Safety Switch, Clutch/Brake Safety Switch) which would not let the starter receive voltage and crank, if faulty.

Many newer vehicles also have PCM/ECM/ECU computer control units that require seeing certain “signals” before allowing the vehicle to start (such as fuel pressure, camshaft location, vehicle anti-theft etc.).

You & the Customer: At the Counter

There are two situations when dealing with the customer: the initial purchase or a warranty exchange.

Initial Purchase

Inspect the core for root cause of failure. If signs indicate something other than natural wear, inform the customer of other repairs needed.

Warranty Exchange

Test the unit on the tester. If the unit passes, ask the customer to bring the vehicle in when possible. Also, use the information learned today to discuss other possible causes. If the unit failed, visually inspect the unit for root causes external from the unit. (ie. loose connections, ground arching, etc). Discuss these finding with the customer to ensure the new unit will last.

When exchanging the unit, check the customers warranty file for multiple exchanges. This will help you to determine if the customers vehicle has other issues.

When a customer brings in a starter or alternator, first test the unit with the tester.

Unit Passes on Tester

Discuss with the customer all the things on the vehicle that could make one think it was a starter or an alternator failure.

- Is the customers battery new or old?
- Is there a lot of corrosion buildup on the battery cables?
- Could it be a fuse or fusible link or several other things in the system?

Ask the customer if it would be possible to bring their vehicle by the store so you can perform on-vehicle testing.

Unit Fails on the Tester

- Check to see how many times has the unit been exchanged.
- Are there visible signs of root cause of failure external from the unit?
- If the vehicle is available, what other visible signs are present?
- Does the vehicle pass electrical tests?

Trustworthy advice example: “Mr. Smith, it appears this starter is heavily coated with oil. I see we have exchanged this for you twice in the past. If you do not replace the valve cover gaskets, the new unit will not last.”

You & the Customer: Trouble Not Found

Symptom	Possible Cause	Action Needed
Starter passes on test	• Discharged or defect battery • Loose or corroded battery cables or connections to starter • Defective or misaligned neutral safety switch • Loose Starter mounting bolts or dirty mounting surface • Defective ignition switch • Vehicle anti theft system activated • Defective relay	• Charge and test battery/replace as needed • Clean and tighten all connections and perform volt drop test • Check operation/ replace or align as needed • Clean surfaces and tighten mounting bolts • Ensure battery voltage is correct at solenoid switch terminal with key in start position /replace as needed • Look for security dash light to be illuminated during attempted start • Test relay/replace as needed
Alternator passes on test	• Discharged or defective battery • Loose or corroded battery cables or connections to alternator • Belt tensioner defective • Belt worn or broken • Fuse or fusible link broken • Check engine light code for charging system • Dash board charging light burned out	• Charge and test battery/replace as needed • Clean and tighten all connections and perform volt drop test • Check tensioner spring for alignment and spring tension/replace as needed • Check belt/ replace as needed • Test fusible links and fuses for voltage and replace as needed • Read “check engine light” codes – perform needed repairs • Replace bulb

You & the Customer: At Vehicle Testing

1. Verify Customer Concerns:
- Try and reproduce customer concern
- Ask when issue first appeared
- Is the issue intermittent (i.e. rain, bump in the road, heat etc.)
- Ask, if any work has been done to the vehicle recently.

2. Visual Test:
- Look for corrosion on battery cables
- Wiggle cables to see if connections are tight (battery, alternator & starter).
- Check to see if the battery is secure (battery hold down)
- Check belt for wear
- Check tension on belt

3. Hand Held System Testing:
- Perform electrical system check using hand held tester.
- The battery is tested first. Without a good battery, other charging system tests will not be accurate.
- Continue on with the starter and alternator tests

4. OBD II Codes:
- Pull codes
- Determine if OBD II codes are related to starting or charging issues
- Give the customer the printout and recommend repairs or use shop referral

5. Volt Drop Testing:
- Engine at 2000 rpm, all loads on
- Perform positive voltage drop testing from positive battery post to alternator B+ terminal. (max .5 volts)
- Perform negative voltage drop testing from negative battery post to back casing of alternator (max .3 volts)

Addition Resources

Most units have TSBs located in the box to help identify common system problems as well as unit supersession. Make sure these TSBs are given to and reviewed with the customer

Tech Lines are staffed with Engineers, ASE & Manufacture Certified technicians to help answer any questions you may have.

1-800-854-0076

Notes

Remy Inc. is a leading global manufacturer of Delco Remy brand heavy duty starters and alternators, light duty starters and alternators, and electric motor technology for EV and hybrid vehicles. We lead with product innovation and performance – you win with trusted, knowledgeable support.

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