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TOYOTA'S SUPPORT TO AFTERMARKET REPAIR

## Electrical Diagnosis and Repair



### **Electricity** the Unseen **Force**

Troubleshooting Principles  
Reading Diagrams  
Wiring Repairs  
Parts News

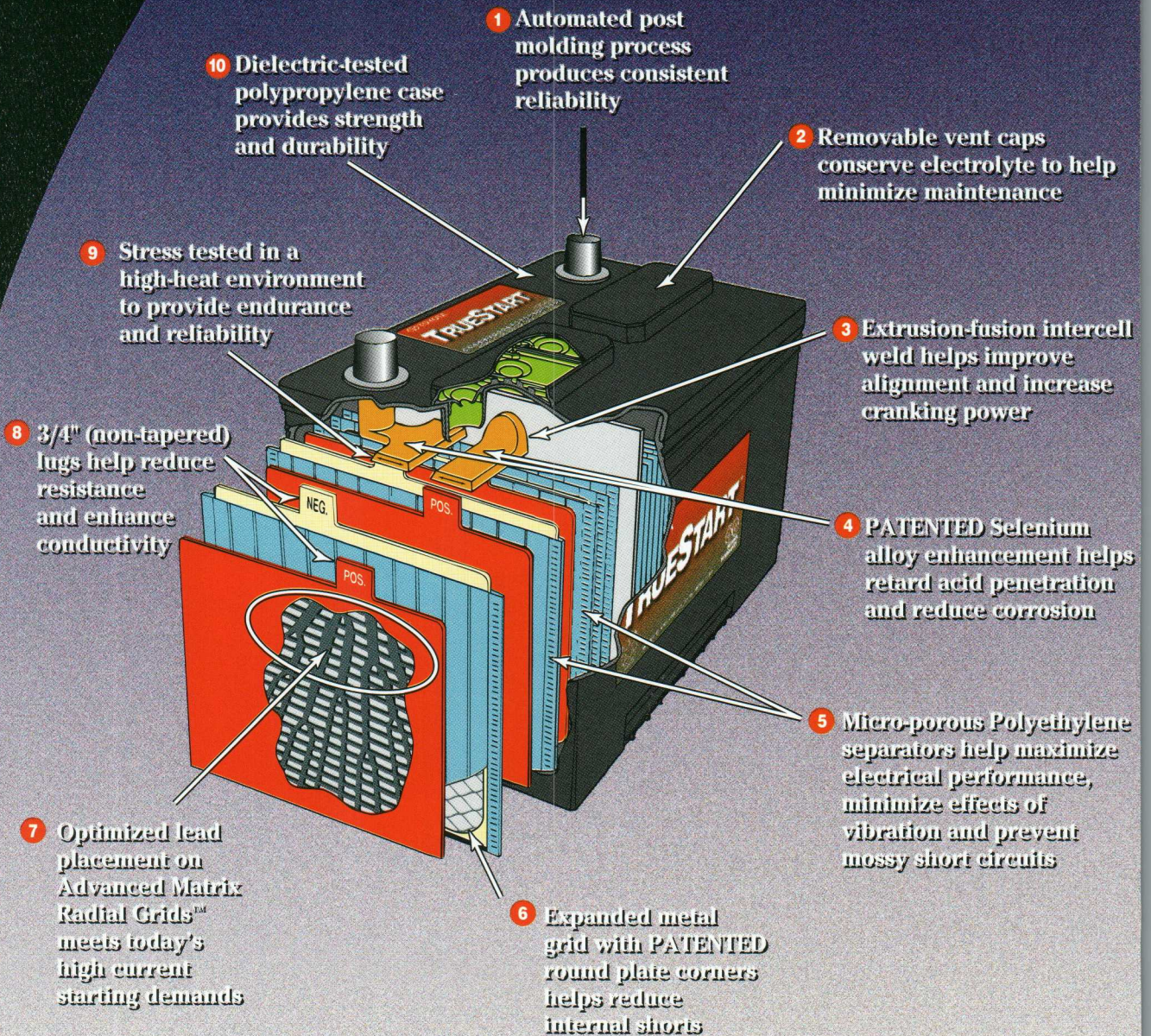
**BONUS**

Glossary of Electrical Terminology

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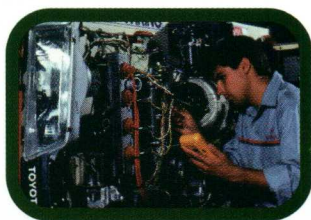
# TRUESTART™



## TEN REASONS YOUR BATTERY SHOULD BE A TRUESTART™

# ServiceNews

## Electrical Diagnosis and Repair



### What is a STAR dealer?

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## Electricity the Inseen Force

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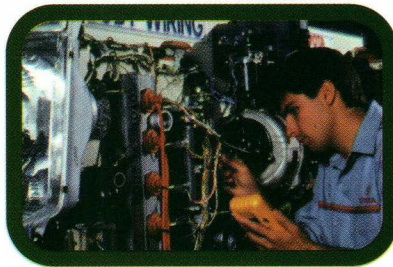
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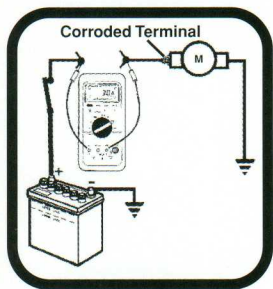
# Electricity

## the Unseen Force

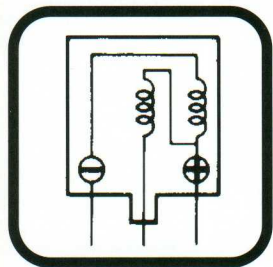
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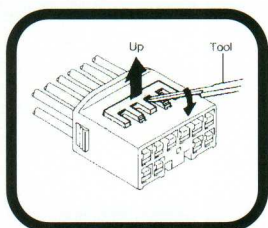
January/February 1997 Issue 62



Troubleshooting Principles



Reading Toyota Wiring Diagrams



Electrical Repairs

**E**lectricity can't be seen, touched, heard, or smelled. Yet, we can see, hear, touch, and smell its effects. We can see the effects of electricity when a lamp lights, a motor turns, or a cigarette lighter gets red hot. We can hear the effects of electricity when a horn blows or a radio is turned on. Most of us have definitely felt the effects of electricity if we have been shocked by a spark plug wire. And anyone who has smelled burned wire insulation caused by a short circuit knows about the effect of electricity when it ends up in the wrong place at the wrong time.

No one completely understands exactly what electricity is, but there are methods of controlling and measuring it, and we have learned how to fix electrical problems when they inevitably occur. The task of diagnosing and repairing automotive electrical problems becomes possible (and a good deal easier) when electrical terms and concepts are fully understood; when we understand the fundamental relationships between voltage, current, and resistance; when a diagnostic plan is followed; when we can make accurate electrical measurements and analyze their results; and when we can understand how a circuit should operate by reading and interpreting electrical wiring diagrams. Once the problem has been identified, proper repair techniques must be employed to prevent damage to related systems and to ensure a long-lasting repair.

We'll give you the benefit of the doubt for this edition of Toyota STAR Service News. We'll assume that you already have a firm grasp of electrical fundamentals. This will allow us to skip over the first two requirements listed in the previous paragraph. Unfortunately, we don't have room to begin our discussion of electrical troubleshooting and repair with the atom. So if you're not already comfortable with basic electrical terms and concepts, including Ohm's Law and how it explains the relationship between voltage, current, and resistance, we'd suggest that you begin a comprehensive course of electrical study as soon as possible.

### Troubleshooting Principles

If you're faced with a particularly vexing electrical problem, it may seem that the whole car is to blame. When so many parts are involved, it's difficult to determine where to start.

Would it surprise you to know that there are only three basic types of electrical problems. Once you understand what they are, the problem you're facing might not seem quite so large.

The next step is to develop a strategy to attack the problem. We'll show you a six-step troubleshooting strategy that will organize your thoughts and direct you to the cause of the problem.

Unless the wiring is burned up, it's usually pretty difficult to see the cause of an electrical problem. That brings us to another component of electrical troubleshooting—effective and accurate use of diagnostic equipment.

### Reading Toyota Wiring Diagrams

Ever try to get to an unfamiliar destination without a road map? Maybe you reached your destination, but it probably took longer, or you may have ended up hopelessly lost.

Electrical wiring diagrams are the electrical road maps for the dozens of electrical circuits that are contained in the average Toyota vehicle. You're really lost without a wiring diagram, because unlike a road, much of the wiring inside a typical Toyota vehicle is hidden from sight. Without a wiring diagram, you might be able to figure out where a circuit starts, but you could have a pretty hard time deciding where it ends.

We'll show you how to get useful information out of Toyota wiring diagrams, plus illustrate and describe many of the special signs and symbols that are used in Toyota wiring diagrams.

### Electrical Repairs

Using proper diagnostic techniques and a Toyota electrical wiring manual, you've found the cause of your electrical problem. Now what? How an electrical problem is repaired can make all the difference in the world. An improperly performed electrical repair may not last, or worse yet, it may cause damage to adjoining circuits or systems. Our final electrical article will demonstrate correct wire, terminal, and connector repairs.

# Troubleshooting Principles

## Possible Electrical Problems And Their Solutions

There are basically only three types of electrical problems: **high-resistance faults, low resistance faults, and component faults.**

### High-Resistance Faults

This may be the most common electrical problem on the vehicle. High resistance in a circuit will reduce available current or stop it completely. It can be caused by an **open circuit or circuit problems.**

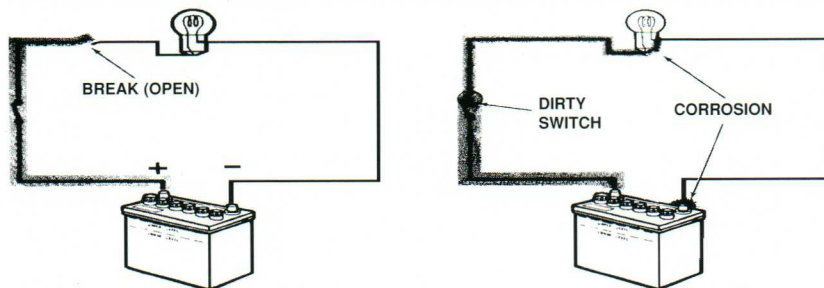
#### Open Circuit

A complete path is needed for current to flow. A break in the path stops current completely. It can be caused by a broken connector, faulty component, disconnected harness, or a disconnected ground wire. A common open circuit is a loss of ground. Remember, many components are mounted to the engine or chassis. A poor mount may cause loss of ground. An open circuit does not blow a fuse, unless a short circuit causes the open.

#### Circuit Resistance

All circuits and loads have built-in resistance. Such resistance is needed to change current into useful work such as heat, light, or motion. Loads add resistance in a series circuit. The number of branches reduce resistance in a parallel circuit.

High-resistance problems, though common, are very often overlooked in electrical diagnosis. Often, the cause is loose, dirty, or corroded connections. Lamps will flicker or dim, some devices may not work, or motors may run slowly. This type of fault does not blow a fuse.



High-Resistance Faults

### Glossary of Electrical Terms

**A** - Abbreviation for ampere, the unit of measurement of current.

**Active Materials** - The metals and acids used in a storage battery which cause a chemical reaction to occur and voltage potential to be developed.

**Afterglow** - The time the glow plugs remain activated after fuel in a diesel engine starts to self ignite. The added heat is used to reduce white smoke and improve slow idle.

**Alternating Current (AC)** - An electric current whose polarity is constantly cycling between positive and negative. (Reverse direction of flow at regular intervals.)

**Alternator** - A type of generator used in automobiles to produce electric current. Its AC (Alternating Current) output is internally rectified (changed) to DC (Direct Current) through the use of diodes.

**Ammeter** - An electrical meter used to measure the amount of current flowing in a circuit. It reads amperes of current flow. The ammeter must be connected in series with the circuit—red lead toward the voltage source, black lead toward ground.

**Ampereage** - The amount of current (amperes) flowing in a circuit.

**Ampere** - The unit of measure for the flow of electrons, or current, in a circuit. The amount of current produced by one volt acting against one ohm of resistance.

**Ampere Hour** - Unit used to rate batteries. The quantity of electricity delivered by a current of one ampere flowing for one hour.

**Ampere-Hour Rating** - A battery rating based on the amperes of current that a battery can supply steadily for 20 hours, with no battery cell falling below 1.75 volts. Also called a 20-hour discharge rating.

**Ampere Turn** - The amount of magnetism or magnetizing force produced by a current of one ampere flowing around a coil of one turn. The product of the current flowing through a coil multiplied by the number of turns or loops of wire in a coil.

**Analog** - Method of transmitting information through an electrical circuit by regulating or changing the current or voltage.

**Anode** - Positive terminal or electrode through which current flows in a semiconductor.

**Armature** - Conductor or coil of wire moved through a magnetic field to produce current. In an alternator, the rotor is a magnetic field that rotates inside the stator coils to induce voltage in them. In a motor, it is the rotating electro-magnetic field interacting with the stationary magnets to produce a turning motion.

**Armature Circuit Tests** - Tests used to determine if there are any short circuits or opens and grounds in the armature of a starter motor.

**Atom** - The small particles which make up all matter. An atom is made up of a positive-charged nucleus with negative-charged electrons orbiting around it.

**Ballast (Primary) Resistor** - A resistor in the primary circuit that stabilizes ignition system voltage and current flow.

**Bar Magnet** - A straight permanent magnet.

**Base** - The center layer of semiconductor material in a transistor.

**Battery** - A group of two or more cells of a lead-acid (storage) battery connected together. It produces an electric current by converting chemical energy into electrical energy. Also, a dry cell.

**Battery Acid** - Mixture of sulfuric acid and water used in a storage battery. Also called the battery electrolyte.

**Battery Cell** - Group of positive and negative plates, covered with electrolyte, in a compartment of the battery case separate from other elements. A cell of an automotive battery has a voltage of about 2.2 volts.

## Glossary of Electrical Terms (cont.)

**Battery Charge** - Reverse chemical reaction that takes place when current is reversed through a battery to restore the metal in the plates and the electrolyte to their original condition.

**Battery Charger** - Rectifier used to change alternating current into direct current to send a reverse current through the plates of a battery to restore the chemical imbalance needed to produce electrical energy.

**Battery Element** - Group of positive and negative plates with separators and covered with electrolyte and contained in a battery cell.

**Belt Tension** - The tightness of a drive belt.

**Biasing** - Applying voltage to a junction of semiconductor materials.

**Bimetal** - Sensing device made from two metals with different heat expansion rates. Temperature changes cause the device to bend or distort. Activates another component.

**Bimetallic** - A substance made up of two metals bonded together.

**Bonding** - Process by which the electrons in the valence ring of one atom are shared with those of another.

**Bound Electrons** - Five or more tightly held electrons in an atom's outer ring.

**Breakdown Voltage** - Voltage applied to a diode or transistor in the reverse direction from that in which it passes current. The voltage is large enough to cause a massive failure to hold back current. Breakdown voltage is also that applied to a zener diode to allow a reverse current flow through the diode.

**Brushes** - Bars of carbon, or other conductive material, that make an electrical connection with the rotating commutator or slip rings.

**Buss Bar** - A solid metal strip, or bar, used as a conductor in a fuse panel.

**Cable** - Conductor made from a number of wires twisted together.

**Capacitance** - The ability of two conducting surfaces, separated by an insulator, to store an electric charge.

**Capacitor** - Electrical component used to store and release a current through a secondary circuit. Can be used to protect a circuit against surges in current, store and release a high voltage, or smooth out current fluctuations. Also called a condenser.

**Capacity Test** - Test of a battery's condition by applying a heavy load (300 amp) to the battery for a brief time (15 seconds), then measuring the voltage.

**Carbon Pile** - A pile, or stack, of carbon disks enclosed in an insulating tube. When the disks are pressed together, the resistance of the pile is decreased.

**Cathode** - The negative terminal of a semiconductor toward which the current flows.

**Cell** - A dry cell, e.g., a flashlight battery. In a storage (wet cell) battery, one of the sets of positive and negative plates which, with electrolyte (sulphuric acid and water), produces electricity. Each cell can produce about 2.2 volts.

**Cell Gassing** - The emission of hydrogen gas from battery cells during charging.

**Central Processing Unit (CPU) or Microprocessor** - The processing and calculating portion of a micro-computer.

**Charge (Recharge)** - To restore the active materials in a battery cell by electrically reversing the chemical action.

**Charging System** - Components to restore electrical potential in the battery and supply the current needed to meet the electrical demands of the vehicle.

**Circuit** - A combination of elements physically connected to provide an unbroken flow of electrical energy from a power source through a conductor to a working device, and through a return conductor, back to the power source.

**Circuit Breaker** - Device used to open an electric circuit when overheated to prevent damage by excess current flow.

**Circuit Diagram** - Drawing showing the wires, connections, and components (loads) in an electric circuit.

**Closed Circuit** - A circuit which is uninterrupted from the current source and back to the current source.

## Low-Resistance Faults

A low-resistance fault allows too much current flow or current flow where it doesn't belong. It can be caused by a short circuit or an unintentional ground. Some low-resistance problems, though, may be caused by the addition of non-OEM accessories which reduce the overall circuit resistance. This causes more current to flow in the circuit and the fuse may blow.

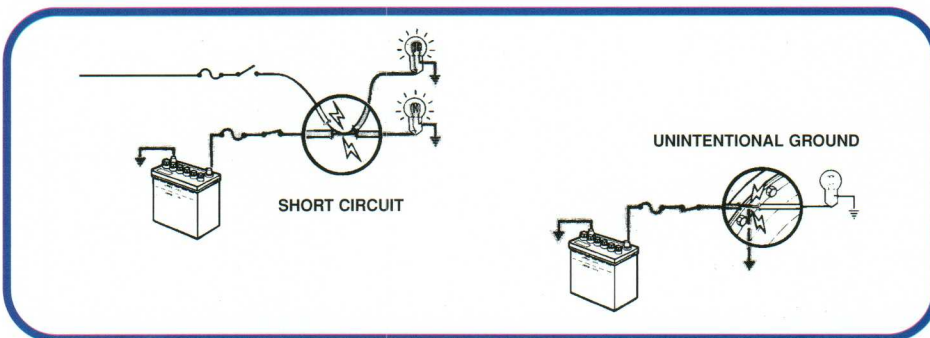
### Short Circuit

A short circuit is one that is completed the wrong way. It usually occurs when wire insulation wears away, and the wire touches another bare wire. This allows current to flow into another circuit.

A short can also occur inside components. A "short" is indicated if two circuits operate when only one is turned on, if insulation is burned away, if a component draws more current than the spec says it should, if the fuse or fusible link is blown or if a circuit breaker keeps opening.

### Unintentional Ground

This is a short circuit between a circuit-carrying wire and the vehicle's ground return system. Some loads may be bypassed and fail to work. Some circuit parts may be damaged by high currents caused by the ground. A fuse or fusible link will melt, or a circuit breaker will open.



Low-Resistance Faults

## Component Faults

Component faults are becoming less common on today's vehicles. Parts are built with higher quality. Electronic control systems maximize component life. Bench repairs and adjustments are needed less often. Component faults can be traced to wear and defects and to loss of power.

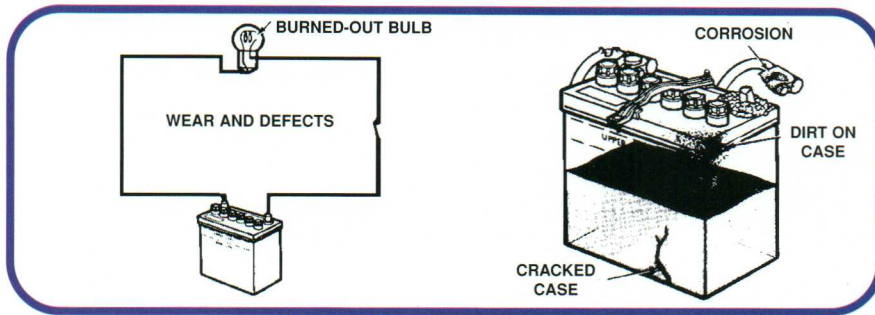
### Wear And Defects

Electrical parts do wear out and require service and replacement. Lamps burn out, batteries become discharged, switch contacts burn away, connectors corrode, motors short, drive belts break, fuses melt, and electronic components fail—especially when hit with voltage surges and high temperatures.

Faulty components are easily recognized. Only one device in a circuit is not working. Part or all of the circuit is not working. And, depending on the problem, a fuse or fusible link may be blown.

## Loss Of Power

Always make sure there's power to the problem circuit. No voltage means no current, and low voltage means low current. The problem usually involves a discharged battery, faulty charging system, blown fuses, or loose/corroded connections.



Component Faults

## Troubleshooting Principles

Electrical diagnosis and testing is not a difficult job. You just have to be prepared.

You need to know how the electrical system or component should work. And, you need to know what certain problem symptoms indicate.

You also need to know how to use electrical test equipment—how to choose the proper tool to locate the problem cause, how to make sure the tool you choose is accurate, and how to check the system in the fastest way possible.

And, finally, you need a plan—a logical, systematic method of identifying the trouble and correcting it.

## A Troubleshooting Plan

The following six-step troubleshooting plan will give you a logical approach for locating the cause of an electrical problem, regardless of the system or component involved. With the electrical systems on today's Toyotas becoming more and more complex, and with the increasing use of electronics, this plan can save you time and—most importantly—help you accurately diagnose and correct most any electrical problem.

### 1 Verify The Complaint

Ask the driver, then check the vehicle. Make sure the problem actually occurs by using an **operational check**—e.g., if the complaint is “hard starting,” check the starting performance.

Such operational checks will identify the symptoms of the problem. **Positive symptoms** are those that give a positive result—e.g., the starter motor cranks the engine when the ignition key is turned to “Start.” **Negative symptoms** are those that give a negative result—e.g., the engine cranks too slow to start.

## Glossary of Electrical Terms

**Cold-Cranking Rating** - A battery rating based on the amperes of current that a battery can supply for 30 seconds at 0 degrees F, with no battery cell falling below 1.2 volts.

**Collector** - The area of a transistor which collects emitted electrons and then passes them on through a conductor to complete a circuit.

**Color Coding** - The use of colored insulation on wire to identify an electrical circuit.

**Commutator** - That part of a starter motor where current is sent to the rotating coils in the armature. It is the rotating connector between the armature windings and the brushes. It consists of copper bars at one end of the starter motor armature electrically insulated from the shaft and insulated from each other by mica.

**Compound Motor** - A motor that has both series and shunt field windings. Often used as a starter motor.

**Computer Control** - Control of any automotive system using solid state devices and operating with a preprogrammed set of commands (program), sensors to monitor various engine conditions (input), and signals set to affect the function of some component (output). Also holds commands in memory for later use.

**Condenser** - Electrical component used to store and release a current through a secondary circuit. Can be used to protect a circuit against surges in current. Store and release a high voltage, or smooth out current fluctuations. Also called a capacitor.

**Conductivity** - Measure of how easily an electrical component conducts current.

**Conductor** - Any material that allows electric current or heat to flow. Current flows easily through a conductor because there are many free electrons.

**Constant Voltage Charging** - Method of charging battery in which a constant voltage is prepared and the current decreases as the battery approaches the charged condition.

**Continuity** - Continuous, unbroken. Used to describe a working electrical circuit or component that is not open.

**Control Circuit Resistance Test** - Test used to determine if there is high resistance in the control circuit that will reduce current flow through the starter solenoid or relay windings and cause improper operation of the starter circuit.

**Conventional Theory** - The current flow theory which says electricity flows from positive to negative. Also called the positive current flow theory.

**Copper** - A metal used for electrical conductors because it has less resistance than most other metals.

**Counter-electromotive Force** - An induced voltage that opposes the source voltage and any change (increase or decrease) in the charging current. Abbreviated: CEMF.

**Cranking** - The act of engaging the starter by turning the ignition switch to make the engine turn over.

**Cranking Circuit** - Motor feed and ground circuits required to supply heavy current to the cranking or starter motor.

**Cranking Circuit Resistance Test** - Test used to determine if there is excessive electrical resistance in the cranking circuit preventing full power from reaching the starter motor.

**Current** - Flow of electrons through a circuit, measured in amperes.

**Cutout Relay** - A relay that keeps the battery from discharging when the engine is off or idling. It acts as a circuit breaker to open the circuit between the battery and alternator.

**Cycle** - Any series of events repeating continuously. In an electrical system, the flow of current alternates first in one direction and then in the opposite direction.

**Cycling** - Battery electrochemical action. One complete cycle is the operation from fully charged to discharged and back to fully charged.

**D'Arsonval Movement** - A small, current-carrying coil mounted within the field of a permanent horseshoe magnet. Interaction of the magnetic fields causes the coil to rotate. Used as a measuring device within electrical gauges and test meters.

**Defective Device** - A type of circuit malfunction in which a component of electrical circuit does not work as it should. This could be a worn-out battery, corroded switch, burned-out lamp bulb, or broken connector.

## Glossary of Electrical Terms

**Delta-Type Winding** - An alternator stator design in which the three windings of a 3-phase alternator are connected end-to-end. The beginning of one winding is attached to the end of another winding. Used in alternators that must give high amperage output.

**Dielectric** - The insulating material between the two conductive plates of a capacitor.

**Digital** - Method of sending information through an electrical circuit by switching the current on or off.

**Digital Computer** - A computer that uses numbers to perform logical and numerical calculations, usually in a binary (two digits) numbering system. Faster and superior performance to an analog computer.

**Digital Readout** - A display of numbers or a combination of numbers.

**Diode** - A semiconductor device made of P-material and N-material bonded at a junction. It permits current to flow in one direction only, and is used in rectification (changing alternating current to direct current).

**Diode Trio** - Six diodes, arranged in pairs front to back, each at the end of a stator winding in an alternator. Used to rectify both phases of an alternating current cycle to direct current.

**Direct Current (DC)** - A steady flow of current moving continuously in one direction along a conductor from a point of high potential to a point of lower potential.

**Doping** - Addition of a small amount of a second element to a semiconductor element to change its electrical characteristics.

**Drive Belt** - A flexible belt connecting the fan and the alternator, causing both to turn through a pulley system at the end of the crankshaft.

**Dry Cell** - Voltage source consisting of three elements: a zinc cylinder, a paste of electrolyte, and a carbon rod or electrode.

**Eddy Current** - Currents in armatures, pole pieces, and magnetic cores induced by changing electromagnetic force. It is wasted energy and creates heat.

**Effective Resistance** - All electrical and inductive losses of a circuit.

**Electrical Balance** - An atom or an object in which positive and negative charges are equal.

**Electrical Charge** - Property of electrons and protons that give a substance its electrical characteristics. A deficiency of electrons in the outer ring of atoms of a substance will give it a positive charge. An excess will give the substance a negative charge.

**Electrical Symbols** - Simple drawings used to represent different parts of an electrical circuit.

**Electrical System** - Parts of the vehicle that crank the engine for starting, furnish high voltage sparks in the cylinders, operate lights and accessories, and charge the battery. Electrical systems of a diesel include circuits to operate the glow plug system.

**Electricity** - The controlled movement of electrons in a conductor.

**Electrochemical Device** - A device that operates on both electrical and chemical principles (a lead acid storage battery, for example).

**Electrochemistry** - In a battery, voltage caused by the chemical action of two dissimilar materials in the presence of a conductive chemical solution.

**Electrolyte** - A solution of sulphuric acid and water used in a storage battery that through chemical reaction produces electric potential.

**Electromagnet** - Coil of current-carrying wire usually wound around a soft iron core that becomes magnetized when current passes through the wire and demagnetized when the current stops.

**Electromagnetic Field** - The invisible field of force which surrounds a charged conductor or coil.

**Electromagnetic Induction** - The creation of a voltage within a conductor when relative motion exists between the conductor and a magnetic field.

**Electron** - Those parts of an atom which are negatively charged and orbit around the nucleus of the atom.

**Electron Flow Theory** - Belief that current flow consists of electrons flowing from a point with a high potential of free electrons (negative) to a point with fewer electrons (positive).

**Electronic** - Any system using integrated circuits or semiconductors to control the flow of current. As opposed to electrical that describes systems in which there are no solid state components and devices are controlled by current applied to such components as motors, solenoids, and relays.

## 2 Determine Related Symptoms

Know the vehicle, and know how the problem system should work.

Related symptoms are identified by operational checks on circuits or components connected to the problem circuit. For instance, is there a grinding noise? Do the headlamps dim during cranking? Is the charge indicator lamp on or off? How does the engine sound?

No test equipment is needed. The vehicle's wiring diagram is most important. Look for circuits that tie to the problem circuit either through a common ground or common power feed.

## 3 Analyze The Symptoms

*Think.* What did the driver say? What did the operational checks show? Consider the symptoms and their possible causes.

Positive symptoms rule out certain causes, while negative symptoms indicate certain causes. The trouble may be in a component of the problem circuit (e.g., ignition switch, starter motor, magnetic switch), or in a different circuit (e.g., battery, alternator).

## 4 Isolate The Trouble

Be logical and systematic. Start with knowing the system. Then, test from the general to the specific.

*"How can the least number of checks be made?"* is an important question.

The **split-half method** of testing can save a lot of time. The trouble lies between a positive symptom and negative symptom. Start half-way between. If a positive result is obtained, split the next half—going toward the problem. If a negative result is found, split the other half—going back toward the area where a positive symptom was found.

Next, choose the right test equipment. This may be a simple jumper wire or voltmeter or battery-starting-charging tester. Decide **where** to make the checks and **what** the test results should be. *And, finally, find the cause of the problem.*

## 5 Correct The Trouble

Start with "quick fixes." For example, don't remove and replace a starter motor until all other possible problems have been identified and corrected first. Many electrical problems are caused by loose connections and bad grounds. And, starting problems can often be traced to something as simple as a discharged battery, loose alternator drive belt, corroded connections, and engine problems. Never rule out mechanical trouble when checking the electrical system.

Repair wiring problems, replace faulty components, service or adjust parts if possible.

## 6 Check For Proper Operation

Don't assume that the system is trouble-free after making one or two repairs. Is the specific complaint corrected? Has what caused the problem been identified and corrected? What may cause it to happen again? Are all the symptoms now positive? Have any new problems shown up in other circuits?

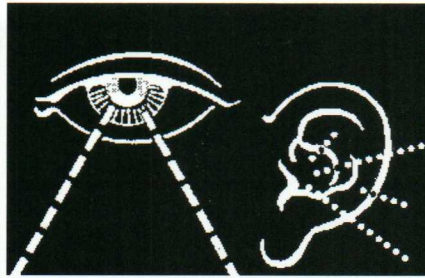
**Avoid comebacks by answering each of these questions.**



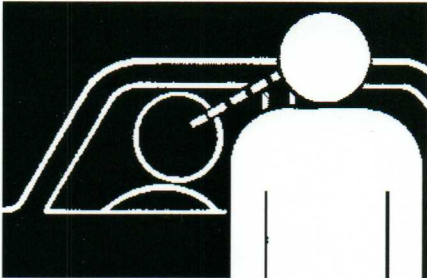
### 1. Verify The Complaint



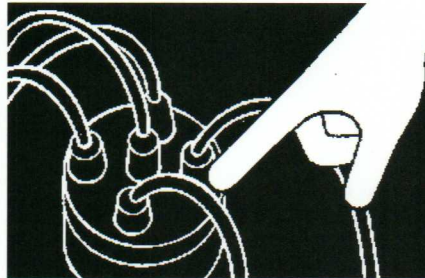
### 2. Determine Related Symptoms



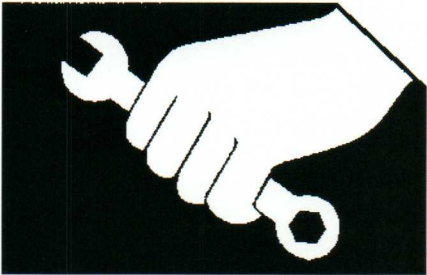
### 3. Analyze The Symptoms



### 4. Isolate The Problem



### 5. Correct The Trouble



### 6. Check For Proper Operation



Six-Step Troubleshooting Plan

## Measuring Voltage

Voltage is electrical pressure. If the pressure is too high, components will fail early. If the pressure is too low, insufficient current may cause improper operation. Some components may not work at all. High voltage may be caused by shorts, grounds, or a faulty voltage regulator. Low voltage may be caused by a discharged battery, low alternator output, and—most commonly—by high resistance in the circuit.

Checks for available voltage can be made with a voltmeter, or a special tester such as a digital probe, multimeter, or Sun VAT-40 tester.

### Checking Available Voltage

A test lamp can tell you if voltage is available, but it can't tell you how much. A volt meter can. It must be connected in parallel with the load or a portion of the circuit being checked. And, the power must be "on."

### Glossary of Electrical Terms

**Electron Theory** - States that all matter is made up of atoms which are made up of a nucleus and orbiting electrons. The "free" electrons can move from one atom to another, producing electricity.

**Electrostatic Field** - The area around an electrically charged body resulting from the difference in voltage between two points or surfaces.

**Element** - A substance that cannot be further divided into a simpler substance. In a battery, a group of positive and negative plates, separated by insulators that make up each cell.

**Emitter** - Region in a transistor that emits (NPN) or collects (PNP) large number of electrons as a small number of electrons are taken from or added to the base.

**Energize** - To put energy into. The iron core of an electromagnet is energized by passing current through the coil.

**Equivalent Resistance** - The total resistance of a parallel circuit. The single mathematical equivalent of all the parallel resistances.

**Farad** - The unit of measurement of capacitance.

**Feedback System** - Electronic system in which sensors monitor the output of various automotive systems and provides input to control the operation of the system and change the output. It is a self-correcting system.

**Feed Circuit** - Line supplying all the branch circuits with the main supply of current. Generally used to refer to the (not grounded) feed from the battery to the electrical components of a vehicle.

**Field Coil** - Winding of current-carrying conductors used in a starter motor to produce a magnetic field.

**Field Magnet** - A magnet for producing and maintaining a magnetic field, especially in an alternator or electric motor.

**Field Relay** - A magnetic switch used to open and close the alternator field circuit, or in a charging circuit with a warning lamp, to control the lamp circuit.

**Field Strength** - The density or magnitude of the magnet lines of force. The denser the magnetic field, the more lines of force will extend from pole to pole in the magnet and the stronger the field will be.

**Field Windings** - Insulated wire wrapped around an iron or steel core. When current flows through the windings, a strong magnetic field is created.

**Filament** - A resistance in an electric light bulb which heats up and glows, producing light, when an adequate current (bombardment by electrons) is sent through it.

**Flux** - The lines of magnetic force flowing in a magnetic field.

**Flux Density** - The number of flux lines in a magnetic field area. The more flux lines in a unit of area the stronger the magnetic field at that point.

**Forward Bias** - The application of a voltage to produce current flow across the junction of a semiconductor.

**Free Electron** - An electron in the outer orbit of an atom, not strongly attracted to the nucleus, and can therefore be easily forced out of its orbit into orbit around the nucleus of another atom.

**Frequency** - Number of times every second an alternating current goes through a complete cycle. Now measured in units of hertz (Hz) but previously measured in cycles per second (cps).

**Full-Wave Rectification** - A process by which all of an AC voltage wave is rectified and allowed to flow as DC.

**Fuse** - A device containing a soft piece of metal which melts and opens, or breaks, the circuit when it is overloaded. Similar in function to a "circuit breaker," but must be replaced after the circuit problem is corrected.

**Fusible Link** - A short piece of wire soldered into a heavy feed circuit, designed to melt when an overload occurs. Performs the same function as a fuse or circuit breaker. Like the fuse, it must be replaced after the circuit problem is corrected.

**Gassing** - Escape from a battery of highly explosive hydrogen gas formed during charging.

**Generator** - An apparatus that produces an electric current through magnetism. Its AC (Alternating Current) output is internally changed to DC (Direct Current) through the commutator. The alternator, a type of generator, changes its AC output to DC through the use of diodes.

## Glossary of Electrical Terms

**Germanium** - A metalloid element used as a semiconductor material in transistors.

**Glow Plug** - A resistance heater, shaped somewhat like a spark plug, heated by low voltage current. Used to heat compressed air in a diesel engine until the heat of combustion reaches the temperature to cause self-ignition without assistance.

**Grid** - Frame of a storage battery plate having spaces in which the active material in paste form is pressed.

**Ground** - The return path for current flow in a circuit. In automotive use, the circuit ground path is usually the vehicle frame and metal body parts.

**Ground Cable** - The battery cable that provides a ground connection from the vehicle chassis to the battery.

**Grounded Circuit (Unintentional)** - A type of circuit malfunction in which the current in the circuit is accidentally shunted, or diverted to ground. Usually, this condition bypasses a load. If a load is bypassed, it reduces the resistance of the circuit and can cause wiring to overheat, fuses to blow, etc.

**Ground-Seeking** - A test method using a 12-volt test light where one lead is connected to a known power source and the other lead is touched to various points of a circuit to seek a point where the circuit is grounded.

**Ground Terminal** - The terminal of the battery connected to the metal frame and chassis of the vehicle for the return path of current flow back to the battery, usually to the negative terminal.

**H2O** - Chemical symbol for water.

**H2SO4** - Chemical symbol for sulfuric acid.

**Half-Wave Rectification** - A process by which only one-half of an AC voltage wave is rectified and allowed to flow as DC.

**Heat Sink** - Device to absorb heat from one medium by transferring it to another. Diodes in alternators are mounted on heat sinks to prevent the diodes from overheating.

**High Rate Discharge Test** - Battery test in which the battery is discharged at a high rate of current while cell voltages are checked.

**High Resistance** - A type of circuit malfunction in which a loose, dirty or corroded connection limits current flow below specifications. The result can be dimmed lamps, flickering lamps, or even inoperative devices.

**Hold-In Winding** - The coil of small-diameter wire in a solenoid that creates a magnetic field to hold the solenoid plunger in position inside the coil.

**Hole** - The space in a valence ring where another electron could fit.

**Hydrogen** - (H) Colorless, odorless, highly flammable gas. Simplest and lightest element having only one electron orbiting around the nucleus.

**Hydrometer** - Device used to measure the weight of a liquid, or its specific gravity. Used to measure the acid content of electrolyte in batteries or the ethylene-glycol content of coolant.

**Ignition** - Action of the spark in starting the burning of the compressed air/fuel mixture in the combustion chamber.

**Ignition Coil** - An induction coil used to produce a high voltage current to jump the gap in a sparkplug and ignite the air/fuel mixture in the combustion chamber. A small voltage turned on and off in the primary windings induces a much larger voltage as the output from the secondary winding.

**Ignition Resistor** - A resistance in the primary ignition circuit to reduce the amount of battery voltage available at the coil.

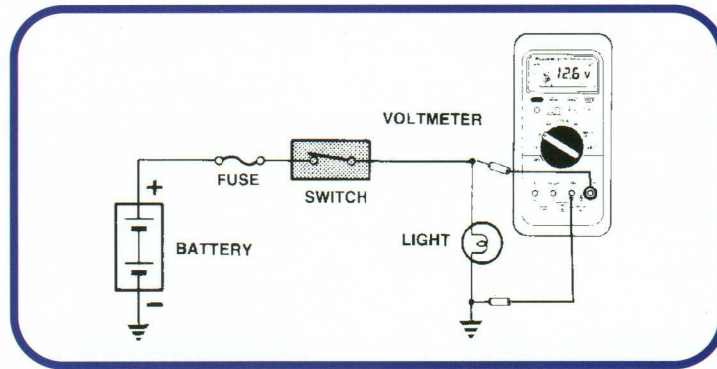
**Ignition Switch** - Switch used to open and close the circuit to the primary ignition coil. Also used to open and close accessory circuit on the vehicle.

**Ignition System** - System to furnish high voltage sparks to the cylinders to ignite the compressed air/fuel mixture at the right time. Consists of the battery, ignition coil, distributor, ignition switch, wiring and spark plugs.

**Impurities** - The doping elements added to pure silicon or germanium to form semiconductor materials.

**Indicator** - Device used to make some condition known by use of a light or gauge.

**Indicator Light** - An illuminated warning or indicator to the driver of a vehicle of some condition, such as when the alternator is not supplying current or when the coolant temperature is close to overheating.



Checking Available Voltage

## Checking Voltage Drop

Voltage drop testing is one method of electrical diagnosis that can quickly locate high resistance problems in a circuit.

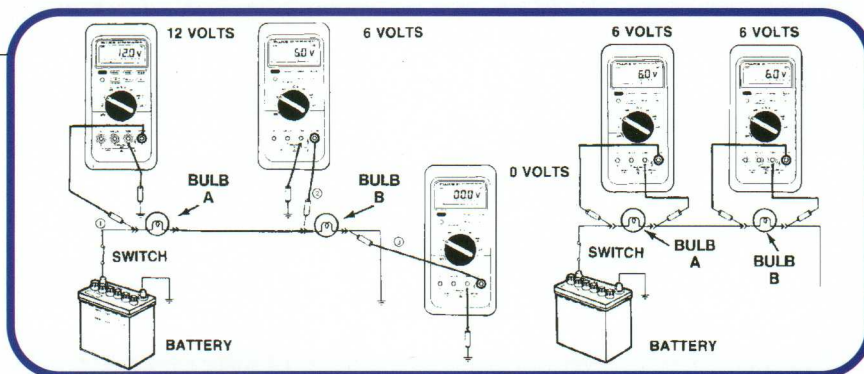
Each component must receive its rated voltage to operate properly. If not enough voltage is available, the component will not operate in the way that it should.

In a voltage drop test, we measure how much voltage is "used up" between the power source (battery or alternator) and the component. When compared to specs, the available voltage at the component should be above the minimum specified. If not, a loose connection, corrosion, or faulty power source is indicated.

Remember, some voltage drop normally occurs in each section of the circuit. But, these voltage drops add up and could reduce the available voltage below specs. The high resistance problem can be located by moving the voltmeter lead through the circuit—stopping at each possible location—until the problem is found.

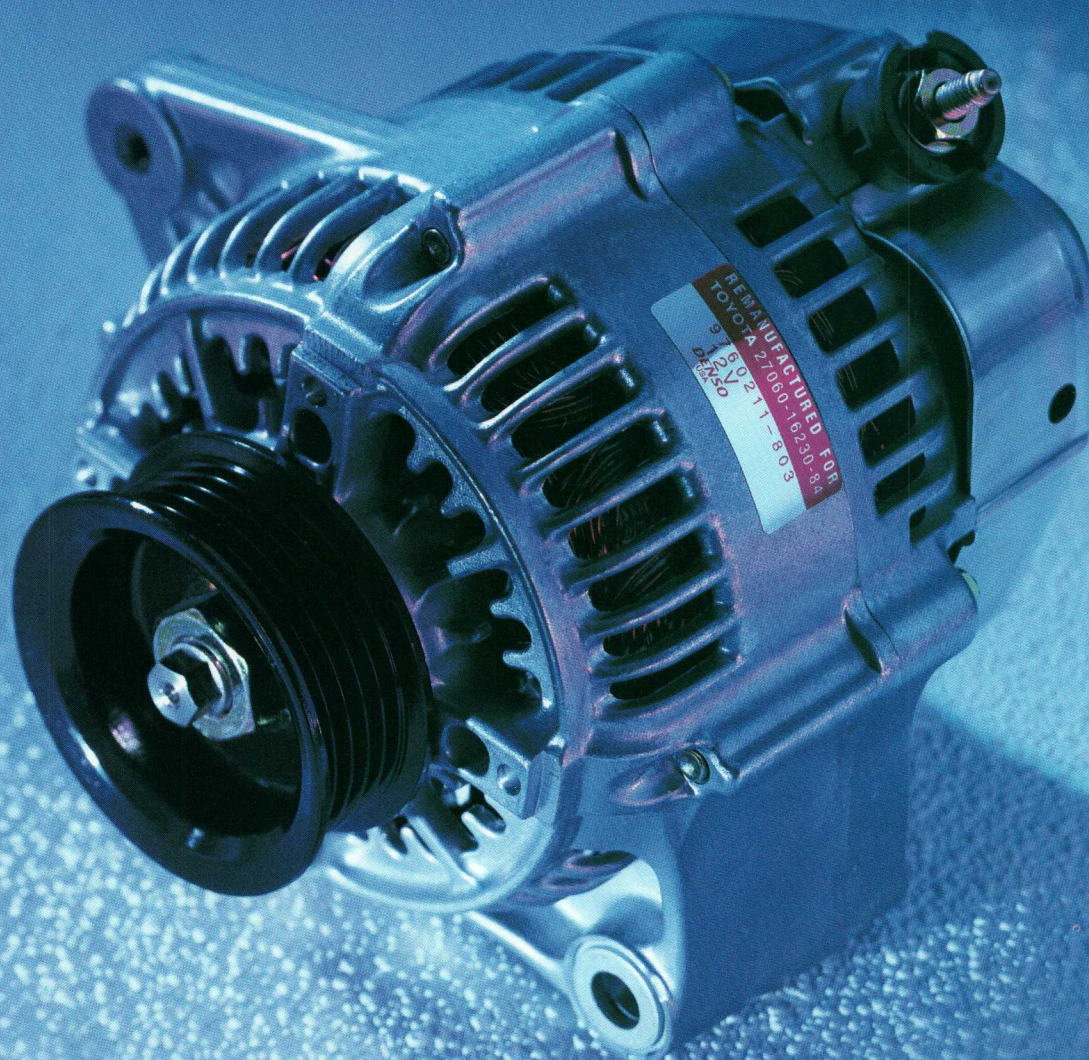
Normally, the voltage drop on the power feed side of an individual circuit should be less than one-tenth volt; on the ground side, less than 0.5 volt.

Voltage drop testing is so important because high resistance can prevent proper circuit operation. Circuits with low current draw can tolerate high resistance, while circuits with high current draw cannot. For instance, a loose or corroded connection can easily add several ohms of resistance to a circuit. This amount of resistance in the starting circuit would severely reduce current flow to the starter, not allow sufficient cranking speed, and possibly result in a "no start" condition. This amount of resistance in the ignition primary circuit would prevent proper coil buildup and reduce secondary voltage below that needed to "fire" the spark plugs.



Checking Voltage Drop

Keep your customer's satisfaction  
at full charge.



### Toyota Genuine Remanufactured Alternators

- Meets OEM Specifications
- Fits Like the Original Part
- Long-term Reliability
- Same Warranty as New Units

• Toyota Quality at a Great Value



**DENSO**

## Glossary of Electrical Terms

**Induced Voltage** - The voltage which appears in a conductor when relative motion exists between it and magnetic flux lines.

**Induction** - Producing a voltage in one conductor or coil by moving the conductor or coil through a magnetic field or by moving the magnetic field past the conductor or coil.

**Infinite Reading** - A reading of infinity on an ohmmeter that indicates an open circuit - broken wire, defective component.

**Infinite Resistance** - Very high resistance, a value higher than can be conceived. No current can move through. Usually, circuit is broken with no complete path for current flow.

**Initial Charge Rate** - The current a battery will accept at the start of charging. Charging current decreases as charging progresses.

**Input** - Generally used to refer to the data or instructions given or fed into a microcomputer.

**Insulated Cable** - The battery cable that conducts battery current to the automotive electrical system.

**Insulators** - Materials that will not conduct electron flow because of their many bound electrons.

**Integrated Circuit** - (IC) An electronic circuit containing transistors, diodes, resistors, and capacitors along with electrical conductors processed and contained entirely within a single chip of silicon.

**Lead Sulfate** - Hard, insoluble layer that slowly forms on the plates of a discharged battery and can only be reduced by slow charging, caused by the chemical reaction of the acid in the electrolyte acting on the lead peroxide and sponge lead of the active material in the plates.

**Leakage Current** - Unwanted current flowing through a semiconductor or capacitor.

**Left-Hand Rule** - A method of determining the direction of the magnetic flux lines surrounding a current-carrying conductor when the electron theory of current flow is used (negative to positive). If the conductor is grasped with the left hand so the thumb points in the direction of current flow, the fingers will point in the direction of magnetic flux.

**Light Emitting Diode (LED)** - A semiconductor diode designed so light is emitted when forward current is applied to the diode.

**Light-Load Test** - A test applied to storage batteries during which the voltage is measured while the battery is subjected to a light load, such as the car headlights.

**Linear Integrated Circuit** - An integrated circuit designed to amplify signals rather than switching.

**Lines of Force** - Imaginary lines representing the direction of magnetism around a conductor or from the end of a magnet.

**Liquid Crystal Display (LCD)** - Uses a polarized light principle and a liquid crystal to display numbers and characters.

**Loss of Power** - A type of circuit malfunction in which the voltage source for the circuit or device is lost. This could be a worn-out or defective battery or an OPEN CIRCUIT on the battery side of the electrical load.

**Magnet** - Any body with the property of attracting iron and steel. Temporary magnets are made by surrounding a soft iron core with a strong electromagnetic field. Permanent magnets are made with steel.

**Magnetic Circuit** - Paths taken by lines of force in going from one end of the magnet to the other.

**Magnetic Field** - The area near a magnet where the property of magnetism can be detected. Also the flow of magnetic force between opposite poles of a magnet.

**Magnetic Flux** - The invisible, directional lines of force which make up a magnetic field.

**Magnetic Flux Density** - Strength of the magnetic lines of force. The denser the magnetic flux, the more lines of force will extend from pole to pole in the magnet.

**Magnetic Induction** - Producing magnetism in a magnetic body by bringing it near a magnetic field.

**Magnetic Pole** - Point where the lines of force enter and leave a magnet.

**Magnetic Saturation** - The condition when a magnetic field reaches full strength and maximum flux density.

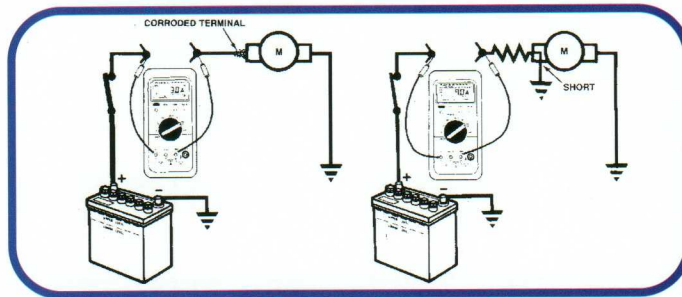
## Measuring Current

Current is the "flow" of electricity through a circuit and its components. This flow only occurs when voltage is present and there are no breaks in the circuit. Shorts and grounds, however, may cause the current to flow into other circuits away from the components that need it. An ammeter is the only tool available to check for the proper amount of current in the circuit. The meter can be analog or digital, part of another tester or meter, or an inductive device when a precise measurement is not needed.

Remember, the ammeter must always be connected in series with the circuit, load, controls, and protective devices. It measures current flow only with the power "on." Make sure the meter scale is set high enough for the amount of current being measured.

### Checking Current Flow

To check for a component's current flow, open the circuit and connect an ammeter in series with the component. With power to the component, the current flow should meet specs. If flow is too low, check for high resistance or a discharged battery. If it is too high, check for a short or bad component.



Checking Current Flow

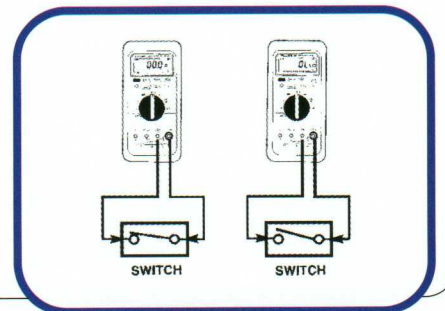
## Measuring Resistance

Resistance opposes current flow. It is put to good use in components to change electrical energy into other forms of energy—light, heat, motion. But, it can cause problems if it is caused by loose or corroded connections in the circuit or shorts or grounds in components.

An ohmmeter is seldom used to find areas of high resistance in a circuit. Voltage-drop testing is much quicker and more accurate because it tests the circuit when it is in use. An ohmmeter, however, is especially useful for checking component resistances to make sure they meet specs. It is also useful for checking circuit continuity to locate opens, shorts, and grounds.

### Checking Relay And Switch Continuity

Most Toyota electrical diagnostic procedures call for ohmmeter checks of relay or switch continuity and operation. Continuity checks will identify opens with readings of infinite resistance, shorts with little or no resistance, and operation "OK" with resistance within specs.

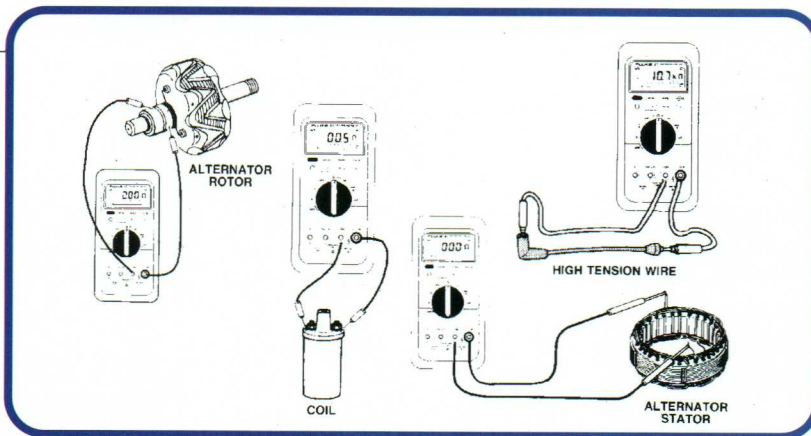


Checking Switch Continuity

## Checking Component Resistances

A number of components can be checked for proper resistance. The readings obtained should be compared with specs. If the reading is below specs, a short or ground may be indicated. If it is above specs, loose connections, burnt contacts, or other problems are indicated.

Remember, the ohmmeter has its own battery. The circuit or component must be disconnected before connecting an ohmmeter. Also, always "zero" the analog meter before each use, and use the lowest scale possible to ensure accuracy.



Resistance Check

## Checking Continuity

Continuity checks can be made with a jumper wire, test lamp or ohmmeter.

### Jumper Wire

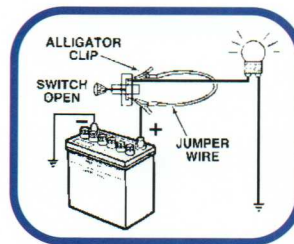
A jumper wire can be used to bypass a suspected "open" in the circuit. Never use a jumper wire to bypass a load or in such a way that a power circuit is shorted to ground. Only bypass switches or other controls, fuses or other protective devices, wires, and connectors. Never bypass loads.

### Test Lamps

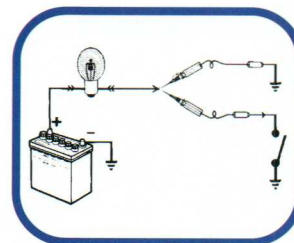
Test lamps "light" when there is continuity in a circuit or component. If they do not light, the circuit section is open and no current is flowing. 12 volt test lamps are connected with the power "on" without regard to polarity. A self-powered test lamp must be used with the power "off." It can check for both opens and shorts.

### Ohmmeter

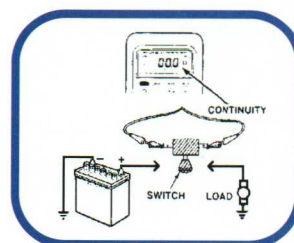
An ohmmeter is an excellent continuity tester. It can not only show whether the circuit or component has a continuous path for current (continuity), it can also show the "quality" of that path. It can identify opens and shorts, and—more important—areas of high resistance.



Jumper Wire



Test Lamp



Ohmmeter

## Glossary of Electrical Terms

**Magnetic Shunt (Magnetic Bypass)** - A piece of metal on a voltage regulator coil that controls voltage output at varying temperatures by affecting the coil's magnetic field.

**Magnetism** - A form of energy caused by the alignment of atoms within certain materials. The ability of a metal to attract iron.

**Maintenance - Free Battery** - Battery that does not require the addition of water during its normal service. Grids in maintenance-free batteries are made of metals other than antimony to produce less gassing and therefore, less chance of pushing electrolyte from the battery.

**Matter** - The substance of which a physical object is composed.

**Memory** - Part of a microprocessor or microcomputer in which instructions or data are stored as electrical impulses.

**Micro** - Prefix of measurement meaning one millionth of a part.

**Microprocessor** - Set of integrated circuits that can be programmed with stored instructions to perform given functions. A computer in the lowest range of size and speed containing a central processing unit (CPU), instructions stored in a read-only memory (ROM), and a random access memory (RAM) for receiving data and instructions. Also called a micro-computer.

**Milli** - Prefix of measurement meaning one thousandth of a part.

**Millisecond** - Unit of measurement for time, meaning one thousandth of a second. **Module** - A self-contained, sealed unit that houses the solid-state circuits needed to control certain electrical or mechanical functions.

**Molecule** - Two or more atoms joined together to form an element or a chemical compound.

**Motor** - An electromagnetic device used to convert electrical energy into mechanical energy.

**Mutual Induction** - Creation of voltage in one conductor by the rise and collapse of the magnetic field surrounding another conductor. Magnitude or strength of induced voltage depends on the ratio of turns between one coil and the other and the strength of current causing the induced voltage.

**Nanosecond** - One billionth of a second. A unit of measurement usually referring to the speed the circuit in a microcomputer can work. Electricity, traveling at the speed of light, will travel about 11.8 inches in one nanosecond. In comparison the same electricity will travel about 930 feet in one microsecond (millionth of a second).

**Negative Polarity** - Also called ground polarity. A correct polarity of the ignition coil connections. Coil voltage is delivered to the spark plugs so that the Center electrode of the plug is negatively charged and the grounded electrode is positively charged.

**Negative Pole** - The point to which the electrons forming an electric current return from a circuit. Also referred to as the south pole in magnetism.

**Negative Temperature Coefficient** - The property of any substance in which the electrical resistance increases as the temperature of the substance decreases.

**Negative Terminal** - The battery terminal closest to the negative potential in the battery.

**Neutral Junction** - Center connection of the three windings in a Y-type alternator stator.

**Neutron** - A particle in an atom that has no charge and is electrically neutral.

**N-Material** - A semiconductor material that has excess free electrons because of a layer of impurity added. It has a negative charge and will repel additional electrons.

**No-Load Test** - A cranking-motor test in which the cranking motor is operated without load; the current draw and armature speed at the specified voltage are noted.

**North Pole** - The area of a magnet from which the lines of force are said to leave the magnet. The end of a magnet that will point toward the north if freely suspended.

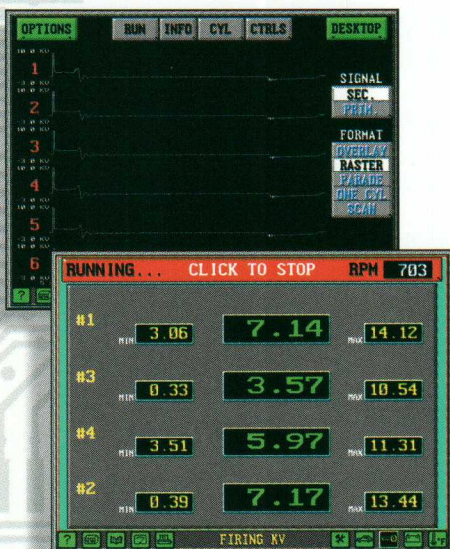
**NPN Transistor** - Transistor with two layers of N-type material separated by a layer of P-type material. Base circuit must be positive relative to the emitter for current to flow through the collector circuit.

# The New Benchmark in State-of-the-Art Engine Analysis!

ENGINE-TECH™ redefines state-of-the-art engine and fuel system analysis, pushing it to the limits of innovation. No matter which of its wide range of self-configuring diagnostic functions you use, it always leaves you in charge of the diagnostic process. Winner of MOTOR magazine's prestigious 'Top New Tool' award for '95, ENGINE-TECH also fully supports the SIMU-TECH™ diagnostic module, enabling you to monitor both ignition and electronic control system signals on the screen at one time — an industry first!

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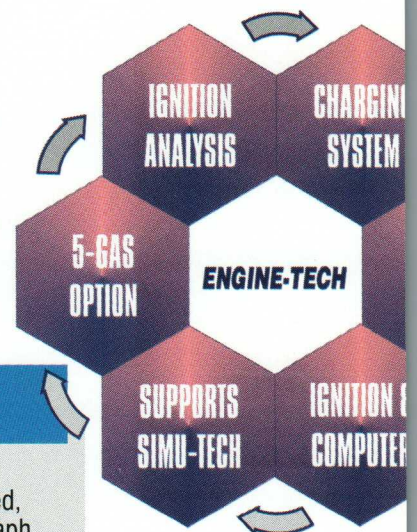


## Simple to Operate and Incredibly Accurate

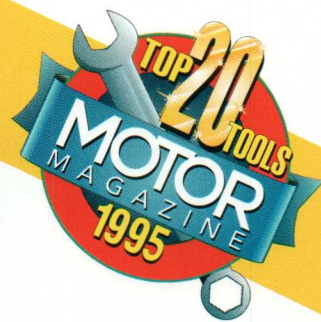
- Fully automated, state-of-the-art ignition scope accurately, and reliably, displays the ignition patterns of even the most advanced ignition systems.
- Cable hookup to DIS, integrated coil, and conventional ignition systems is quick and easy.
- Instantaneous display of state of all cylinders.
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- See on one screen all the signal information necessary to make a fast, accurate diagnosis.
- Save and print the signal data displayed.

## Range of Ignition Signal Display Formats

- Select the display format best suited to showing the ignition signal detail you need, including waveform, digital, bar chart, graph and RPM.

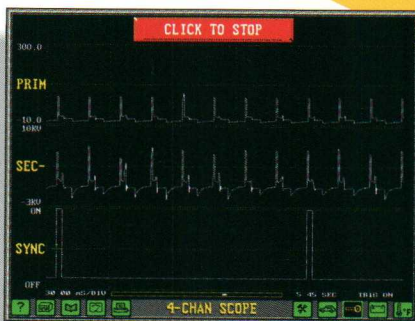


**EDGE**   
Diagnostic Systems



### Four-Trace Lab Scope With Record and Playback Functions

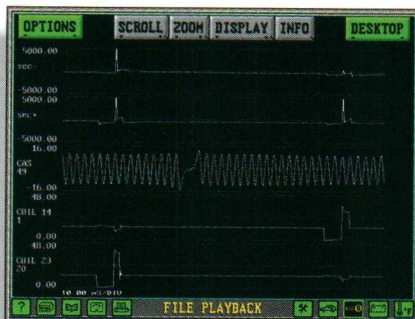
- Use the self-configuring multi-trace scope to view the live signal output of up to four signals you select, including secondary and primary ignition, vacuum, pressure, amps and temperature.
- The Primary lead can also be connected to non-ignition signals (e.g., TPS).
- Record, play back and zoom in on all signal data displayed.



### View Multiple Ignition and Engine Control System Signals

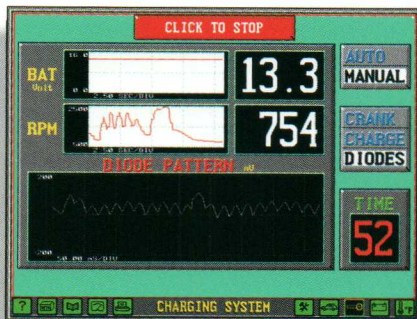
- Used in combination with SIMU-TECH, ENGINE-TECH enables you to view the live signal data of up to seven different ignition and engine control system signals.

Example: With a DIS-equipped 2.8L GM vehicle, you could display the secondary ignition signals, both positive and negative, and the pressure sensor input from the fuel rail, along with the signal waveforms for the distributor reference (DREF), electronic spark timing (EST) and both fuel injector driver circuits. With this screen you could diagnose numerous ignition faults (e.g., faulty coils, faulty ignition modules, bad spark plugs/wires) as well as fuel injection faults. You would be able to view both the cause of the problem and its related effect on the ignition, emissions and fuel systems.



### Battery/Starting/Charging System Diagnostics

- View on one screen and in simple, easy-to-understand meter display formats all the diagnostic data necessary to diagnose the complete electrical system.



“ENGINE-TECH is just unbelievable. Now technicians have the diagnostic capabilities that have been lacking in other analyzers for years. One example is the ability to record, play back and analyze the relationship between ignition and computer signals, which is absolutely incredible. EDGE has finally bridged the gap between ignition and computer signal diagnostics.”

— Mark Warren  
Owner, Mark's Auto

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**FOR MORE INFORMATION CALL 800-362-8326 TODAY!**

# Reading Diagrams

## Glossary of Electrical Terms

**N-Type Material** - Semiconductor material with an excess of free electrons because of some impurity added. It has a negative charge and will repel additional electrons.

**Nucleus** - The center core of an atom that contains the protons and neutrons.

**Ohm** - The standard unit for measuring the resistance to current flow. One ohm of resistance will limit current flow to one ampere when one volt of pressure is applied.

**Ohm's Law** - The mathematical relationship between voltage, current, and resistance. The pressure of one volt applied to one ohm of resistance will cause one ampere of current to flow. Amps equal volts divided by ohms ( $I = E/R$ ). Volts equal amps times ohms ( $E = I \times R$ ). Ohms equal volts divided by amps ( $R = E/I$ ).

**Ohmmeter** - An electrical meter used to measure the resistance to current flow in a circuit or working load. It reads ohms of electrical resistance. The ohmmeter can only be connected across a circuit or device with the power removed. This meter has its own battery and will be damaged if connected to a circuit that has power applied.

**Open Circuit** - A type of circuit in which there is an incomplete path for current flow. The open circuit may be caused deliberately, by a switch that is in the OFF position, or it may be caused by a break in the conductor. An open circuit can occur on either side of the load; however, an open circuit in the ground side of the circuit is usually referred to as a LOSS OF GROUND.

**Open-Circuit Voltage** - The voltage across the battery terminals with no load applied.

**Oscilloscope** - An electric instrument producing, on a screen, a visual display or trace of voltage changes in an electrical circuit.

**Overcharging** - Continued charging of a storage battery after it has reached the fully charged state. This damages the battery and shortens its life.

**Overload** - Carrying a greater load than the device, machine, or electric circuit is designed to carry.

**Parallel Circuit** - A circuit in which the components are arranged so that there is a separate current path to each component. In a parallel circuit, the components are connected positive-to-positive and negative-to-negative.

**Peak Inverse Voltage** - Highest reverse bias voltage that can be applied to a junction of a diode before the semiconductor material breaks down and allows current to flow in that opposite direction.

**Permanent Magnet** - Piece of metal that holds its magnetism without the use of continuing electric current to create a magnetic field.

**Permeability** - A measure of the ease or difficulty with which materials can be penetrated by magnetic flux lines. Iron is more permeable than air.

**Photoelectricity** - Voltage caused by the energy of light as it strikes certain materials.

**Piezoelectricity** - Voltage caused by physical pressure applied to the faces of certain crystals.

**Plate** - Material in a storage battery that reacts with the acid in electrolyte to produce a voltage for current flow. Usually made of a soft porous lead compound supported by a harder metal grid. If the plate is sponge lead it has a positive charge; if it is made of lead peroxides, it has a negative charge.

**Plate Group** - The positive and negative plates in one cell of a battery, connected together to produce approximately 2.2 volts.

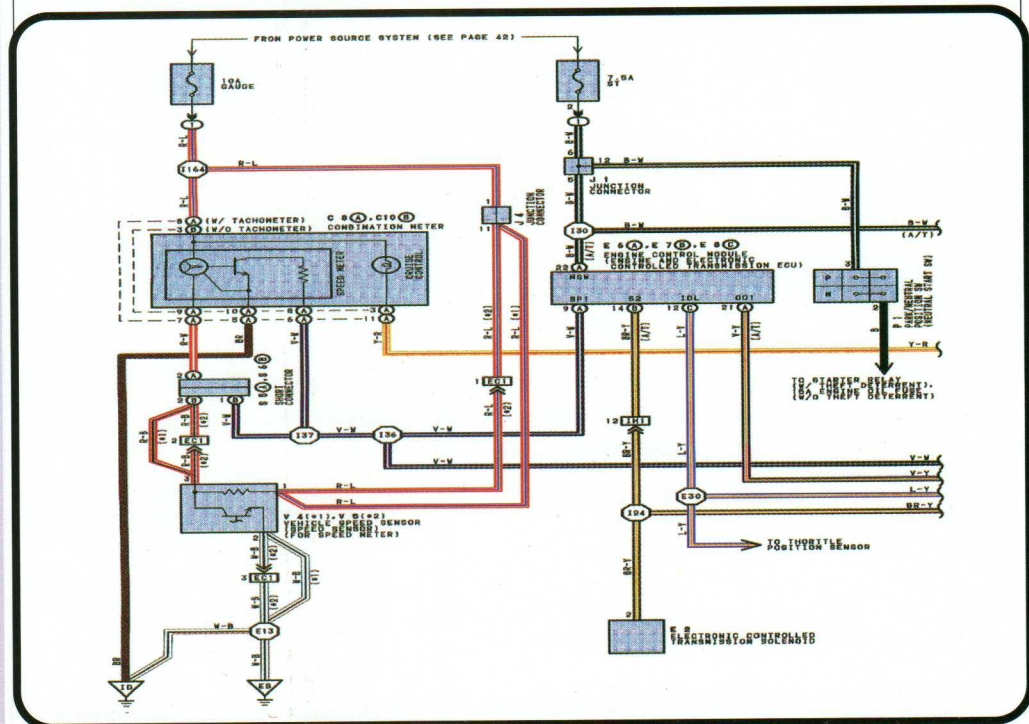
## Reading Toyota Wiring Diagrams

Knowing how to read Toyota wiring diagrams is especially important for accurate electrical diagnosis and testing. These diagrams show wire routing as well as common points where related circuits tie in—important points for making the six-step troubleshooting plan work as it should.

As you develop your knowledge and skills on electrical systems, one effective method of using the wiring diagrams is:

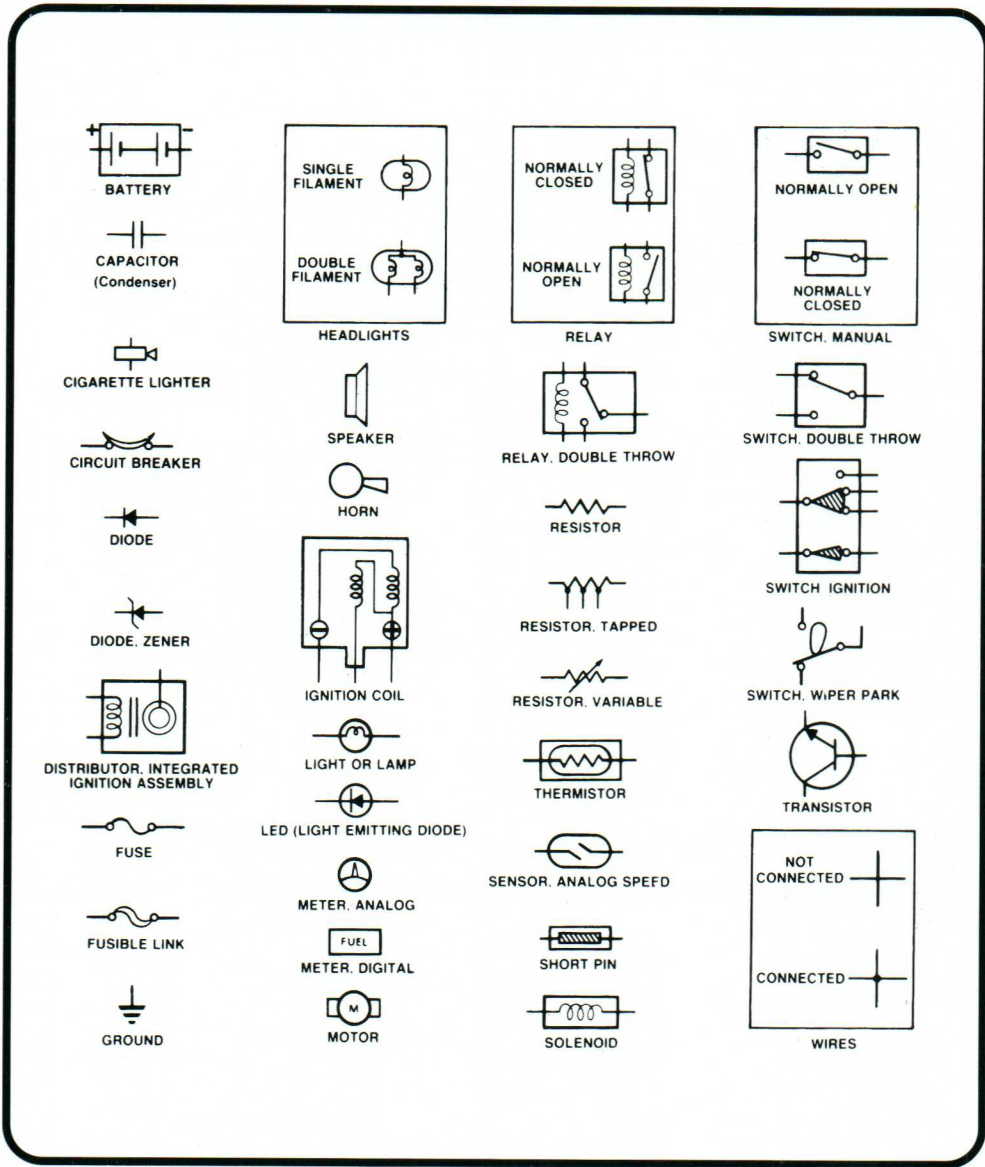
- 1 Check the complete electrical wiring diagram (foldout) to position the system you are working on.
- 2 Refer to the appropriate System Diagram for greater detail.
- 3 Find the connector locations on the Electrical Wiring Routing Diagram.
- 4 Check for common points on the Power Source Diagram and the Ground Points Diagram.
- 5 Find the relay, junction block, and component locations on the Relay Locations Diagram.

For additional information on how to use wiring diagrams, familiarize yourself with the **Toyota Electrical Wiring Diagram** manuals. Especially, read the "Introduction" and "How To Use This Manual" sections in the **Toyota Electrical Wiring Diagram** manuals.



Vehicle Wiring Diagram





Electrical Symbols

**Glossary of Electrical Terms**

- PN Junction** - Dividing line in a semiconductor between P-type material and N-type material. Electrons can flow from N to P but not from P to N.
- PNP Transistor** - Transistor with two layers of P-type material separated by a layer of N-type material. Base circuit must be negative relative to the emitter for current to flow through the collector circuit.
- Polarity** - The quality or condition in a body that has opposite properties or directions. A collective term applied to the positive (+) and negative (-) ends of a magnet or electrical component such as battery or coil.
- Polarize** - The process of establishing positive and negative polarity across alternator fields and thus determining the direction of current flow.
- Polarizing** - A method of maintaining the electrical and magnetic polarity of the pole shoes and field in an alternator.
- Poles** - Positive and negative terminals of a cell or battery. Also, the ends of a magnet (north and south).
- Pole Shoes** - Magnetic iron cores, or poles, that provide the magnetic field in an alternator or motor and strengthen the electromagnetic field of the field windings.
- Positive Charge** - The electrical characteristics of a substance with a deficiency of electrons in the outer ring of its atoms.
- Positive Plate** - The dioxide of lead plate in 5 lead-acid storage battery.
- Positive Polarity** - Also called reverse polarity. An incorrect polarity of the ignition coil connections. Coil voltage is delivered to the spark plug so that the center electrode of the plug is positively charged and the grounded electrode is negatively charged.
- Positive Pole** - The point from which the electrons forming an electric current enter a circuit as defined by the "Conventional Theory." Also referred to as the north pole in magnetism.
- Positive Temperature Coefficient (PTC) Resistor** - or heating element in which the resistance increases with temperature. Heat created by current flowing through it. Eventually the resistance will get so high that it will oppose all current flow. Then, the resistor or heating element will cool down until current can begin to flow again, increasing the temperature.
- Positive Terminal** - The battery terminal from which electrons flow in a complete electrical circuit. Generally the side of the circuit not connected to ground.
- Potential** - The pressure (voltage) existing between two points available to force electrons through the circuit as current.
- Potentiometer** - Electrical component that can vary the amount of resistance placed in a circuit by turning or sliding a contact on the resistance wire windings.
- Power** - Rate at which work is done. Common unit of measure for power is horsepower. Power is also measured by kilowatt (kW). About three-fourths of a kilowatt equal one horsepower.
- Power Feed Circuit** - Wires that carry current from the positive terminal of the battery to the electrical components of the vehicle.
- Power-Seeking** - A test method using a 12-volt test light where one lead is connected to a known ground and the other lead is touched to various points of a circuit to seek a point where power is present.
- Power Supply** - Sources of voltage in a circuit. Pregelov - The time it takes a glow plug to reach a temperature at which it will cause ignition of the mixture in the cylinder.
- Primary Winding** - Winding of relatively heavy wire in an ignition coil that receives current from the battery to create a magnetic field and induce a voltage in the secondary windings of the coil.
- Primary Wiring** - The low-voltage wiring in an automobile electrical system.
- Printed Circuit** - An electrical circuit made by etching conductive material on an insulated board into a pattern to provide current paths between components mounted on the board.
- Programmable Read Only Memory (PROM)** - Part of a microprocessor or computer in which instructions or data are semi-permanently located. PROM data can be changed (like a RAM) but are not volatile memory (they do not erase when the power is turned off but are permanently configured as part of the electronic circuit).
- Proton** - One of the positive-charged particles in the nucleus of an atom.
- P-Type Material** - Semiconductor material with holes as part of its basic structure. It has a positive charge and will attract additional electrons.

# Reading Diagrams

## Glossary of Electrical Terms

**Pull-In Winding** - The coil of large-diameter wire in a solenoid that creates a magnetic field to pull the solenoid plunger into the coil.

**Quick Charger** - Battery charger used to produce a high charging current to boost the charge of a battery in a short time.

**Random Access Memory (RAM)** - Part of a micro-processor or computer into which information can be written and from which information can be read.

**Reactance** - Property of an electrical device or conductor to impede change in current passing through it or voltage exerted on it.

**Read Only Memory (ROM)** - Part of a micro-processor or computer where information and instructions are permanently integrated into the circuits and can only be read by the processor. Usually used to store the program or instructions for the processing unit to act on.

**Rectifier** - Device used to change alternating current to direct current.

**Regulator** - Device in the charging system used to control alternator output to prevent excessive voltage from being fed to the battery or to the electrical components in a vehicle.

**Relative Motion** - Movement of a conductor in relation to magnetic flux lines or movement of magnetic flux lines in relation to a conductor.

**Relay** - An electromagnetic switch. A relay uses a small amount of current flow to control the flow of a larger amount of current through a separate circuit.

**Reluctance** - The tendency of some materials to resist penetration by magnetic flux lines.

**Required Voltage** - Voltage needed to fire a spark plug.

**Reserve Capacity Rating** - A battery rating based on the number of minutes a battery at 80 degrees F can supply 25 amperes, with no battery cell falling below 1.75 volts.

**Resistance** - The opposition to the free flow of an electric current, measured in ohms.

**Resistor** - A device made of carbon or wire that presents a resistance to current flow. Any device in a circuit that produces work, loads the circuit, and causes a voltage drop acts as a resistor.

**Resistor Plug** - A sparkplug with a resistor in the center electrode to reduce the inductive portion of the spark discharge. Used to minimize radio and television interference caused by spark plugs.

**Resistor Wire** - Conductor of a given diameter and length that adds resistance, usually a low value, to a circuit.

**Reverse Bias** - Polarity of voltage applied to the junctions of a diode or transistor so normally no current will flow across the junction.

**Reverse Breakdown Voltage** - The reverse voltage beyond which a diode cannot hold back reverse current.

**Reverse Current** - Amount of current flowing from cathode to anode when a given reverse voltage is imposed on a diode or transistor.

**Rheostat** - A resistor for regulating a current by means of variable resistances.

**Right-Hand Rule** - A method of determining the direction of magnetic flux lines surrounding a current-carrying conductor; when the conventional theory of current flow is used (positive to negative). If the conductor is grasped with the right hand so the thumb points in the direction of conventional current flow, the fingers will point in the direction of magnetic flux.

**Rotor** - Revolving part of a device, such as an alternator rotor, distributor rotor, or rotary combustion engine rotor.

**Schematic Diagram** - A drawing of a circuit, or any part of a circuit, that shows how it works.

**Secondary Circuit** - High voltage circuit of the ignition system consisting of the coil, rotor, distributor cap, spark plug cables, and spark plugs.

**Secondary Winding** - The coil winding made of many turns of a fine wire, in which voltage is induced by the rise and collapse of the magnetic field of the primary winding.

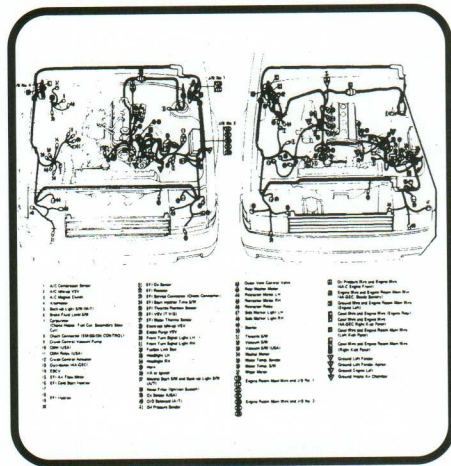
**"See-Saw" Rule** - An easy way to remember and use Ohm's Law in your work. If voltage stays the same, but current is above specs, resistance must be down - possibly a short circuit. If voltage stays the same, but current is below specs, resistance must be up - possibly a bad connection.

## Wiring Diagrams

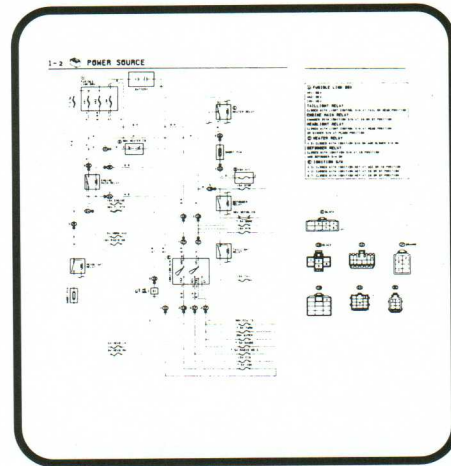
Many feet of wiring link the circuit loads to the battery in Toyota vehicles. All of this wiring is wrapped with color-coded insulation to aid circuit tracing in diagnosis and testing. These color codes are shown on Toyota wiring diagrams issued with each new model.

Toyota wiring diagrams also show components as symbols to aid your understanding of how each circuit works. Circuit grounds are especially important—devices may have case grounds (mount) or remote grounds (white wire with black tracer). Knowing the locations and operating positions of switches and relays is also important switches may be on the power or ground side, while relays are almost always on the power side.

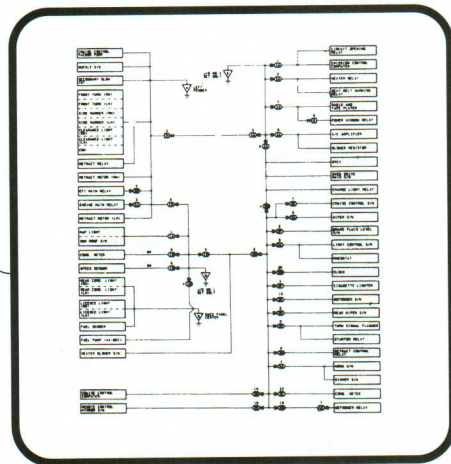
Connector locations, which make good test points, are shown on the wiring routing diagram. Common test points are shown on the power source diagram and ground points diagram. Relays, junction blocks, and components are shown on the relay locations diagram.



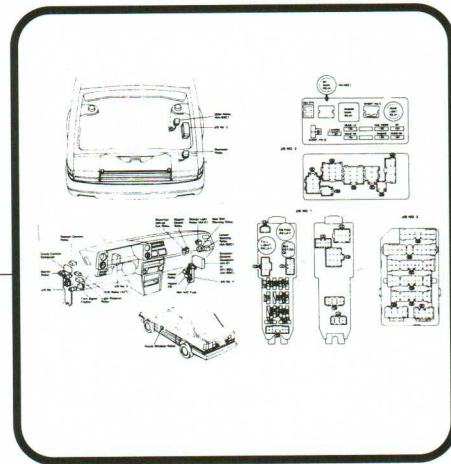
Wire Routing Diagram



Power Source Diagram



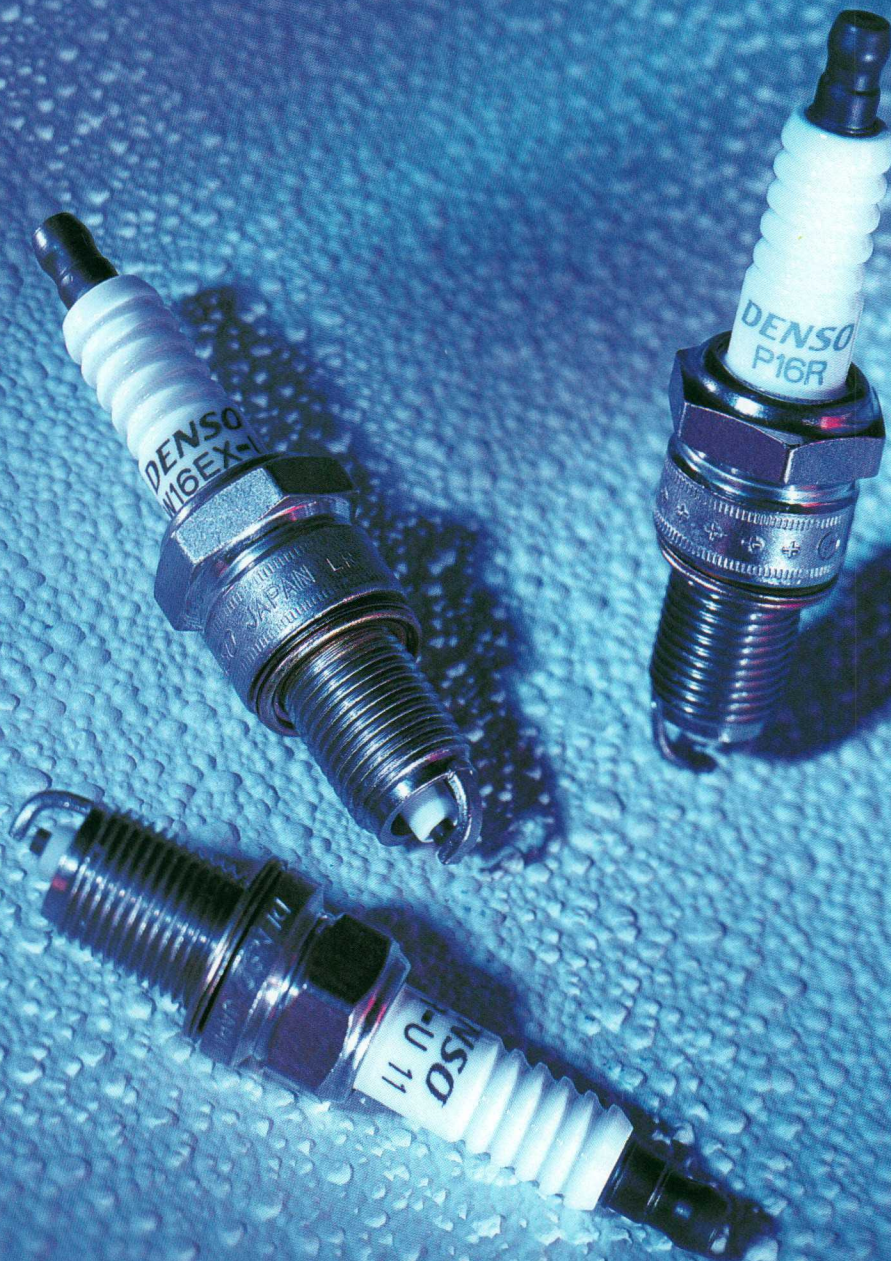
Ground Points Diagram



Relay Locations Diagram



Spark your customer's loyalty.



**Toyota Genuine U-Groove Spark Plugs**

- Meets OEM Specifications
- Quick Starts
- Smooth Idle
- Improved Fuel Economy
- Improved Throttle Response
- Peak Vehicle Performance



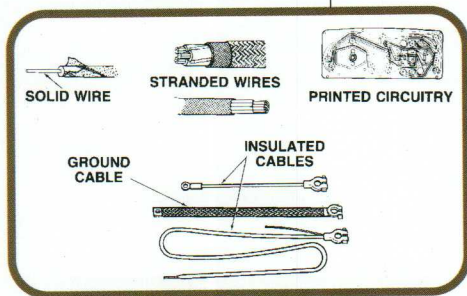
**DENSO**

# Wire, Terminal, And Connector Repairs

## Conductors

Conductors are needed to complete the path for electrical current to flow from the power source to the working devices and back to the power source.

### Power or Insulated Conductors

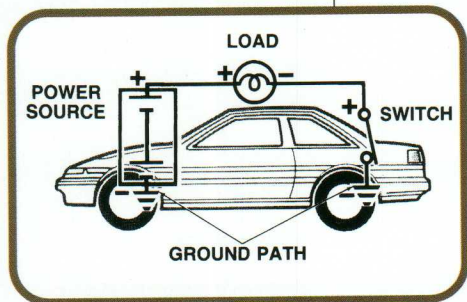


Power or Insulated Conductors

Conductors for the power or insulated current path may be solid wire, stranded wire, or printed circuit boards. Solid, thin wire can be used when current is low. Stranded, thick wire is used when current is high. Printed circuitry- copper conductors printed on an insulating material with connectors in place- is used where space is limited, such as behind instrument panels.

Special wiring is needed for battery cables and for ignition cables. Battery cables are usually very thick, stranded wires with thick insulation. Ignition cables usually have a conductive carbon core to reduce radio interference.

### Ground Paths



Ground Paths

Wiring is only half the circuit in Toyota electrical systems. This is called the "power" or insulated side of the circuit. The other half of the path for current flow is the vehicle's engine, frame, and body. This is called the ground side of the circuit. These systems are called single-wire or ground-return systems.

A thick, insulated cable connects the battery's positive (+) terminal to the vehicle loads. As insulated cable connects the battery's negative (-) cable to the engine or frame. An additional grounding cable may be connected between the engine and body or frame.

Resistance in the insulated side of each circuit will vary depending on the length of wiring and the number and types of loads. Resistance on the ground side of all circuits must be virtually zero. This is especially important: Ground connections must be secure to complete the circuit. Loose or corroded ground connections will add too much resistance for proper circuit operation.

## System Polarity

System polarity refers to the connections of the positive and negative terminals of the battery to the insulated and ground sides of the electrical system. On Toyota vehicles, the positive (+) battery terminal is connected to the insulated side of the system. This is called a negative ground system having positive polarity.

Knowing the polarity is extremely important for proper service. Reversed polarity may damage alternator diodes, cause improper operation of the ignition coil and spark plugs, and may damage other devices such as electronic control units, test meters, and instrument panel gauges.

## Harnesses

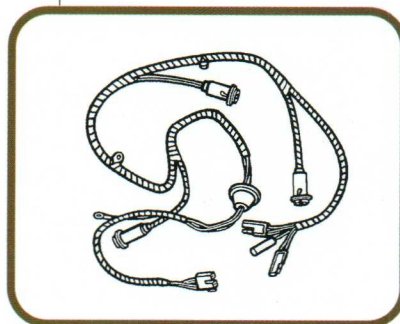
Harnesses are bundles of wires that are grouped together in plastic tubing, wrapped with tape, or molded into a flat strip. The colored insulation of various wires allows circuit tracing. While the harnesses organize and protect wires going to common circuits, don't overlook the possibility of a problem inside.

## Wire Insulation

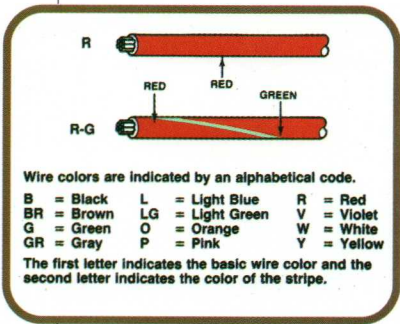
Conductors must be insulated with a covering or "jacket." This insulation prevents physical damage, and, more important, keeps the current flow in the wire. Various types of insulation are used depending on the type of conductor. Rubber, plastic, paper, ceramics, and glass are good insulators.

## Connectors

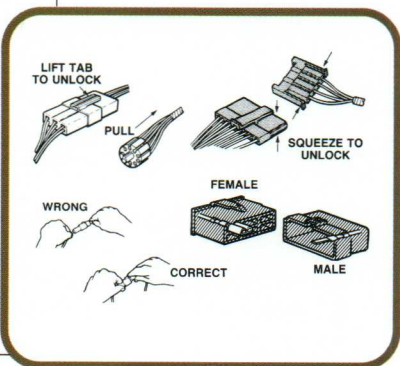
Various types of connectors, terminals, and junction blocks are used on Toyota vehicles. The wiring diagrams identify each type used in a circuit. Connectors make excellent test points because the circuit can be "opened" without need for wire repairs after testing. However, never assume a connection is good simply because the terminals seem connected. Many electrical problems can be traced to loose, corroded, or improper connections. These problems include a missing or bent connector pin.



Wiring Harness



Wire Color Codes



Connectors

## Glossary of Electrical Terms

**Self Discharge** - Chemical activity in a battery causing the battery to discharge even though it is not supplying a circuit or component with current.

**Self-Induced Voltage** - Voltage created in a conductor by the magnetic lines of a current through that same conductor.

**Self-Powered Test Light** - Used to check for continuity in a circuit or load device. Test unit uses a low voltage battery (1.5 volts) and bulb, and test leads.

**Semiconductor** - Popular name associated with almost any solid state circuit or component. Materials with four electrons in the outer ring of the atom which show the properties of a conductor or a non-conductor under different conditions.

**Sending Unit** - Sensor in the engine at a convenient point of an oil gallery or coolant passage to send a signal to a gauge or light indicating the pressure or temperature of the oil or coolant.

**Series Circuit** - A circuit in which the parts are connected end to end, positive pole to negative pole, so that only one path is available for all current flow.

**Series Motor** - A motor that has only one path for current flow through the field and armature windings. Commonly used for starter motors.

**Series-Parallel Circuit** - The connection of several loads in a circuit in such a way that current must flow through some loads, but can flow to one or more other loads without affecting the rest of the circuit. A series-parallel circuit is simply a circuit containing elements of both a series circuit and a parallel circuit.

**Short Circuit** - A type of circuit malfunction in which two or more wires touch each other accidentally, in such a way that the circuit(s) are completed wrong. A short circuit between two different circuits interconnects the two in such a way that if either circuit is electrically energized, both will function.

**Shunt** - Parallel. An electrical connection or branch circuit in parallel with another branch circuit or connection.

**Shunt Motor** - A motor that has its field windings wired in parallel with its armature. Not used as a starter motor, but often used to power vehicle accessories.

**Silicon** - Element commonly used in making semiconductor material.

**Sine Wave Voltage** - The constant charge, first to a positive peak and then to a negative peak, of an induced alternating voltage in a conductor.

**Single-Phase Current** - Alternating current caused by a single-phase voltage.

**Single-Phase Voltage** - The full wave voltage induced within one conductor by one revolution of an alternator rotor.

**Slip Rings** - Parts of an alternator forming a rotating connection between the field coil windings and the brushes.

**Solenoid** - Electro-mechanical device used to produce mechanical movement by drawing a plunger into a coil when current is applied to the coil. Used to control a valve, switch contacts, or control other moving parts.

**Solenoid-Actuated Starter** - A starter that uses a solenoid both to control current flow in the starter circuit and to engage the starter motor with the engine flywheel.

**Solid State** - Electronic components consisting mainly of silicon chips and similar conductive materials.

**Solid State Regulator** - Voltage regulator made from semiconductor components mounted in the alternator.

**Solid Wire** - A conductor made of one piece instead of being made from a number of smaller wires.

**South Pole** - Area of a magnet where the magnetic lines of force converge and enter the magnet.

**Spark Plug** - Device used to provide the heat or flame to ignite compressed air/fuel mixture in the combustion chamber. Consists of two accurately spaced electrodes and a threaded outer shell to screw into the cylinder head.

**Specific Gravity** - Weight of a substance compared to the weight of water. Any substance with a specific gravity of less than 1.00 is lighter than water; more than 1.00 is heavier than water. The amount of another substance (such as battery acid or antifreeze) in water can be determined by measuring the specific gravity of the mixture.

## Glossary of Electrical Terms

**Sponge Lead** - Porous lead used as the active material of the negative plate of a lead-acid storage battery.

**Starter Motor** - Electric motor used to crank the engine for starting.

**Starter Motor Load Test** - Test used to identify internal problems in the starter motor.

**Starter No-Load Test** - Test used to uncover such faults as open or shorted windings, rubbing armature, and bent armature shaft.

**Starter Relay** - Electrical switch on the starter motor that uses a smaller current from the ignition circuit to control a larger current from the battery to the starter motor.

**Starter Solenoid** - An electrically operated plunger mechanism on the starter motor used to engage the starter pinion gear with the ring gear on the flywheel. Also used to control the current to the starter motor.

**Starting Bypass** - A parallel branch circuit that bypasses the primary ballast resistor during cranking.

**Starting Control Circuit Test** - Test used to determine whether failure to crank is due to open circuits, defective wiring, or poor connections causing excessive resistance in the starter control circuit.

**Starting Safety Switch** - A neutral start switch. It keeps the starting system from operating when a car's transmission is in gear.

**Starting System** - Components in the electrical system used to crank the engine until it can begin running on its own.

**State-Of-Charge** - A measurement of a battery's internal condition in relation to a fully charged unit, usually expressed as a percentage of full charge.

**Static Electricity** - Voltage resulting from the transfer of electrons from the surface of one material to the surface of another material. The electrons are "static," meaning at rest.

**Stator** - In an alternator, it is the part that contains the conductors within which the field rotates.

**Storage Battery** - Device used to change chemical energy into electrical energy. Part of the electrical system acting as a reservoir for electrical energy, storing it in a chemical form.

**Stranded Wires** - Wires or cables made of a number of smaller wires twisted or braided together.

**Sulfation** - The crystallization of lead sulfate on the plates of a constantly discharged battery.

**Sulfuric Acid** - Highly corrosive chemical compound used in a diluted form as the electrolyte in storage batteries.

**Switch** - A device used for opening, closing, or changing the connections in an electric circuit.

**Symmetrical** - The same on either side of center. In a symmetrical high-beam headlamp, the light beam is spread the same distance to either side of center.

**System Diagram** - A drawing that shows all of the different circuit diagrams in a complete electrical system.

**Temperature Correction** - The amount that must be added to or deducted from a reading taken at one temperature to make it comparable with the same reading taken at a standard temperature.

**Terminal** - A device attached to the end of a wire or to an apparatus for convenience in making electrical connections.

**Test Lamp** - A 12-volt lamp with leads (wires) attached so that the lamp can be temporarily inserted in an electrical circuit, either in series or in parallel with it. It is used to confirm that voltage is available to a specific point in a circuit.

**Thermistor (Thermal Resistor)** - A resistor especially built to reduce its resistance as the temperature increases.

**Thermoelectricity** - Voltage resulting from an unequal transfer of electrons from one metal to another, when one of the metals is heated.

**Three Phase Current** - Combination of three alternating current cycles, each starting one-third of a cycle apart so each of the cycles in the resulting combined wave is 120 degrees out of phase from the others. Provides a smoother direct current flow when rectified because voltages of each alternating cycle are not allowed to decay completely before the next cycle begins to rise.

## Connector Repair

The repair parts now in supply are limited to those connectors having common shapes and terminal cavity numbers. Therefore, when there is no available replacement connector of the same shape or terminal cavity number, please use one of the alternative methods described below. Make sure the terminals are placed in the original order in the connector cavities, if possible, to aid in future diagnosis.

- 1 When a connector with a different number of terminals than the original part is used, select a connector having more terminal cavities than required, and replace both the male and female connector parts.

*Example: You need a connector with six terminals, but the only replacement available is a connector with eight terminal cavities. Replace both the male and female connector parts with the eight terminal part, transferring the terminals from the old connectors to the new connector.*

- 2 When several different type terminals are used in one connector, select an appropriate male and female connector part for each terminal type used, and replace both male and female connector parts.

*Example: You need to replace a connector that has two different types of terminals in one connector. Replace the original connector with two new connectors, one connector for one type of terminal, another connector for the other type of terminal.*

- 3 When a different shape of connector is used, first select from available parts a connector with the appropriate number of terminal cavities, and one that uses terminals of the same size as, or larger than, the terminal size in the vehicle. The wire lead on the replacement terminal must also be the same size as, or larger than, the nominal size of the wire in the vehicle. ("Nominal" size may be found by direct measurement across the diameter of the insulation). Replace all existing terminals with the new terminals, then insert the terminals into the new connector.

*Example: You need to replace a connector that is round and has six terminal cavities. The only round replacement connector has three terminal cavities. You would select a replacement connector that has six or more terminal cavities and is not round, then select terminals that will fit the new connector. Replace the existing terminals, then insert them into the new connector and join the connector together.*

## Conductor Repairs

Conductor repairs are sometimes needed because of wire damage caused by electrical faults or by physical abuse. Wires may be damaged electrically by short circuits between wires or from wires to ground. Fusible links may melt from current overloads. Wires may be damaged physically by scraped or cut insulation, chemical or heat exposure, or breaks caused during testing or component repairs.

### Wire Size

Choosing the proper size of wire when making circuit repairs is critical. While choosing wires too thick for the circuit will only make splicing a bit more difficult, choosing wires too thin may limit current flow to unacceptable levels or even result in melted wires. Two size factors must be considered: wire gauge number and wire length.

## Wire Gauge Number

In the American Wire Gauge system, “gauge” numbers are assigned to wires of different thicknesses. While the gauge numbers are not directly comparable to wire diameters and cross-section areas, higher numbers (16, 18, 20) are assigned to increasingly thinner wires and lower numbers (1, 0, 2/0) are assigned to increasingly thicker wires. The chart shows AWG gauge numbers for various thicknesses.

Wire cross-section area in the AWG system is measured in circular mils. A mil is a thousandth of an inch (0.001). A circular mil is the area of a circle 1 mil (0.001) in diameter.

In the metric system used worldwide, wire sizes are based on the cross-section area in square millimeters (mm<sup>2</sup>). These are not the same as AWG sizes in circular mils. The chart shows AWG size equivalents for various metric sizes.

NWS - Nominal Wiring Size is used in the wire repair kit charts.

## Wire Length

Wire length must be considered when repairing circuits because resistance increases with longer lengths. For instance, a 16-gauge wire can carry an 18-amp load for 10 feet without excessive voltage drop. But, if the section of wiring being replaced is only 3-feet long, an 18-gauge wire can be used. Never use a heavier wire than necessary, but- more important- never use a wire that will be too small for the load.

## Wire Repairs

Cut insulation should be wrapped with tape or covered with heat-shrink tubing. In both cases, overlap the repair about 1/2-inch on either side.

If damaged wire needs replacement, make sure the same or larger size is used. Also, attempt to use the same color.

When splicing wires, make sure the battery is disconnected. Clean the wire ends. Crimp and solder them using rosin-core, not acid-core, solder.

## Soldering

Soldering joins two pieces of metal together with a lead and tin alloy.

In soldering, the wires should be spliced together with a crimp. The less solder separating the wire strands, the stronger the joint.

## Solder

Solder is a mixture of lead and tin plus traces of other substances.

Flux core wire solder (wire solder with a hollow center filled with flux) is recommended for electrical splices.

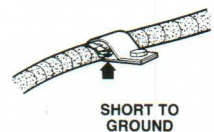
Wire gauge numbers are determined by the conductor's cross-section area.

Gauge Size	Conductor Diameter (Inch)	Cross Section Area (Circular Mils)
20	.032"	1,020
16	.051"	2,580
12	.081"	6,530
8	.128"	16,500
2	.258"	66,400
0	.325"	106,000
2/0	.365"	133,000

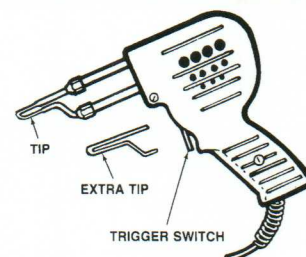
American Wire Gauge Sizes

AWG Size	Metric Size (mm <sup>2</sup> )
20	0.5
18	0.8
16	1.0
14	2.0
12	3.0
10	5.0
8	8.0
6	13.0
4	19.0

Equivalent sizes



Conductor faults



Soldering Iron

### Soldering Flux

Soldering heats the wires. In so doing, it accelerates oxidization, leaving a thin film of oxide on the wires that tends to reject solder. Flux removes this oxide and prevents further oxidation during the soldering process.

Rosin or resin-type flux must be used for all electrical work. The residue will not cause corrosion, nor will it conduct electricity.

### Soldering Irons

The soldering iron should be the right size for the job. An iron that is too small will require excessive time to heat the work and may never heat it properly. A low-wattage (25-100 W) iron works best for wiring repairs.

### Cleaning Work

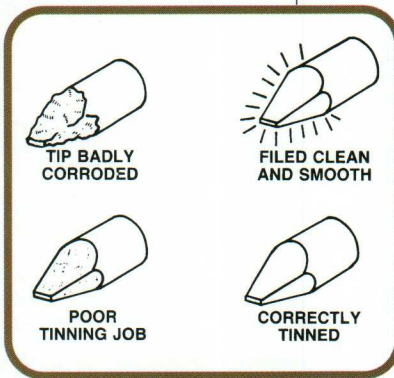
All traces of paint, rust, grease, and scale must be removed. Good soldering requires clean, tight splices.

### Tinning The Iron

The soldering iron tip is made of copper. Through the solvent action of solder and prolonged heating, it will pit and corrode. An oxidized or corroded tip will not satisfactorily transfer heat from the iron to the work. It should be cleaned and tinned. Use a file and dress the tip down to the bare copper. File the surfaces smooth and flat.

Then, plug the iron in. When the tip color begins to change to brown and light purple, dip the tip in and out of a can of soldering flux (rosin type). Quickly apply rosin core wire solder to all surfaces.

The iron must be at operating temperature to tin properly. When the iron is at the proper temperature, solder will melt quickly and flow freely. Never try to solder until the iron is properly tinned.

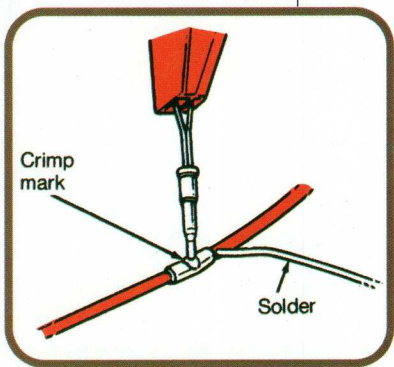


### Soldering Wire Spices

Apply the tip flat against the splice. Apply rosin-core wire solder to the flat of the iron where it contacts the splice. As the wire heats, the solder will flow through the splice.

### Rules For Good Soldering

- 1 Clean wires.
- 2 Wires should be crimped together.
- 3 Iron must be the right size and must be hot.
- 4 Iron tip must be tinned.
- 5 Apply full surface of soldering tip to the splice.
- 6 Heat wires until solder flows readily.
- 7 Use rosin-core solder.
- 8 Apply enough solder to form a secure splice.
- 9 Do not move splice until solder sets.
- 10 Place hot iron in a stand or on a protective pad.
- 11 Unplug iron as soon as you are finished.





# Terminal Replacement

These steps must be followed when replacing a terminal.

**Step 1:** Identify the connector and the terminal type.

**Step 2:** Remove the terminal from the connector.

**Step 3:** Replace the terminal.

**Step 4:** Install the terminal into the connector.

## Step 1. Identify the connector and terminal type.

### 1. Replacing Terminals

- Identify the connector name, position of the locking clips, the unlocking direction and terminal type from the pictures provided on the charts.

## Step 2. Remove the terminal from the connector.

### 1. Disengage the secondary locking device or terminal retainer.

- Locking device must be disengaged before the terminal locking clip can be released and the terminal removed from the connector.
- Use a miniature screwdriver or the terminal pick to unlock the secondary locking device.

### 2. Determine the primary locking system from the charts.

- Lock located on terminal
- Lock located on connector
- Type of tool needed to unlock
- Method of entry and operation

### 3. Remove terminal from connector by releasing the locking clip.

- Push the terminal gently into the connector and hold it in this position.
- Insert the terminal pick into the connector in the direction shown in the chart.
- Move the locking clip to the un-lock position and hold it there.

**NOTE:** Do not apply excessive force to the terminal. Do not pry on the terminal with the pick.

- Carefully withdraw the terminal from the connector by pulling the lead toward the rear of the connector.

**NOTE:** Do not use too much force. If the terminal does not come out easily, repeat last 4 steps.

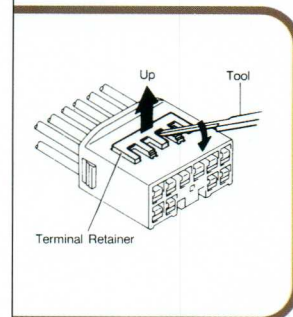
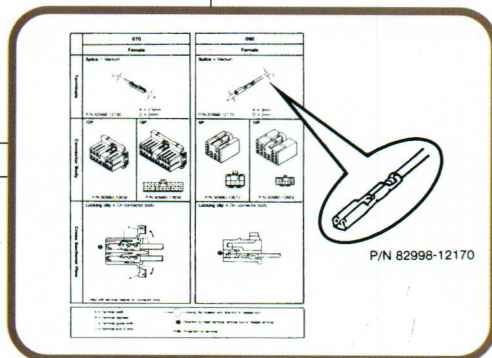
4. Measure "nominal" size of the wire lead by placing a measuring device, such as a micrometer or Vernier Caliper, across the diameter of the insulation on the lead and taking a reading.

5. Select the correct replacement terminal, with lead, from the repair kit.

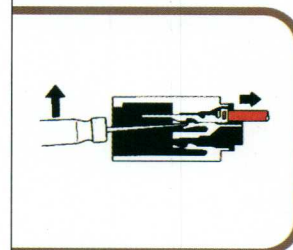
6. Cut the old terminal from the harness.

- Use the new wire lead as a guide for proper length.

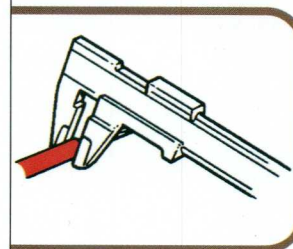
**NOTE:** If the length of wire removed is not approximately the same length as the new piece, the following problems may develop:



Secondary locking device



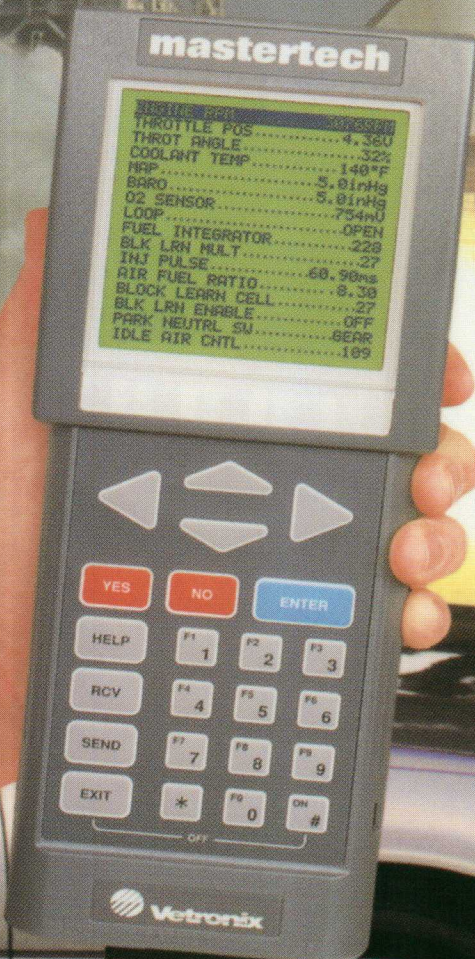
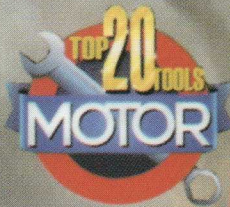
Releasing the locking clip



Calipers

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**Vetronix Corporation**  
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THROTTLE POS	4.360
THROT ANGLE	32%
COOLANT TEMP	140°F
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BARO	5.0inHg
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LOOP	OPEN
FUEL INTEGRATOR	229
BLK LRN MULT	27
INH PULSE	60.90ms
AIR FUEL RATIO	8.38
BLK LRN CELL	27
BLK LRN ENABLE	OFF
PARK NEUTRL SW	BEAR
IDLE AIR CNTL	169

In 1984, after helping to put Americans on the moon, the founder and key employees of Vetronix Corporation decided to apply the same aerospace technology to the automotive industry. It was a bold concept at the time and it caused a revolution in technology that is still going on. Today, Vetronix diagnostic equipment is recommended or required by automotive manufacturers for use by their franchise dealers for warranty service on more than 40% of all new vehicles produced in the world.

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**Too short** - tension on the terminal, splice, or the connector, causing an open circuit.  
**Too long** - excessive wire near the connector, may get pinched or abraded, causing a short circuit.

**NOTE:** If the connector is of a waterproof type, the rubber plug may be reused.

**7. Strip insulation from wire on the harness and replacement terminal lead.**

- Strip length should be approximately 8 to 10 mm (3/8 in.).

**NOTE:** Strip carefully to avoid nicking or cuffing any of the strands of wire.

**NOTE:** If heat shrink tube is to be used, it must be installed at this time, sliding it over the end of one wire to be spliced.

**NOTE:** If the connector is a waterproof type, the rubber plug should be installed on the terminal end at this time.

**Step 3. Replace The Terminal**

**1. Select correct size of splice from the repair kit.**

- Size is based on the nominal size of the wire (three sizes are available).

	Part Number	Wire Size
<b>Small</b>	00204-34130	16-22 AWG 1.0 - 0.2 mm
<b>Medium</b>	00204-34137	14-16 AWG 2.0 - 1.0 mm
<b>Large</b>	00204-34138	10-12 AWG 5.0 - 3.0 mm

**2. Crimp the replacement terminal lead to the harness lead.**

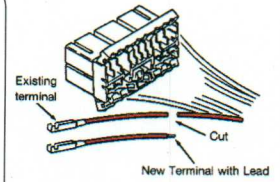
- Insert the stripped ends of both the replacement lead and the harness lead into the splice, overlapping the wires inside the splice.

**NOTE:** Do not place insulation in the splice, only stripped wire.

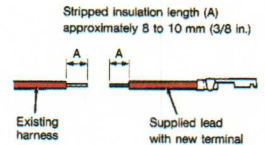
- Do not use position marked "INS".
  - The crimping tool has positions marked for insulated splices (marked "INS") that should not be used, as they will not crimp the splice tightly onto the wires.
- Use only position marked "NON INS".
  - With the center of the splice correctly placed between the crimping jaws, squeeze the crimping tool together until the contact points of the crimper come together.

**NOTE:** Make sure the wires and the splice are still in the proper position before closing the crimping tool ends. Use steady pressure in making the crimp.

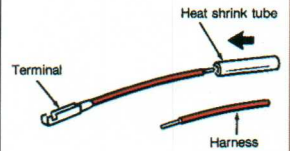
- Make certain that the splice is crimped tightly.



Cut proper length

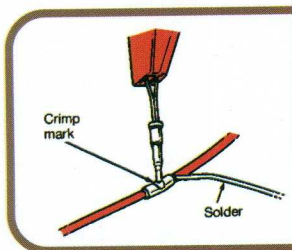


Strip Insulation



Installing heat shrink tube

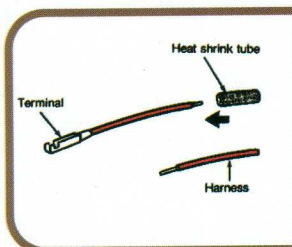
# Wire, Terminal, And Connector Repairs



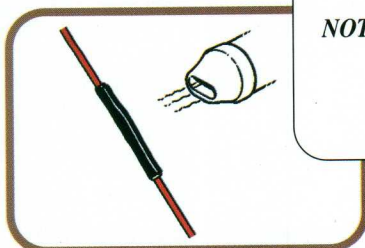
Soldering



Taping



Heat shrink tube



Heat shrinking

### 3. Solder the completed splice using only rosin core solder.

- Wires and splices must be clean.
- A good mechanical joint must exist, because the solder will not hold the joint together.
- Heat the joint with the soldering iron until the solder melts when pressed onto the joint.
- Slowly press the solder into the hot splice on one end until it flows into the joint and out the other end of the splice.

**NOTE:** Do not use more solder than necessary to achieve a good connection. There should not be a "glob" of solder on the splice.

- When enough solder has been applied, remove the solder from the joint and then remove the soldering iron.

### 4. Insulate the soldered splice using one of the following methods:

- Silicon tape (provided in the wire repair kit)
  - Cut a piece of tape from the roll approximately 25 mm (1 in.) long.
  - Remove the clear wrapper from the tape.

**NOTE:** The tape will not feel "sticky" on either side.

- Place one end of the tape on the wire and wrap the tape tightly around the wire. You should cover one-half of the previous wrap each time you make a complete turn around the wire. (When stretched, this tape will adhere to itself.)
- When completed, the splice should be completely covered with the tape and the tape should stay in place. If both of these conditions are not met, remove the tape and repeat steps 1 through 4.

**NOTE:** If the splice is in the engine compartment or under the floor, or in an area where there might be abrasion on the spliced area, cover the silicon tape with vinyl tape.

- Heat shrink tube (provided in the wire repair kit)
  - Cut a piece of the heat shrink tube that is slightly longer than the splice, and slightly larger in diameter than the splice.
  - Slide the tube over the end of one wire to be spliced. **THIS STEP MUST BE DONE PRIOR TO JOINING THE WIRES TOGETHER!**
  - Center the tube over the soldered splice.
  - Using a source of heat, such as a heat gun, gently heat the tubing until it has shrunk tightly around the splice.

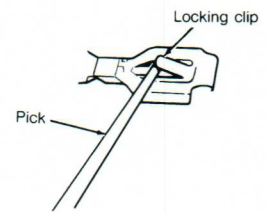
**NOTE:** Do not continue heating the tubing after it has shrunk around the splice. It will only shrink a certain amount, and then stop. It will not continue to shrink as long as you hold heat to it, so be careful not to melt the insulation on the adjoining wires by trying to get the tubing to shrink further.

## Step 4. Install the Terminal into the Connector.

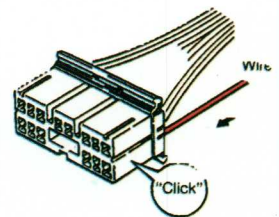
1. If reusing a terminal, check that the locking clip is still in good condition and in the proper position.
  - If it is on the terminal and not in the proper position, use the terminal pick to gently bend the locking clip back to the original shape.
  - Check that the other parts of the terminal are in their original shape.
2. Push the terminal into the connector until you hear a "click".

**NOTE:** Not all terminals will give an audible "click".

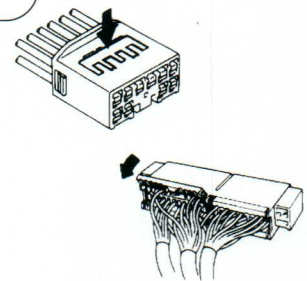
- When properly installed, pulling gently on the wire lead will prove the terminal is locked in the connector.
3. Close the terminal retainer or secondary locking device.
    - If the connector is fitted with a terminal retainer, or a secondary locking device, return it to the lock position.
  4. Secure the repaired wire to the harness.
    - If the wire is not in the conduit, or secured by other means, wrap vinyl tape around the bundle to keep it together with the other wires.



Check locking clip



Hearing the "click"



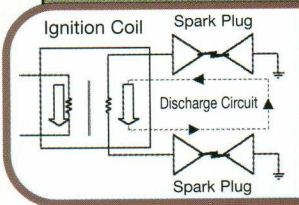
Locking position



## Toyota Electrical Products

January/February 1997 Issue 62

The Tercel's direct ignition system fires two plugs during each four-stroke cycle.



Dual Ground Electrode Spark Plug



Conventional Spark Plug

### Dual Ground Electrode Spark Plugs

A new type of spark plug has been developed to be used with the new direct / distributorless ignition systems which are being used on several different Toyota vehicles. It was first introduced on 1995 model year Toyota vehicles. The development goal was to lower required voltage and to extend the service life of the spark plug. The unique feature of the spark plug is that it utilizes two ground electrodes rather than a single electrode found on a conventional spark plug. The use of two electrodes offsets the increased wear incurred by the firing of each spark plug twice as often and promotes longer service life. For even greater service life, selected models utilize a platinum tipped dual ground electrode spark plug ( see chart below ).

The 5E-FE 1.5 liter 16 valve, DOHC engine found in the 1995-1997 Tercel is an ideal example of the direct ignition system in operation. On the Tercel, the distributorless ignition system uses two independent coils, each igniting two spark plugs at the same time. One plug is fired with the cylinder on the compression stroke while the other cylinder is fired on the exhaust stroke. The first coil is mounted on top of the number three cylinder spark plug and a high tension wire connects it to the number two spark plug. The second coil is mounted on top of the number four spark plug and fires the number one cylinder as well.

#### Dual ground electrode spark plugs have the following unique features:

- Stronger electric field on both the center and ground electrodes which results in reduced required voltage.
- Shortened ground electrodes (3MM) drops the electrode temperature by approximately 10 degrees.
- Extra ground electrode decreases the number of discharges per electrode and increases spark plug life.
- Dual platinum tips reduce wear on center electrodes.

Please refer to the chart below for current dual electrode spark plug applications.

Model / Year	Engine	Part Number	Plug Type
Avalon	1996-1997 V6 (1MZFE)	90919-01194	PK20TR11 *
Camry	1996-1997 V6 (1MZFE)	90919-01194	PK20TR11 *
	1997 4 CYL (5SFE)	90919-01194	PK20TR11 *
Paseo	1995 4CYL (5SEFE) CAL	90919-01192	K16TR11
	1996-1197 4CYL (5SEFE)	90919-01192	K16TR11
T 100	1995-1997 V6 (5VZFE)	90919-01192	K16TR11
Tacoma	1995-1997 V6 (5VZFE)	90919-01192	K16TR11
Tercel	1995-1997 4 CYL (5EFE)	90919-01192	K16TR11
Truck / 4 Runner	1996-1997 V6 (5VZFE)	90919-01192	K16TR11

\* Platinum Spark Plug



## Toyota Offers High-Quality Remanufactured Alternators

Each part that makes up a Toyota vehicle is designed and manufactured with the highest of standards. This commitment to quality extends to Toyota's line of replacement parts, including Toyota Genuine Remanufactured Alternators.

The remanufacturing process begins with the total disassembly and cleaning of each unit. Only high-quality, genuine Toyota alternator cores are chosen for remanufacture.

In each instance, the rotor, stator and rectifier are carefully inspected for proper operation. In order to confirm insulation and integrity, the rotor and stator are tested with 600 volts. In addition, the voltage regulator is replaced and tested for voltage stability. Since Toyota alternators turn up to 18,000 rpm, concentricity of the commutator is critical. Our runout specification is 20 microns.

Many other parts are also routinely replaced, such as all bearings, brushes, boots, terminals, and any out-of-specification parts. Springs are always replaced, to ensure proper Pressure between the brushes and the commutator. Bearings are sealed with high load, high temperature grease for excellent performance.

Finally, many external parts and all hardware are replated for resistance to corrosion. After assembly, all units are load tested.

Only after passing Toyota's strict requirements can each alternator earn the label "Toyota Genuine Remanufactured Part." These units are backed by the same 12 month/unlimited mileage warranty which is offered on all Toyota Genuine Replacement Parts.

These remanufactured alternators are offered at up to 50 percent savings on the price of a comparable new unit while also being competitive with the aftermarket. So by offering your customers this choice up front, you'll build credibility for your business.

***Toyota Genuine Remanufactured Alternators provide an outstanding combination of quality and value.***

### Glossary of Electrical Terms

**Thyristor** - A silicon-controlled rectifier (SCR) that normally blocks all current flow. A slight voltage applied to one layer of its semiconductor structure will allow current flow in one direction while blocking current flow in the other direction.

**Transducer** - A device that changes one form of energy into another. In an ignition system, it may sense a mechanical movement and change it to an electrical signal.

**Transformer** - Device used to change alternating current from one voltage to another. Consists of two coils, one with more windings than the other, that induce voltage in one coil when current flows to the other. Can increase or decrease applied voltage.

**Transistor** - A semiconductor device with three connections. A small current at the control junction between semiconductor materials is used to control a larger current between two rectifying junctions.

**Trickle Charge** - A low rate of charge given to a storage battery over a long period of time.

**Twenty Hour Rate** - Battery rating measuring the amount of current a battery can deliver for 20 hours with an electrolyte temperature of 80 degrees F (27 degrees C) before the cell voltage drops to 1.75 volts.

**V** - Abbreviation for volt, a unit of measurement for electrical potential.

**Vacuum Fluorescent Display (VFD)** - Process of displaying numbers and letters by using free electrons from a heated filament striking a phosphor-coated material emitting a blue-green light. Used in many electronic display devices.

**Valence Ring** - The outermost electron shell of an atom.

**Volt** - The unit for measuring current pressure in a circuit. One volt of pressure causes one ampere of current to flow against one ohm of resistance.

**Voltage** - The electromotive force that causes current flow. The potential difference in electrical force between two points when one is negatively charged and the other is positively charged.

**Voltage Drop** - The difference in potential (voltage) between one point in a circuit and another; typically the voltage difference from one side of a component to the other.

**Voltage Leak** - The loss of charge in a capacitor because of the imperfect insulating characteristics of the dielectric, allowing voltage to "leak" across, neutralizing the electrical charge.

**Voltage Loss** (Also called Voltage Drop) - Reduction in voltage across an electrical device or circuit because of the resistance to current flow of that device or circuit.

**Voltage Regulator** - A relay that limits an alternator's voltage output.

**Voltmeter** - An electrical meter used to measure the difference in voltage between two points in a circuit. It reads volts of electrical pressure. The voltmeter must be connected across the load or circuit—red lead on the battery side of the circuit, black lead on the ground side of the circuit.

**W** - Abbreviation for watt, a unit of measurement for power.

**Warning Light** - Light that illuminates to alert the driver to some condition in the vehicle such as battery charging rate, high coolant temperature, or low oil pressure.

**Watt** - The unit of measurement for electric power. One way to measure the rate of doing work. Watts equal volts times amperes.

**Watts Rating** - A method of rating the available cranking power of a battery. The rating can be found by multiplying the current available from the battery by the battery voltage at 0 degrees F.

**Wire Gauge** - Wire size numbers based on the cross section area of the conductor. Larger wires have lower gauge numbers.

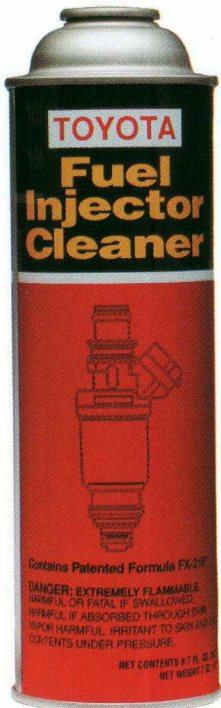
**Wiring Diagram** - A schematic. The representation of an electrical circuit by a drawing. A wiring diagram may contain electrical symbols for various loads and components.

**Wiring Harness** - A bundle of wires enclosed in a plastic cover and routed to various areas of the vehicle. Most harnesses end in plug-in connectors. Harnesses are also called looms.

**Y-Type Winding** - An alternator design in which one end of three windings is connected at a neutral junction.

**Zener Diode** - A semiconductor made so it will allow reverse current flow without damage at a voltage above a specific value.

# Genuine Toyota Pressurized Fuel Injector Cleaner



- Dissolves harmful deposits
- Helps restore engine power
- Increases fuel economy
- Lowers emissions
- Enhances smooth idle and acceleration

**Super  
Fast  
Satisfaction**

**T**oyota Pressurized Fuel Injector Cleaner (PFIC) is TMC tested and approved to *dissolve* harmful deposits that form on injectors. This one-can system is hooked up to the vehicle's fuel rail using the PFIC Apparatus with the appropriate PFIC adapter, and the injectors are **cleaned** while the engine is running off the contents of the can. Most of the cleaning is completed within the first four minutes, and the entire process takes approximately **20 minutes** from beginning to end.

Toyota PFIC and the PFIC tools are available at your local Toyota dealership.  
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