SUBARU

QUALITY DRIVEN® SERVICE

CERTIFIED SUBARU TECHNICIAN

Technician Reference Booklet

Basic Electrical Theory & Diagnosis

Module 601

AUTOMOTIVE Youth Educational Systems

September 2006

MSA5P0134C

Technical Training

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Table of Contents

Introduction

This Technicians Reference Booklet contains information pertaining to basic automotive electricity, and the Subaru electrical system. It reviews electron theory, current flow, circuitry, and the types and causes of electrical shorts. Electrical terms are defined, Ohm's Law is explained, and the following major components of Subaru electrical systems are discussed: the battery, circuit protectors, switches, relays, and motors. The six-step method of troubleshooting is introduced. This method presents a logical step by step process of identifying and correcting typical electrical system problems.

It reviews solid state devices, operation and diagnosis of Subaru starting and charging systems, computer terminology and operation, and the troubleshooting and diagnosis of intermittent faults.

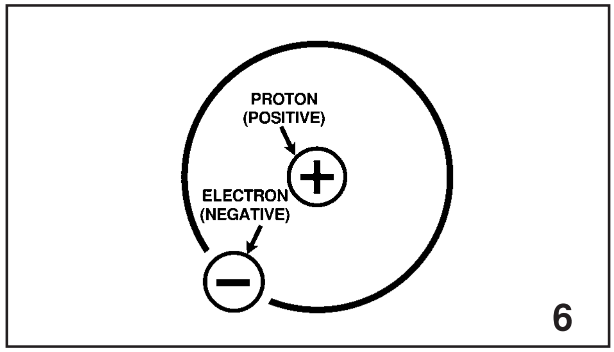
The text and illustrations are derived from the classroom lecture and slide presentation material and are intended to reinforce previous classroom instruction and lab participation.

Technicians Worksheets provided by your instructor will be completed during the "hands-on" lab work segments of the Basic Electrical Theory & Diagnosis Module. Always refer to the appropriate model year Subaru Service Manual and the applicable Service Bulletins for all specifications and detailed service procedures.

In addition, the use of the Select Monitor is also explained during the presentation of the module and will be demonstrated during the lab exercises.

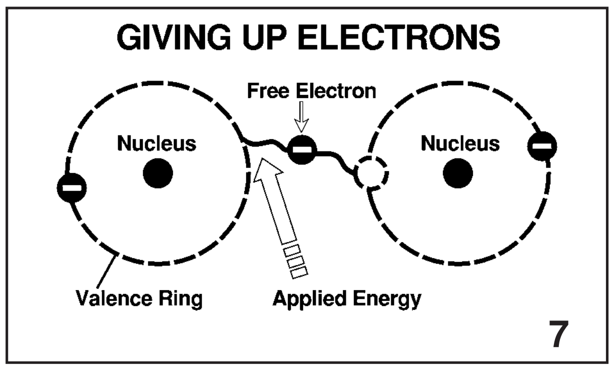
This booklet contains a Glossary of electrical terms for your reference. Refer to the Glossary when appropriate throughout the duration of this module.

Electrical System Theory



Electron Theory Artwork

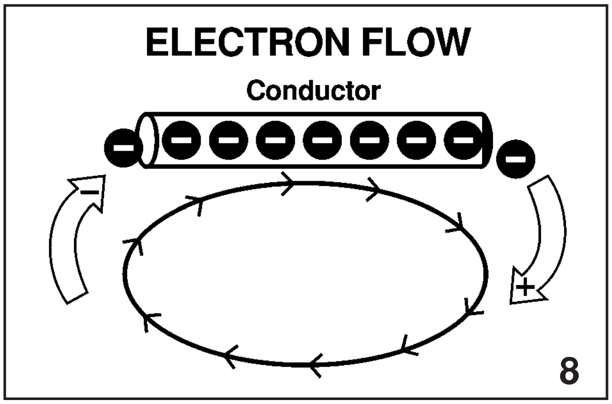
Atoms are composed of electrons and protons. Electrons have a negative charge and whirl around a nucleus composed of protons, which have a positive charge.



Electron Flow Artwork

The electrons can move from the valence ring of one atom to the valence ring of another atom. This chain reaction effect type of movement of electrons constitutes electric current.

Atoms with fewer than four electrons are considered to be conductors because they give up electrons to other atoms easily.

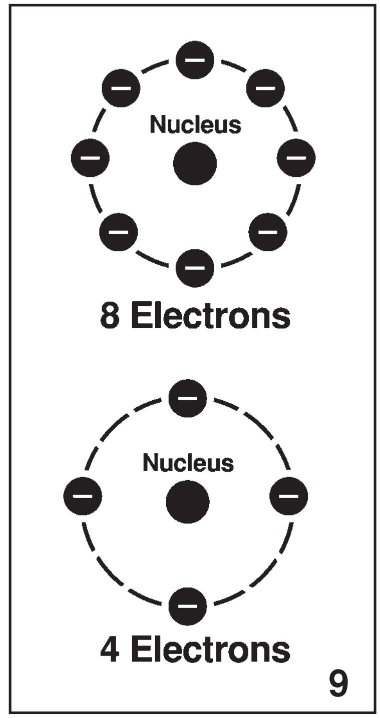


Conductors Artwork

All circuits must have conductors and insulators to operate properly. Electricity will always return to its source if a path (circuit) is available. Circuits provide a path for electrons to travel from a source to the load and back to the source.

Conductors such as copper, iron, and aluminum allow electrons to flow freely, or be released. There are several methods to produce electromotive force which causes electrons to be released:

- Magnetic (Alternator)
- Pressure (Knock sensor)
- Heat (Thermo-couple)
- Chemical (Storage battery)



Insulators/Semiconductors Artwork

Atoms with more than four electrons are insulators because they do not freely give up electrons. Examples are:

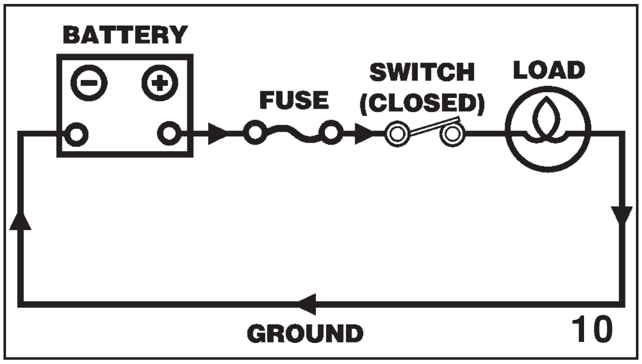
- Glass
- Rubber
- Vinyl

The best insulators have eight (8) electrons.

Atoms with exactly four electrons in the outer valence ring are called semiconductors. Examples are:

- Carbon
- Silicon
- Germanium

A semiconductor may be a conductor or an insulator, depending on the application and circuit conditions.



Circuit Artwork

Electrical Terms

- Amps—Current flow of electrons or intensity: Symbol = I
- Volts—Electromotive force or pressure: Symbol = V
- Ohms—Resistance to electron movement: Symbol = R

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Electrical Terms Artwork

Watts

- Measurement of electrical power: Symbol = W
- Watts = Volts x amps: W = V x I
- Example: 1) 12 V x 5.01 = 60 W
  2) 120 V x 0.51 = 60 W

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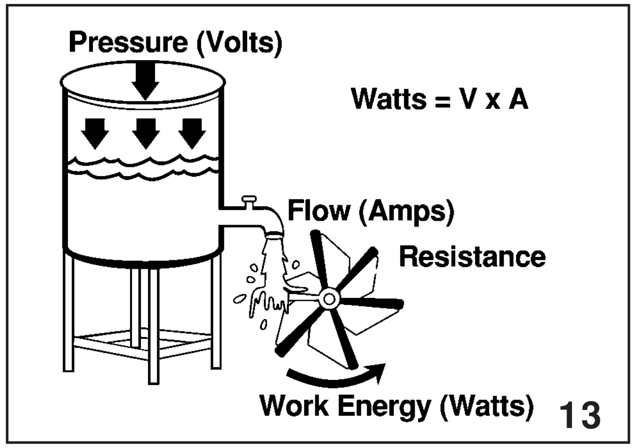
Watts Definition Artwork

It is important that you understand the definitions of the electrical terms listed above.



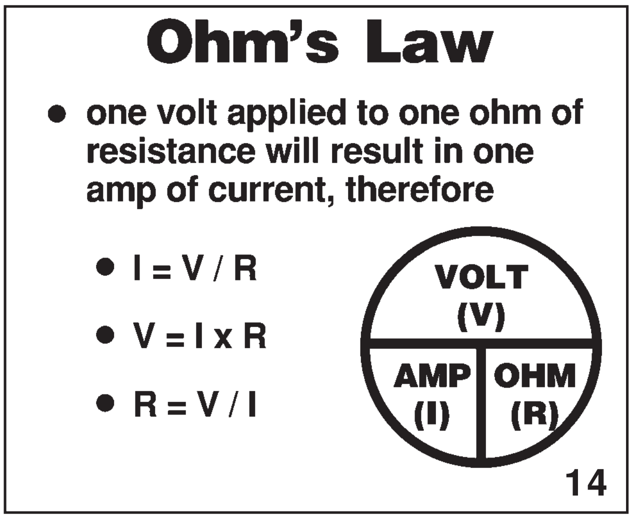
An Electrical Analogy Artwork

Think of an electrical system as a water system in which the water tank represents the power source (potential energy). The tank is similar to a battery. The water flowing from the water tank is measured in gph (gallons/hour) and represents electron flow. In a battery, chemical interaction produces this electron flow which is measured in amperes (amps).

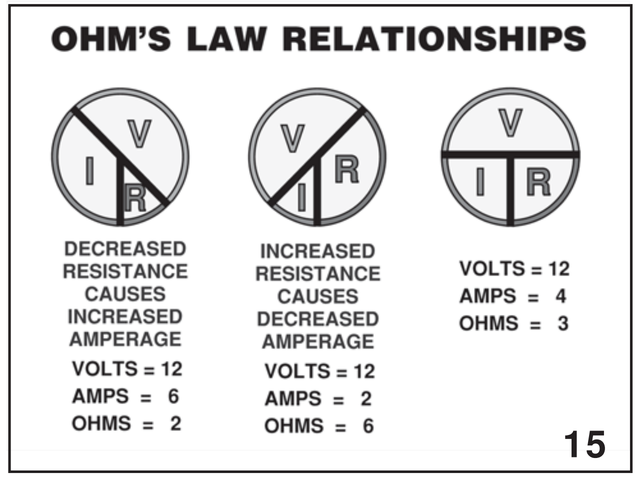
Pressure is created by the physical weight of the water which causes the water to move. Water pressure is measured on pounds/in^2 (psi). Similarly, the pressure that moves the electrons, which is called electromotive force, is measured in volts (V).

As the water strikes the water wheel, the weight of the water causes the wheel to turn. A continuous volume of water keeps the wheel turning. The weight of the wheel impedes (provides resistance to) the flow of the water. This resistance is measured as friction or drag. In an electrical system, the wire provides resistance through the covalent bonding of the electrons. This resistance is measured in ohms (R).

Work is equal to the pressure of the water times the flow of water which is equal to rotation of the wheel. An increase in the pressure or volume at the same resistance will equal an increase in the flow of water which in turn increases the speed or amount of wheel rotation. In an electrical system, the voltage (pressure - V) X amps (flow of electrons - I) will equal the watts (the wheel rotation) or work performed.



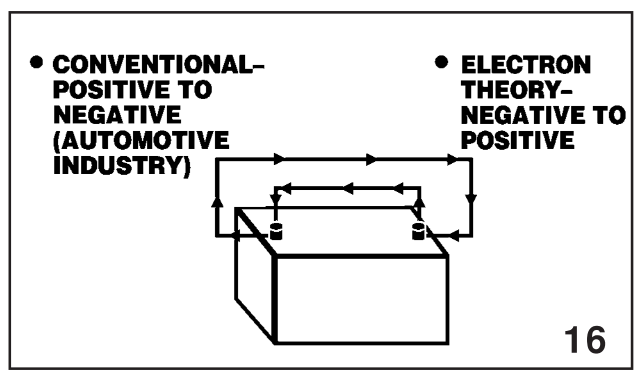
Ohm's Law Artwork



Ohm's Law Relationships Artwork

Using Ohm's Law, complete the following problems:

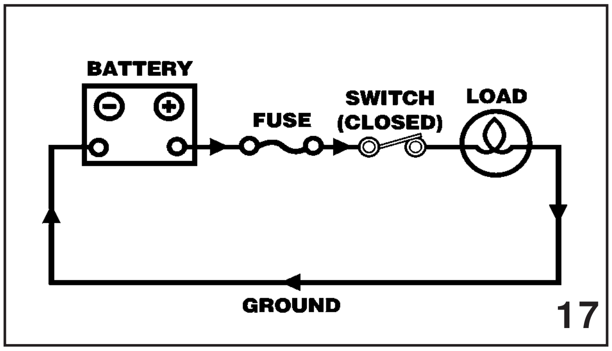
1. How many amps of current can flow through a 12-ohm resistor if 12,000 volts are available?
2. How many volts are required to move 10 amps of current through a 0.5-ohm wire?
3. What resistance value will allow the flow of 15 amps of current if 12 volts are available?



Theory of Electron Flow Artwork

The conventional theory of electron flow states that the direction of current flow is from the positive (+) terminal of the voltage source, through the external circuit, and then back to the negative (-) terminal of the voltage source. The electron theory states that the direction of current flow is from the negative (-) terminal of the voltage source, through the external circuit, and then back to the positive (+) terminal of the voltage source.

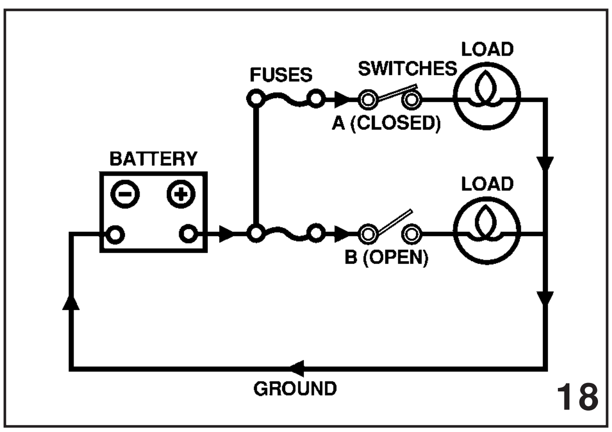
Circuits: Electron Flow



Basic Electrical Circuit Artwork

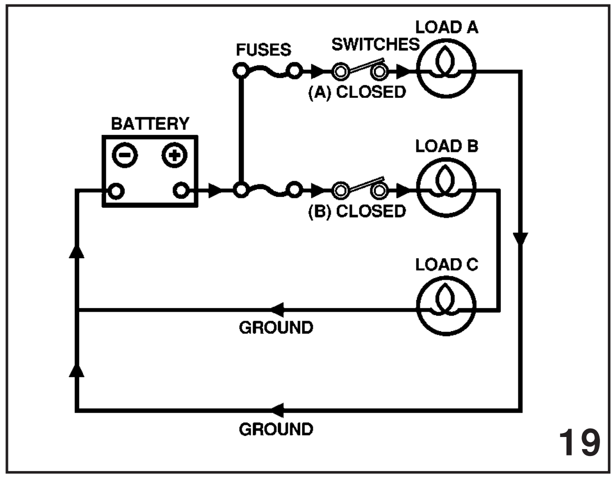
The basic circuit shown above has a battery as the power source. The wires carry the current from the battery (positive wire to the load (bulb) and back to the source (ground wire). A switch controls the flow of current, and a fuse protects the circuit from an overload or an unintentional ground.

The circuit shown above is a series circuit because it provides only one path for current flow. A break or short anywhere in the circuit will stop the current flow.



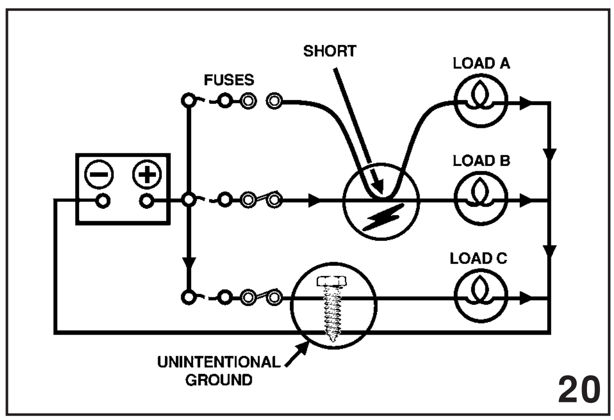
Parallel Circuit Artwork

Current flows through parallel branches of the circuit only affects that branch and does not stop the flow of current to other components on the other branches of the circuit.



Series-Parallel Circuit Artwork

This type of circuit is a combination of the series and parallel forms of circuitry and has the advantages and disadvantages of both types. If the fuse blows in the main feed line, current cannot flow to Load A, Load B, or Load C. On the other hand, a break in the Load A wire will not affect the operation of the Load B or Load C circuit. This is the most common type of circuit used in automotive electrical systems.

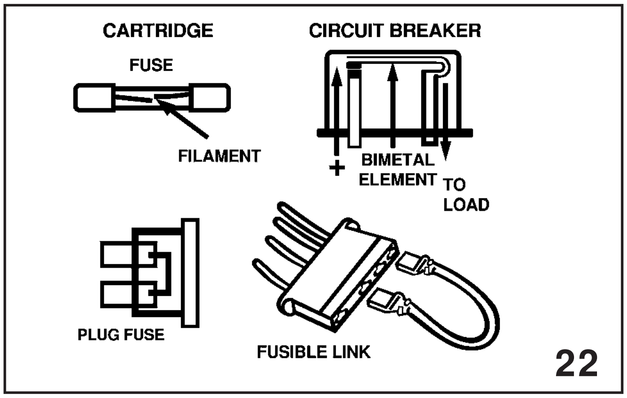


Shorts Grounds and Opens Artwork

The figure above shows two types of shorts that occur in automotive electrical systems. A short circuit can be a connection of two circuits caused by a break in the insulation of the circuits or an unintentional ground caused when a circuit comes in contact with a ground as shown above. An open is an interruption of the current flow in a circuit caused by the activation of a switching device or a break in a conductor.

Electrical Terminology

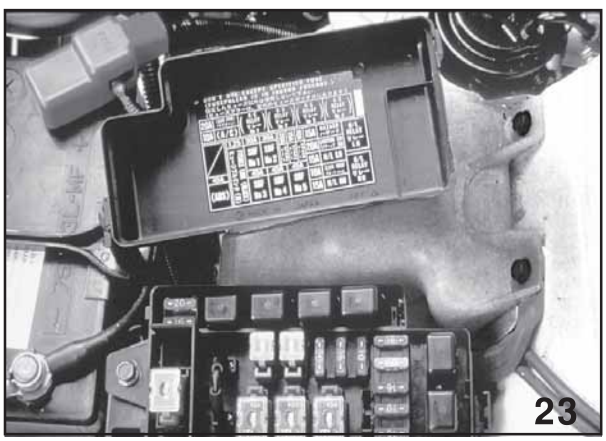
Circuit Protectors



Circuit Protectors

Circuit protectors provide a vital safeguard to an electrical system.

A blown circuit protector is an indication of a problem in the circuit. Replacing the circuit protector is not usually the solution to the problem.



Fusible link

A fusible link is a short piece of insulated wire that is usually four gauges smaller in wire size than the circuit it protects. Subaru vehicles use up to five fusible links depending on model and year.

There are two types of fuses used in Subaru vehicles:

1. Cartridge type

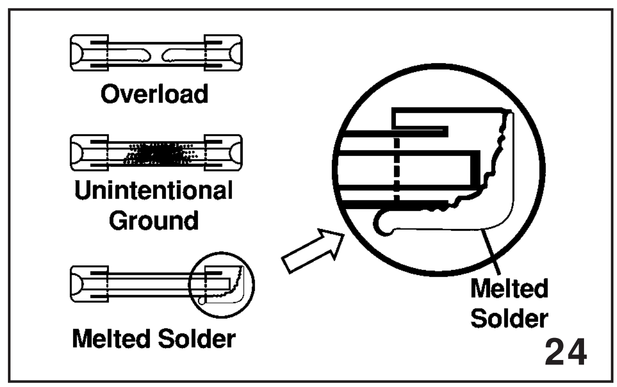
   These fuses have a zinc strip attached to two metal end caps. The end caps are separated by a clear glass tube.

2. Plug type

   This fuse has a zinc strip attached to two metal terminals are imbedded a plastic holder.

Some Subaru vehicles use plug type fuses as main fuses instead of fusible links. Examples are certain circuits in the Legacy and Justy vehicles.

Circuit breakers are a thermal mechanical device that opens a circuit when its amperage rating is exceeded. The advantage of a circuit breaker is that it is reusable and automatically resets.



Fuse interpretation

When a fuse blows because of a circuit fault, it will exhibit one of three visual characteristics as described below. By examining the fuse closely, it can be determined what type of circuit fault caused the problem.

1. Overloaded circuit, occurs when 20 amps pass through a 15 amp fuse. The center of the fuse strip will get hot, droop then melt leaving the ends drooping down at the break point.

2. A short circuit or unintentional ground causes an extremely high current to pass through the fuse strip. The strip melts so quickly that it vaporizes. The strip particles splatter the glass tube or plastic body and the glass tube or plastic body will appear tinted (silvery/black).
3. A poor fuse connection is caused by a loose contact between the fuse cap and holder (cartridge type only). This creates a resistance, which can produce enough heat to melt the solder attaching the fuse strip to the end caps. In this case beads of solder or flux stains may be seen on the inside or on the outside of the glass tube, however the fuse strip will appear to be intact.

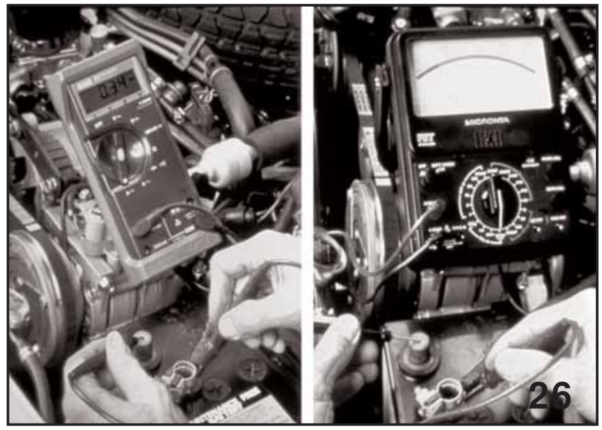
Voltmeter Usage

There are two basic types of voltmeters:
- Digital type which is best for low or fractional voltages.
- Analog type which is best for measuring rapid or large voltage changes.

A high input resistance of usually 10 megohms (W) per volt input resistance prevents overloading of low current circuits by the voltmeter. An overloaded circuit will produce inaccurate voltmeter readings.

Always connect a voltmeter in parallel, i.e., positive (+) lead to the positive (+) side of the circuit/component and the negative (-) lead to the negative (-) side of the circuit/component.

Voltmeter Cautions
- Never connect in series
- Use the proper scale for the circuit voltage
- Always zero the meter
- Voltmeters are precision instruments, handle with care.

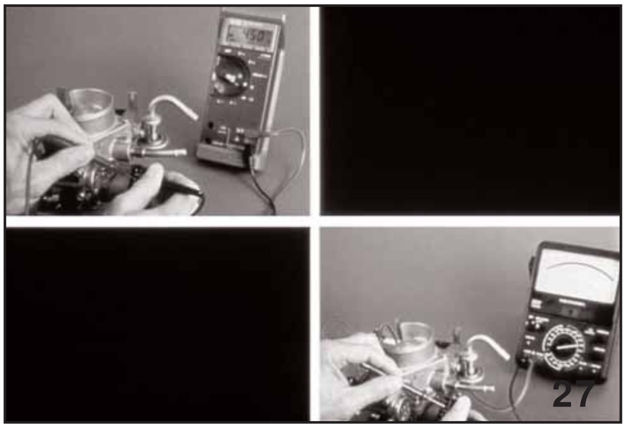


Ammeter Usage

There are two types of ammeters:
- Digital type which is best for low or fractional current readings.
- Analog type which is best for varying current readings.

Always use an ammeter with a low input resistance. There is not a standard input resistance specification available, however higher quality meters offer this feature. Proper connection will protect your ammeter from damage. **Always** connect in series with a circuit. Connect the leads to either end of an opened/separated part of the circuit; the positive (+) lead connector toward the positive (+) side of the circuit/component and the negative (-) lead connector toward the negative (-) side of the circuit/component.

Ammeter Cautions
- **Never connect in parallel with power source** (Will cause immediate meter damage)
- Use a meter with a high enough capacity for the potential current in the circuit being measured
- Use a higher scale first and work down
- Handle the meter carefully
- Always zero the meter



Ohmmeter Usage

There are three types of ohmmeters:

- Digital types are best for reading low and fractional resistance values. Some digital meters are also self-ranging.
- Analog types are difficult to read fractional resistance values. The analog type is not the preferred meter for measuring resistance.
- The field effect transistor type (F.E.T.) A very low voltage is provided at the tips which prevents damage to computer circuits. This feature can be found on either analog or digital type meters, and is used in conjunction with the diode testing scale for checking diodes.

Ohmmeter Cautions

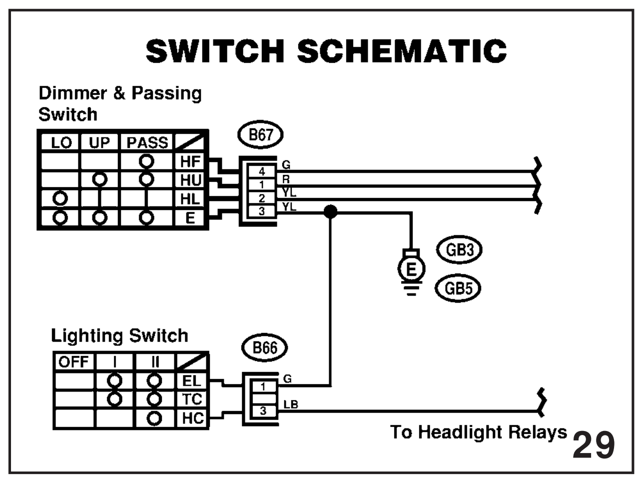
- **Never connect to a powered circuit/ component**
- Use proper scale
- Handle meter carefully
- Always zero the meter

Switches, Relays and Motors

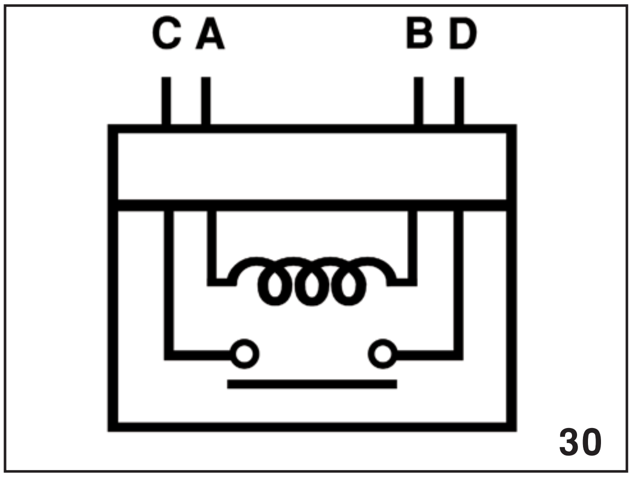
System Components

A switch is a device used to open, close, or redirect the flow of current in an electrical circuit. Switches are available in various shapes, sizes, and capabilities to meet circuit control requirements. A single-position switch, such as a stop light switch, controls the stop light by closing/opening the circuit to allow/stop the flow of current to the stop light.

A multiple-position switch, such as a lighting switch, controls the flow of current to several components. Finally, a switch may work in conjunction with other switches, such as the four courtesy light switches in a four-door vehicle.

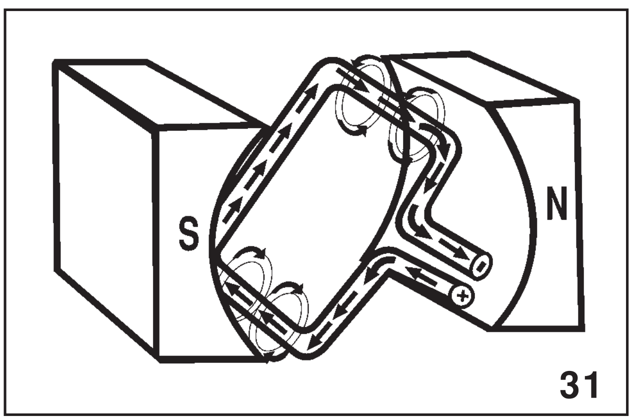


Switch Schematic



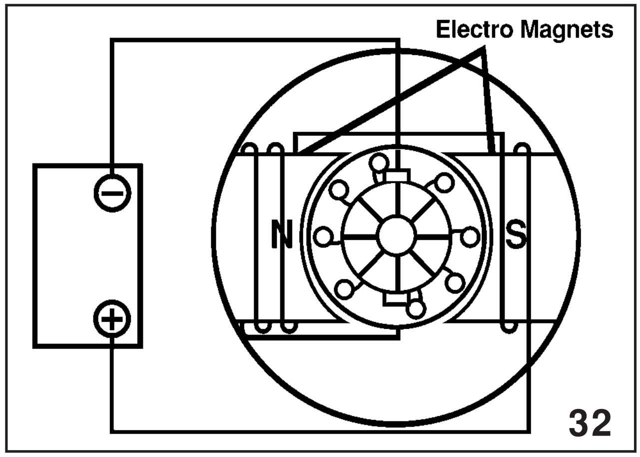
Relays

A relay is an electromagnetic switching device that uses low current to open or close a high-current switching device. There are two basic types of relays used on Subaru vehicles: normally open (NO) and normally closed (NC). A third type of relay is used in special automotive applications. This relay transfers current flow from one circuit to another.



Motors

A motor is an electromagnetic device that converts electrical energy into mechanical energy. Motor operation is accomplished by placing a loop-shaped conductor in a magnetic field and then passing current through the conductor. The flow of the current through the conductor loop causes an unbalanced field condition, which causes the loop to rotate to a position where the field is once again in balance. Then the loop will stop rotating.

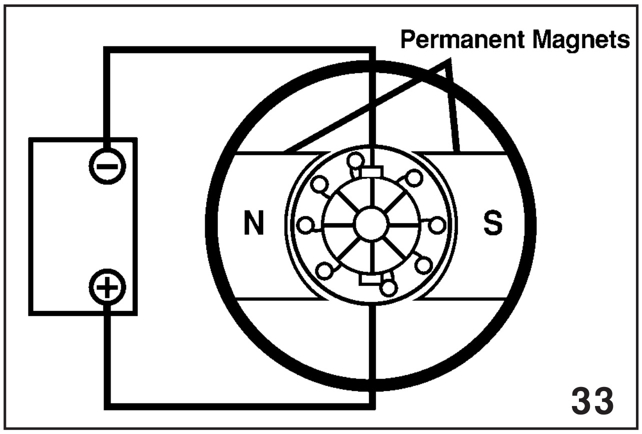


Motor Operation

To obtain continuous rotation, a motor must contain numerous conductor loops, and the direction of the current must be reversed at the halfway point of rotation for each of the loops. This is accomplished through a split ring called a commutator. The rotating loops and commutator make up the armature of the motor.

Rotation of the motor creates a generating action called back voltage or counter electromotive force.

This force limits the current draw of the motor (armature) so that the motor only draws the amount of current to perform the job required. If the force required to perform the job exceeds the current capacity of the armature, the armature will stop rotating, the current will overheat the wires in the armature, and the motor will be damaged.



Permanent Magnet Motor Operation

Permanent magnet motors do not use field coil construction. Because the field magnetism is constantly available from highly efficient permanent magnets, the current is sent directly to the brushes. The operating principle is similar to a field coil type motor. The advantage of this motor design is a significant reduction in the size and weight of the motor with no loss of operating capacity.

Troubleshooting Diagnosis and Intermittent Faults

The Six Step Troubleshooting Method

1. Verify the problem.
2. Determine related symptoms.
3. Isolate the problem.
4. Identify the cause.
5. Repair and/or replace.
6. Verify operation.

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Six Step Troubleshooting Method

This method of troubleshooting will save time and effort in the diagnosis and analysis of electrical problems. It provides a logical approach to solving the problem—not just treating the symptoms. The steps are defined as follows:

1. Verify the problem (operational check). Identify the symptoms of the problem. Are components inoperable or malfunctioning? When, how often, and where does the problem occur?
2. Determine related symptoms (operational check). Identify other symptoms that exist. Are other circuits and components affected? Do the related symptoms always occur with the primary symptom?
3. Isolate the problem. Use the split half technique*, the wiring diagram, and the wiring harness diagram to locate a short in a grounded circuit.

   *The split-half technique is used as follows:
   - Obtain the proper wiring diagrams.
   - Divide the circuit in half at an accessible connector.
   - Check half of the circuit.
   - Repeat the process if the first half of the circuit is good, check the second half of the circuit, etc.,
   - The problem always exists between a positive and a negative result.
4. Identify the cause of the problem. Is the circuit grounded, shorted, feeding through another circuit, or is a component defective?
5. Repair and/or replace defective wiring and components as required.
6. Verify operation. Check the circuit to verify that the problem has been solved. Ensure that all circuit components operate properly under standard operating conditions according to technical specifications. Also check related circuits for proper operation.

Intermittent Faults

Thermal and Mechanical

1. Thermal intermittent
   - This type of problem occurs most often in solid state devices, connectors, switches, etc. Usually as the operating temperature of a component increases, it causes an expansion of the material which causes the circuit to "OPEN". Current flow stops, the material cools and contracts, and restores circuit operation.
2. Mechanical intermittent
   - This is caused by a component or connection bending or shifting during normal vehicle operation.
   - You may sometimes solve intermittent problems using the following strategies:
     - Use a hair dryer to heat a component or connection to simulate a severe operating failure condition which you believe to be heat related.
     - Mist water on a malfunctioning component to determine if heat is causing the problem. This simulates a cooler operating temperature.

NOTE: DO NOT MIST COMPONENTS THAT CANNOT TOLERATE MOISTURE. IT MAY CAUSE DAMAGE TO THE COMPONENTS.

- Use a component cooler which will quickly cool solid state components without damage to the components. This method will identify intermittent diode or transistor problems because the component will usually malfunction when cooled quickly.

NOTE: DO NOT USE FREON WHICH CAUSES DAMAGE TO THE ENVIRONMENT!

- Jumper leads may be used to bypass connectors, switches, and cables to check an intermittent problem.

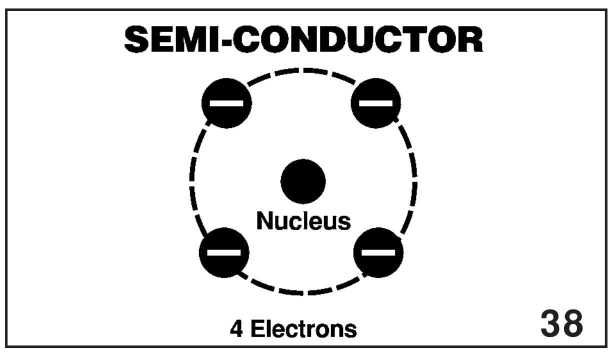
NOTE: DO NOT UNDER ANY SITUATION BYPASS A FUSE OR CIRCUIT BREAKER. SEVERE DAMAGE TO THE VEHICLE AND POSSIBLE PERSONAL INJURY MAY OCCUR.

Solid State Devices

The charging circuit will be used for the purpose of explaining semiconductors (diodes and transistors) and the functions of semiconductors. These principles may also be applied to other types of circuits.

Basic electrical terms for the study of advanced electrical theory and diagnosis:

1. Alternating current (AC) — an electric current which constantly changes polarity from positive to negative. (Or an electric current that reverses its direction regularly and continually).
2. Direct current (DC) — an electric current which flows in one direction only.
3. Sine wave — a wave that alternately moves between a positive and a negative value over an equal length of time.
4. Square wave — a square or rectangular-shaped wave that alternately assumes a "ON" or "OFF" mode. The length of the "ON" time compared to the "OFF" time indicates a "duty ratio".



Diodes (Semi-Conductor)

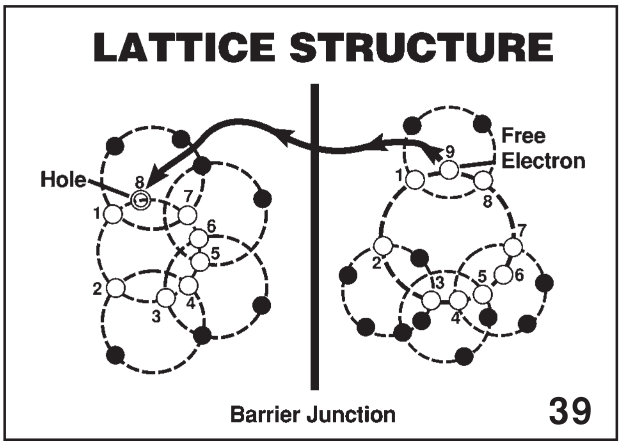
We begin our study of advanced electrical theory with an explanation of the construction and operation of diodes.

Diodes are commonly constructed of one of two materials:

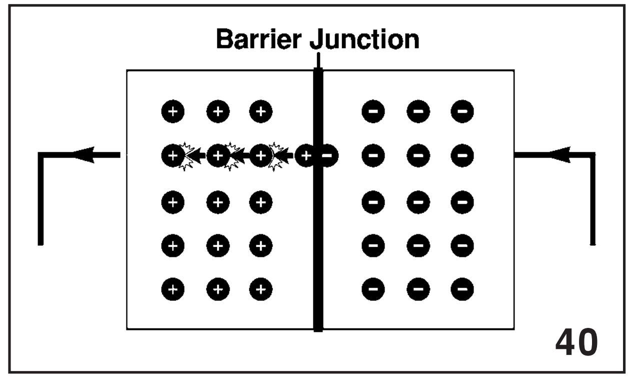
- Silicon
- Germanium

These two materials possess the unique property of having exactly four electrons in the outer valence ring of their atoms. To create a diode, one of four impurities, (Gallium, Indium, Arsenic, or Antimony) may be combined with either Silicon or Germanium to form a new lattice structure. The maximum number of electrons that can reside in a valence ring is eight (8).

NOTE: THE PROCESS OF COMBINING IMPURITIES SUCH AS GALLIUM, INDIUM, ARSENIC, OR ANTIMONY WITH EITHER SILICON OR GERMANIUM IS CALLED DOPING.



Lattice Structure



Electron Current Flow

The impurities Gallium and Indium each have three (3) electrons in the outer orbit (valence ring) of their atoms. When either of these impurities is mixed with Silicon or Germanium, (4 electrons), the result is a new atom which has seven electrons in the valence ring (4 + 3 = 7). This situation is equal to a deficiency of one electron (hole) in the valence ring. The result is that the new material takes on a positive (+) charge.

Arsenic and Antimony each have five (5) electrons in their atom's outer orbit (valence ring). When either of these impurities is mixed with Silicon (or Germanium) the result is an atom with nine electrons, (5 + 4 = 9). Nine electrons cannot reside in a valence ring, and therefore is equivalent to one excess or "FREE" electron. This ninth electron rejected by the valence ring has a negative charge.

Negative charges are attracted to positive charges at the barrier junction, when the proper polarity voltage is applied. When the negative and positive charged atoms meet at the barrier junction, the electrons will then move in a chain reaction toward the positive terminal of the diode. This is equal to current flow through the diode.

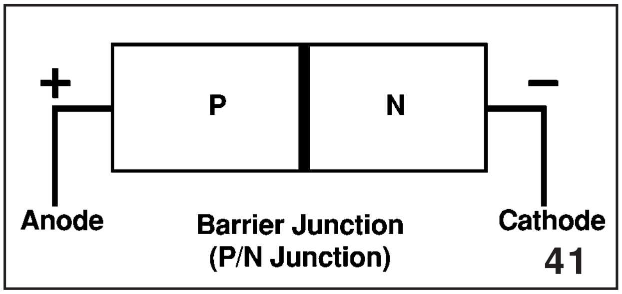


Diagram of Diode

The negative pole of a diode is called the cathode and the positive pole is the anode. In the center of the diode is the positive (+)/ negative (-) junction (P/N junction).

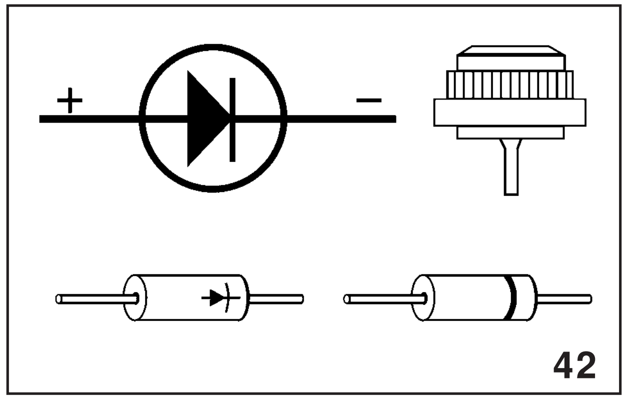
This is also called a "barrier junction". The P/ N junction determines the maximum allowable current flow of the diode and it is this feature which allows the diode to function as a one-way switch.

A silicon diode normally requires approximately 0.7v to cause a current to flow in the normal forward bias mode. Forward bias means the polarity of the input voltage will allow current to flow through the diode. However, if current flow is reversed, (reverse bias mode), the polarity causes the semiconductor's barrier junction to resist current flow. It may require up to 1000 volts to cause a current to flow through the diode in the reverse bias mode. This is called the P.I.V. (peak inverse voltage) rating.

Exceeding the amperage rating of the diode may:

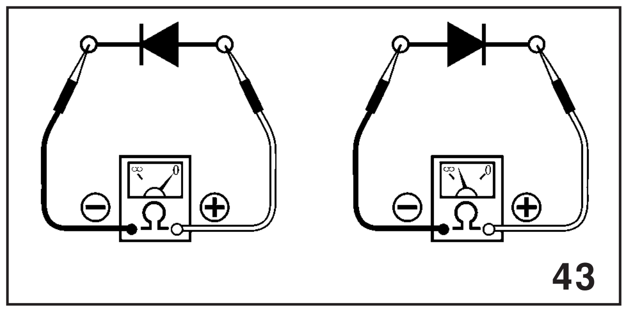
- Fuse the P/N junction, creating a short circuit. The diode will then act like a solid wire conductor, or
- Open the P/N junction creating an open circuit through which no current may flow.

The automotive industry primarily uses silicon diodes because of their excellent heat tolerance characteristics.



Diode Symbols

A line (mark) on the body of most diodes will always identify the cathode or negative end of the diode for testing and installation purposes.



DiodeTesting

You may use an ohmmeter of a voltmeter to test the operation of a diode.

1. Ohmmeter test
   - Connect the meter positive lead to the cathode (-) lead of the diode and the meter negative lead to the anode (+) lead of the diode. The result should be high resistance meter reading, ex: 5k ohms or more. This is due to the "unlike" charges of the voltage source (ohmmeter) and the diode material. The electrons and "holes" are pulled to the outside ends of the diode causing a large depletion region at the P/N junction. A low resistance reading would indicate that the diode is "shorted", and requires replacement.

- If you now reverse the meter lead connections, the result should be a low resistance reading, ex 100 ohms or less. This is due to the "like" charges of the voltage source (ohmmeter) and the diode material. The electrons and "holes" are repelled (pushed) to the P/N junction which allows current to flow. A high resistance reading indicates that the diode is "open", and must be replaced.

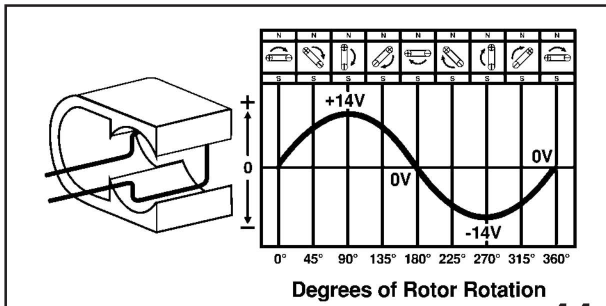
NOTE: WHEN USING AN OHMMETER TO TEST A DIODE, MAKE SURE THE POWER IS TURNED "OFF", OR WHERE POSSIBLE, REMOVE THE DIODE FROM THE CIRCUIT.

2. Voltmeter test
   - The diode must in an operating circuit. Connect the voltmeter leads to the diode leads, (observe polarity). Refer to the appropriate wiring diagram to determine the voltage that should be in the circuit. In most automotive applications this will be B+ voltage. The diode is "OK" when the meter readout is as follows:
     - Silicon diode — approx. 0.7 voltage drop (dynamic resistance)
     - Germanium diode — Approx. 0.2 voltage drop (dynamic resistance)

The voltage drop reading always identifies the diode type. Any other reading indicates a circuit or diode defect, and further testing will by required.

If the meter readout voltage is equal to the circuit voltage, the diode is open (all current is flowing through the voltmeter). When the meter readout voltage is equal to 0.0 volts, the diode is fused (shorted). All the current is flowing through the diode.

NOTE: A DIODE'S PERFORMANCE DOES NOT DETERIORATE WITH TIME OR USE. THEREFORE, WHEN TESTING, THE RESULT WILL EITHER BE "GOOD" OR "BAD", HOWEVER, IT IS POSSIBLE FOR A DIODE TO BE INTERMITTENTLY "GOOD" OR "BAD".



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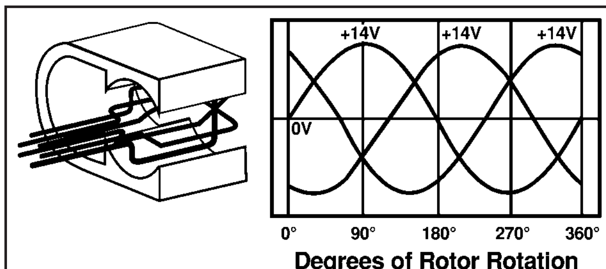
AC Sine Wave

A diode may be used to convert (rectify) AC voltage to a pulsing DC voltage. Because of the diode's polarity, current is only allowed through the diode in one direction. Remember that opposite polarity is denied conduction due to the high P.I.V. (peak inverse voltage rating) of the diode.

The negative pulses (opposite polarity) are then sent through an additional diode to the ground terminal of the battery. The result is single phase (DC) current.



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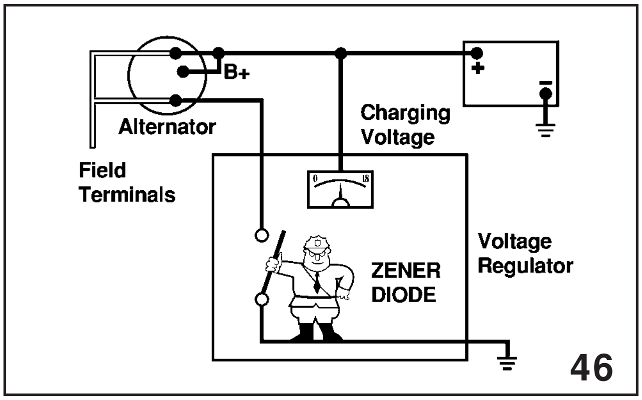
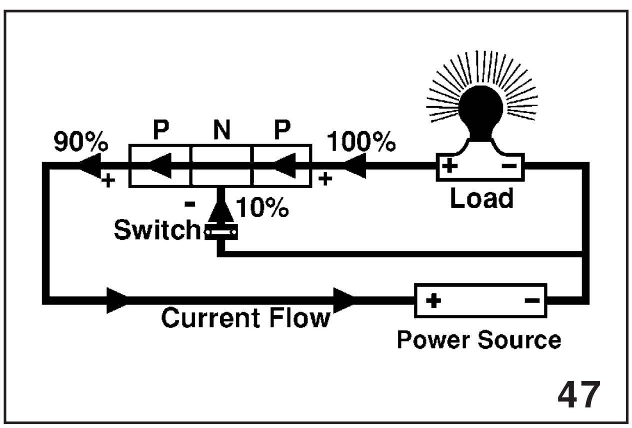
Three Phase Sine Wave

Place three stator windings, positioned 120 degrees apart, within a stator assembly. During each rotation of the field, three (3) separate voltage charges/pulses will be produced. When the voltage is passed through six (6) diodes, (3 positive and 3 negative), the result is three phase DC current. The three phases overlap each other which maintains a sufficient voltage level to properly charge the battery.



Zener Diode Operation

The zener diode allows reverse bias (voltage) at a predetermined level based on the impurity added to the adhesive between the P and N materials. This places the P.I.V. rating of the zener diode at a required specific value, i.e., 14 volts. Remember that silicon diodes may have a P.I.V. of a 1000 volts. This allows the zener diode to modify current flow by switching the circuit rapidly "ON" and "OFF" when the applied voltage increases or decreases. The zener diode is used in voltage regulators to prevent overcharging or undercharging of the battery.



Transistor Construction (PNP)

A transistor is a solid state device used to control current flow. Two of many types of transistors which may be identified by their polarity/lead designation are:

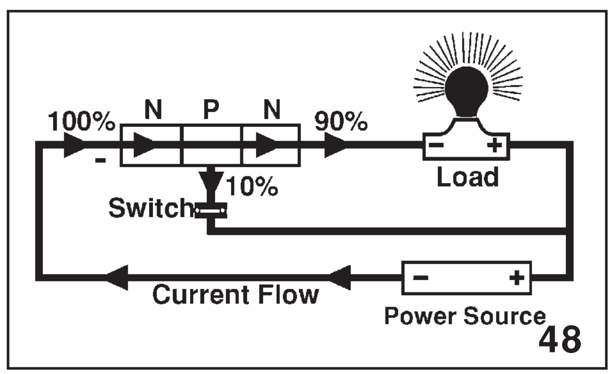
- PNP = positive/negative/positive
- NPN = negative/positive/negative

While a diode is formed by the joining of two specially doped materials, a transistor is formed by the joining of three doped materials.

- Emitter material emits current
- Collector material collects current.
- Base material supplies the path used to initiate or control current flow.

The base material is formed using a different doping process than the emitter/collector material and is thus the opposite polarity of the emitter/collector material.

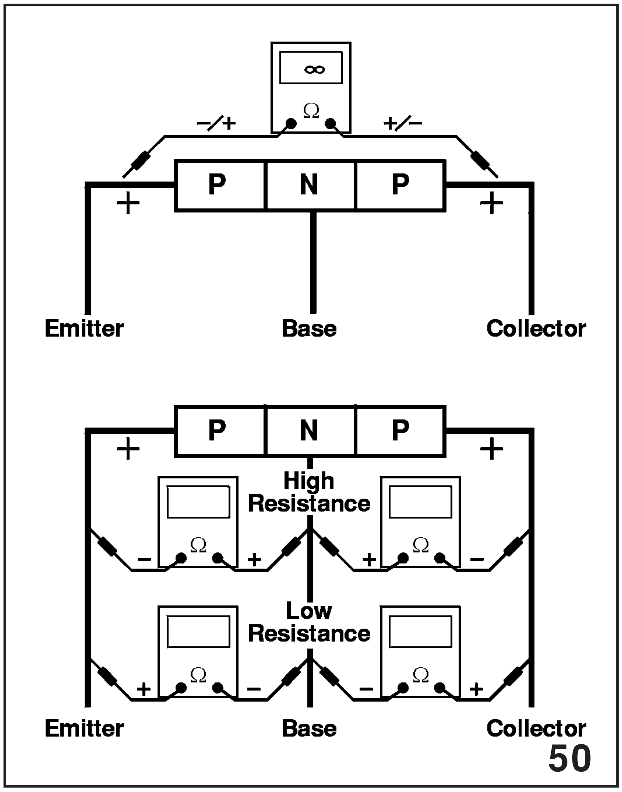
Operational control of a transistor is determined by the polarity of the base material which determines the polarity of the voltage supplied to the base. Thus, a PNP transistor operates by flooding the base material with free electrons (negative polarity). This allows the transistor to act as a switching relay, initiating current flow from the emitter to the collector. One of many applications of a PNP transistor is in the electronic ignition system.



Transistor Construction (NPN)

Construction and operation of the NPN transistor is similar to the PNP transistor. In this case however, the base material is flooded with holes (positive polarity) to control current flow from the emitter to the collector. The NPN transistor is often used as an amplifier in audio systems and other solid state circuits. This is the transistor which has allowed the miniaturization of electrical circuits by eliminating bulky vacuum tube circuitry.

Testing Transistors



PNP Transistor Testing

You may use an ohmmeter to test the operation of a transistor.

1. Always use the diode testing scale of an ohmmeter to test a transistor.
2. Test the transistor like two diodes.
   - First test the emitter to base (E-B)
   - Then test the collector to base (C-B)
3. The result will be "good" or "bad". Meter readings will vary depending on transistor type.

Ohmmeter test (PNP)

1. Connect the meter positive lead to the emitter lead of the transistor.
2. Connect the meter negative lead to the base lead of the transistor.
3. The result should be a LOW resistance reading.
   - Example: 100 ohms or less
4. Reverse the meter lead connections.
5. The result should be a HIGH resistance reading
   - Example: 5 K ohms or more
6. Connect the meter positive lead to the collector lead of the transistor.
7. Connect the meter negative lead to the base lead of the transistor.
8. The result should be LOW resistance.
   - Example: 100 OHMS or LESS
9. Reverse the meter lead connections
10. The result should be a HIGH resistance.
    - Example: 5 K OHMS or MORE
11. Meter readings will vary depending on the transistor type.
12. A final test includes a continuity test between the emitter and collector terminals of the transistor. Results should equal infinite regardless of meter polarity.

Ohmmeter test (NPN)

1. Reverse the lead connections in the above test steps.

NOTE: REVIEW THE TRANSISTOR LEAD IDENTIFICATION CHART SHOWN IN THIS TRB.

A voltmeter test of transistor operation is not practical in most automotive applications.

NOTE: A TRANSISTOR'S PERFORMANCE DOES NOT DETERIORATE WITH TIME OR USE.

Battery in Car

Battery

- converts chemical energy to electrical energy
- does not store electricity, stores chemical energy
- supplies energy for ignition/cranking motor
- backup energy source when accessory demands exceed alternator output capability
- stabilizes voltage in system

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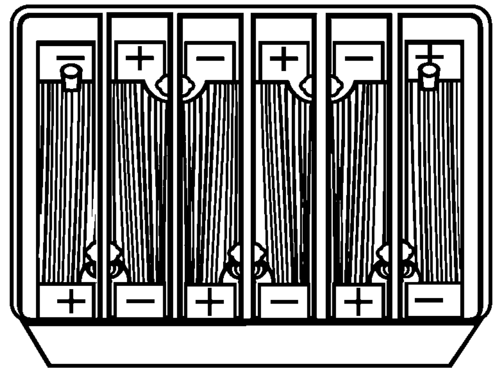
Purpose of Battery



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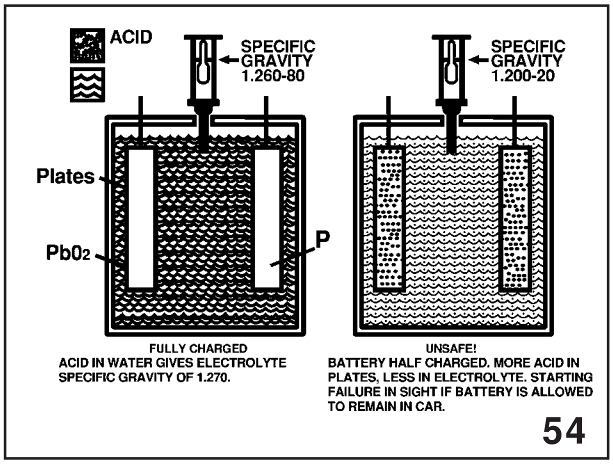
Battery (Artwork)

The automotive battery is an electrochemical device that stores and converts chemical energy into electrical energy. It is not a storage container for electricity. The battery provides the initial electrical energy for the ignition system and starting system. It also supplies additional current when the current demand of the system exceeds the output of the alternator.

Automotive batteries normally have six cells. Each cell produces 2.1 volts; thus a six-cell battery produces 12.6 volts. The voltage output of the battery is determined by the material used in the construction of the plates.

Automotive battery plates are made of two dissimilar materials, for example, lead peroxide (positive plate) and sponge lead (negative plate). A thin separator of rubber or plastic is between each negative and positive plate.

The cells are then connected in series, i.e., the positive plates of one cell are connected to the negative plates of the next cell, etc. Note that additional plates in a cell do not increase the voltage capability of the cell or battery, but they do increase the length of time that the battery can produce electricity (amperage rating).

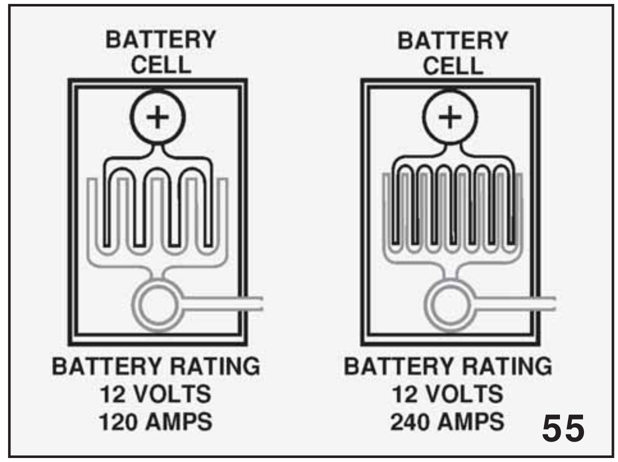


Electrolyte Specific Gravity

Electrolyte is the final ingredient required for an active battery. Without electrolyte, a battery is inactive and does not produce electricity. Electrolyte is a solution of water and purified sulfuric acid which allows the chemical reaction to occur between the plates. Generally, the percentage of sulfuric acid in a battery is 36 percent by weight and 25 percent by volume.

To determine the amount of charge of a battery, the specific gravity of the electrolyte is measured. A full charged battery theoretically should have an electrolyte specific gravity of 1.299. However, a normally charged battery will most likely indicate specific gravity readings ranging from 1.260 to 1.280 at 80° F.

Specific gravity is the ratio of the weight (or mass) of the water to the weight (or mass) of the sulfuric acid. Thus, a specific gravity of 1.000 is equal to water. Specific gravity will change with changes in temperature of the electrolyte, For each 10° above 80° F., add .004 to the electrolyte reading. For each 10° below 80° F., subtract .004 from the electrolyte reading. Or you may use an electrolyte temperature correction chart or a temperature equipped hydrometer.



Battery Voltage Artwork

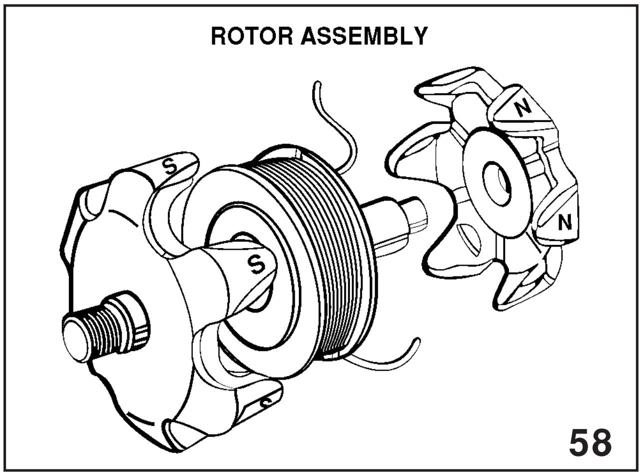
NOTE: THE SPECIFIC GRAVITY READINGS MUST NOT VARY MORE THAN 50 POINTS BETWEEN CELLS. A VARIATION OF MORE THAN 50 POINTS INDICATES CELL DETERIORATION, AND A NEED FOR BATTERY REPLACEMENT.

Alternators

Alternator Components

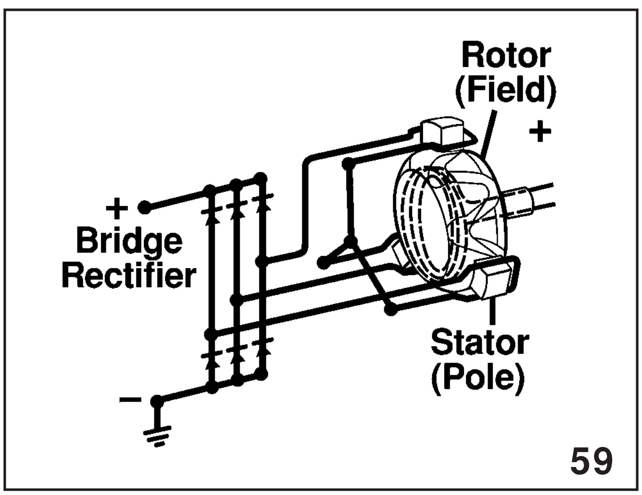
The components of a Subaru alternator are:

- Pulley
- Front cover/bearing
- Rotor (field coil)
- Stator
- Voltage Regulator
- Brush assembly
- Rectifier
- Rear cover/bearing
- Cooling fan



Alternator Component Operation

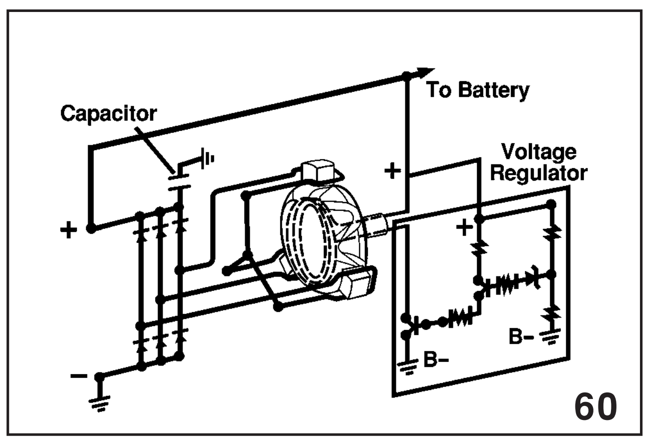
Because the field winding (rotor assembly) is lighter in weight and therefore easier to rotate, it rotates inside a stationary stator. Alternating north and south magnetic fields are created by bending the front and rear plates over the coil in a star-shaped interwoven type pattern.



Stator Construction

The standard stator design is a 3 phase "Y" configuration with three coils connected at one end. The coil of the "Y" are spaced at 120 degree intervals. Full wave rectification is accomplished through the use of six diodes, (3 positive and 3 negative). As the field coil rotates, current is induced into each stator winding, charging the winding. Negative (-) and positive (+) polarities are created at the ends of the stator winding. Each stator winding end is connected to a respective diode in the rectifier assembly. The charge in each winding causes the diode to allow charging current to flow to the battery for that period of rotation ONLY. As the field continues to rotate, it sequentially charges the remaining stator windings, causing their respective diodes to allow charging current to flow to the battery.

Four phase rectification incorporates a fourth winding which spaces the windings at 90 degrees intervals. Four phase units use 8 silicon diodes, (4 positive and 4 negative). The advantages of four phase rectification are an increase in current output and a reduction of ripple voltage output.



Capacitor Operation

The capacitor maintains stator voltage between phases by charging at peak voltage and discharging as the phase voltage drops. This has the effect of smoothing the "ripple" voltage produced by the phases of the alternator. The capacitor also reduces radio frequency interference (RFI).

Solid State Voltage Regulator

The internal solid state type of voltage regulator controls voltage within a specified range (usually 14.1 - 14.8 volts). The regulator provides an "ON" and "OFF" voltage pattern to the field coil. The field coil is turned "OFF" by the regulator when the battery voltage reaches a preset level. This stops the alternator from charging. When the battery voltage drops below the preset level, the regulator charges the field coil to the maximum. The "ON" and "OFF" threshold level is determined by a zener diode that is incorporated into the regulator assembly.

Alternator Testing Precautions

1. Disconnect all connectors properly.
2. Do not ground circuits with tools.
3. Never lay tools on the battery.
4. Always disconnect the battery prior to alternator replacement.
5. Secure loose harness/wiring to prevent damage caused during alternator removal/ replacement.
6. When full-fielding the alternator, never exceed 16.0 volts. Voltage levels in excess of this specification may cause damage to electrical system components.
7. Never disconnect the battery during an alternator test.
8. An alternator performance test should only be made with a serviceable battery.
9. Conduct an alternator performance test when any of the following conditions are present:

- The battery is discharged, but holds a charge when charged. Also, the battery performance test indicates a good battery.
- The vehicle voltmeter indicates a discharging condition or the charge warning light is illuminated during normal vehicle operation.

Conduct the alternator performance test in accordance with the operator's instructions for the test equipment you are using.

Conduct an alternator charging test, a voltage regulator test, and a diode/stator test. Compare the results of the tests to the specifications listed in the appropriate MY Subaru Service Manual. Repair and or replace components as required.

Conduct a charging system requirements test in accordance with the operator's instructions for the test equipment you are using. Be sure to connect the D-Check connectors so that the fuel pump and other fuel system components operate.

Restore the D-Check and alternator connections to the normal operating condition. Listed in the appropriate MY Subaru Service Subaru Starting Systems.

Starters

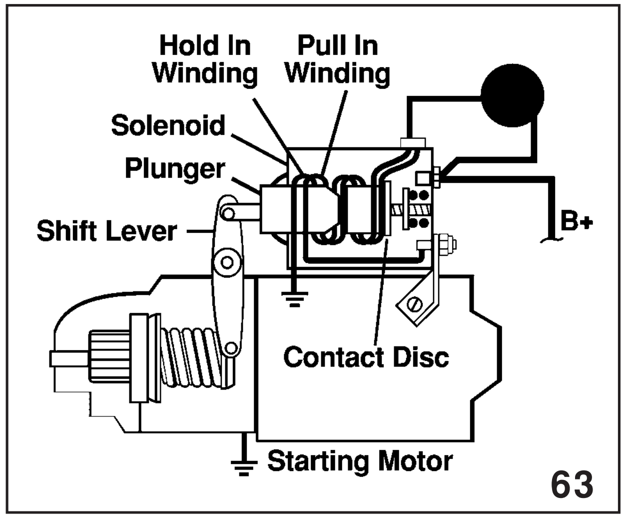
Starter Types

- Reduction Gear
- Direct Drive

Starter Components

The components of the starter assembly are:

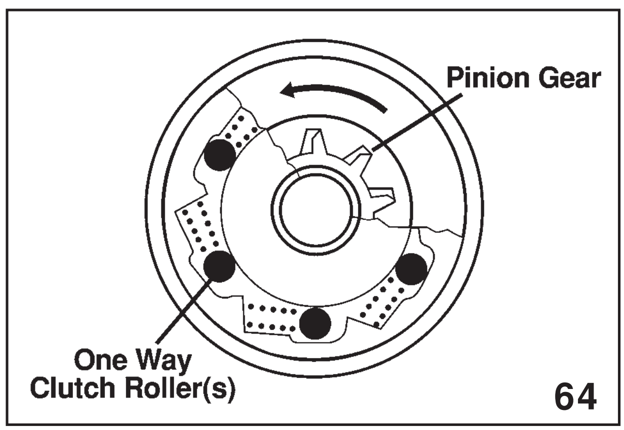
- Pinion (drive) / one-way clutch
- Armature
- Commutator
- Field shoes
- Brushes/brush holders
- End caps/bushings



Starter Solenoid

The components of the magnetic switch/ solenoid are:

- Pull-in winding
- Hold-in winding
- Plunger
- Return spring
- Shift lever
- Starter motor contacts



Starter Drive

Operation

When the ignition switch is turned to the "START" position, battery voltage (B+) is allowed to energize the magnetic switch/ solenoid pull-in and hold-on coils. The field created by the coils moves the plunger which in turn moves the shift lever engaging the starter pinion with the flywheel. The movement of the plunger also activates the starter motor switch contacts. This allows B+ voltage from the battery cable to flow to the starter motor through the magnetic switch.

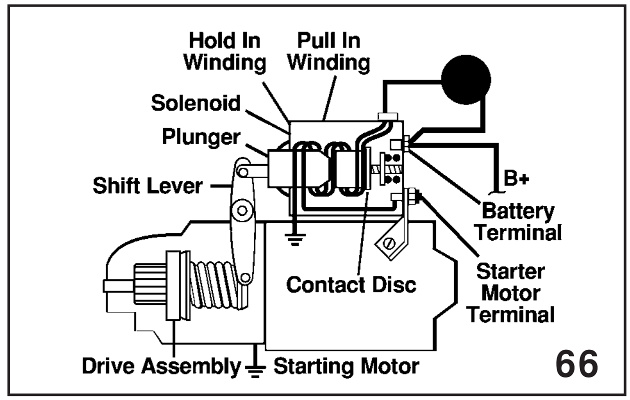
The starter rotates the pinion which rotates the flywheel to crank the engine. When the engine "starts", the one-way clutch "freewheels" to protect the starter armature and commutator from an "over-speed" condition.

When the ignition switch is released from the "START" to the "ON" position, this eliminates the flow of B+ voltage to the magnetic switch/ solenoid which collapses the field. The plunger spring returns the plunger to its original position moving the shift lever which disengages the pinion from the flywheel. The plunger also releases the switch contacts and the starter motor stops rotating.

An occasional problem with starting systems is a defective hold-in winding in the solenoid. In this situation, the solenoid will "click" rapidly. This occurs because the pull-in winding moves the plunger but the hold-in winding is not energized. Since no hold-in field is created and the pull-in winding field is released as the start switch is engages, the plunger return spring returns the plunger to the pre-start position. This process repeats and the plunger moves back and forth rapidly. This action will momentarily engage the flywheel, and occasionally may rotate the flywheel enough to start the engine.

NOTE: THESE SYMPTOMS ARE SIMILAR TO THOSE CAUSED BY A DEFECTIVE BATTERY OR BATTERY CONNECTIONS. THEREFORE, A BATTERY PERFORMANCE TEST, AND AN INSPECTION OF THE BATTERY CONNECTIONS MUST ALWAYS BE PERFORMED PRIOR TO TROUBLESHOOTING THE STARTER SYSTEM.

Starter/Solenoid Testing Procedures



Magnetic Switch / Solenoid

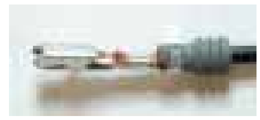
Use an ohmmeter to test the pull-in and hold-in windings. Always refer to the appropriate MY Subaru Service Manual.
Use a voltmeter to conduct a starter motor test for intermittent operation. Complete the following steps:

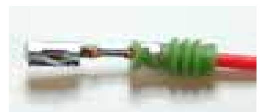
1. Connect the voltmeter leads to the starter motor terminal and to a ground.
2. By-pass the solenoid by connecting a jumper cable from the solenoid B+ terminal to the solenoid starter motor terminal. This spins the starter, but does not engage the magnetic switch/solenoid.
3. If there is a steady voltage reading the starter motor components are OK.
   - Brushes
   - Commutator
   - Armature
4. A variable voltage reading indicates a problem in:
   - Brushes are arching
   - Commutator is dirty or has a defective segment
   - Armature is open or has a shorted winding

Finally, be sure to test all cables using the voltage drop method.

Harness Repair Kit

(Part # J-47606)





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PRECAUTIONS

(1) Wear protective clothing, including a cap, protective goggles, and protective shoes during operation.

(2) Remove contamination (including dirt and corrosion) before terminal pin removal, installation, or disassembly.

(3) Keep the parts disassembled in order and protect them from dust or dirt.

(4) Before removal, installation or disassembly, be sure to clarify the failure. Avoid unnecessary removal, installation, disassembly, and replacement.

(5) Use caution when working on a vehicle that has been running since some vehicle components will be very hot to the touch.

(6) Be sure to tighten fasteners such as bolts and nuts to the specified torque described on the service manual if applicable.

(7) Before disconnecting electrical connectors of sensors, be sure to disconnect the ground cable from battery.

(8) All removed parts, if to be reused, should be reinstalled in the original positions and directions.

(9) Bolts, nuts, and washers should be replaced with new ones as required.

(10) Be sure to protect the vehicle from dirt and damage.

(11) Do not apply rotational torque to pin removal tools. Such torque will damage or break the tool itself.

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COMPONENT LIST

Joint piece (Small size): RK-JFA-001

Joint piece (Large size): RK-JFA-002

Insulation adhesive: RK-BFA-003

Repair terminal: RK-TFA-015 (Gilded Terminal)

Repair terminal: RK-TFA-019

Repair terminal: RK-TFA-020

Repair terminal: RK-TFA-021

Repair terminal: RK-TFA-022

Repair terminal: RK-TFA-023

Repair terminal: RK-TFA-024 (Gilded terminal)

Repair terminal: RK-TFA-025

Repair terminal: RK-TFA-026

Repair terminal: RK-TFA-028

Repair terminal: RK-TFA-043

Terminal lock release tools:

Removal Tool No. 5 (J-47606-5)

Removal Tool No. 6 (J-47606-6)

Removal Tool No. 7 (J-47606-7)

Removal Tool No. 8 (15315247)

Removal Tool No. 9 (J-42019)

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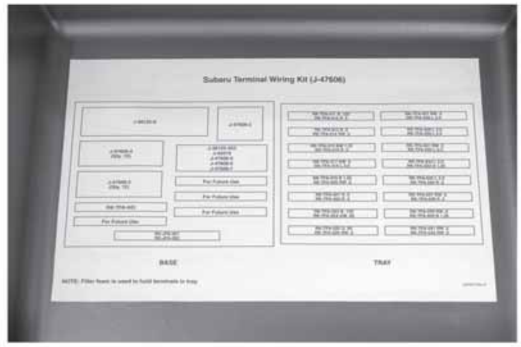
Terminal crimpers

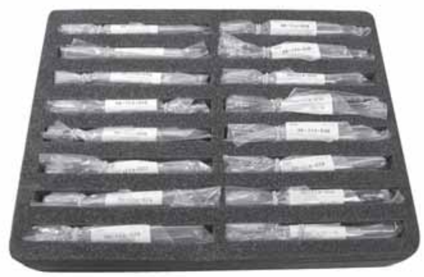
Heat shrink tubing (J-47606-3)

Heat shrink tubing (J-47606-4)

Kit locator guide



Upper tray



Upper and lower trays

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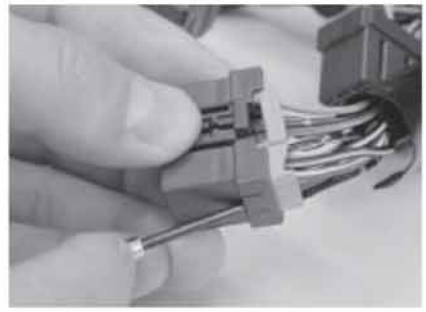
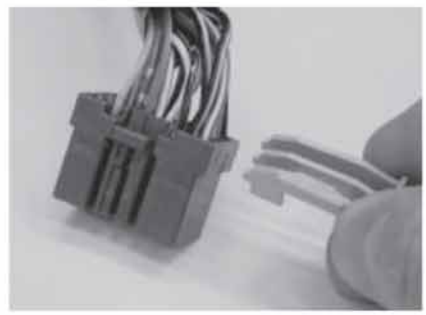
REPAIR EXAMPLE

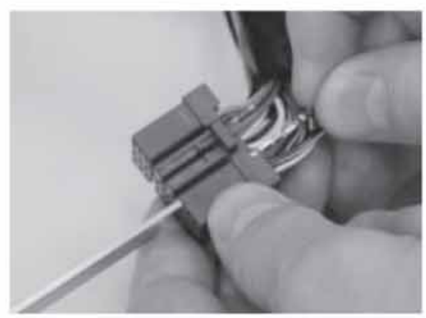
1. Using a thin screw driver, push up the double locking piece on the connector.



2. Remove the locking piece from the connector.



3. Insert the terminal pick release tool into the terminal hole and pull the terminal out.



4. Cut the defective terminal from the harness.

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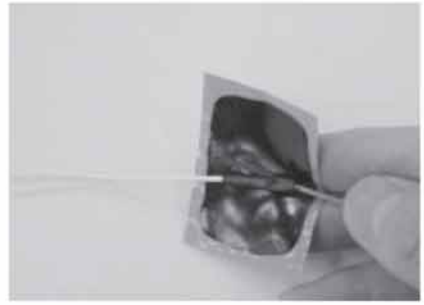
5. Using a pair of wire strippers, remove 10mm of insulation from the original harness.

6. Crimp the original harness and the repair harness with a joint piece (RK-JFA-001 or RK-JFA-002) using the terminal crimpers.

7. Solder is applied to complete the joint.

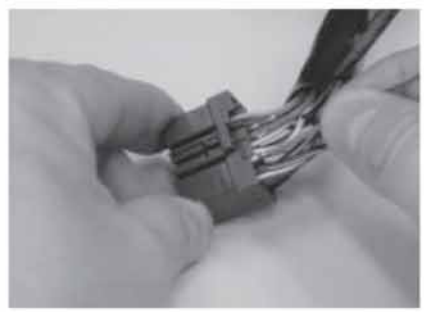
8. Wrap insulation tape around the joint of the two harnesses.

9. If the joint is installed in a location of moisture, humidity, and/or dust, apply a piece of waterproof adhesive around the joint (RK-BFA-003).



10. Wrap insulation tape over the adhesive.

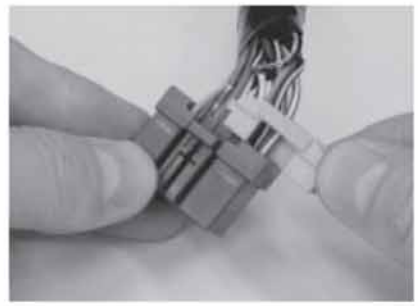
11. Insert the terminal into the terminal hole of the connector until it stops completely.



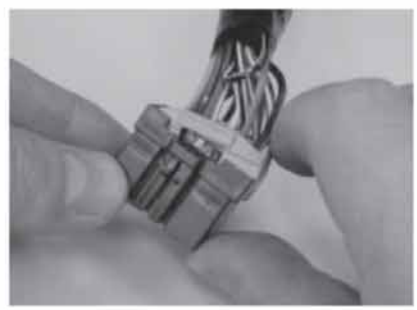
12. Fasten the repair harness on the original harness with insulation tape.

13. Confirm that harness is not kinked or wound excessively.

14. Reinstall the double locking piece to the connector.



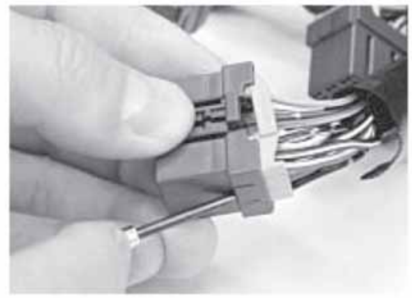
15. Push down the side of the locking piece until it locks completely.



TERMINAL LOCK RELEASE MANUAL

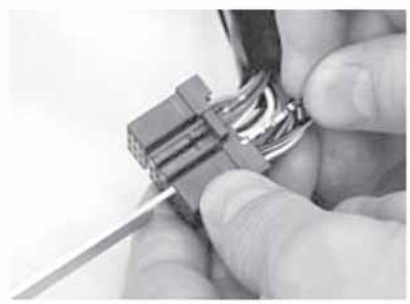
Manual No. RM-5

1) Release the lock on the connector.



2) Remove the locking piece from the connector.

3) Using the appropriate terminal pick release tool, remove the defective terminal.



Page 12 - Harness Repair Kit

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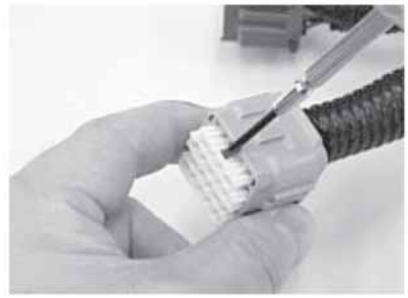
Manual No. RM-9

1) Release the lock on the connector.



2) Remove the locking piece from the connector.

Harness Repair Kit - Page 13

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TERMINAL ADAPTATION TABLE

SPX Tool No.	Part No.	Parts Name
GM 12085271-C	RK-JFA-001	Joint piece - S
GM 12085271-B	RK-JFA-002	Joint piece - M
	RK-BFA-003	Insulation adhesive

SPX Tool No.	Removal Tool	Part No.	Wire	Wire Color
DELPHI 15315247	No8	RK-TFA-011	1.25	B
DELPHI 15315247	No8	RK-TFA-012	0.5	R
J47606-6	No6	RK-TFA-013	0.5	R
J47606-6	No6	RK-TFA-014	0.5	R/W
J-42019	No9	RK-TFA-015	1.25	B/W
DELPHI 15315247	No8	RK-TFA-016	0.5	R
DELPHI 15315247	No8	RK-TFA-017	0.5	R/W
DELPHI 15315247	No8	RK-TFA-018	2	L
DELPHI 15315247	No8	RK-TFA-019	1.25	B
DELPHI 15315247	No8	RK-TFA-020	0.5	R/W
DELPHI 15315247	No8	RK-TFA-021	0.5	R
J47606-6	No6	RK-TFA-022	0.5	R
J47606-5	No5	RK-TFA-023	1.25	B
J47606-5	No5	RK-TFA-024	0.85	G/W
J47606-5	No5	RK-TFA-025	0.85	G
DELPHI 15315247	No8	RK-TFA-026	0.5	R/W
DELPHI 15315247	No8	RK-TFA-027	0.5	R/W
DELPHI 15315247	No8	RK-TFA-028	2	L
DELPHI 15315247	No8	RK-TFA-029	2	L
J47606-7	No7	RK-TFA-030	2	L
DELPHI 15315247	No8	RK-TFA-031	0.5	R/W
DELPHI 15315247	No8	RK-TFA-032	2	L
DELPHI 15315247	No8	RK-TFA-033	2	L
J47606-7	No7	RK-TFA-034	1.25	B
DELPHI 15315247	No8	RK-TFA-035	2	L
DELPHI 15315247	No8	RK-TFA-036	0.5	R
DELPHI 15315247	No8	RK-TFA-037	0.5	R/W
DELPHI 15315247	No8	RK-TFA-038	0.5	R
DELPHI 15315247	No8	RK-TFA-039	0.5	R/W
DELPHI 15315247	No8	RK-TFA-040	1.25	B
DELPHI 15315247	No8	RK-TFA-041	0.5	R/W
J47606-7	No7	RK-TFA-042	0.5	R/W
DELPHI 15315247	No8	RK-TFA-043	1.25	B

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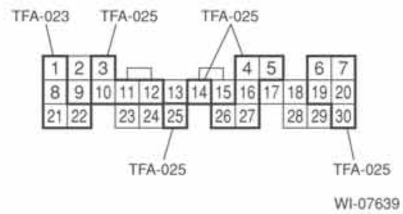
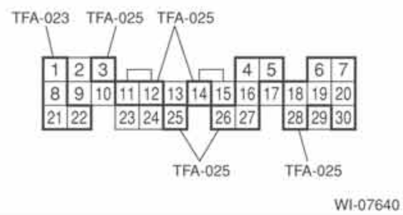
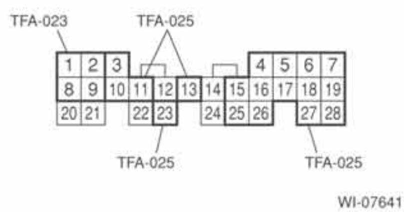
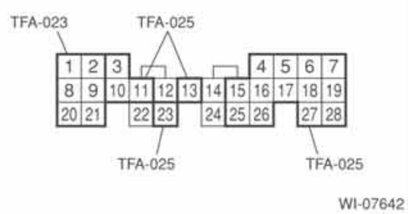
EXAMPLE

Harness Repair Kit

WIRING SYSTEM

Connector No.	Adaptive repair kit	Terminal No.	Harness repair kit No.
B280 (2.5 L Non-turbo and 2.5 L Non-turbo (U5) model)		1, 8, 21, 22	TFA-023
		3 — 7, 10 — 12, 14, 16, 19, 20, 25 — 27, 30	TFA-025
		2, 9, 13, 15, 17, 18, 23, 24, 28, 29	Not available
B280 (3.0 L model)		1, 8, 21, 22	TFA-023
		3 — 7, 11, 12, 14, 16, 18 — 20, 25 — 28, 30	TFA-025
B280 (2.5 L Turbo model)		2, 9, 10, 13, 15, 17, 23, 24, 29	Not available
B281 (2.5 L Non-turbo and 2.5 L Non-turbo (U5) model)		1, 2, 8, 9	TFA-023
		3 — 7, 10, 11, 13, 15 — 19, 23, 25 — 28	TFA-025
		12, 14, 20 — 22, 24	Not available
B281 (3.0 L model)		1, 2, 8, 9, 20, 21	TFA-023
		3 — 7, 10, 11, 13, 15 — 19, 23, 25 — 28	TFA-025
B281 (2.5 L Turbo model)		12, 14, 22, 24	Not available

WI-227

Harness Repair Kit - Page 15

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Battery Replacement Claim Requirements

SUBARU

Battery Replacement Claim Requirements

Midtronics inTELLECT EXP Electrical Diagnostic Platform and GR1 Dynamic Conductance Charger

April 1, 2006 will mark the official requirement date for all dealers to begin using the new Midtronics Battery Test and Charge equipment. Both pieces of equipment (inTELLECT EXP and GR1) produce a Battery Test Code that is required in order to process a battery claim. This test code can be found at the bottom of the inTELLECT EXP or GR1 print-out (see examples 1 and 2, right).

Both pieces of equipment not only provide the technician with an exceptional tool for diagnosing battery health, but they also offer a proactive way to show each customer the current condition of their battery prior to failure. Simply show the customer the battery test print-out with graphical representation of their vehicle's battery health. Increased battery sales and customer loyalty will result.

Claim Requirements:

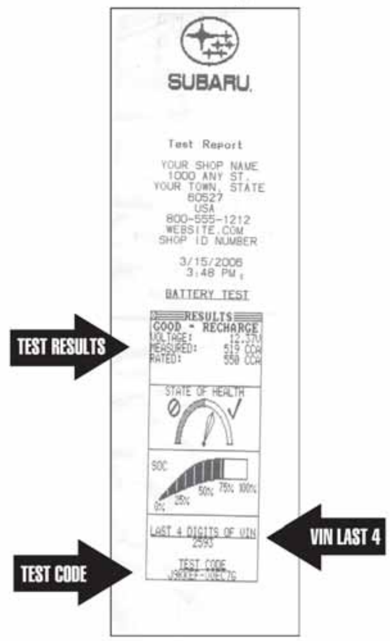
Battery testing using Midtronics Battery Test and Charge equipment is required when performing battery replacement in all cases except for leaking batteries. All claims submitted for battery replacement (except leaking batteries) requires entry of the 12 character Battery Test Code in the "Exch/Serial/Inv." field. Authorization for battery replacement on new or used in-stock vehicles will no longer be required from your Field Service Manager except in the case of a leaking battery. Claims without the battery test code (except leaking batteries) will be rejected.

Always confirm the entry of the last 4 VIN characters prior to Battery test to avoid claim rejections. The following characters are not used in the Battery Test Code.

Dashes
Hyphens
Decimals
The letter I
The letter O
The letter Y
The letter Z

Note: Recharging of batteries is not considered a matter for warranty unless it is a direct result of the failure of a covered component.

Example 1



Example 2

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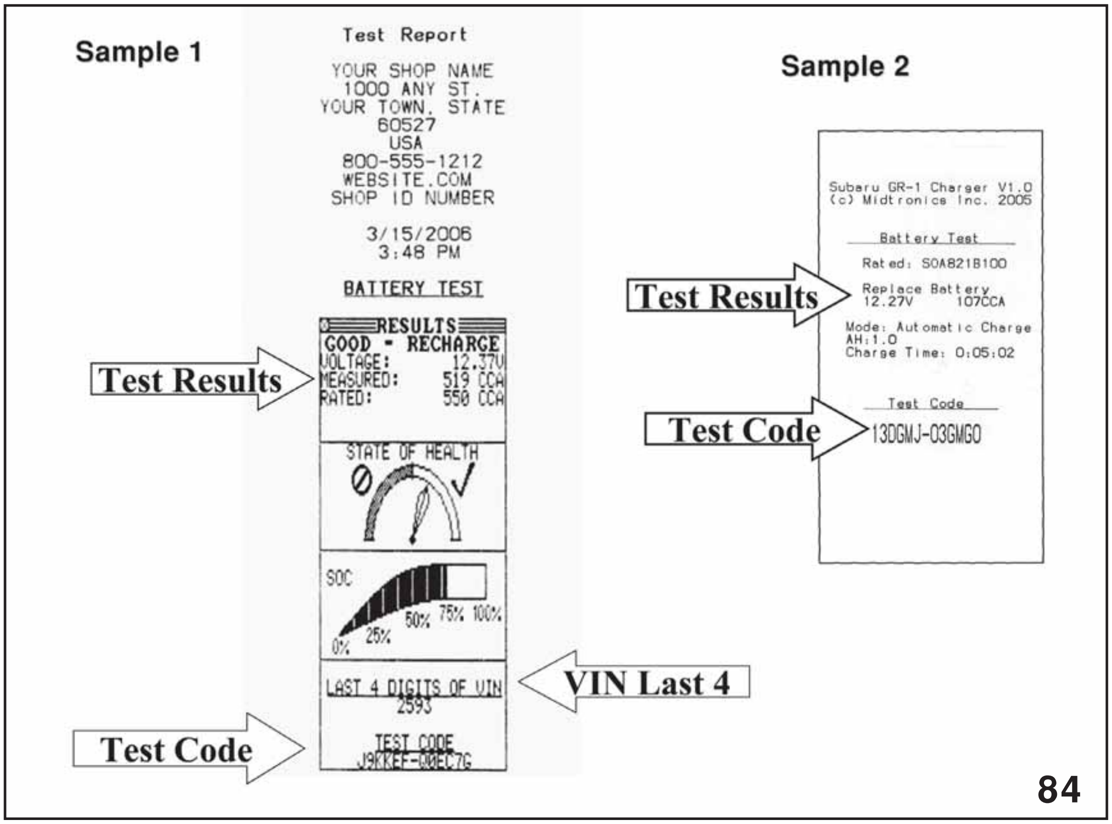
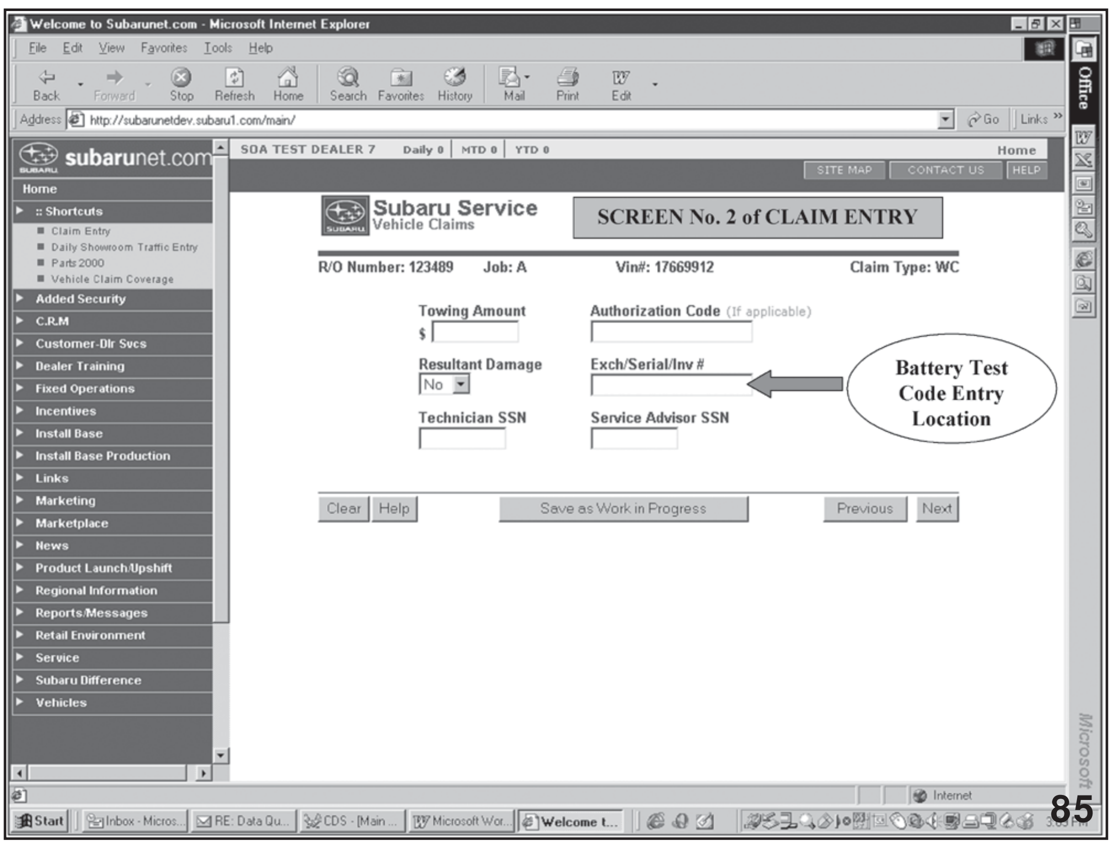
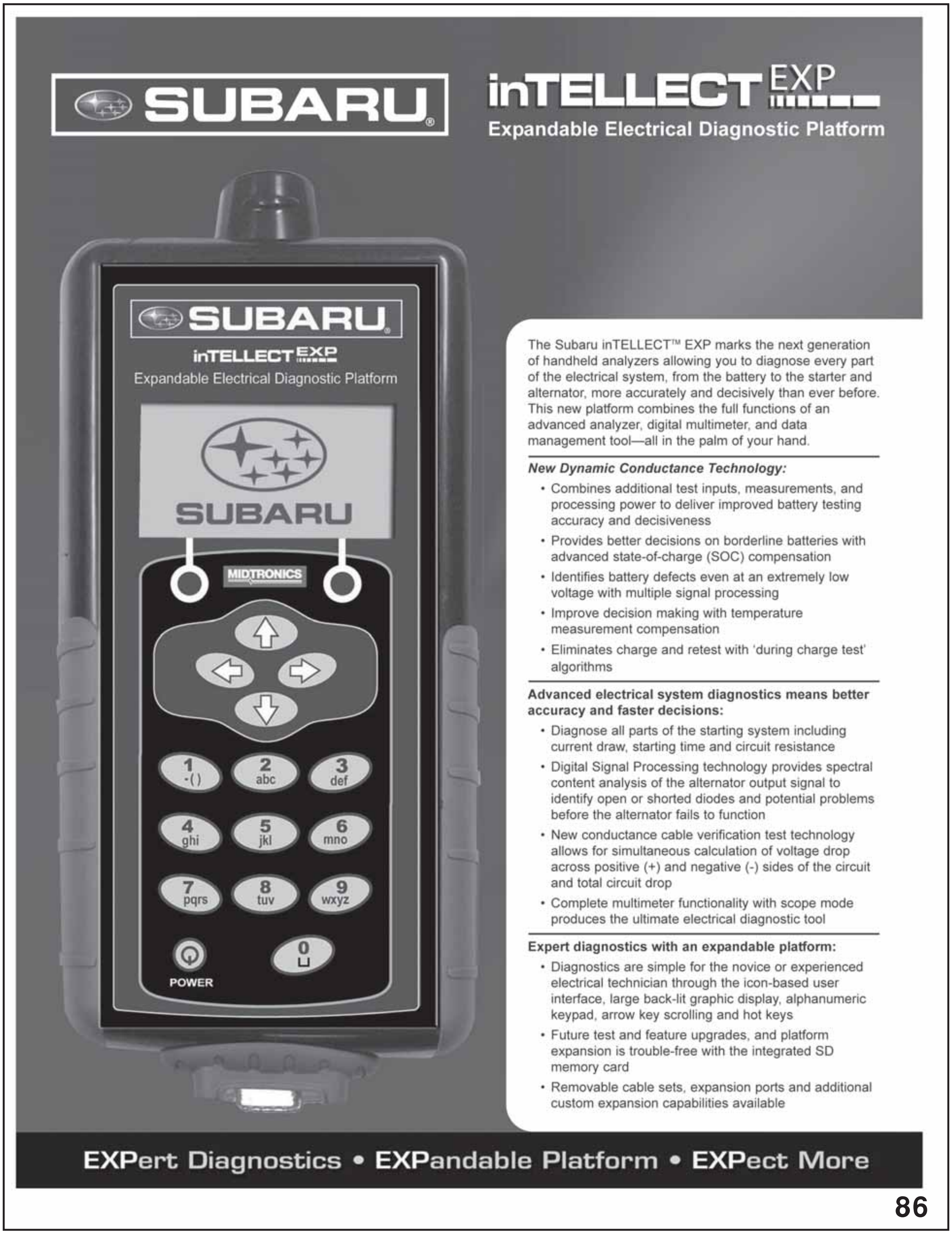
Battery Replacement Claim Requirements Sheet



Test Report Samples



Subarunet.com screen



Subaru inTellect EXP

SUBARU

inTELLECT EXP

Expandable Electrical Diagnostic Platform

Specifications

Model:
- EXP-1000S AMP -Tester, battery clamps, amp clamp, cable verification clamps, DMM probes, carrying case

Applications:
- 12 volt automotive battery testing (including AGM batteries)
- 12 volt charging system diagnostics

Power Requirements:
- (6) AA Alkaline batteries

Operating Ranges:
- 12 volt individual batteries

Rating System	Range
CCA	100 - 3000
JIS	By JIS number

Display:
- 128 x 64 pixel graphic, backlit display

Temperature Compensation:
- Built-in temperature measurement when prompted by tester

Operating Temperature:
- 32 ºF - 120 ºF (0 ºC - 49 ºC)

Test Leads:
- 10' dual conductor Kelvin clamps

Housing Material:
- ABS plastic with Santoprene overmolds

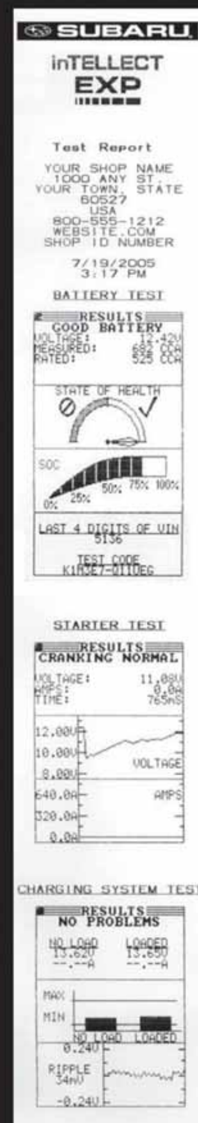
Dimensions:
- 9 ½" H x 4" W x 2 ½" D

Weight:
- 1 lb. / 427 g.

Carrying Case:
- Heavy-duty molded plastic

Voltmeter Specifications:

Feature	Range	Accuracy
DC Voltage	0 – 60 V	0.05% + 2 VDC
AC Voltage	0 – 24 V	0.1% + 3 VAC
Resistance	10 ohm – 2 Mohm	2.0% + 4
DC and AC Amps	0 – 70 A	+/- 3% of reading +/- 1 A
	0 – 700 A	+/- 3% of reading +/- 1 A
Continuity	< 10 ohm	2.0% + 4 ohm
Diode	0 – 1.5 V	0.05% + 2 V
Temperature	-20 – 200º F	1.0% + 5



Sample Custom Printout

There are two IR data ports on the top of the EXP.
- An IR data transmitter, which transmits test results to the optional IR printer.
- An IR temperature measurement sensor.

The EXP also has a DB-9 connector for future expandability and an SD card slot for future software upgrades or data logging.

The EXP ships with an unprogrammable card to protect the slot from dust and debris.

MIDTRONICS
Battery Management Innovation

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Subaru inTellect EXP Specifications and Parts

MIDTRONICS

Battery Management Innovation

GR1-SUBARU

Dynamic Conductance Charger

Specifically designed for use in Subaru service facilities, the GR1 is the ONLY tool that provides total battery service. Just connect to the battery, enter the battery rating, and press enter.

The GR1 does the rest, charging good discharged batteries or giving a replace decision and the Subaru warranty code for defective or weak batteries.

Features:

- Advanced battery diagnostics and ongoing monitoring mean you only charge good batteries and minimize charging hazards
- Generates Subaru Test Code for improved warranty management
- Charges most batteries to 85% state-of-charge in less than an hour while monitoring battery condition, so every battery gets the right amount of charge every time
- Advanced user interface makes battery diagnostics and charging simple
- Quickly and easily recovers aging batteries from vehicles in dealer's lots
- Fully automatic fast-charge/diagnostic mode
- Multiple diagnostic/charging algorithms, including AGM/Spiral batteries
- Top-off mode to trickle charge battery
- Field upgradeable for future enhancements
- 250 Amp Jump-start capability
- 10/30/60 Amp manual charge mode
- Integrated printer for printing of GR1 test results in seconds (Printer also works with Subaru EXP tester)

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GR1-Subaru Dynamic Conductance Charger

GR1-Subaru

Dynamic Conductance Charger
Total Battery Service - FAST™

The Total Battery Service Process:

STEP 1: Initial Battery Analysis:
At the beginning of the process, the GR-1 analyzes the condition of the battery, making a replace or charge decision - FAST!

STEP 2: Diagnostic Charging:
If the battery is not found to be defective and requires charging, GR-1 starts the diagnostic charging process, designed to stress the battery and expose hidden defects in batteries by combining testing and charging measurements. Within the next five minutes, GR-1 will determine if the battery needs additional charging or should be replaced, so your customer gets an accurate diagnosis - FAST!

STEP 3: Conductance Controlled Charging:
At this point, the GR-1 can concentrate on charging the battery. GR-1 controls the process, while providing the user with continuous updates of charging conditions. At the end of the process, GR-1 sounds a loud and long tone to signal the end of the process so the customer is on their way - FAST!

STEP 4: Final Conditioning and Decision:
GR-1 removes surface charge and performs one last test, to ensure an accurate decision every time.

Battery Types/Algorithms
- 12 V Lead Acid Battery (standard starting batteries)
- 12 V AGM/Spiral Battery
- 12 V Group 31 – Truck Battery

Rating Systems/Test Range
- 100-1500 CCA 100-1500 CA
- 100-1500 MCA – Marine Cranking Amps
- JIS-Japanese OEM Batteries

Operating Range
100-2400 CCA
JIS Range by Number

Charging Voltage:
- 0.7 volts to 17 volts, .1 resolution

Charging Current:
- 0 – 70 amps, 1 amp resolution
- 80 Peak amps

Manual Charging:
- 60/30/10 amps

Jump Start Vehicle:
- 250 amps

Outputs:
- Amp hours put into the battery
- Time remaining to charge in minutes
- Voltage
- CCA's
- Charge Code
- Subaru Warranty Code

Charge Cycles
- Diagnostic/one-hour fast charge, including unlimited trickle charge
- Manual-timed (max. 120 minutes)

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Battery Process

inTELLECT EXP Instruction Manual

Look for PDF of Manual on STIS

GR-1 120 Diagnostic Conductance Charger

Look for PDF of Manual on STIS

Moonroof

Moonroof Closed

The moonroof on the 2.5XS and 2.5XS premium package model operates slightly different than previous Subaru moonroofs. When activated to open, the moonroof will continue to open with no continued contact with the open button to the ¾ open position.

Moonroof 3/4 Open

Pushing the button again and releasing the button will carry the moonroof to the fully open position.

Moonroof Open

When activated to close, the moonroof will continue to close with no continued contact with the close button, to the ¾ closed position. Pushing the button again and releasing it will carry the moonroof to the fully closed position.

Moonroof 3/4 Closed

An increase in the amount of current closing the moonroof will activate an obstruction safety feature that will interrupt the auto close feature and reverse the moonroof to open about 6 inches beyond the obstruction. Removing the obstruction and pushing the close switch again should restore the auto close of the moonroof. If the safety feature continues to operate the auto close feature will turn off. It will only be restored after the safety feature circuit has cooled down. A vehicle speed sensor input is supplied to the moonroof control unit it will increase the sensitivity of the obstruction detection.

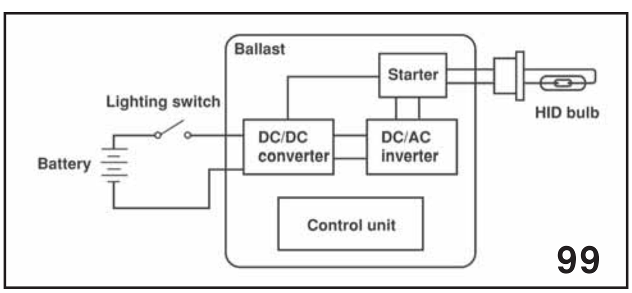
HID Headlights

Headlight

WRX STI is equipped with a High Intensity and Discharge (HID) low beam headlight system. The high beam headlights are halogen. The vehicle is not equipped with day time running lights.

High intensity and discharge (HID) headlights work by applying a high electrical charge between two electrodes which are surrounded by a gas (Xenon) in sealed glass tube. The gas emits light as it is heated and electrical current passes through it.

WARNING: THE HID HEADLIGHTS GENERATE HIGH HEAT AND REQUIRE HIGH VOLTAGES TO FUNCTION. EXTREME CARE SHOULD BE TAKEN TO PREVENT INJURY.

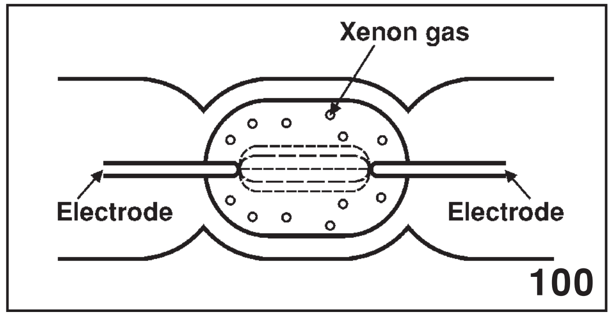


HID Schematic

The illumination portion of the headlight assembly for the HID consists of a ballast and HID bulb.

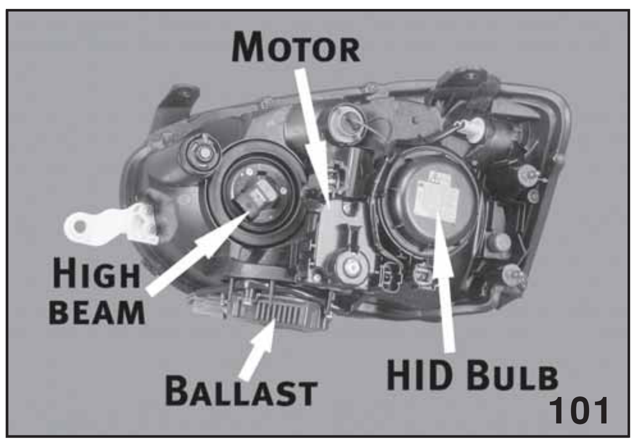
The ballast contains a DC/DC converter, DC/AC converter, starter and control unit. The DC/DC converter raises 12 volts DC to 85 volts DC. The DC/AC converter changes the 85 volts DC to 85 volts AC.

NOTE: HID BULBS CONTAIN MERCURY. FOLLOW LOCAL REGULATIONS FOR PROPER DISPOSAL.

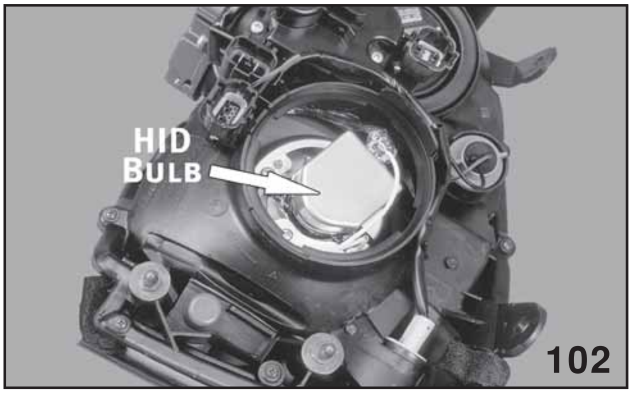


Bulb Schematic

When the HID is turned on the voltage required to begin operating is much higher than an HID already on. The starter generates 23,000 volts AC. The voltage will drop to 85 volts AC as the HID warms and light is generated.



Head Light Complete



Hid Bulb

CAUTION: DO NOT DISASSEMBLE THE BALLAST, BULB SOCKET HARNESS OR BALLAST HARNESS.

DO NOT DISCONNECT THE HEADLIGHT ASSEMBLE WITH THE LIGHTS ON.

Headlight Leveler Switch

The headlight assemble is equipped with a motor that is controlled by the driver to lower the headlights, both high and low beam. The switch allows the headlights to be lowered in 3 steps. Step 3 is the lowest setting. The purpose of the head light leveler switch is to allow the driver to lower the headlights if the illumination becomes an objection to on coming traffic.

Rear Gate

Subaru B9 Tribeca

Rear Gate Button

The rear gate is opened from the outside by the use of a remote electrical switch located between the rear license plate lights.

Manual Release Lever

The switch sends a signal to the BIU and the BIU activates the actuator which is located behind the rear gate trim.

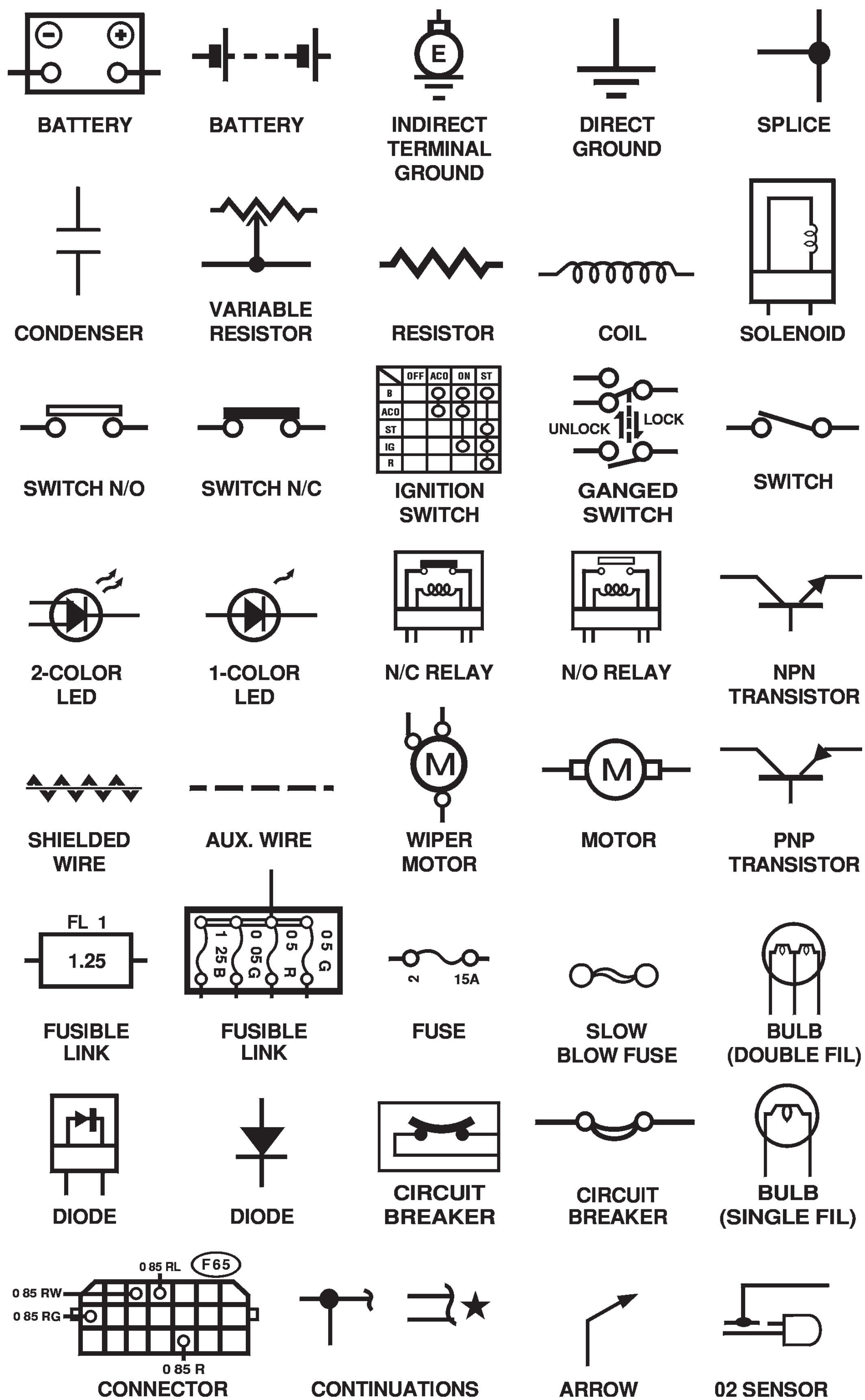
Manual Release Trim

If the battery is discharged or the electrical circuit for the actuator has failed a mechanical override is proved through the access panel located on the rear gate interior trim.

NOTE: REAR GATE AUTOMATICALLY LOCKS VEHICLE

SPEED > THAN 3 MPH.

UNLOCKS < THAN 3 MPH.


BATTERY
BATTERY
E
INDIRECT TERMINAL GROUND
DIRECT GROUND
SPLICE
CONDENSER
VARIABLE RESISTOR
RESISTOR
COIL
SOLENOID
OFF ACO ON ST
B
ACO
ST
IG
R
UNLOCK
LOCK
SWITCH N/O
SWITCH N/C
IGNITION SWITCH
GANGED SWITCH
SWITCH
2-COLOR LED
1-COLOR LED
N/C RELAY
N/O RELAY
NPN TRANSISTOR
M
M
SHIELDED WIRE
AUX. WIRE
WIPER MOTOR
MOTOR
PNP TRANSISTOR
FL 1
1.25
1 25 B
0 05 G
0 5 R
0 5 G
2
15A
FUSIBLE LINK
FUSIBLE LINK
FUSE
SLOW BLOW FUSE
BULB (DOUBLE FIL)
DIODE
DIODE
CIRCUIT BREAKER
CIRCUIT BREAKER
BULB (SINGLE FIL)
0 85 RL
F65
0 85 RW
0 85 RG
0 85 R
CONNECTOR
CONTINUATIONS
ARROW
02 SENSOR

Electrical Terms Glossary

Alternating Current (AC)

An electric current which constantly changes polarity from positive to negative, (or an electric current that reverses its direction regularly and continually).

Direct Current (DC)

An electric current which flows in one direction only.

Sine Wave

a wave that alternately moves between a positive and a negative value over an equal length of time

Square Wave

A square or rectangular-shaped wave that alternately assumes a "ON" or "OFF" mode. The length of the "ON" time compared to the "OFF" time indicates a "duty ratio".

Resistance

Property of an electrical circuit that tends to prevent or reduce the flow of current.

Dynamic Resistance

Effect of a resistor or resistance in a circuit.

Voltage Drop

The difference in voltage between one point in a circuit and another, or the difference in measured voltage from one side of a component to the other side.

Resistor

Device that permits a predetermined current to flow at a given voltage. Examples are a SPFI ballast resistor and a 4EAT dropping resistor.

Rheostat

See Variable resistor.

Variable Resistor/Rheostat

A device that adjusts the amount of resistance required. An example is a sliding contact resistor. The position of the contact determines the amount of resistance. The fuel sending units of a vehicle equipped with an analog dash use a variable resistor.

Potentiometer

A resistive element with a sliding wiper contact that is used in applications in which a division of resistance is required (such as a three-terminal adjustable resistive divider). Example: The throttle sensor on SPFI and MPFI fuel systems.

Splice

Joining of two or more conductors at a single point.

Terminal

Device attached to the end of a wire or cable to make an electrical connection.

Ground/Chassis ground

Negative side of a complete circuit. In automotive applications the negative side of the battery or any wire connected to the engine, frame, or body sheet metal.

Relay

Electromagnetic switching device using low current to open or close a high-current device.

Solenoid

An electromagnetic device consisting of a tubular coil of wire containing a core that moves when the coil is energized. Movement of the core can open/close a circuit. A solenoid converts electrical energy to mechanical energy.

Filament

A fine high resistance wire or thread which glows and produces light when current is forced through it.

Slide Sequence

Slide Sequence

Slide Sequence

Service Bulletins

No.	Date	Title	Subject
07-49-93R	05/07/93	Combination Meter Wiring	1992 Legacy S/W Manual Transmission
07-50-93R	12/02/94	Repair of rear window defogger metal tab. Repair of rear window defogger grids	All Models
07-52-96	09/13/96	Legacy Power antenna not retracting fully	Legacy sedan 1995-1996
07-53-05	02/25/05	Fuse Label	2003MY Legacy, Outback & Baja Vehicles
07-54-05	11/21/05	Front Fog Light Lens & Reflector	2000~04MY Legacy Outback; 2003~06MY Baja
07-56-06	08/01/06	Fog Ligh Lens and Body	2006 and Later B9 Tribeca
07-57-06	08/24/06	Seat Heater Anchor Point Modification	2006MY Forester and Impreza
07-58-06	08/25/06	Change in Horn(s)	2006MY Impreza and Later

Tech TIPS

Date	Subject
01/00	2000MY LEGACY BLOWS FUSE #5
02/00	2000MY SUBARU LEGACY TURN SIGNAL OPERATION
04/00	2000MY LEGACY & OUTBACK VEHICLES FOGLIGHT OPERATION
07/00	GROUNDS, GROUNDS, GROUNDS
08/00	DAYTIME RUNNING LIGHTS
11/00	WINDSHIELD WIPER DE-ICER SYSTEM NOT WORKING
11/00	TURN SIGNALS FLASHING RAPIDLY
01/01	BLOWER MOTOR RESISTOR REPAIRS
06/01	IN-DASH CIGARETTE LIGHTER USAGE
08/01	ALTERNATOR SUPPLIER UPDATE
03-04/02	LEGACY TRANSIT (D-CHECK-PLUG) CONNECTORS
03-04/02	FUSE 4 BLOW-OUT
03-04/02	REAR WIPER OPERATION
07/05	2005MY LEGACY / OUTBACK TRAILER HITCH HARNESS LOCATION
10/05	BACKUP POOR SUPPLY FUSE
11/04	2005MY FORESTER DIAGNOSTIC CONNECTOR
02/05	2005MY LEGACY / OUTBACK ELECTRICAL DIAGNOSIS
03/05	BODY INTEGRATED UNIT (BIU) REPLACEMENT
04/05	HVAC & AUDIO UNIT INOPERATIVE AFTER WIRING HARNESS CHANGE
04/05	2005MY BAJA WITH POOR RADIO RECEPTION
05/05	HVAC INOPERATIVE AFTER WIRING HARNESS CHANGE-MORE INFORMATION
08/05	2003MY FORESTER FUSE INFORMATION
09/05	BATTERY GOING DEAD OR ALARM GOING OFF
11/05	INFORMATION REQUESTED FOR HARNESS REPAIR KITS
02/06	2006MY LEGACY / OUTBACK AND B9 TRIBECA COMGINATION METER SELF DIAGNNOSIS
02/06	CHAGE OF SEAT HEATER RELAY
06/06	LOW BATTERY VOLTAGE
06/06	2005MY FORESTER A/F & 02 SENSOR RELAY LOCATION
07/06	SBF-5 FUSE BLOWS ON 2005MY/2006MY IMPREZA VEHICLES
08/06	MIDTRONICS EXP
09/06	2004~2007MY FORESTER SUNFOOF OPERATION

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