

SUBARU 



Technicians Reference Booklet

**Advanced Electrical
Theory & Diagnosis**

Module 602

Technical Training

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Advanced Electrical Theory & Diagnosis Module

Introduction

This Technicians Reference Booklet contains information pertaining to advanced automotive electrical technology, and the Subaru electrical system. It reviews solid state devices, operation and diagnosis of Subaru starting and charging systems, operation and diagnosis, computer terminology and operation, and the troubleshooting and diagnosis of intermittent faults. 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.

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 Advanced 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.

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.

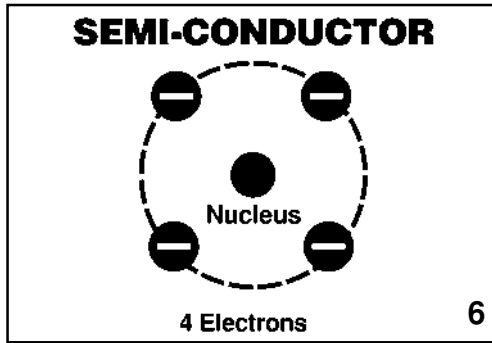
Basic electrical terms for the study of advanced electrical theory and diagnosis:

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".

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

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Diodes

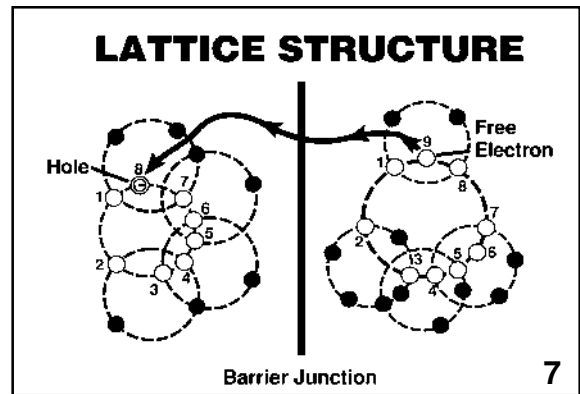
We begin our study of advanced electrical theory with an explanation of the construction and operation of diodes.

Diodes are commonly constructed of one of two materials:

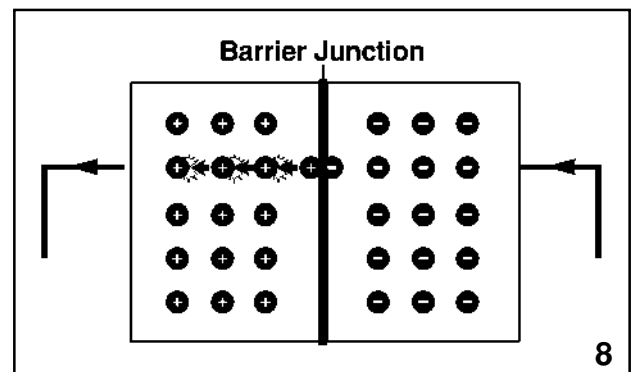
- Silicon
- Germanium

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



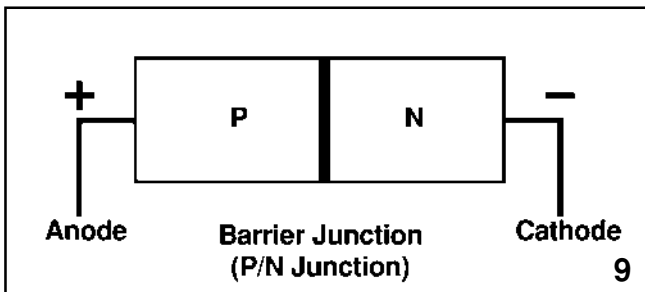
Structural changes to the atoms

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.

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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.



Diode polarity

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).

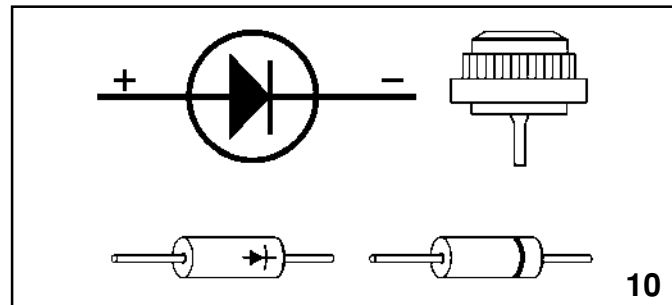
This is also called a "barrier junction". The P/N junction determines the maximum allowable current flow of the diode and it is this feature which allows the diode to function as a one-way switch.

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.

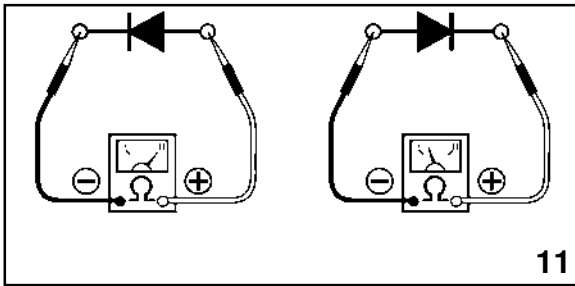
The automotive industry primarily uses silicon diodes because of their excellent heat tolerance characteristics.



Schematic/pictorial 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.

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Testing diodes

You may use an ohmmeter or 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

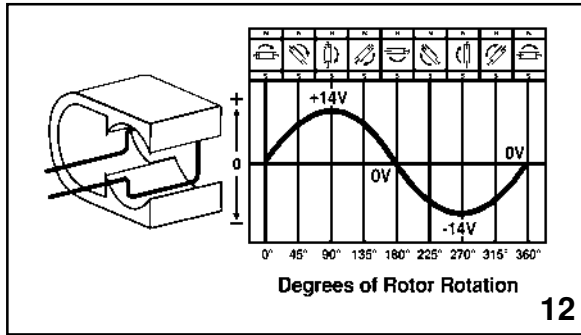
- The diode must be in an operating circuit. Connect the voltmeter leads to the diode leads, (observe polarity). Refer to the appropriate wiring diagram to determine the voltage that should be in the circuit. In most automotive applications this will be B+ voltage. The diode is "OK" when the meter readout 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 be 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".

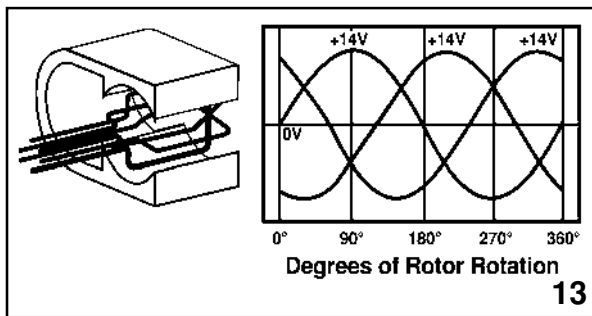
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Full wave rectification

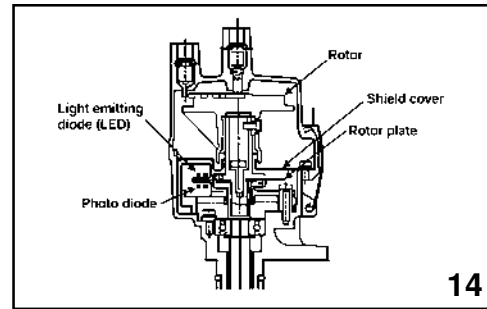
A diode may be used to convert (rectify) AC voltage to a pulsing DC voltage. Because of the diode's polarity, current is only allowed through the diode in one direction. Remember that opposite polarity is denied conduction due to the high P.I.V. (peak inverse voltage rating) of the diode.

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.



Three phase current

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.



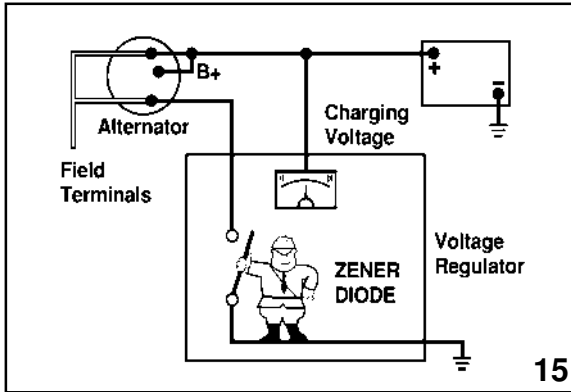
LED/PSD

A light emitting diode (LED) is similar to a P/N diode. It can act as rectifier, converting current to infrared or visible light. The color of the light produced by the LED is determined by the color of the lens over the LED. Because the LED only requires a very low operating current of 20 ma, it has a long life which makes it most suitable for automotive uses. When testing LED operation, Always check the operation of the component in which the LED is used. It is usually difficult to test LED operation by itself.

A photo sensitive diode (PSD) is similar to an LED, however, it will conduct current when exposed to light. The PSD can also act as a rectifier. As with the LED, it is better to test the operation of the component than the PSD itself.

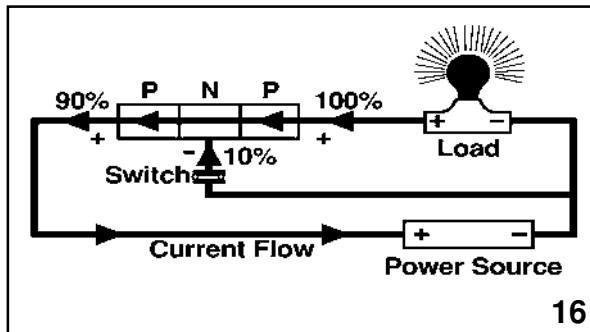
NOTE: AN LED AND A PSD ARE EMBEDDED AS ONE UNIT IN THE DISTRIBUTOR ON SOME SUBARU MODELS, AND IS USED AS A CRANK ANGLE SENSOR.

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Zener diode

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 give 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.



PNP transistor

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:

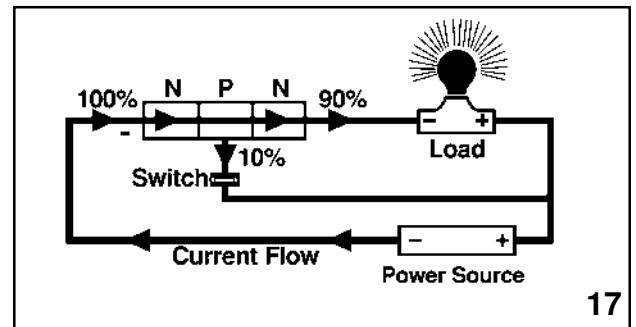
- PNP = positive/negative/positive
- NPN = negative/positive/negative

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.

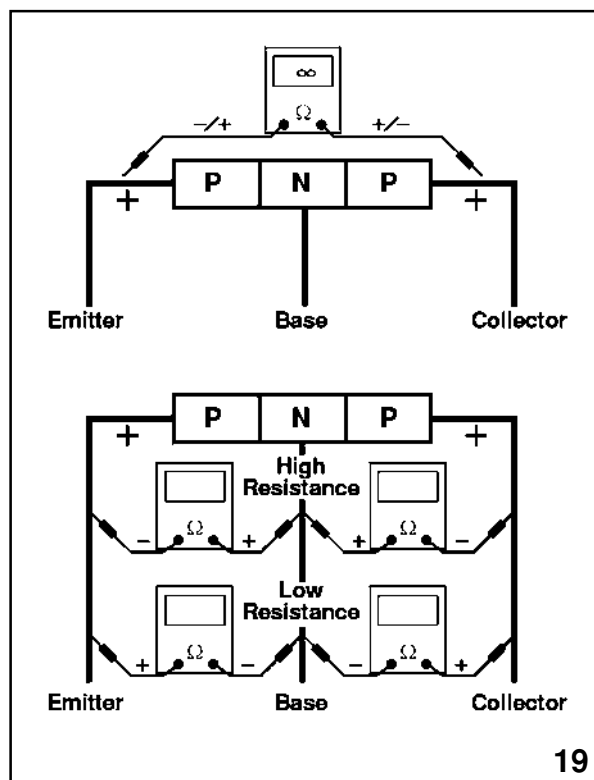


NPN transistor

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.

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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 as 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 K 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.

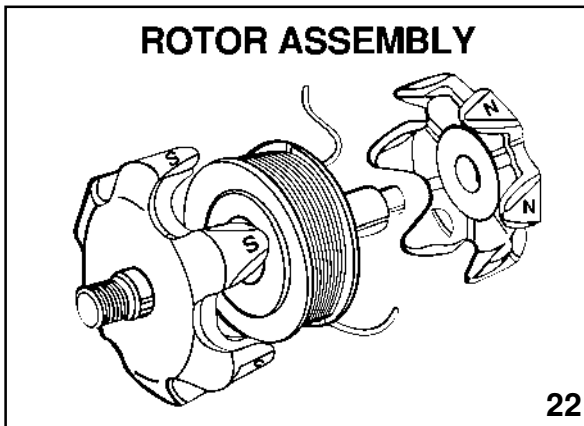
Alternators



Alternator components

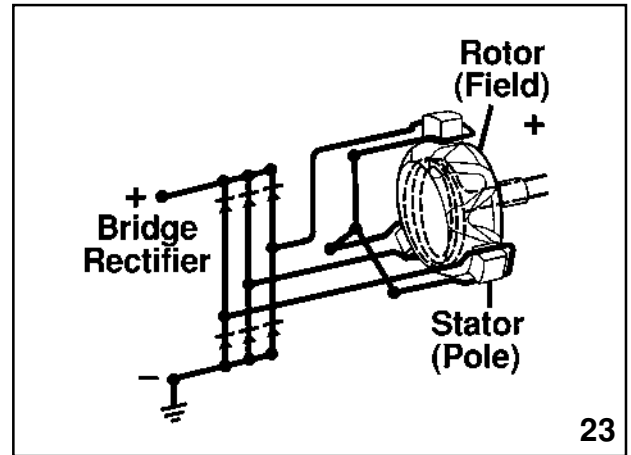
The components of a Subaru alternator are:

- 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.

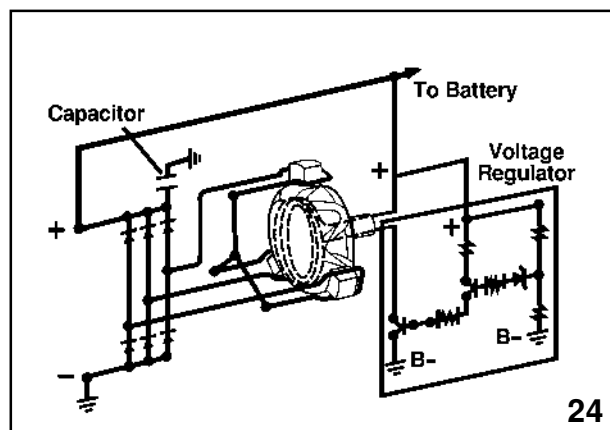


Stator construction

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.

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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

Disconnect all connectors properly.

Do not ground circuits with tools.

Never lay tools on the battery.

Always disconnect the battery prior to alternator replacement.

Secure loose harness/wiring to prevent damage caused during alternator removal/replacement.

When full-fielding the alternator, never exceed 16.0 volts. Voltage levels in excess of this specification may cause damage to electrical system components.

Never disconnect the battery during an alternator test.

An alternator performance test should only be made with a serviceable battery.

Conduct an alternator performance test when any of the following conditions are present:

- The battery is dead (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.

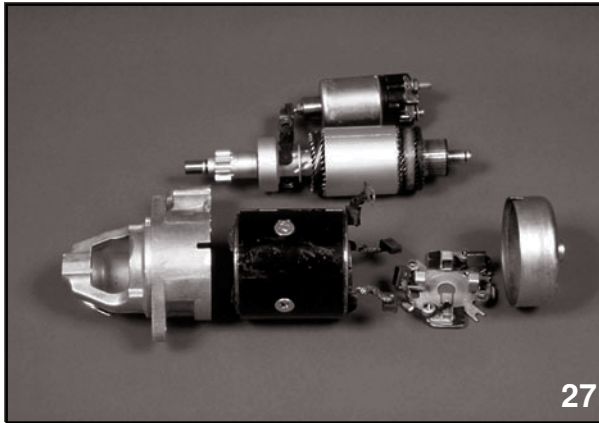
Listed in the appropriate MY Subaru Service Subaru Starting Systems.

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Starters

Starter Types

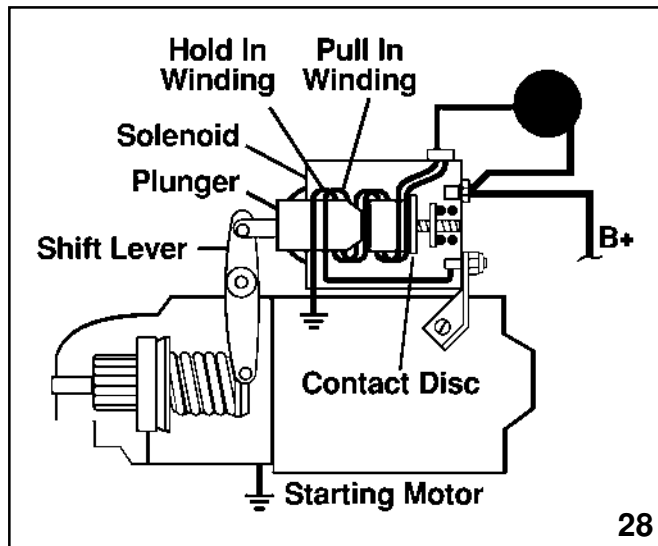
- Reduction Gear
- Direct Drive



Starter components

The components of the starter assembly are:

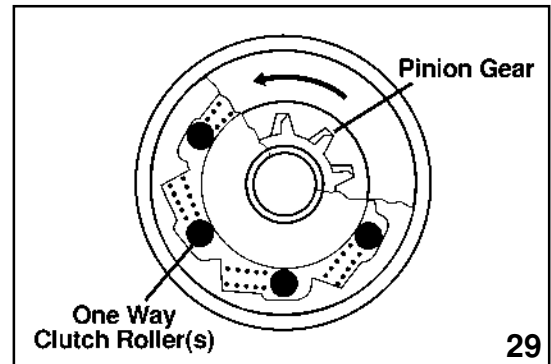
- Pinion (drive)/one-way clutch
- Armature
- Commutator
- Field shoes
- Brushes/brush holders
- End caps/bushings



Magnetic switch/solenoid

The components of the magnetic switch/solenoid are:

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



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 "overspeed" condition.

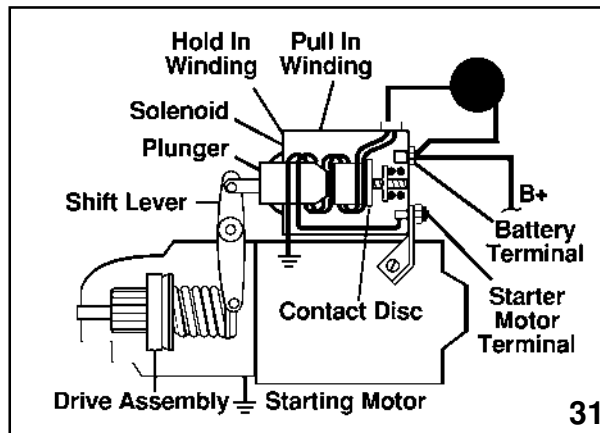
When the ignition switch is released from the "START" to the "ON" position, this eliminates the flow of B+ voltage to the magnetic switch/solenoid which collapses the field. The plunger spring returns the plunger to its original position moving the shift lever which disengages the pinion from the flywheel.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

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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, Section 6-1.

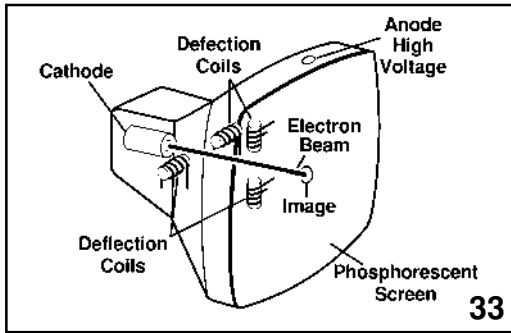
Use a voltmeter to conduct a starter motor test for intermittent operation. Complete the following steps:

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 OH.
 - 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.

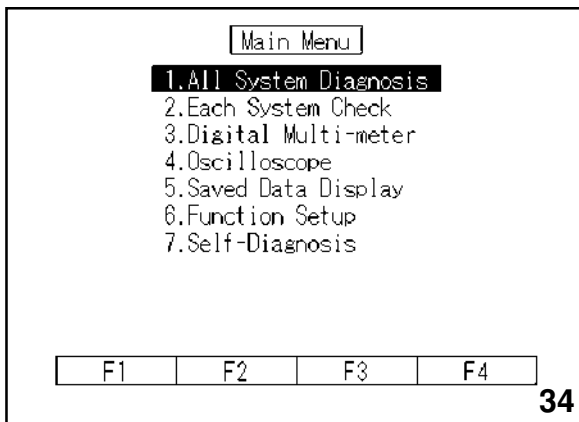
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Oscilloscope Testing and Diagnosis



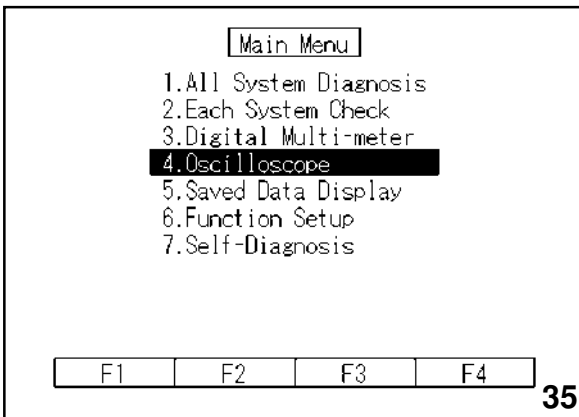
Oscilloscope CRT

Oscilloscope usage during diagnostics can help with finding intermittent or unusual problem conditions

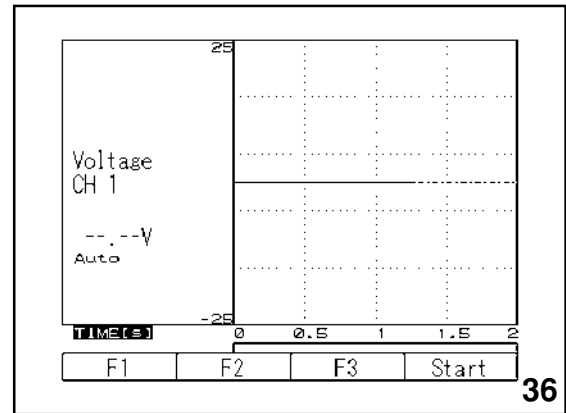


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An Oscilloscope function is included on the Select Monitor. From the main menu cursor over item "4. Oscilloscope." Press the "YES" key.

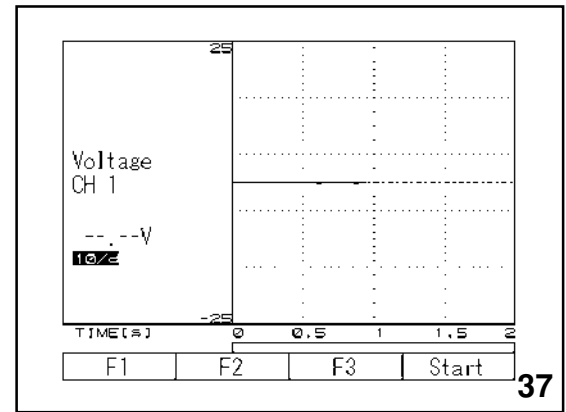


35



36

This will give you one or two channel operation.



37

Press the F3 range key to adjust the voltage per division or cursor down to the TIME[s] and adjust the seconds or milliseconds per division.

Many other features are included for the Select Monitor Oscilloscope and your instructor will guide you through them in the lab section of this module.

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Computer Terminology and Operation

Computer Hardware

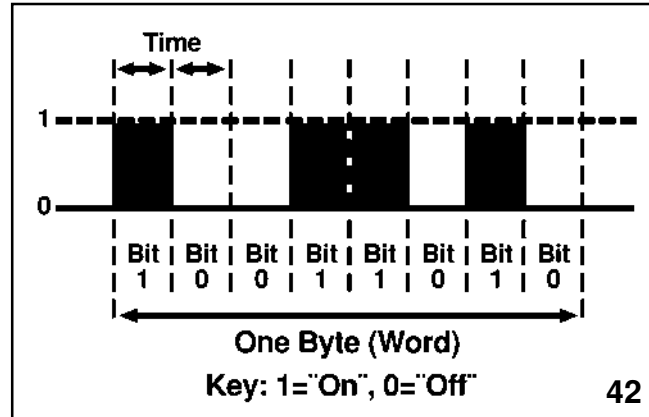
Automotive computer hardware is the electronic and tangible componentry used for its operation.

- The CPU (central processing unit) is the area in which all arithmetic and logic decisions are calculated/computed.
- The address register is similar to a file cabinet. It is where the computer sets up unique file locations to store data in the memory.
- The data register is used by the CPU to "read" and "write" information to/from the memory files.
- The ROM (read only memory) contains information that is programmed into the computer during the manufacture of the computer. These operating commands cannot be changed or updated.
- RAM (random access memory) is where information is continually updated by the inputs from the various engine sensors. The RAM is often called the "scratch pad" of the computer.

Computer Software

The software consists of the programs and data used by the computer to perform specific tasks.

- The PROM (programmable read only memory) is information programmed into the computer "chip". It contains the operating characteristics of a specific model or engine family and can be added to the computer during vehicle assembly to "fine-tune" vehicle operation.
- The EPROM (erasable programmable read only memory) is similar to the PROM in operation. Information can be:
 - Erased under ultra-violet light.
 - Reprogrammed to a new set of values.



Terminology

BIT (binary digit) This is the smallest unit of information in the binary system used by the computer. The computer uses binary numbers to build letters, numbers, and other characters used to record and display information.

The only binary numbers generated and used by the computer are either zero ("0") or one ("1"). Zero equals power "OFF", and one equals power "ON". Switching the power "ON" and "OFF" to specific circuits in the computer, codes the information that is entered or displayed. It requires 8 BITS or 8 binary digits to equal 1 BYTE.

BYTE (binary element string)

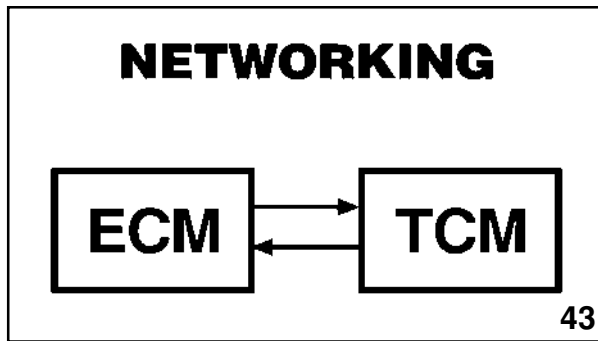
A BYTE is equal to 1 character, such as the letter "a". Therefore a BYTE contains a combination of eight "1's" or "0's" (BITS).

Example: 1 0 0 1 1 0 1 0

"K" = 1000 or kilo (as in metrics). This term is used to indicate the amount of memory space available in a computer. If it has 32K BYTES, then it can store 32,000 characters in its memory.

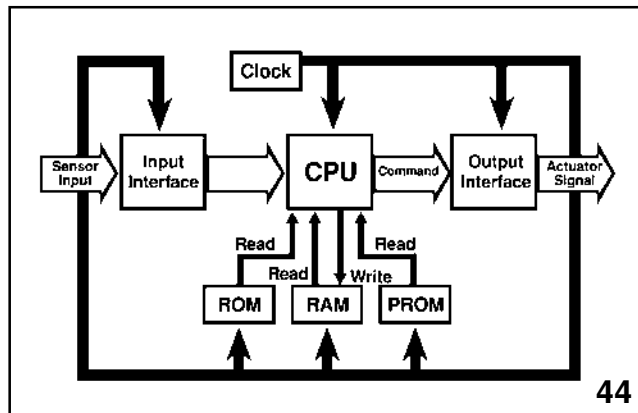
Mega hertz (Mhz) This term defines the processing speed of the computer in millions of cycles per second.

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Handshaking

This term refers to the exchange of predetermined information that establishes a connection between two or more computers. Without handshaking one computer would not be able to understand another computer's data input and vice-versa. The ROM's initiate the connection while the RAM sections exchange information. This process is also called networking.



Computer operation

The CPU sends an information request to the ROM (memory) over the address buss line (connecting wires) to the address register. The CPU then temporarily stores this information in the CPU register while it compares the information to data stored in the RAM. The RAM data is the inputs received by the computer from the various vehicle sensors.

When the data in the CPU register matches the data in the RAM, no action is required. If the data in the CPU register does not match the data in the RAM, the CPU generates a command signal to the appropriate device to alter vehicle or specific component operation.

- Example: The O2 sensor voltage is too high and the fuel mixture is too rich. The response is that the computer narrows the fuel injection pulse width.

If the data received is illogical to or from the computer, the computer generates a fault code.

All information, both to and from the CPU is resented almost simultaneously. However, it is synchronized by an internal clock. The clock also controls the overall processing speed of the computer. Speed is measured in mega hertz

(Mhz), which equal millions of cycles per second. During networking the clock pulse will determine which computer is sending and which computer is receiving.

Troubleshooting Diagnosis of Intermittent Faults

Six Step Troubleshooting

- Step 1 — Verify the problem(s)
- Step 2 — Determine related symptom(s)
- Step 3 — Isolate the problem
- Step 4 — Identify the cause
- Step 5 — Repair/replace
- Step 6 — Verify operation

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NOTE: REFER TO THE SUBARU BASIC ELECTRICAL THEORY & DIAGNOSIS MODULE, STEP 10 FOR ADDITIONAL INFORMATION CONCERNING THE SIX STEP METHOD.

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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. MAY CAUSE DAMAGE TO THE COMPONENTS.

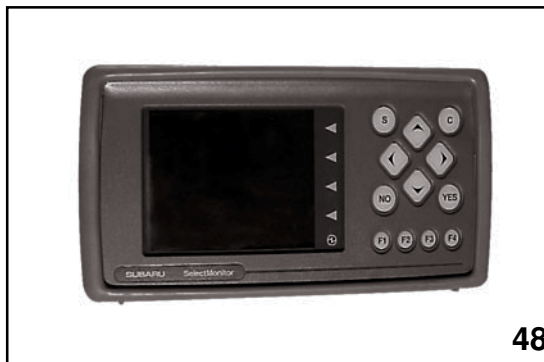
- Use a component cooler which will quickly cool solid state components without damage to the components. This method will identify intermittent diode or transistor problems because the component will usually malfunction when cooled quickly.

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.

Select Monitor Usage



Select monitor

The select monitor allows a review of the actual information processed by the computer. For instance, thermosensor input is displayed as the actual temperature of the coolant. You can then compare the select monitor coolant temperature reading with the actual coolant temperature to determine possible sensor problems. (With a cold engine, the coolant temperature should be equal to the ambient air temperature).

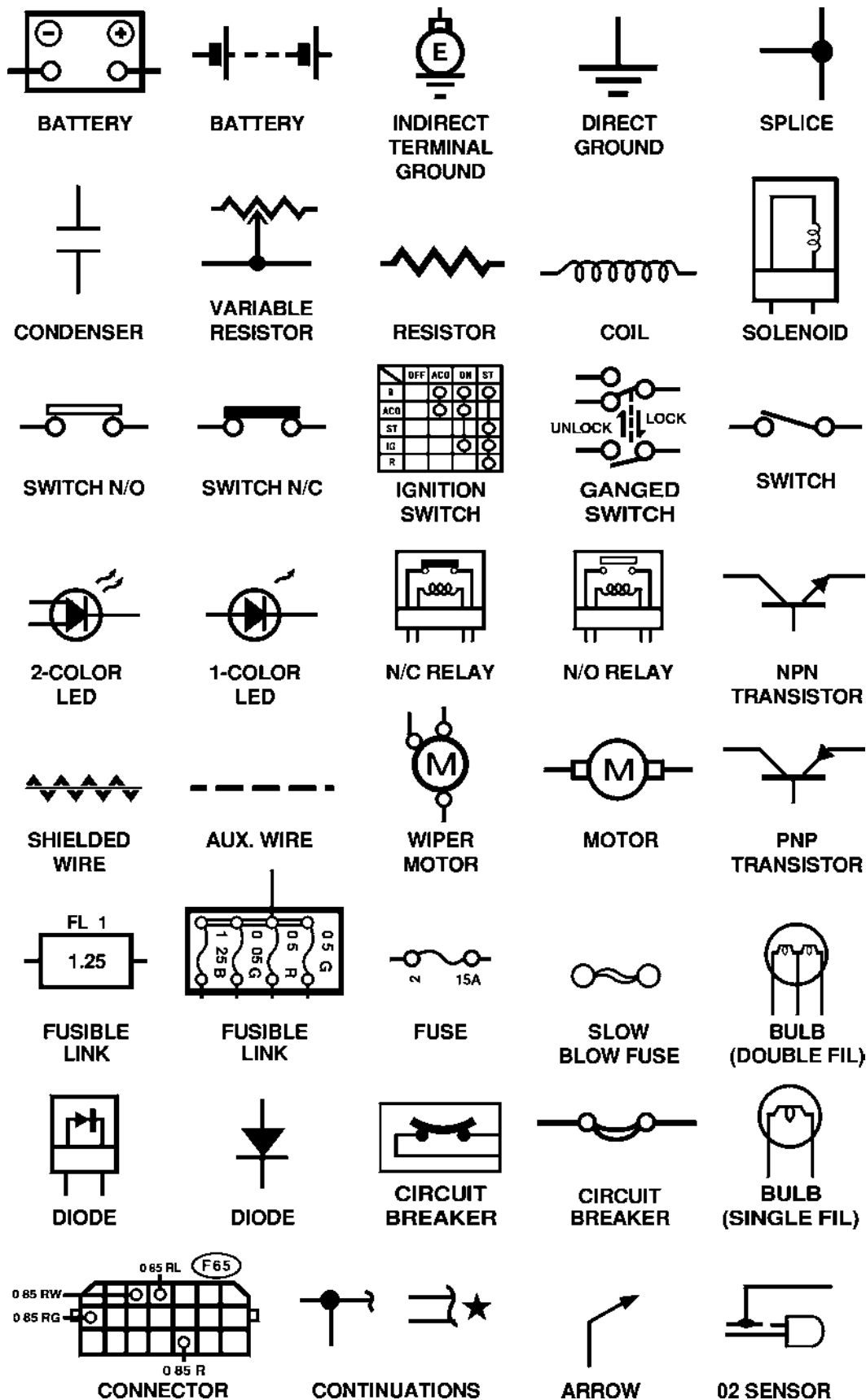
Likewise, computer outputs may also be checked: The select monitor will display the computer output to a system component such as the fuel injector. This signal (injection pulse width) is displayed in milliseconds. We know that thermosensor input will effect injection pulse width. With increased coolant temperature, injection pulse time (duration) should be reduced and the fuel mixture should become leaner. With decreased coolant temperature, injection pulse time should increase and the fuel mixture should become richer. No change in the select monitor injector signal could indicate thermosensor circuit problems.

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**NOTE: REFER TO SELECT MONITOR
INTROCUCTION VIDEO REFERENCE
BOOKLET MSA5AV148B AND THE
APPROPRIATE MODEL YEAR SERVICE
MANUALS FOR DETAILED SELECT
MONITOR INFORMATION.**

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Electrical Symbols



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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.

Diode

solid-state device that permits current to flow in one direction only; performs like a one-way check valve.

Transistor

Solid-state semiconductor that is a combination current amplifier and switch (similar to a solenoid in the starter circuit or a relay in function). It uses low control current to channel high current.

Capacitor (Condenser)

Device used to store an electrical charge.

