SUBARU®

Confidence in Motion

Technician Reference Booklet

Intermediate Electrical Systems & Diagnosis

AUTOMOTIVE Youth Educational Systems PROUD PARTNER

WE SUPPORT PROFESSIONAL CERTIFICATION THROUGH THE National Institute for AUTOMOTIVE SERVICE EXCELLENCE

SUBARU UNIVERSITY

May 2017

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This Technician Reference Booklet (TRB) is designed to be used in a classroom environment or as a guide for self study.
The TRB is not intended to be used as a supplement or substitute for the Subaru Service Manual. Always consult the appropriate Service Manual when performing any diagnostics, maintenance or repair to any Subaru vehicle.

Subaru of America, Inc. reserves the right at any time to make changes or modifications to systems, procedures, descriptions, and illustrations contained in this book without necessarily updating this document. Information contained herein is considered current as of May 2017.

Table of Contents

Subaru Wiring Diagrams

Navigating the Subaru Technical Information System (STIS)

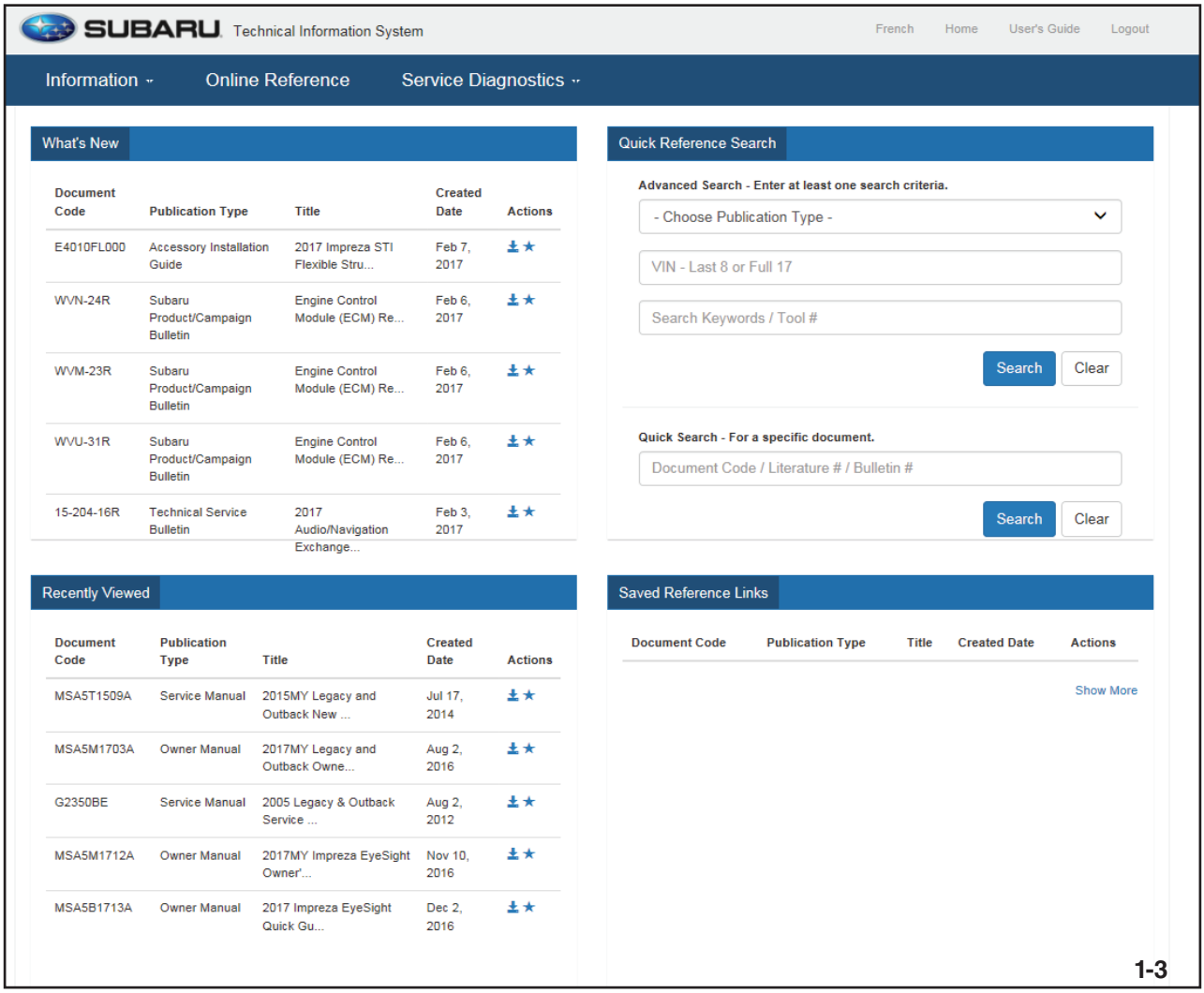
Subaru wiring diagram interpretation is a critical element in the process of diagnosing and repairing electrical faults. A Technicians ability to effectively navigate the Subaru Technical Information online resources in order to accurately identify components, connectors, wires, and their locations directly correlates to the accuracy and efficiency in performing electrical diagnostics and repairs.

Subaru Diagnostic System Graphic User Interface (GUI)

Intermediate Electrical Systems and Diagnosis

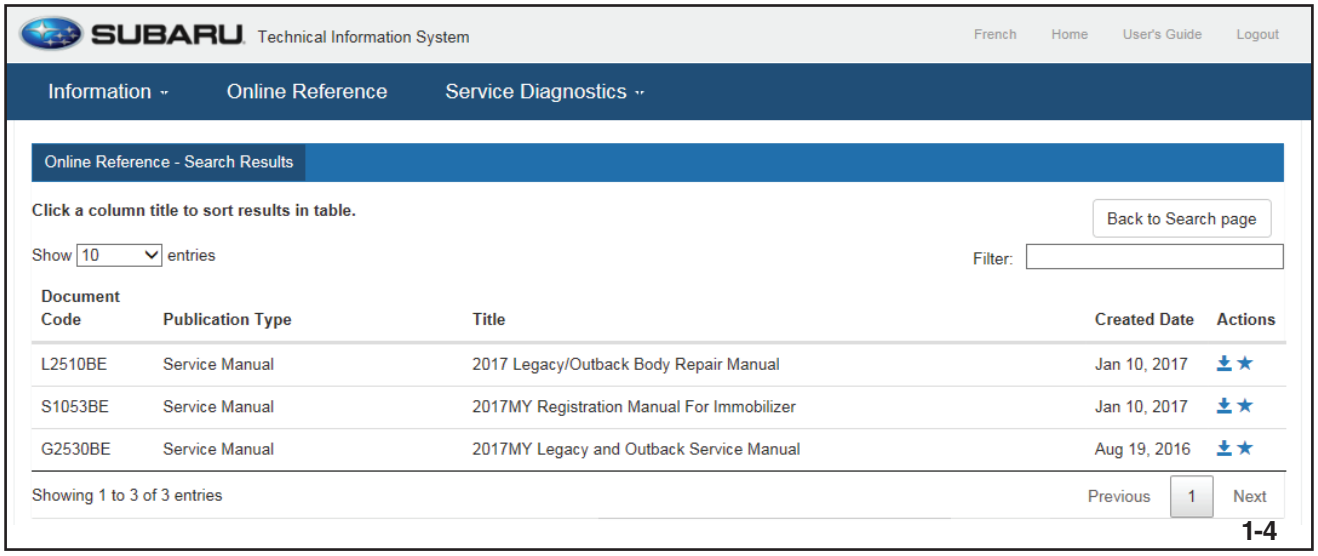
Wiring diagrams can be found on STIS via the "Online Reference" or "Service Diagnostics". Although the core information remains the same within "Online Reference" and "Service Diagnostics" sections, each resource has pros and cons in usability. Regardless, it is acceptable to use either resource for vehicle diagnostics. Newer wiring diagrams feature full color artwork to improve usability.

Note: For further information regarding the use of the STIS web site, please refer to the "User's Guide" link in the upper right of the page. Information can also be obtained by completing the "Subaru Technical Information System (STIS): Overview" web based training (WBT) found on SKILS.



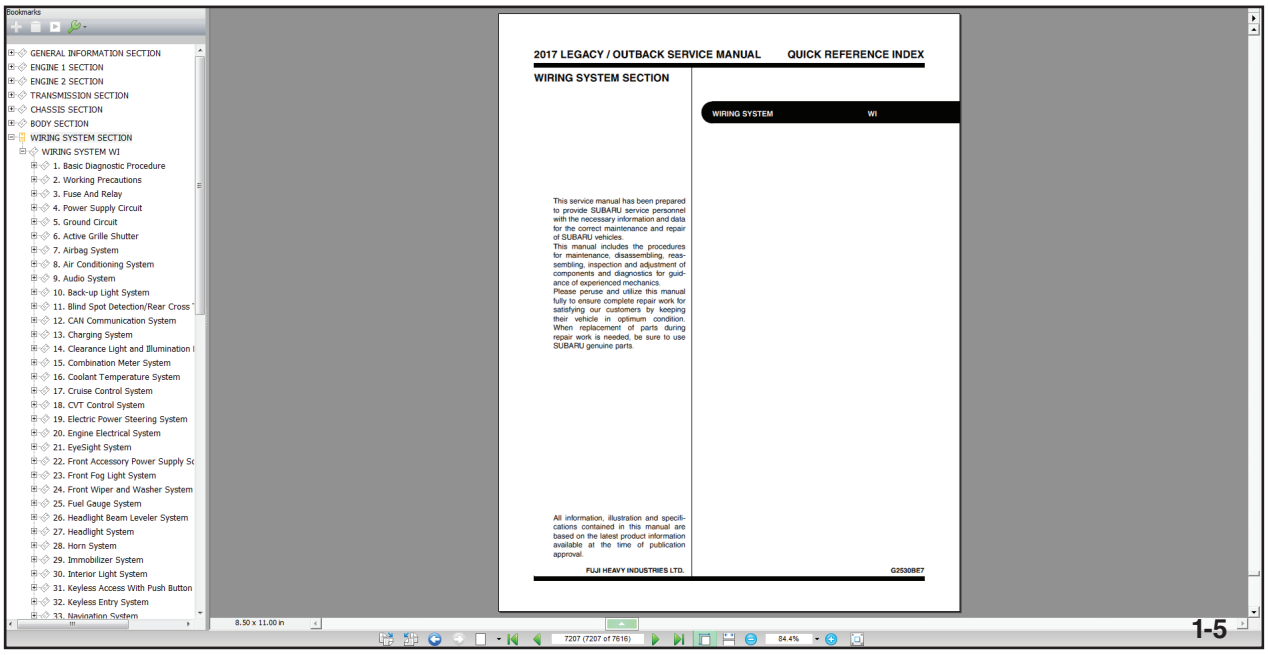
Subaru Technical Information System (STIS) Home page

"Online Reference" offers Wiring Diagrams for 1995MY to current vehicles in PDF format organized by specific vehicle systems. PDF based service manuals must be downloaded in their entirety as a single document.



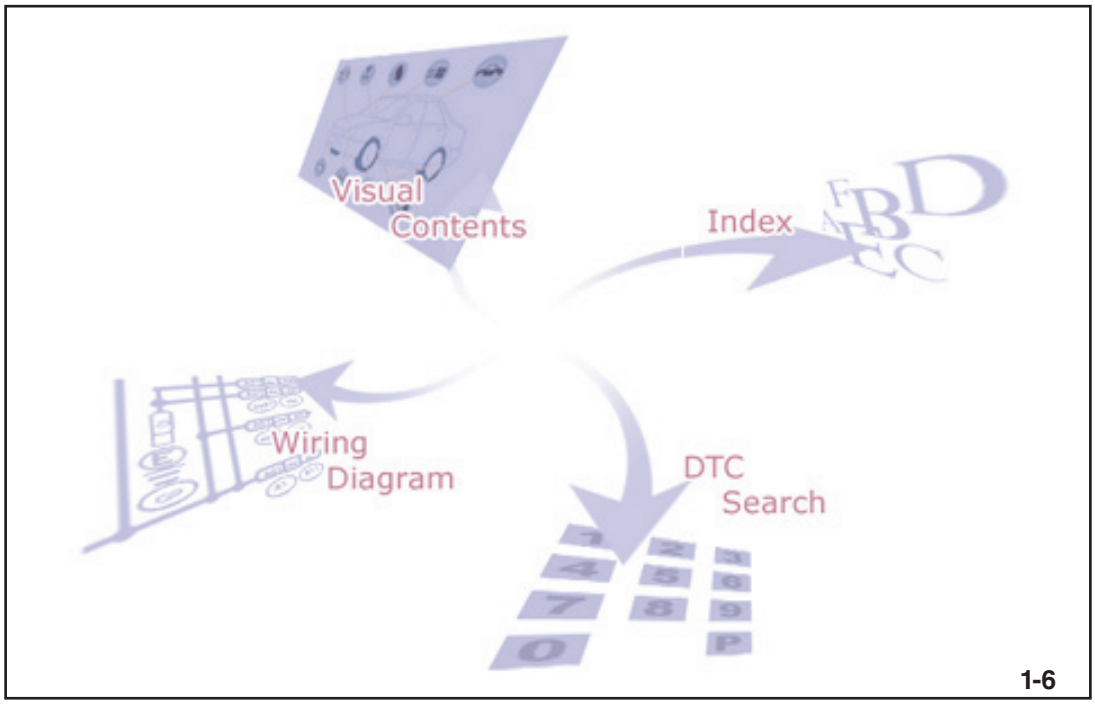
Online reference – Wiring system section

The "Wiring System Section" is typically located toward the bottom of the Subaru Service Manual. Within the Wiring Diagram Section, there are three distinct segments which provide information on general usage, specific systems, and harness/component locations.



PDF Subaru Service Manual - Wiring system section

"Service Diagnostics" offers Wiring Diagrams for 2005MY to current vehicles in an HTML (HyperText Markup Language) format.

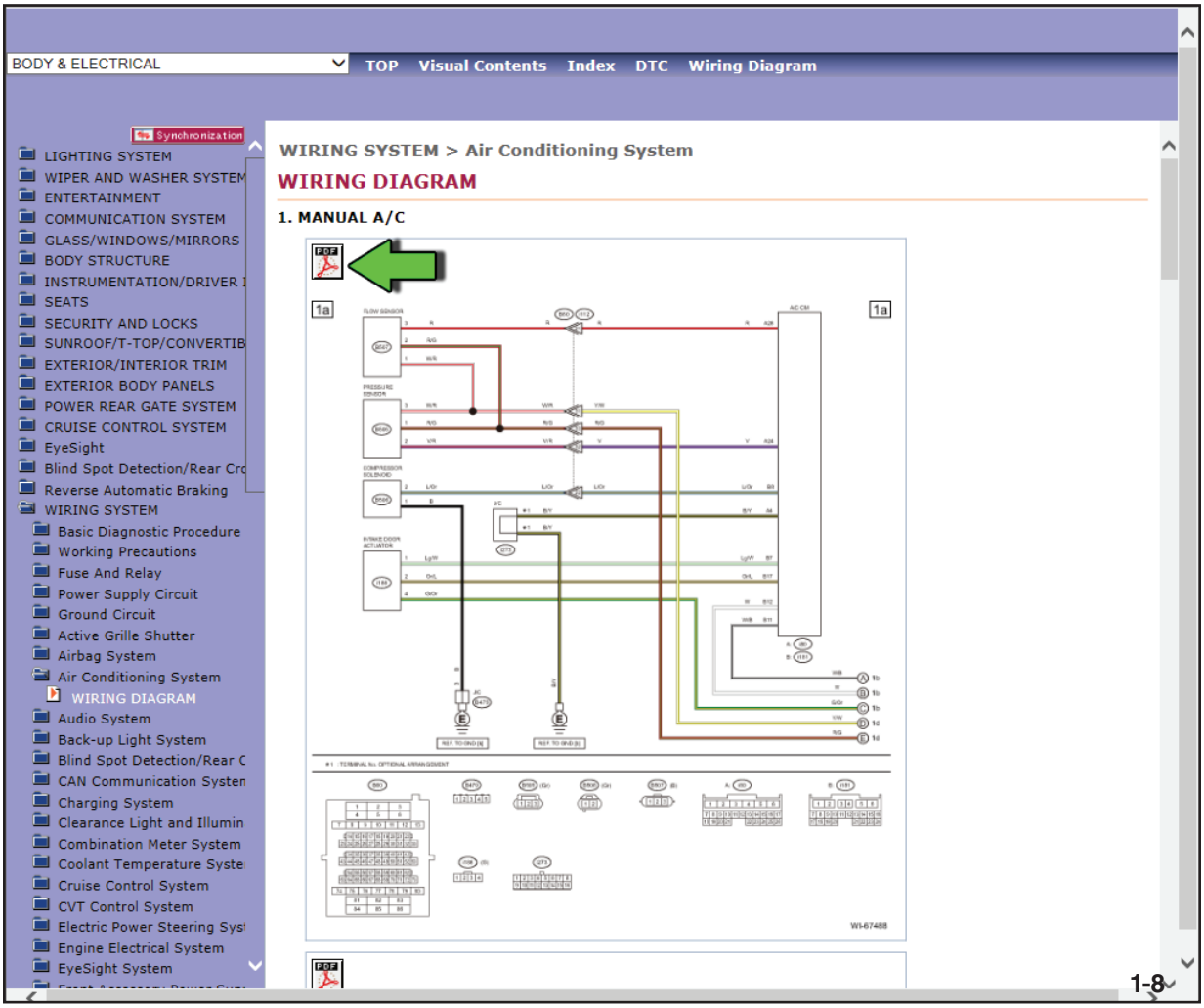


Service Diagnostics

Sections are organized by the initial letter of the word or phrase being searched. The "List" option may also be selected to view a full listing of the systems featured on the selected vehicle.

Wiring diagram index

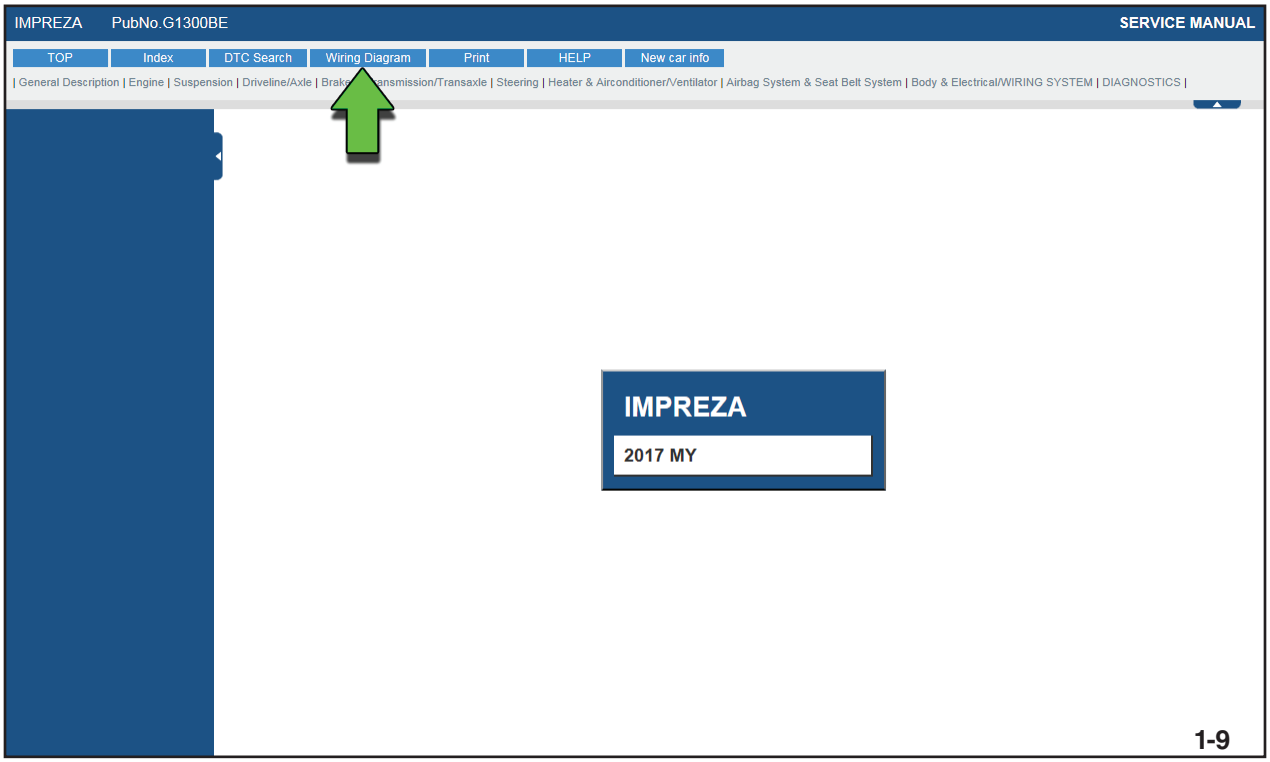
Once a system has been selected, use the “PDF” icon in the upper left corner to enhance the view of the diagram. This allows the user to use the “search” and “zoom” functions of the diagram. However, only one page of the Wiring Diagram can be viewed at a time.



PDF icon

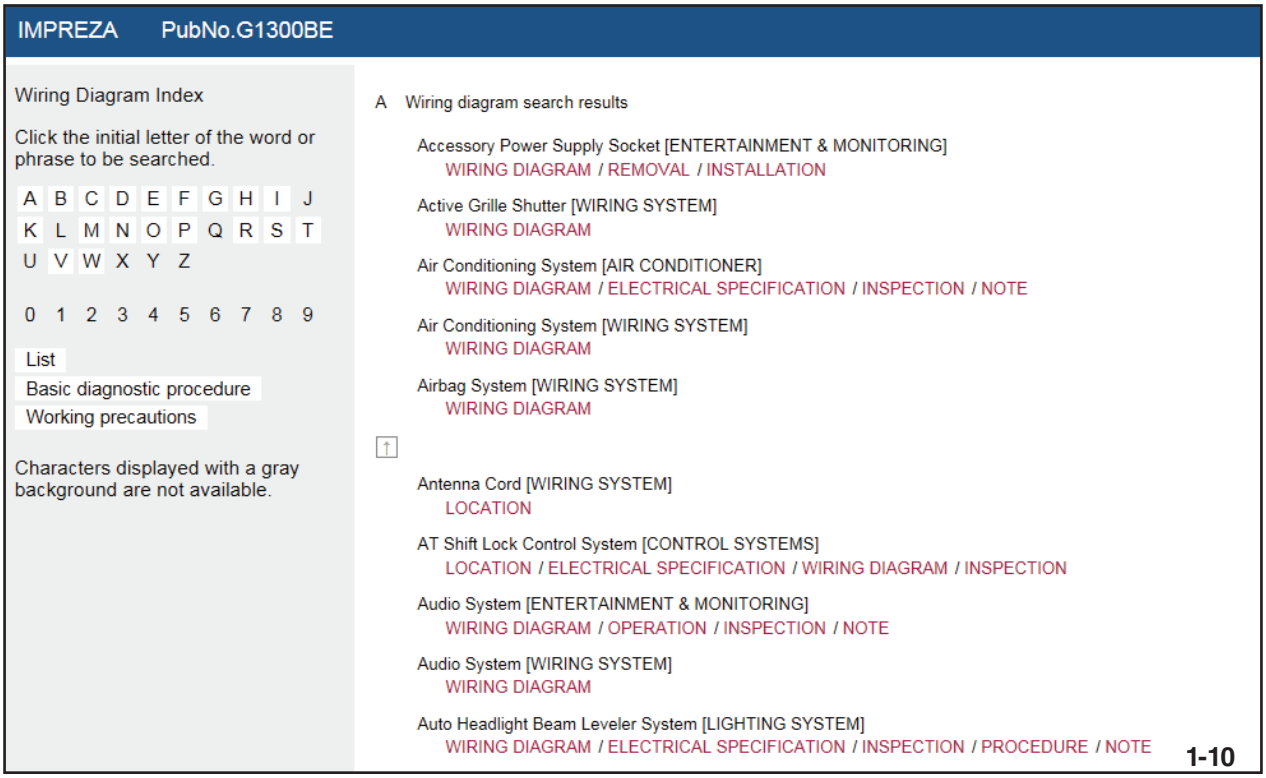
Intermediate Electrical Systems and Diagnosis

Beginning with some 2017MY vehicles, an enhanced HTML format is utilized.



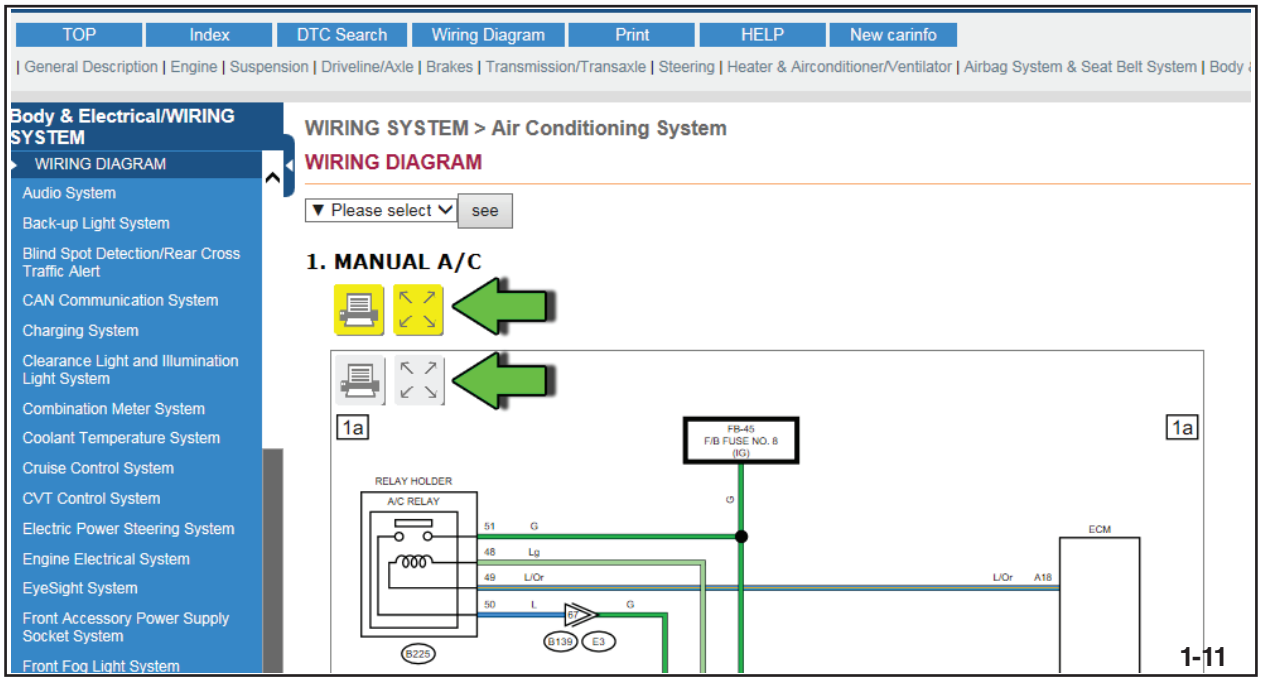
2017MY HTML Service Manual

Organization of the wiring diagrams is similar to previous HTML versions.



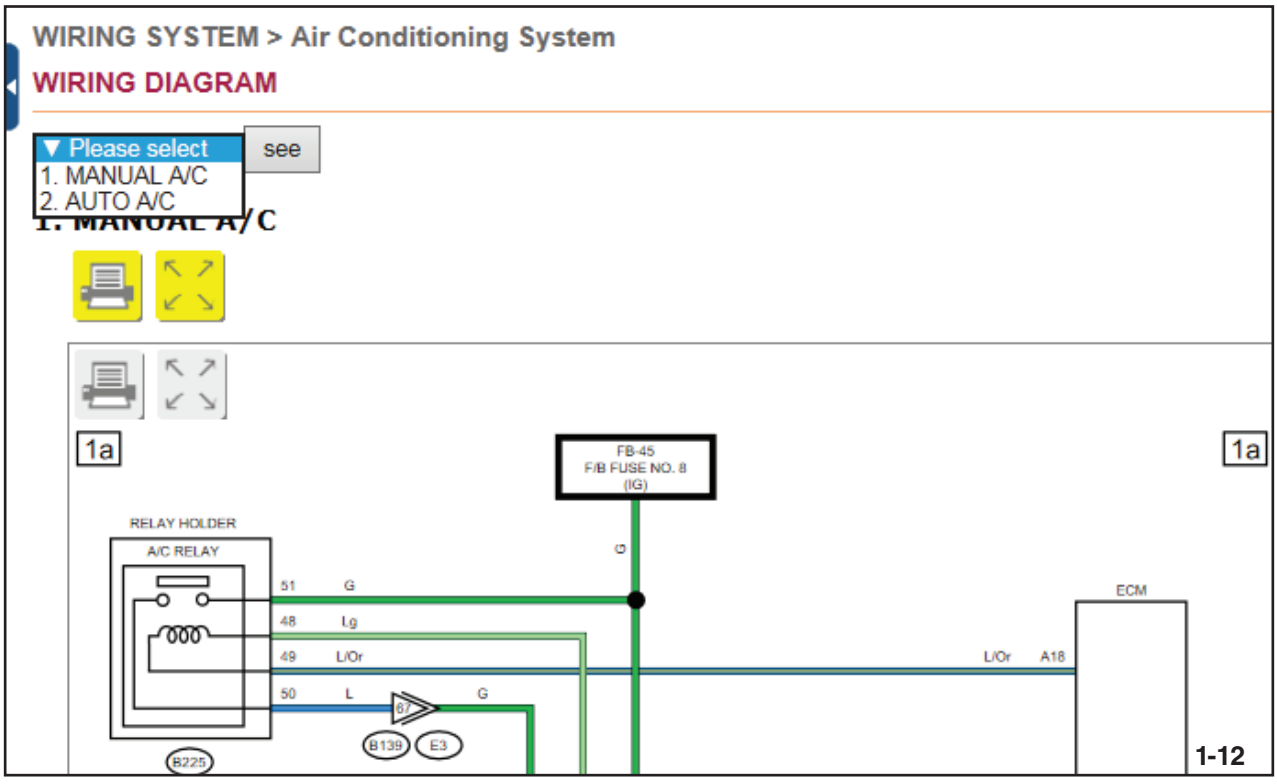
Wiring Diagram Index

In these diagrams, the PDF icon has been replaced with “print” and “enlarge” functions for better visibility. These icons allow for individual pages or entire sections to be enlarged or printed.



Print and Enlarge Icons

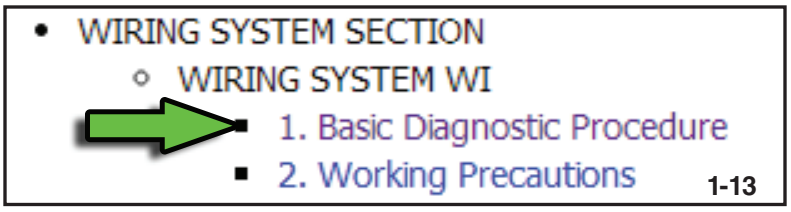
Additionally, a selection control is available to reduce the displayed diagrams to only specific system or equipment types.



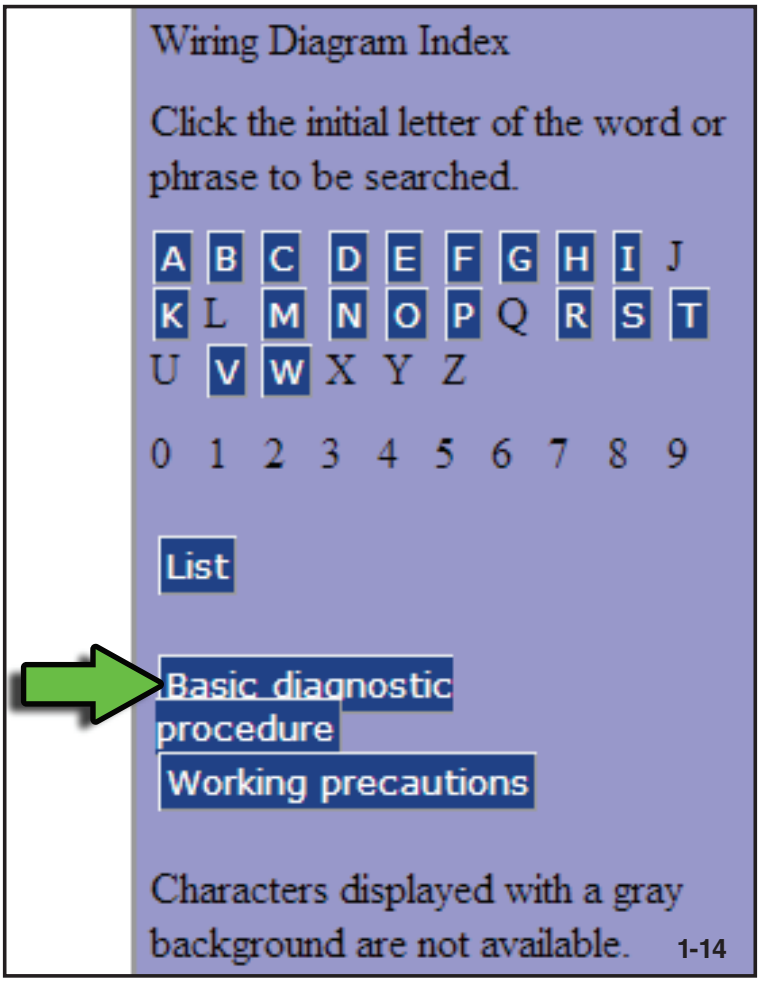
Specification Selection

Diagram Basics

In either version of the Wiring System Section, one of the most useful guides in how to navigate and interpret the wiring diagrams is the "Basic Diagnostic Procedure". The Basic Diagnostic Procedure contains critical information on abbreviations, symbols, wire coloring, connector illustrations, locations, and general diagnostics.



Basic diagnostic procedure (Service diagnostics)



Basic diagnostic procedure (HTML)

Abbreviations

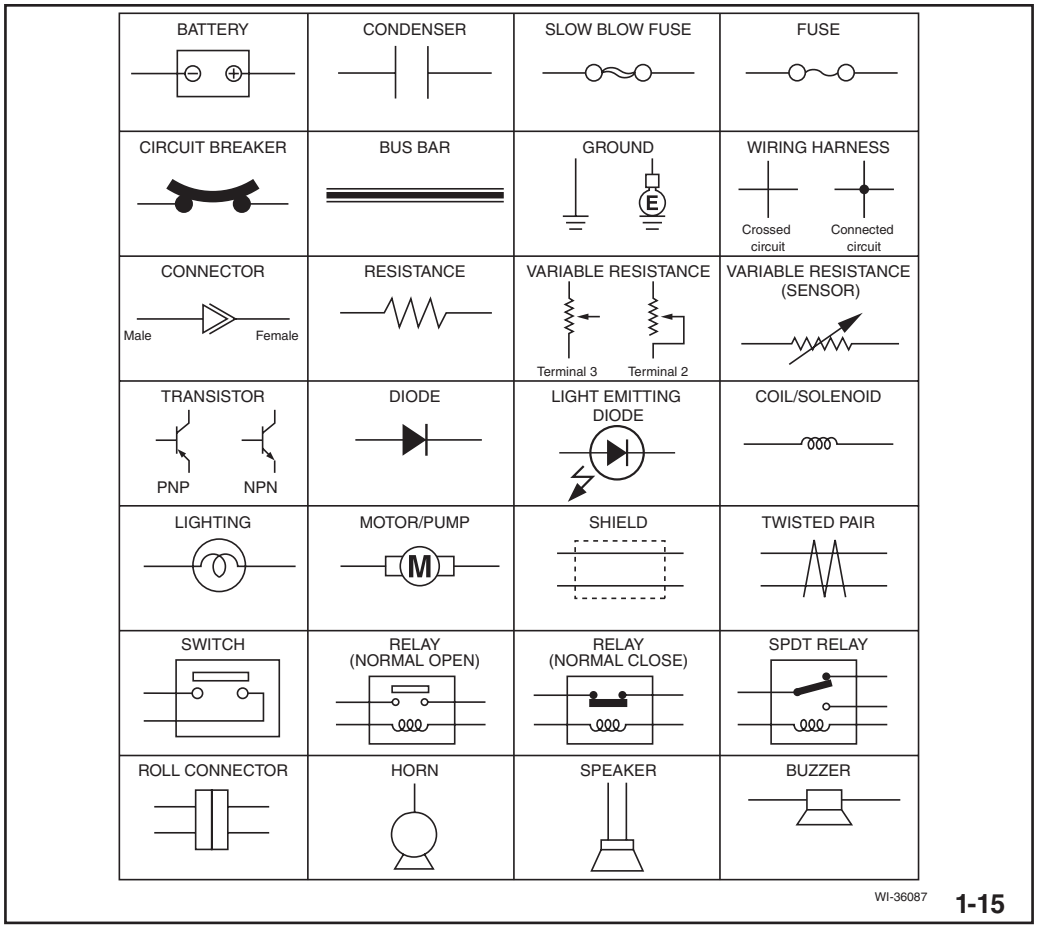
Abbreviations are commonly used throughout the Subaru Service Manual. Always consult the appropriate year and model for the most up to date information as new abbreviations are regularly added.

A full listing of Subaru acronyms and glossary is available on STIS. (STIS > Online Reference > Other/Miscellaneous)

Abbr.	Full Name
ABS	Anti-lock Brake System
A/C	Air Conditioner
ACC	Accessory
ASSY	Assembly
AUX	Auxiliary Audio Input Terminal
AWD	All Wheel Drive
b, BAT	Battery
CAN	Controller Area Network
CL	Close
CVT	Continuously Variable Transmission
D	Drive range or Down
DN	Down
E	Ground (Earth)
ECM	Engine Control Module
EGR	Exhaust Gas Recirculation
F	Front
F/B	Fuse & Relay Box
FL	Front Left
FR	Front Right
H/L	Headlight
IG	Ignition
J/C	Joint Connector
M/B	Main Fuse Box
MFD	Multi Function Display
MT	Manual Transmission
N	Neutral Range
OP	Optional Parts or Open
P	Parking or Parking range
R	Reverse Range
R, RH	Rear or Right Hand
RL	Rear Left
RR	Rear Right
SBF	Slow Blow Fuse
ST	Starter
SW	Switch
TCM	Transmission Control Module
TPMS	Tire Pressure Monitor System
UP	Up
VDC	Vehicle Dynamics Control

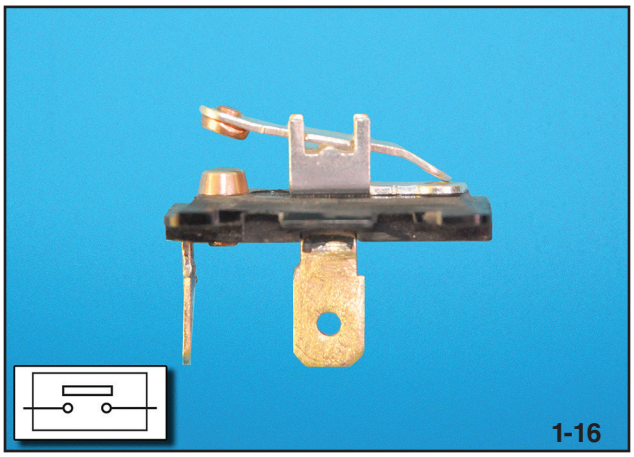
Symbols

When navigating the Subaru wiring diagrams, it is important to accurately identify symbols in a circuit. Symbols are used in wiring diagrams to represent common components found throughout the vehicle. Some symbols contain subtle differences that may cause confusion.

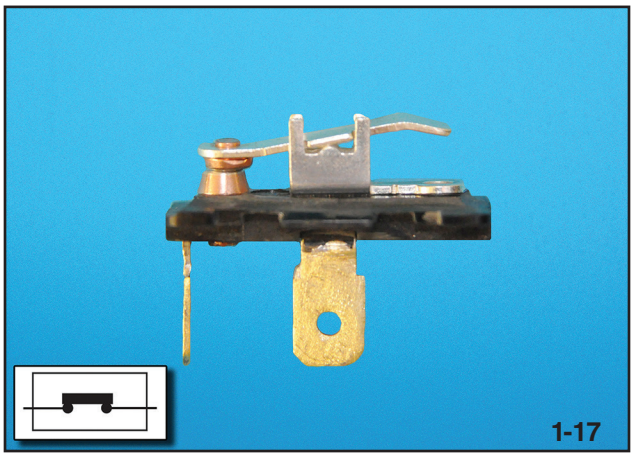


Electrical symbols

Basic switches are illustrated using circles for the terminals and, bars for the mechanical contacts. Shading indicates the position of the switch.

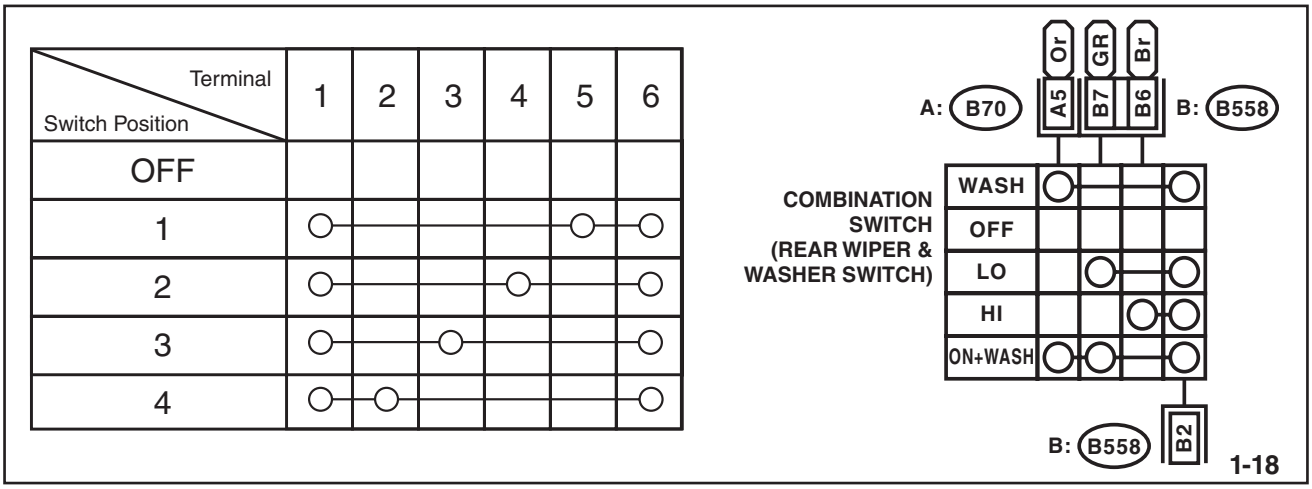


Switch contact open



Switch contact closed

Combination switches are illustrated using circles and lines to indicate continuity across terminals in the various switch positions.



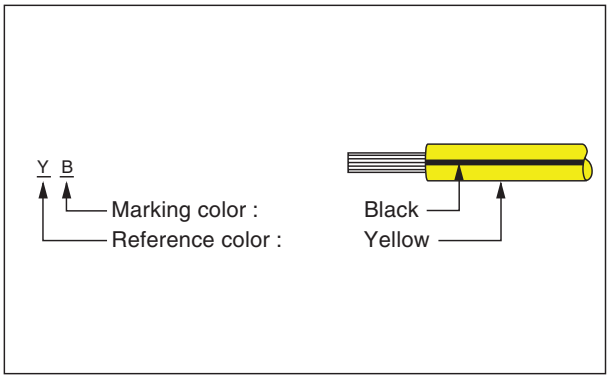
Combination switches

Wiring Identification

Wire colors are identified by lettered coding. The first letter represents the reference color and the second letter represents the marking color. Illustrations may contain one to four letters depending on the combination of reference and marking color. The capitalization of the letter in the color code has an impact on the associated color.

In this example, the reference color is “Y” or Yellow and the marking color is “B” or black.

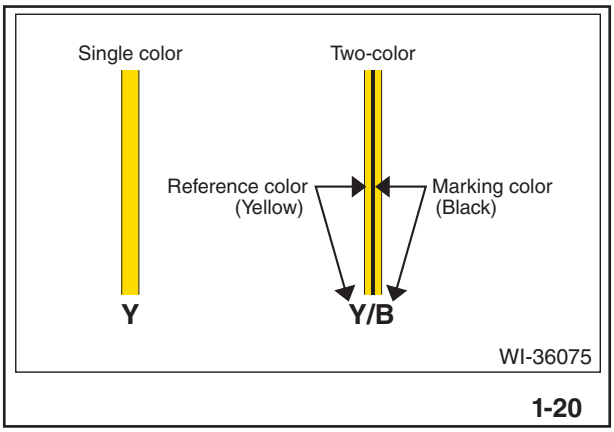
Color Code	Color
L	Blue
B	Black
Y	Yellow
G	Green
R	Red
W	White
Br	Brown
Lg	Light green
Gr	Gray
P	Pink
Or	Orange
Sb	Light blue
V	Violet
SA	Sealed (Inner)
SB	Sealed (Outer)



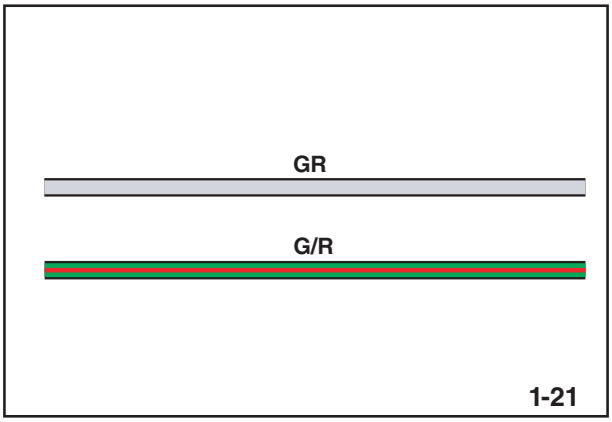
Wire color coding

Newer color diagrams indicate wire color using a slightly different letter structure. Two-color wires are illustrated as "Primary Color/Marking Color". Color coding may contain one to four letters depending on the combination of reference and marking color.

Note **Always refer to the "Basic Diagnostic Procedure" section of the appropriate service manual for wire color coding.**



Wire color distinction

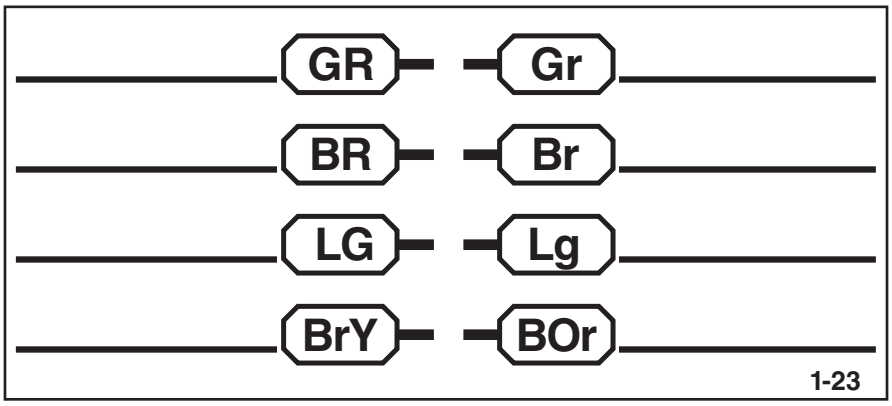


Conventional vs. enhanced comparison

Color code	Color	Color code	Color	Color code	Color
B	Black	S	Shield line	Gr	Gray
G	Green	V	Violet	Lg	Light green
L	Blue	W	White	Sb	Sky blue
Or	Orange	Y	Yellow	★	White or natural color
P	Pink	Be	Beige		
R	Red	Br	Brown		**1-22**

Wire color coding chart

Activity: Identify the following wire colors based on the letter coding.



Color coding activity

The wiring diagram Color Coding chart includes two unique codes identified as SA, Sealed (Inner) and SB, Sealed (Outer). The sealing refers to the use of electromagnetic shielding. Shielding is used when a wire carries a sensitive voltage. Induced voltage from current flow in adjacent conductors may elevate the existing voltage of an unshielded wire. By surrounding the sensitive wire in a conductive layer any induced voltage is directed to a ground source. This conductive layer functions as a Faraday cage reducing electromagnetic interference. Depending on the application several conductive layers may be used.

SA	Sealed (Inner)
SB	Sealed (Outer)

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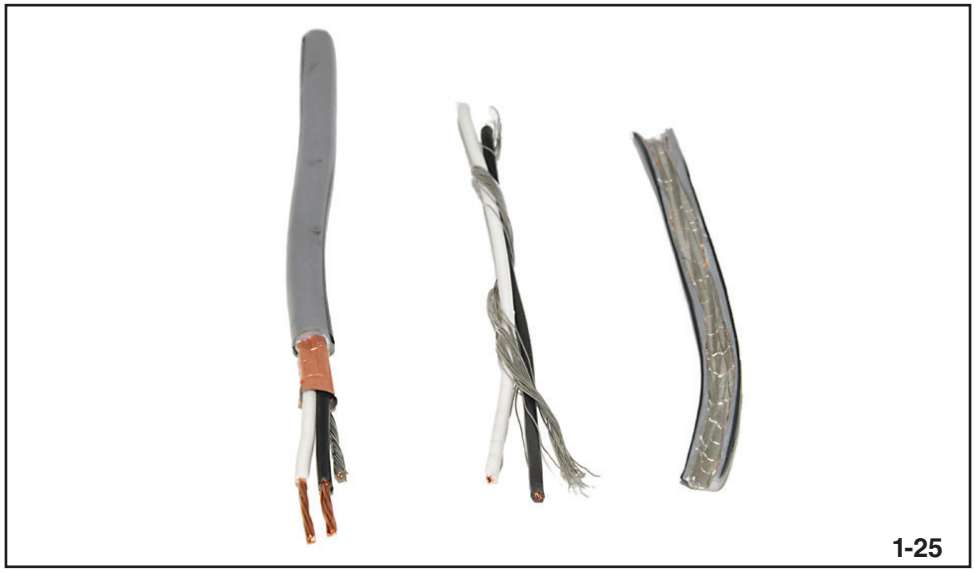
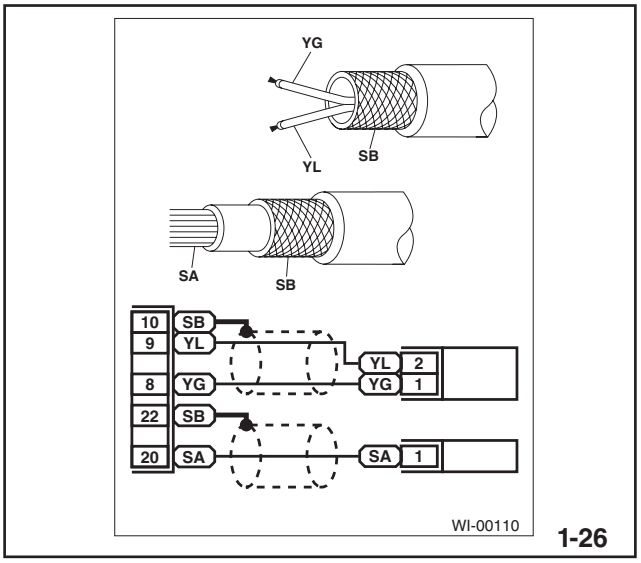
Shielded wire coding



Sealed outer (SB)

SB Sealed (Outer) is constructed of a copper or conductive tape wrapped around one or more conductors. The conductive shielding is typically connected to an indirect ground source. A Sealed Inner (SA) wire contains a flexible tubular layer commonly found on coaxial cables. Most Subaru applications use a SB Sealed (Outer) whereas SA Sealed (Inner) is rarely found.

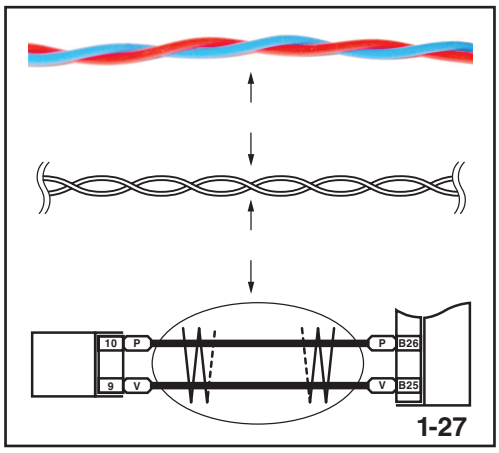
Note: Do not attempt to repair shielded wires. Any shielded wires that are damaged will require harness replacement.



Shielding identification

In contrast to shielded wiring, twisted pair wiring consists of 2 conventional (unshielded) lengths of wire twisted together. Twisted pair wiring is used primarily in vehicle communication systems (CAN). These systems use a difference in potential voltage to form messages. While this construction does not shield the electromagnetic interference it uniformly distributes the EMI across both wires thus canceling the effects from other wires in close proximity. In short, if voltage is increased on both wires equally, the potential difference remains the same and the integrity of the message remains intact.

Note: Do not attempt to repair twisted pair wires. Any twisted wires that are damaged will require a harness replacement.



Twisted pair wiring

Connectors and Terminals

When using the Subaru Wiring Diagrams, connector interpretation becomes crucial when inspecting for potential faults as they can serve as useful probing points when employing the Split-half technique. Checking an incorrect connector or terminal can waste time lead to misdiagnosis.

Connectors are identified by a first letter and connector number. This first letter indicates which harness or system the connector belongs to.

Symbol	Harness/cord	Symbol	Harness/cord
AB	Airbag wiring harness	F	Front wiring harness
AD	Adapter cord		Generator cord
AT/T	Transmission cord	i	Instrument panel Wiring harness
B	Bulkhead wiring harness		
D	Door cord / Rear gate code	R	Rear wiring harness
E	Engine wiring harness		Fuel cord / Roof cord
	Oxygen sensor cord		Rear gate cord / Trunk lid cord
ST	Steering cord		

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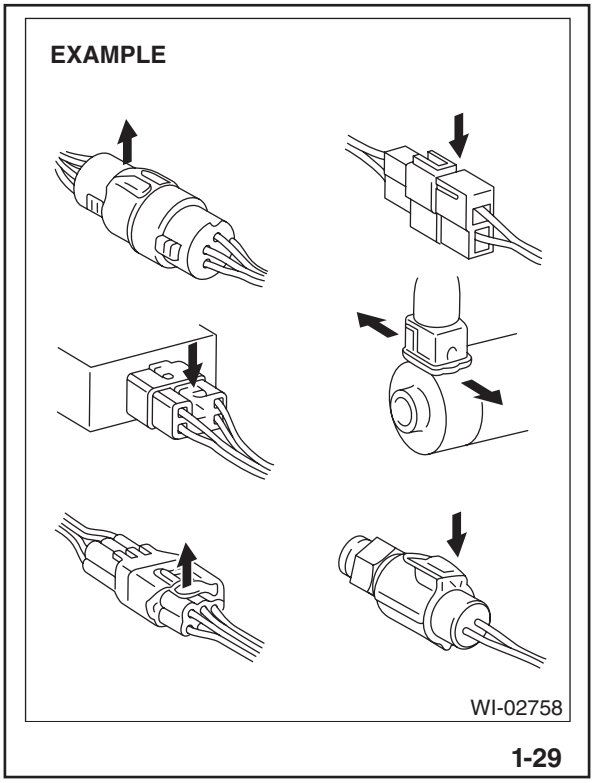
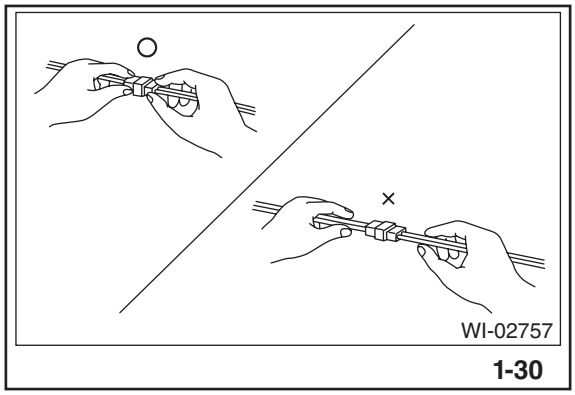
Connector abbreviations

When disconnecting connectors be careful to properly release the lock mechanism and pull from the body of the connector. Never disconnect a connector by pulling from the wires. When reconnecting, insert connector until a snap is heard and confirm it is secured.



1-29

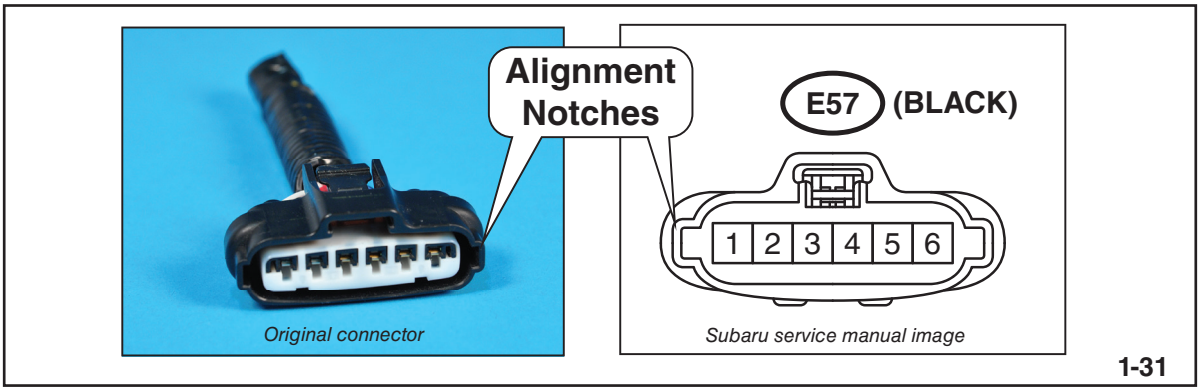
Example of connectors



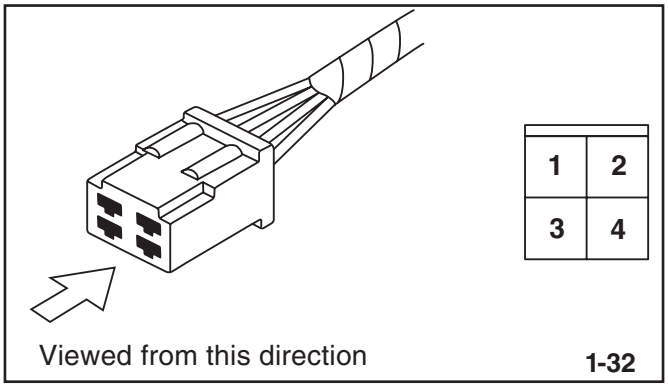
1-30

Releasing connector locks

When viewed in the Subaru Wiring Diagrams, connectors are always illustrated in a disconnected view with the connector lock in the upright position. Connectors can also be distinguished by physical characteristics such as color and alignment notches.

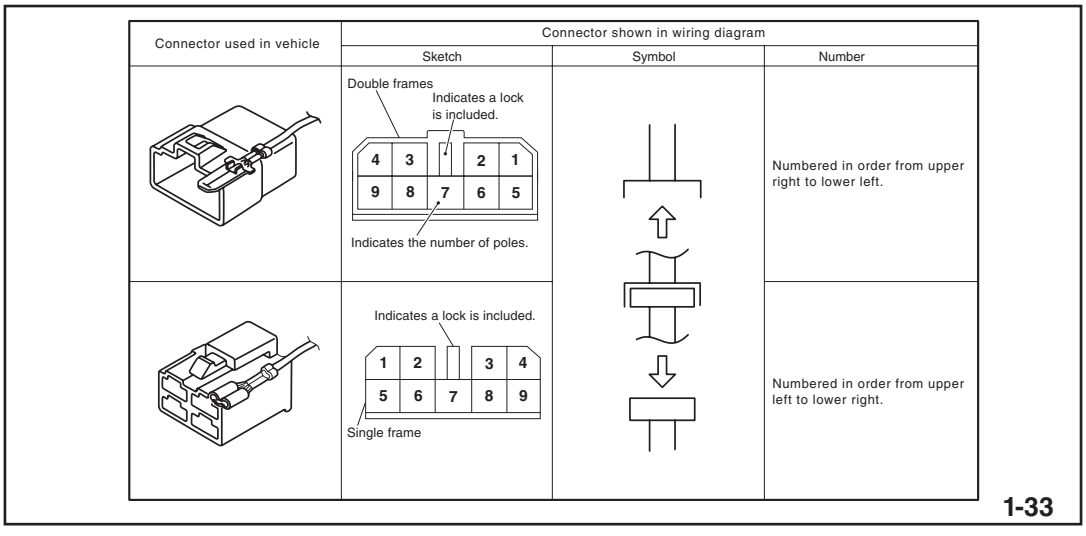


Alignment notches



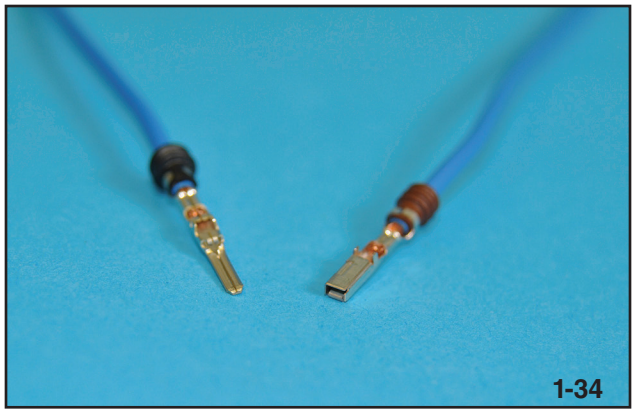
Male connector

Connection points consist of a plug and socket. The plug side is typically referred to as the “male” connector and the socket side is referred to as the “female” connector. The Subaru Wiring Diagram differentiates male and female connectors with unique sketches and symbols.

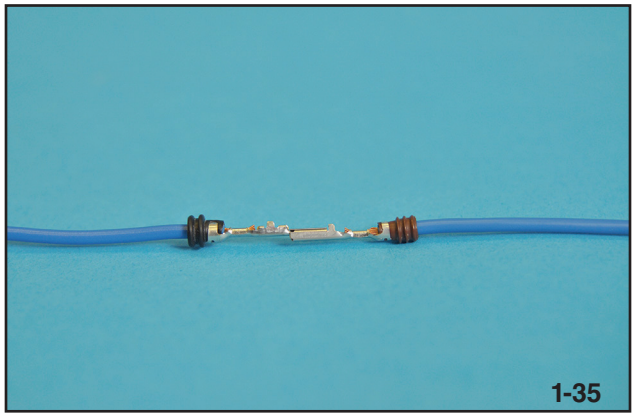


Male and female connectors

Housed within connectors, terminals (commonly referred to as poles) connect circuits as they pass through connectors. Terminals are identified as either male or female types and are sequentially numbered in connector illustrations.



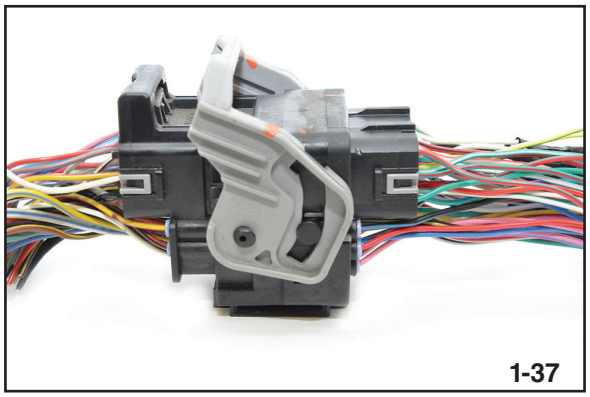
Male and female terminals



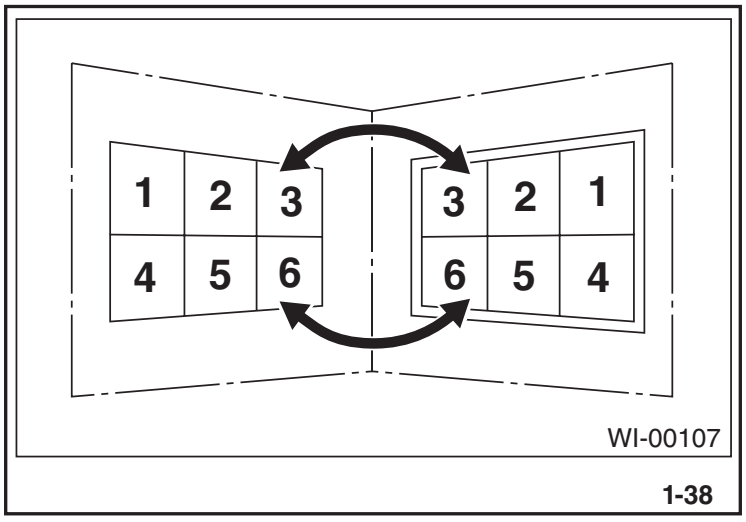
Male and female terminals connected

When identifying numbered connector terminals from wiring diagrams, it may be necessary to invert the location of the terminal numbers based on provided illustration.

Connector separated

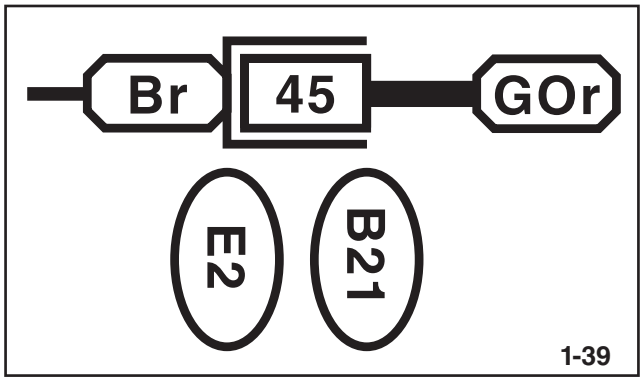


Connector assembled

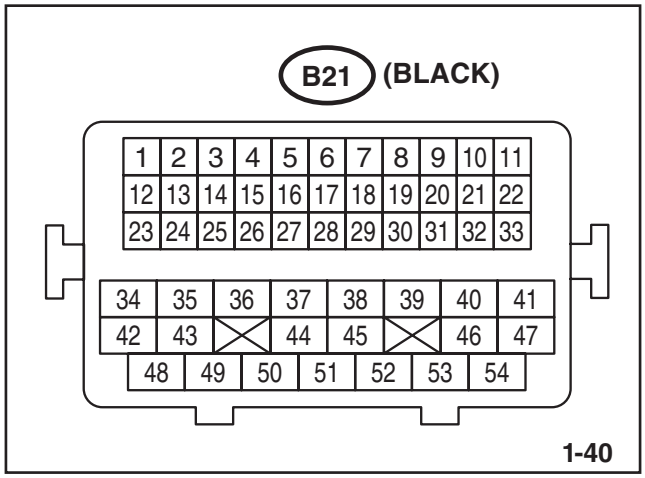


Terminal numbering at connections

Example: **Connector B21 (Black color) is shown where it connects to the E2 connector. However, only connector B21 is illustrated on the bottom of the Subaru Service Manual page. As a result, the terminal orientation must be mirrored on the E2 connector side. Exercise caution when inspecting the E2 connector to ensure the correct terminal is examined.**

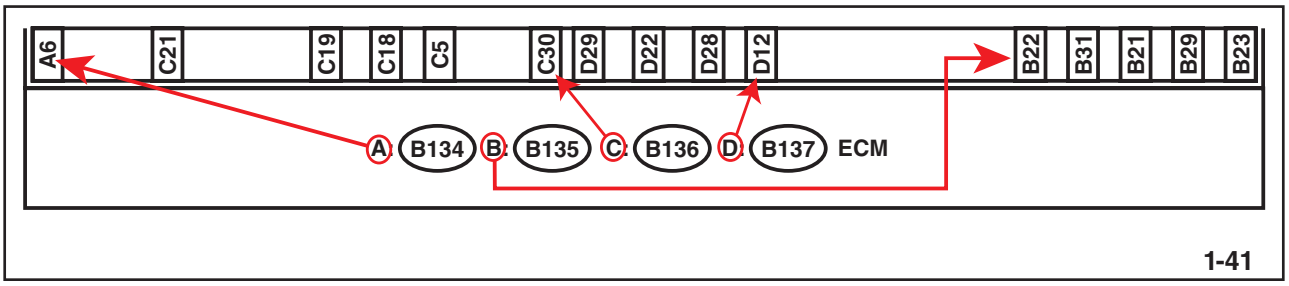


B21 and E2 connecting



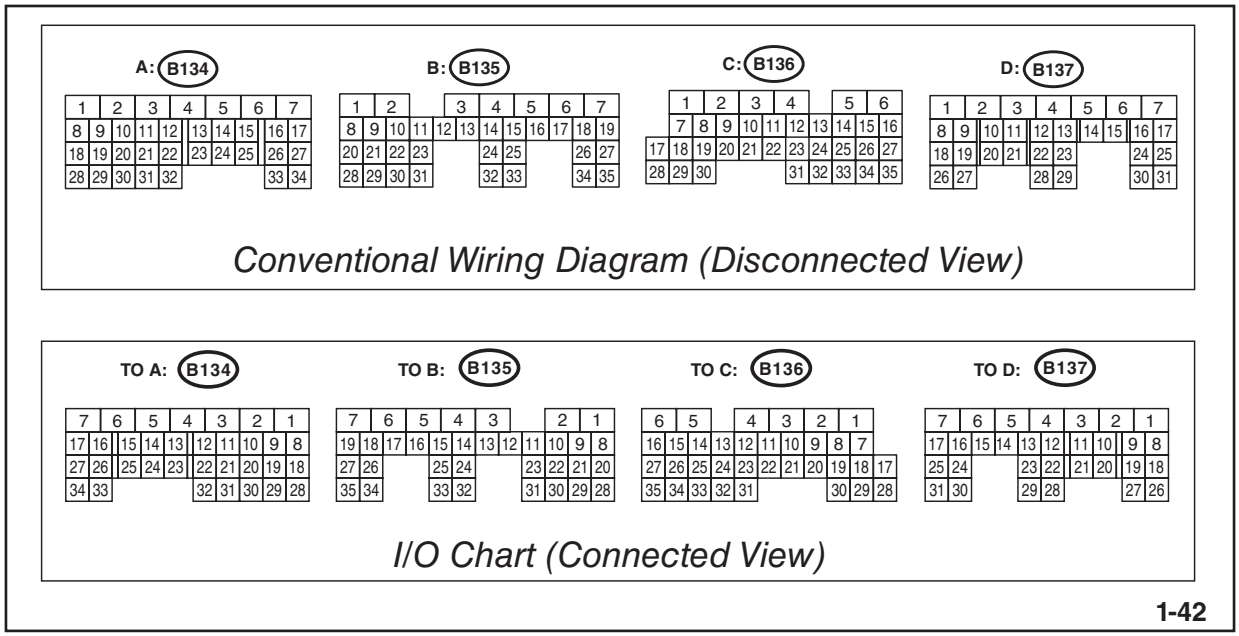
Connector B21

In situations where multiple connectors are connected to a component such as a module or common source, an alphabetic character may be used for identification.



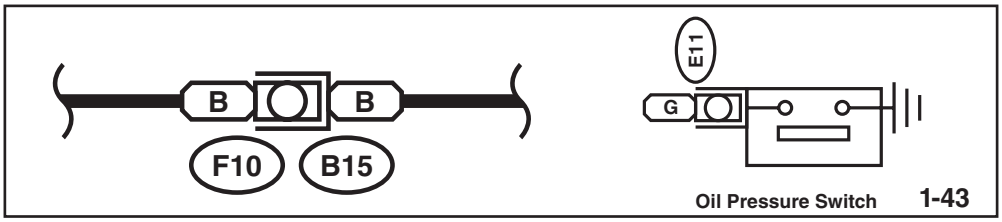
Multiple connectors

Note: When viewing specific module connectors, illustrations shown in Module Input/ output (I/O) Signal diagrams will vary from the conventional wiring diagrams. I/O diagrams are displayed from a "connected" view where as wiring diagrams are displayed from the disconnected view.

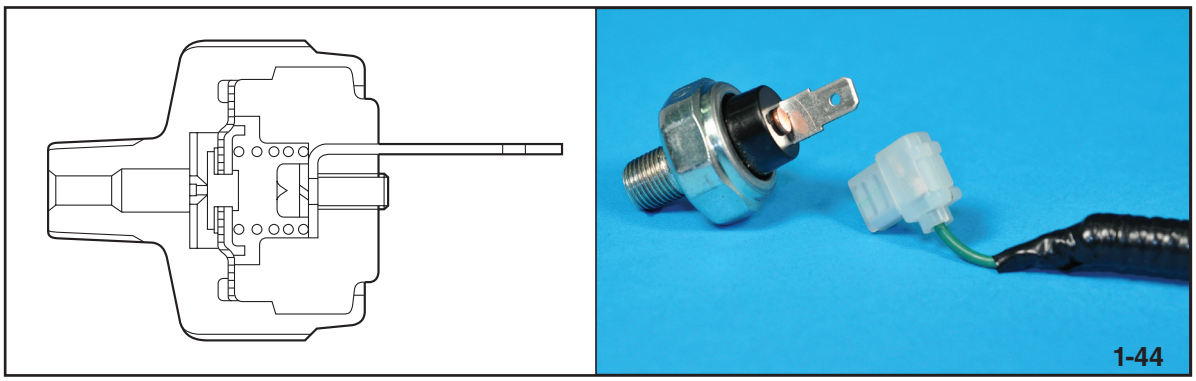


Connector view comparison

Connectors which have no terminal numbers are referred to as "one-pole" types. In this example, no illustrations will be provided on the bottom of the page.



One pole type (Wiring diagram)

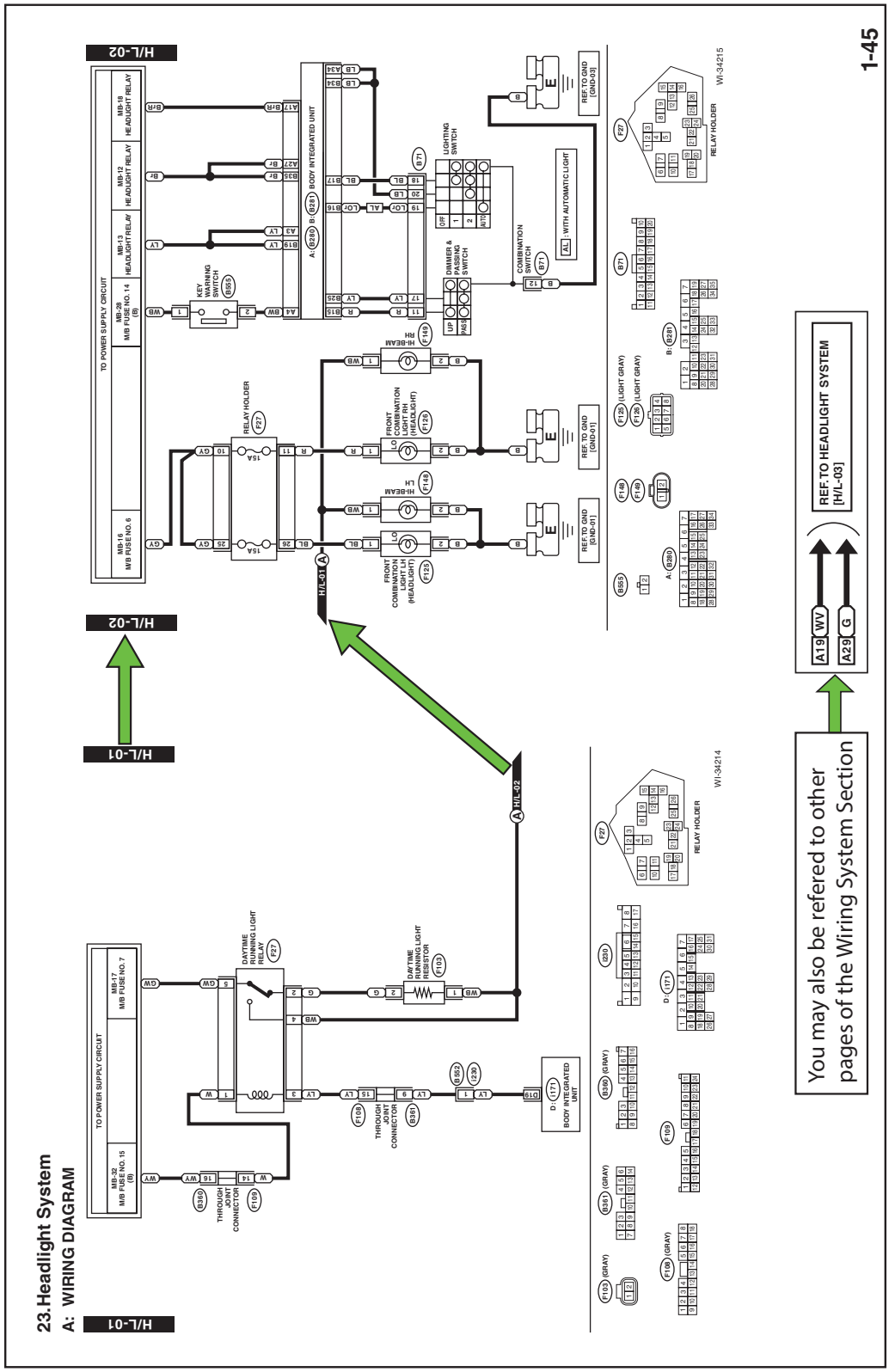


One pole type(Components)

Tracing Circuits

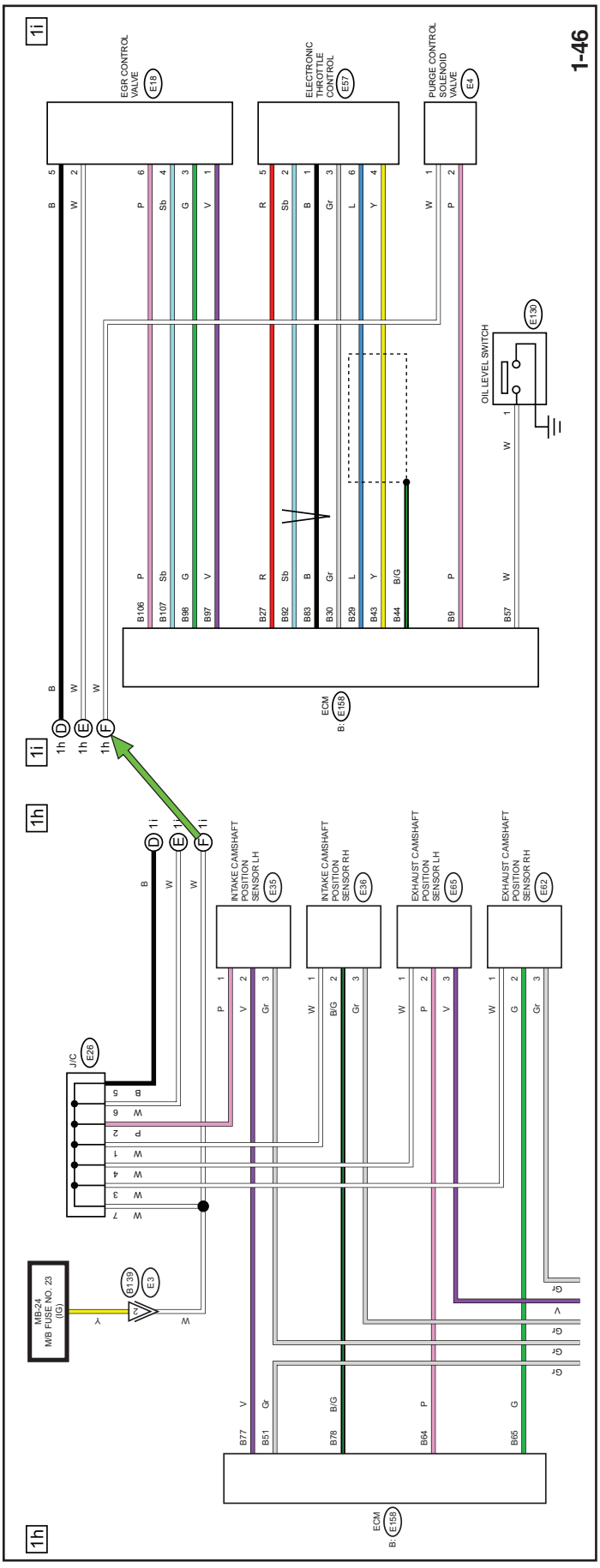
Tracing connector and circuit paths is accomplished by following the wire and splice symbols through the illustrations.

Example: The power supply wire for the Headlights leaves the page from the lower right side at "A H/L-02". This indicates the user must locate Letter "A" on Page 02 in the Headlight System (H/L) section of the diagram.



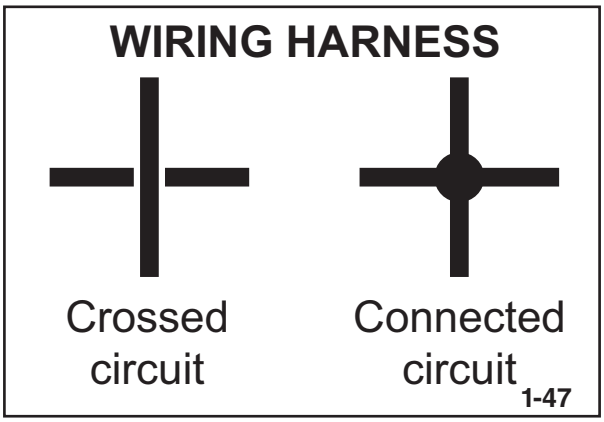
Tracing circuit

HTML based wiring diagrams from 2017MY feature active trace links embedded in the illustrations. Objects such as connectors and page continuation marks (letters) can be selected. Selecting these objects will bring the used directly to either the connector location or matching diagram page.

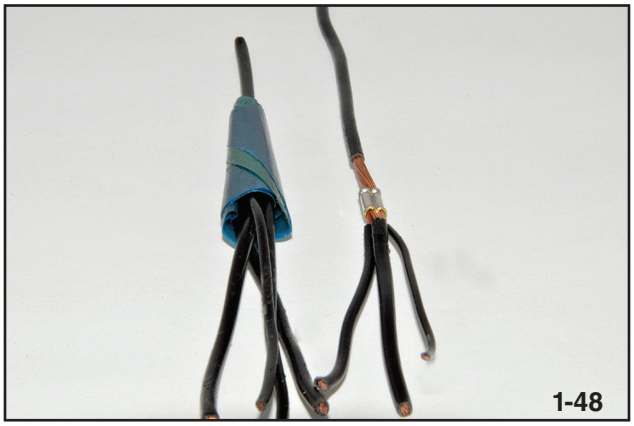


Active Trace links

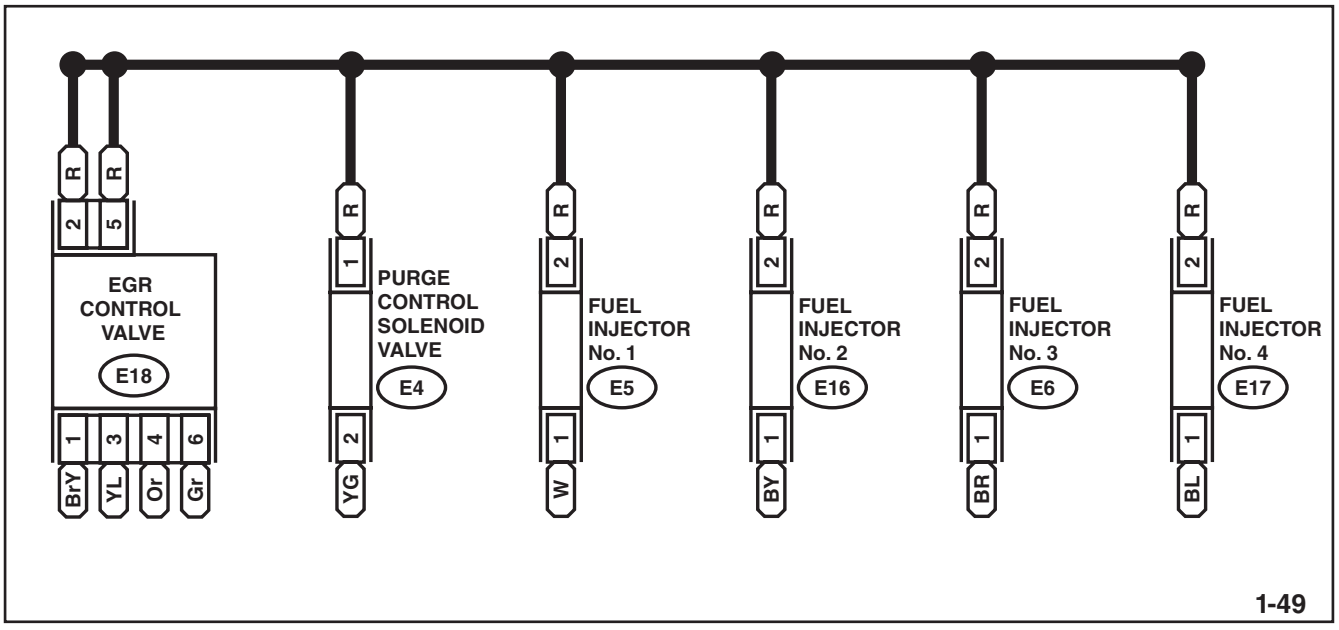
As a circuit is traced, wiring illustrations may appear to intersect or overlap. Symbols for circuit connections are illustrated with a dot where the wires intersect. These wiring splices or connection points can be exceptionally difficult to identify as the wiring diagrams do not specifically identify their locations. These connection points can be located anywhere in a length of harness. When discovered they are typically crimped together and protected with an electrical weather proof insulation tape.



Wire Connection Symbols



Splice Connection

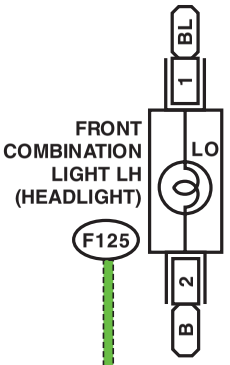


Engine harness splices

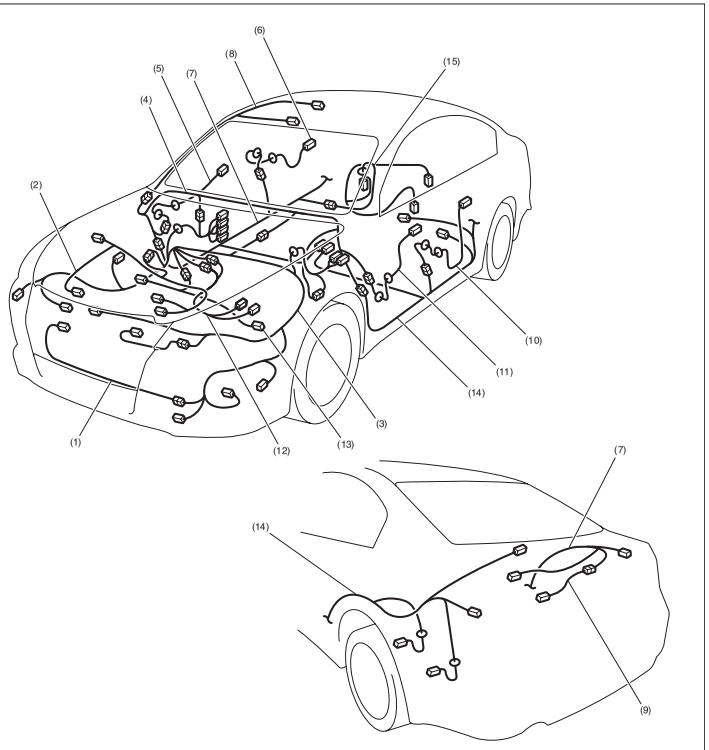
Component and Connector Locations

Determining component and connector locations begins with identifying the connector number in the specific system sections of the wiring diagrams. The first letter in connector abbreviations indicates the section of harness or cord in which a connector is attached.

Example: Connector F125 attaches to the LH Headlight bulb. The "F" indicates this connector is part of the Front Wiring Harness.



Symbol	Wiring harness and cord
F	Front wiring harness, Generator cord
B	Bulkhead wiring harness
E	Engine wiring harness
T	Transmission cord, Rear oxygen sensor cord
D	Front door cord LH & RH, Rear gate cord Rear door cord LH & RH, Rear defogger cord
i	Instrument panel wiring harness
R	Rear wiring harness LH & RH, Fuel tank cord, Roof cord, Rear gate cord
AB	Airbag wiring harness



1-50

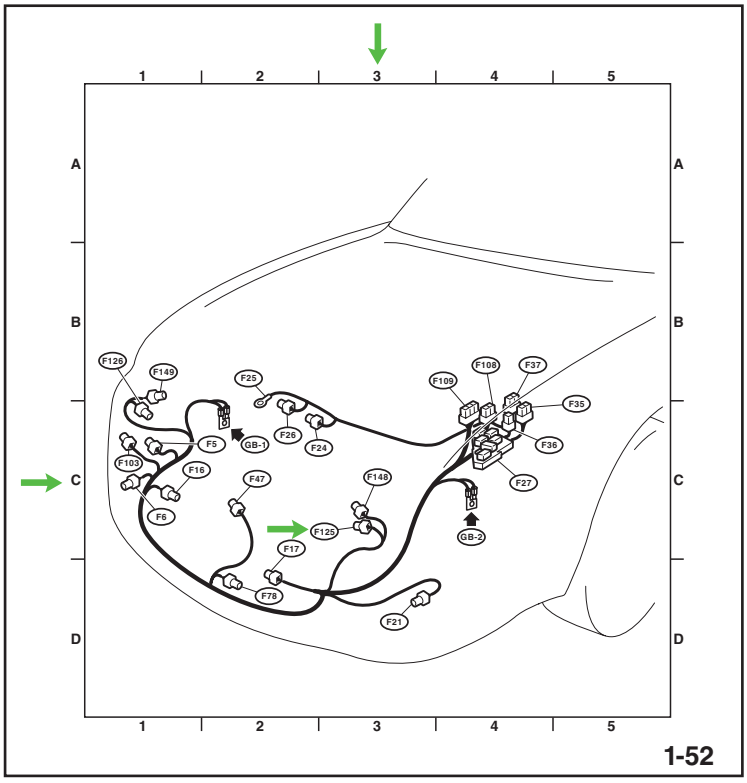
Component locations

In the Front Wiring Harness section, connector F125 is identified as 8 pole, Light Grey connector in the C-3 grid area.

Connector				Connecting to	
No.	Pole	Color	Area	No.	Description
F5	1	Black	C-1		Horn
F6	2	★	C-1		Front fog light RH
F16	2	★	C-1		Sub fan motor
F17	2	★	D-2		Main fan motor
F21	2	★	D-4		Front fog light LH
F24	1	★	C-3		Magnet clutch
F25	1	★	B-2		Generator terminal B
F26	3	★	B-2		Generator
F27	26	★	C-4		Relay holder
F35	12	Blue	B-5		M/B
F36	7	★	C-5		
F37	20	★	B-5		
F47	1	Black	C-2		Horn
F78	2	Black	D-2		Ambient sensor
F103	2	Gray	C-1		Daytime running light resistor
F108	18	Gray	B-4	B361	Through joint connector
F109	24	★	B-4	B360	
F125	8	Light gray	C-3		Front combination light LH
F126	8	Light gray	C-1		Front combination light RH
F148	2	★	C-3		High beam LH
F149	2	★	B-1		High beam RH
★ : White or natural color					

1-51

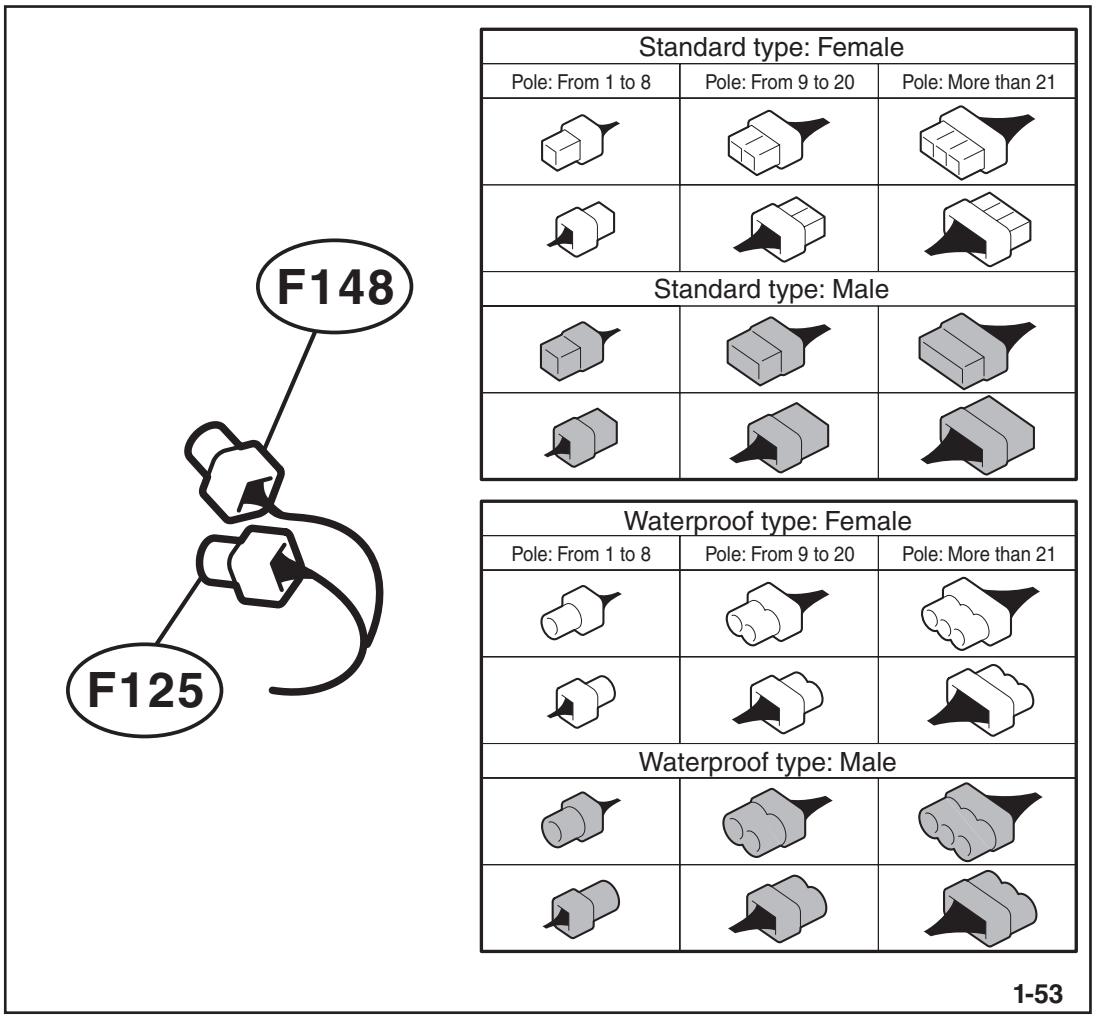
Front wiring harness connector chart



1-52

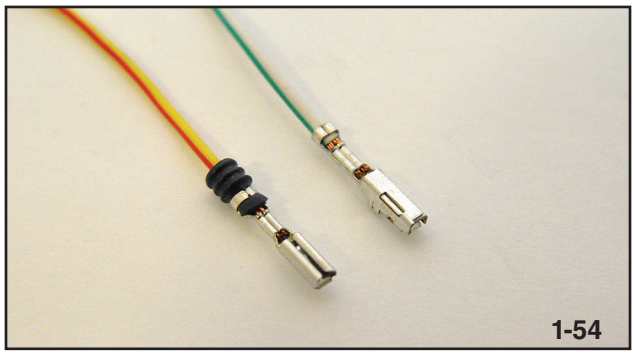
Front harness connector locations

Harness component illustrations have a different symbol system than the conventional wiring diagrams. The connector illustrations shown provide details on several traits of a connector including gender, type, and, size. In this example, connector F125 is illustrated as a 1-8 pole, female and waterproof type connector.

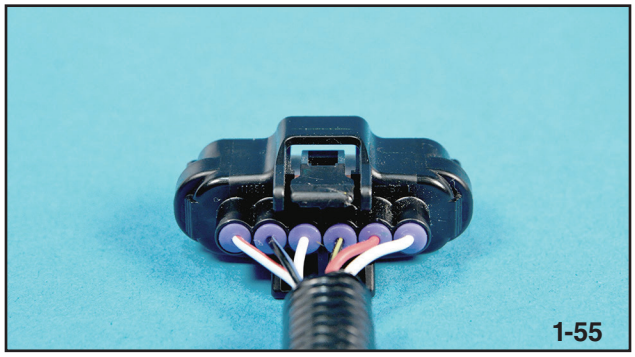


Connector illustrations

In areas exposed to environmental conditions, a terminal may utilize a rubber insert to prevent moisture and other debris from contaminating the connection.

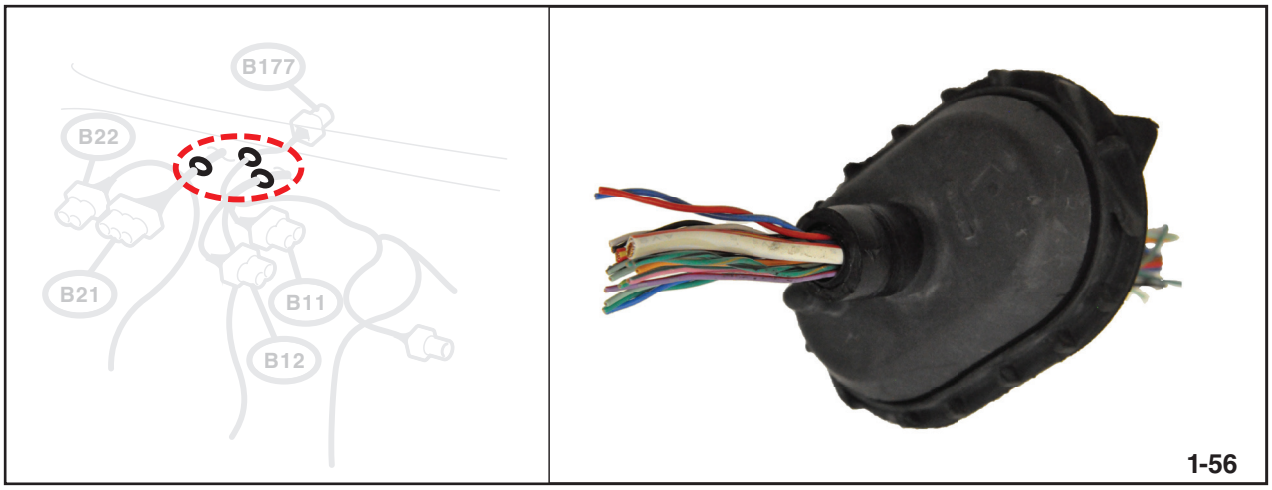


Terminal waterproofing



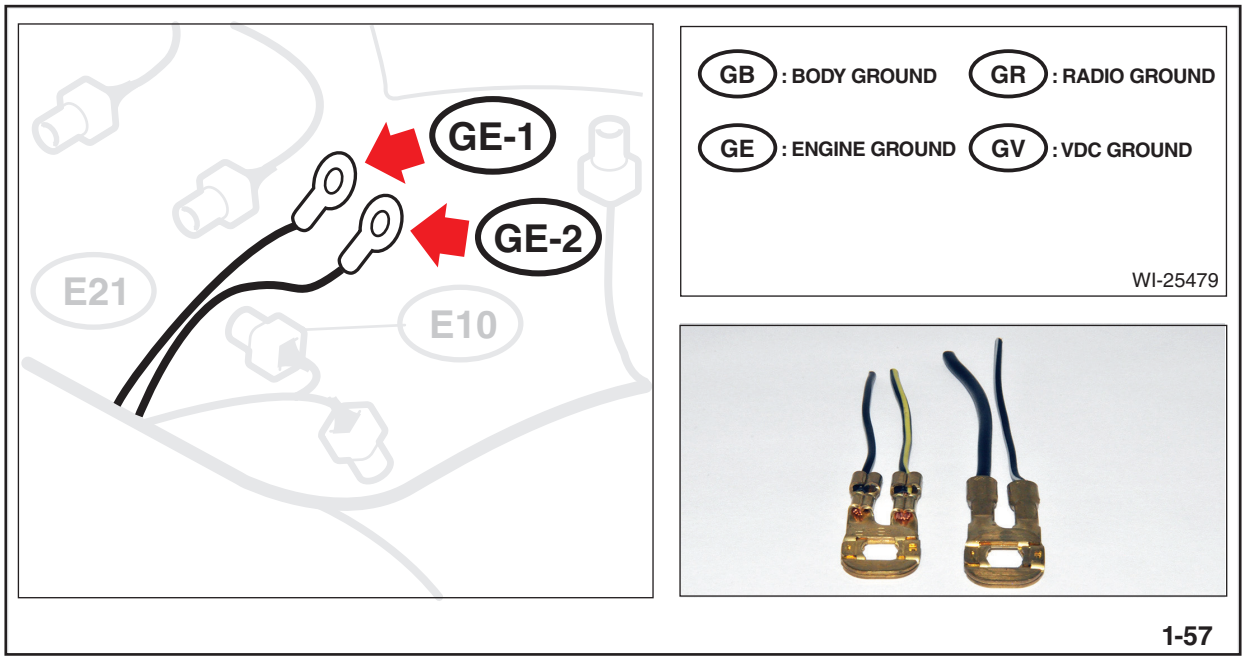
Connector waterproofing

The Harness component sections illustrate grommet locations in order to establish a reference for connector locations.



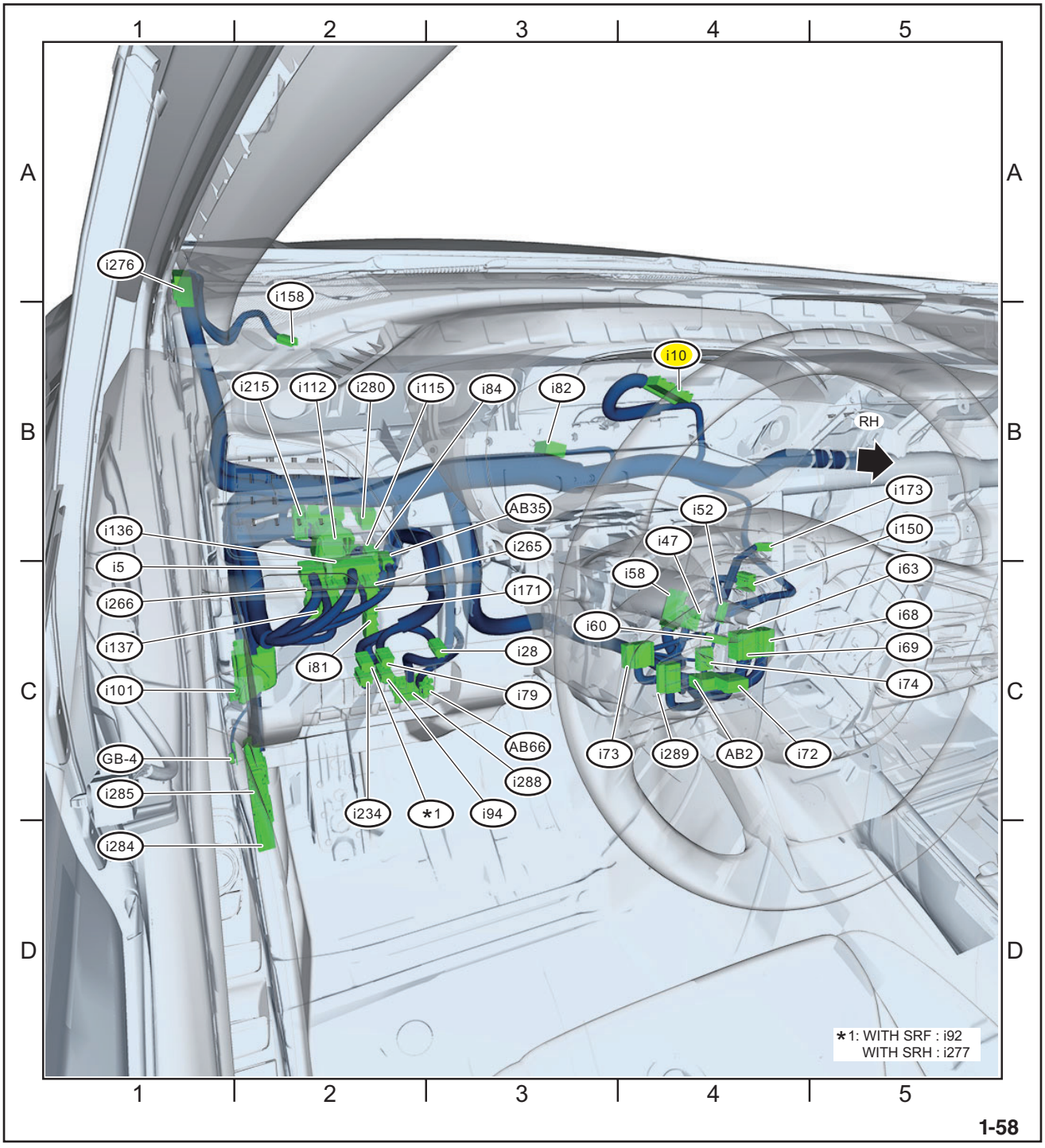
Body grommets

Ground connections are identified in the respective Harness Component sections. Information on the systems supported by these grounds can be found in the Ground Circuit section of the wiring diagrams.



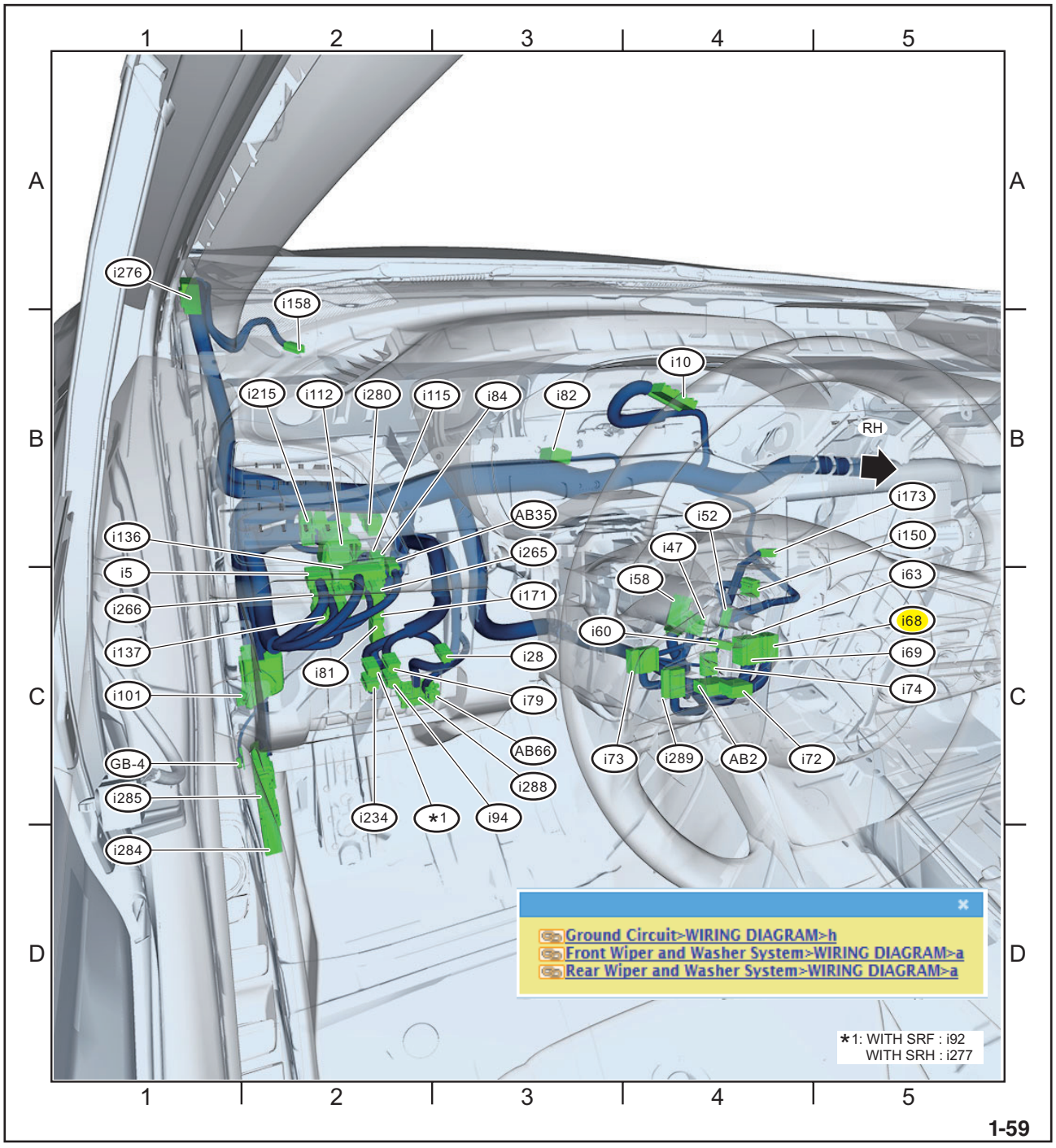
Ground identification

Some newer color diagrams feature enhanced 3D component location illustrations. These illustrations can be found by navigating to the individual sub-section or by using the active trace links within the wiring diagrams.



3D Component Location Illustration

These illustrations also contain active trace links that can be used to link to an individual wiring diagram system.



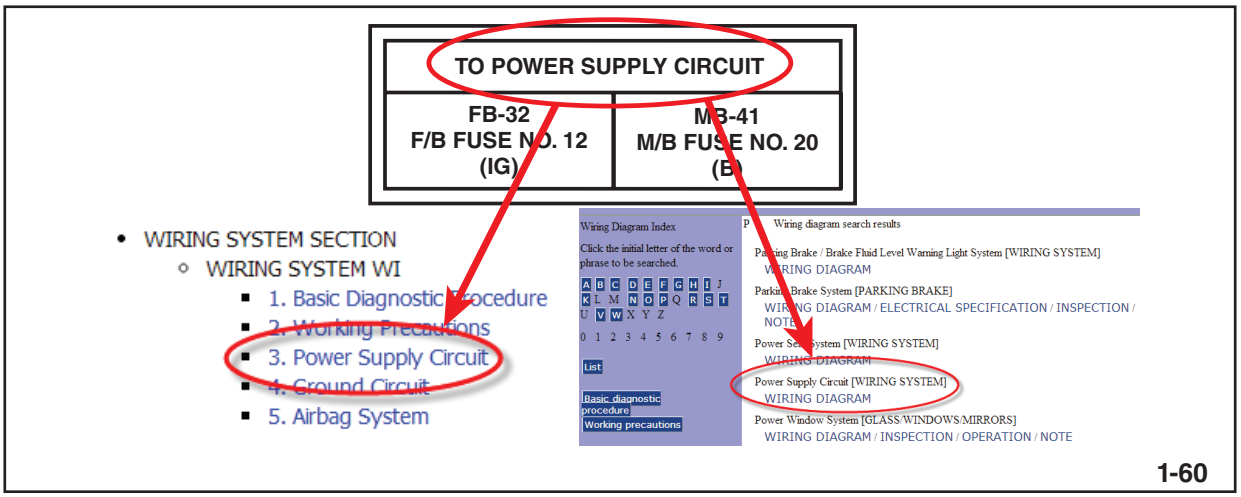
Component Location – Trace Link

Power and Ground

The core principle of the Split-Half technique is to divide a complete circuit into the distinct power and ground segments. Once a component or connector has been located, tracing the power and ground paths are accomplished by following the illustrations and symbols. These paths inevitably lead to dedicated Power Supply and Ground sections. These sections feature a unique style of illustration that can be easily disorienting.

Power Supply

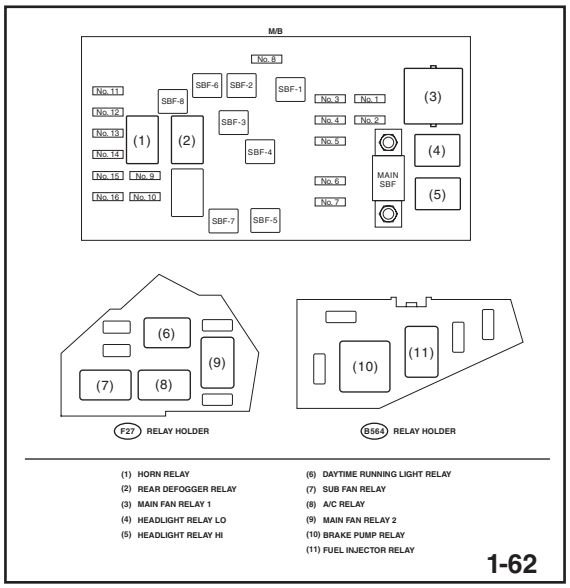
Power Supply circuits are illustrated in a separate portion of the Wiring System Section. During circuit diagnostics, refer to the “Power Supply Circuit” area of the Wiring System Section for specific details on fuse and relay locations.



Power supply section

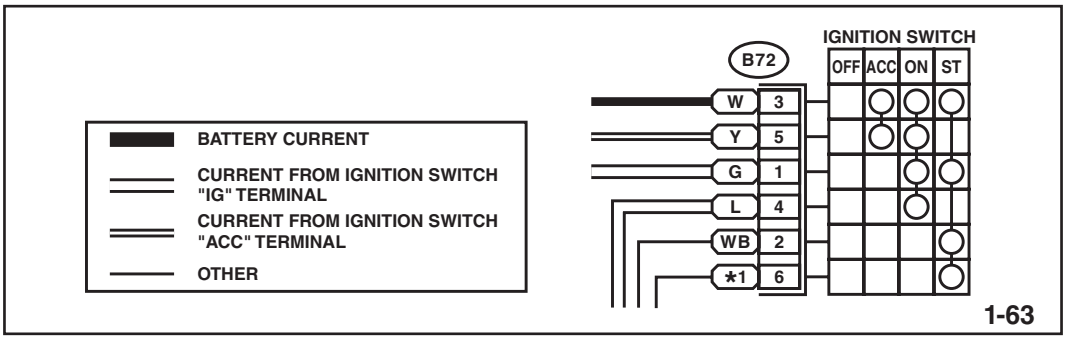
This is the only area of the Service Manual that references fuse and relay locations by their individual numbers.

Fuse and relay identification



Fuse and relay identification (Artwork)

The Power Supply sections illustrates wires that indicate the source of current. These sources can be associated with the various positions of the ignition switch.

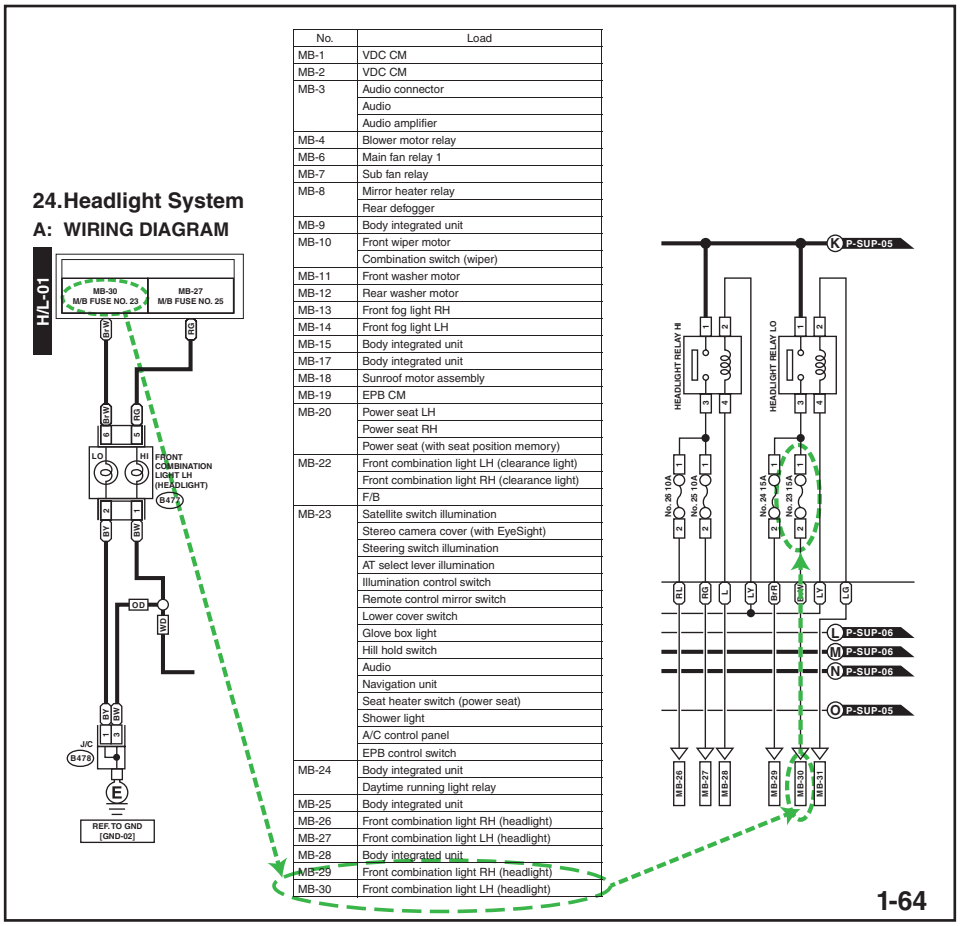


Current sources

Example: Tracing the power supply for the LH Front Combination light directs the user to the MB-30 circuit. Refer to the Power Supply section of the wiring diagram to identify the components supported by the circuit. Like MB-23 in the example below, multiple components may be supported by a single fuse or relay. After the power supply circuit has been identified, locate the

M/B – Main Fuse & Relay Box (Under hood)

F/B – Fuse & Relay Box (Inside Vehicle)

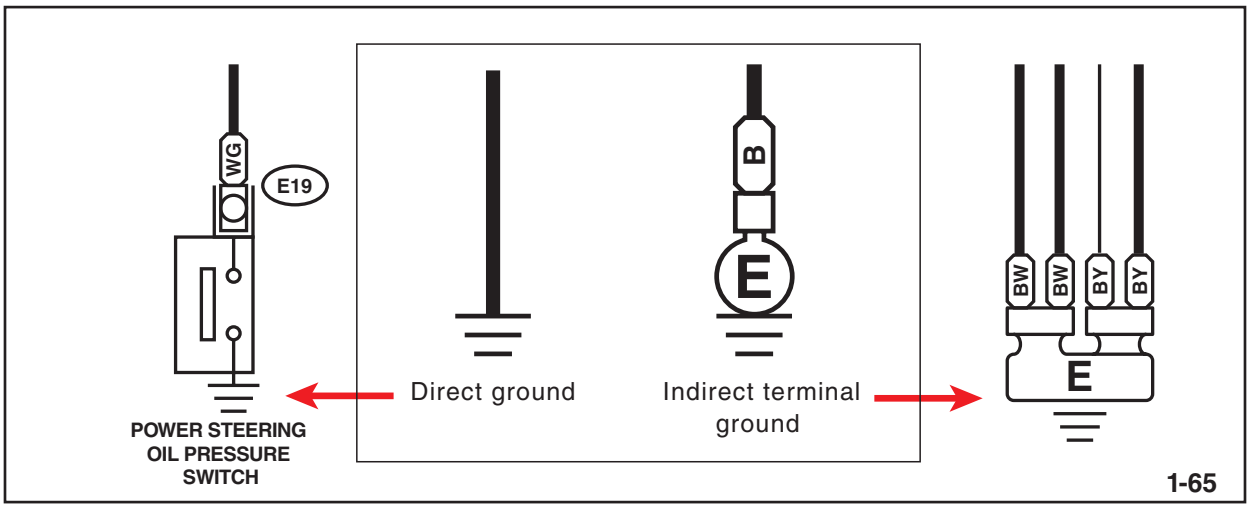


No.	Load
MB-1	VDC CM
MB-2	VDC CM
MB-3	Audio connector
	Audio
	Audio amplifier
MB-4	Blower motor relay
MB-6	Main fan relay 1
MB-7	Sub fan relay
MB-8	Mirror heater relay
	Rear defogger
MB-9	Body integrated unit
MB-10	Front wiper motor
	Combination switch (wiper)
MB-11	Front washer motor
MB-12	Rear washer motor
MB-13	Front fog light RH
MB-14	Front fog light LH
MB-15	Body integrated unit
MB-17	Body integrated unit
MB-18	Sunroof motor assembly
MB-19	EPB CM
MB-20	Power seat LH
	Power seat RH
	Power seat (with seat position memory)
MB-22	Front combination light LH (clearance light)
	Front combination light RH (clearance light)
	F/B
MB-23	Satellite switch illumination
	Stereo camera cover (with EyeSight)
	Steering switch illumination
	AT select lever illumination
	Illumination control switch
	Remote control mirror switch
	Lower cover switch
	Glove box light
	Hill hold switch
	Audio
	Navigation unit
	Seat heater switch (power seat)
	Shower light
	A/C control panel
	EPB control switch
MB-24	Body integrated unit
	Daytime running light relay
MB-25	Body integrated unit
MB-26	Front combination light RH (headlight)
MB-27	Front combination light LH (headlight)
MB-28	Body integrated unit
MB-29	Front combination light RH (headlight)
MB-30	Front combination light LH (headlight)

Power supply tracing

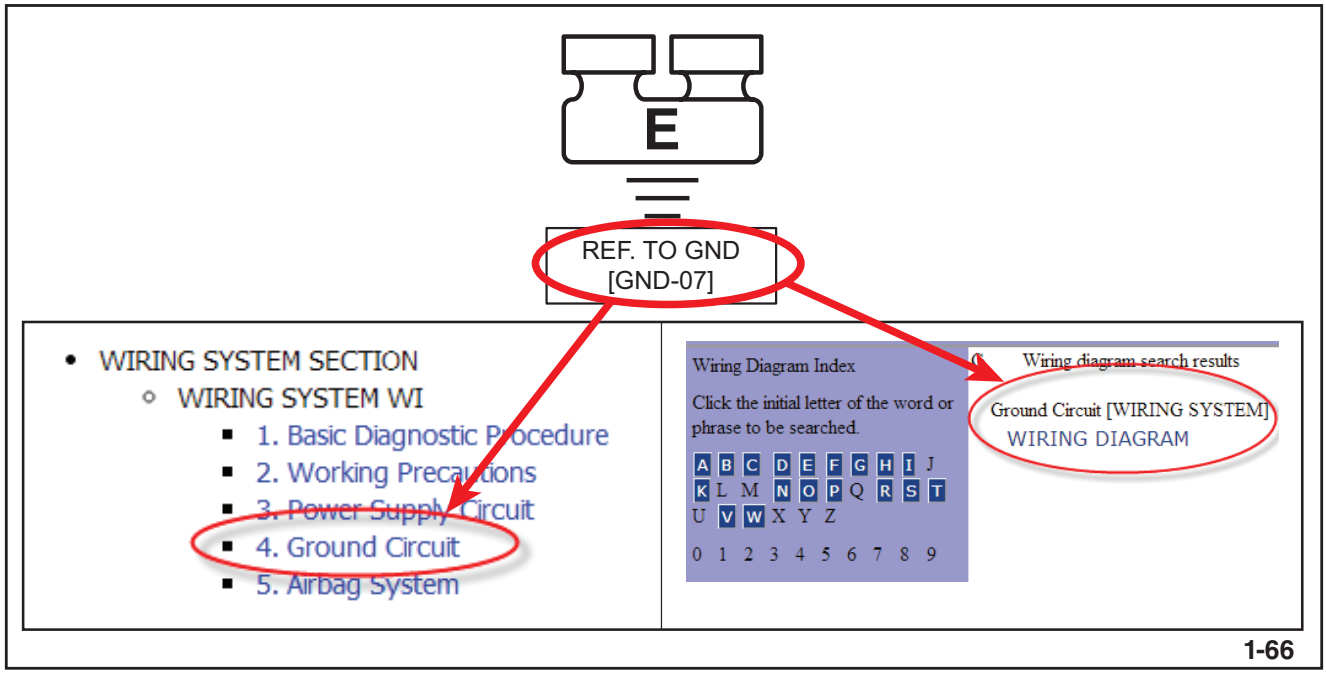
Ground Circuit

Once you have identified the target component, trace the wiring to the “Ground” symbol. Ground symbols may indicate a direct ground or indirect terminal ground depending on the illustration.



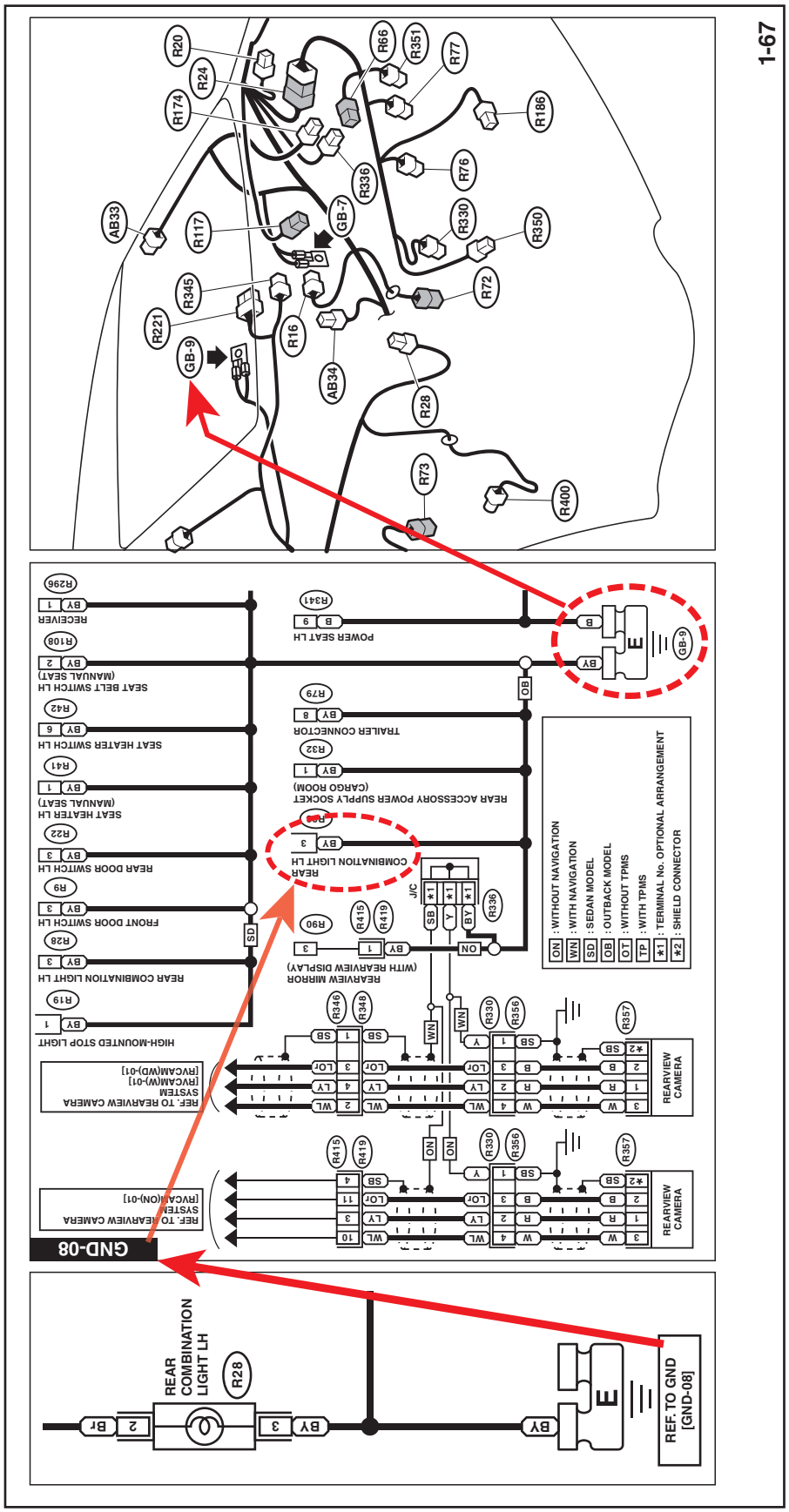
Ground symbols

Similar to Power Supply, Ground circuits are illustrated in a separate portion of the Wiring System Section. The Ground Circuit section of the wiring diagrams provides the paths of indirect ground connections.



Ground circuit section

In this example, the Rear Combination Light LH connects to an indirect terminal ground. The diagram indicates to refer to the GND area, specifically page GND-08. Once you have navigated to GND-08, trace the Rear Combination Light LH to the indirect terminal ground symbol. In this case, the diagram indicates that the ground connector is GB-9. Since the Rear Combination Light LH is part of the Rear Wiring Harness (R28) refer to the Harness Component location section for the Rear Wiring Harness to identify the mounting location for GB-9. In this case, the ground terminal is attached to the rear package shelf.

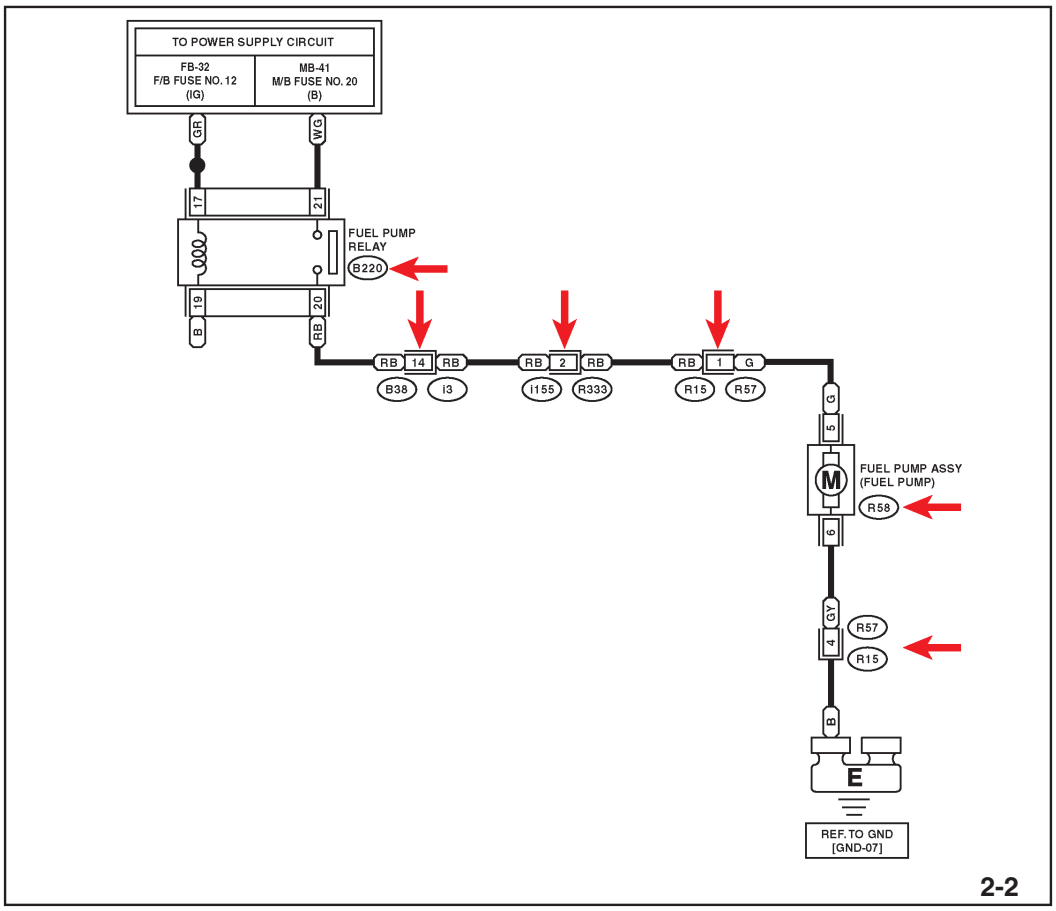


Ground circuit tracing

Troubleshooting

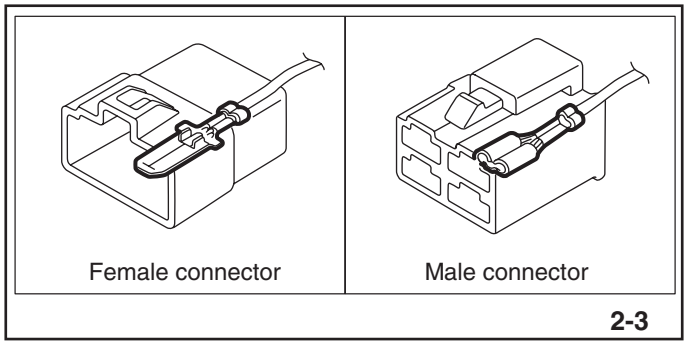
Connector Probing

During conventional troubleshooting, electrical measurements are typically performed at harness connectors. Measuring at these connection points allows complex circuits to be systematically broken down into simpler segments. As a result, diagnostic efficiency and accuracy is greatly improved.



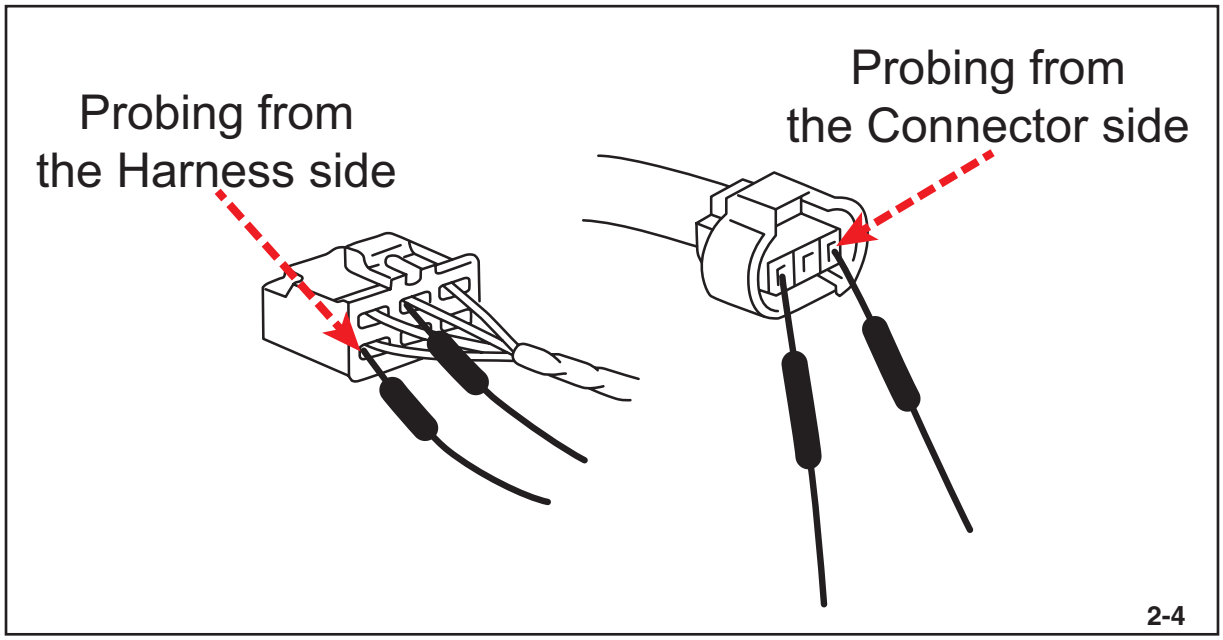
Harness connectors

Connectors consist of a plug and socket. The plug side is typically referred to as the “male” connector and the socket side is referred to as the “female” connector.



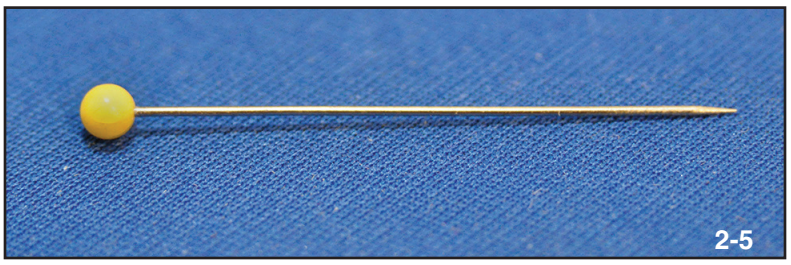
Connector genders

A singular connector consists of a “harness side” and a “connector side”. The side where the wires enter is referred to as the “harness side”. The side that connects to the corresponding connector is referred to as the “connector side”. Certain considerations should be taken when performing electrical measurements or probing at these locations as to reduce the possibility of consequential damage.



Connector sides

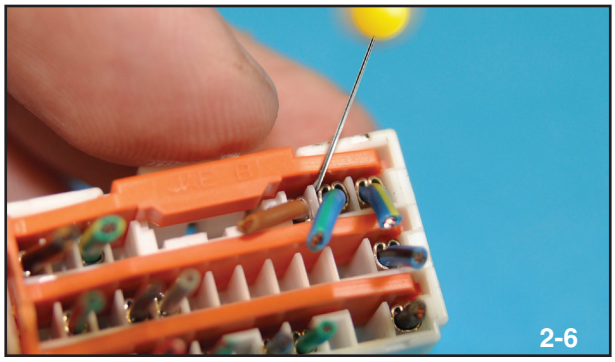
When probing either the harness or connector side of a connector use a tapered pin to make contact with the electrical terminal. It is recommended that the diameter of the pin not exceed 0.6mm (0.024 in) to prevent damage.



Probing pin 0.6mm (0.024 in)

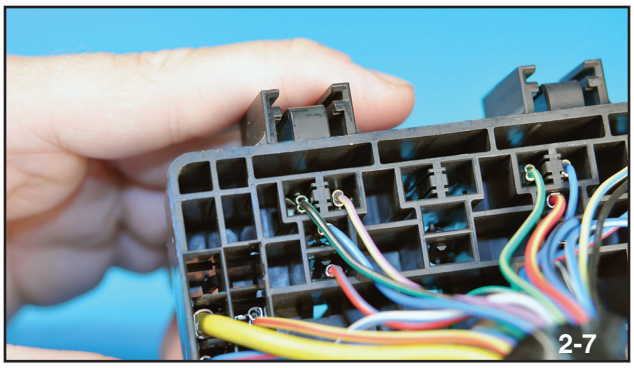
Harness Side Probing (Back Probing)

Performing electrical measurements from the harness side of the connector is typically referred to as “back probing”. This method offers many advantages in diagnosis since the integrity of the connector can be maintained while a measurement is taken. Always exercise caution in correctly identifying the correct terminal since connectors are illustrated in the service manual from the disconnected perspective.

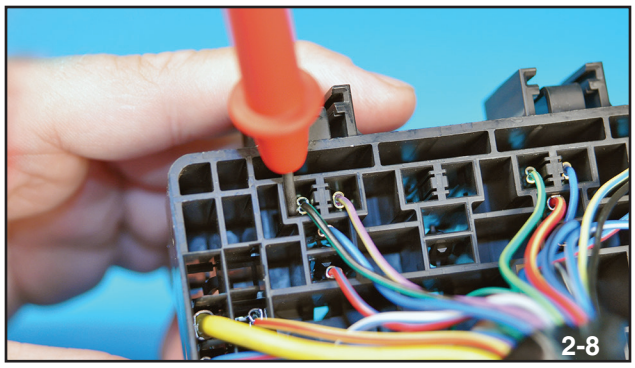


Probing from the harness side (Non-weatherproof)

In some areas of the vehicle larger connectors that do not accommodate the use of a 0.6mm (0.024 in). In these instances, it may be appropriate to insert a DVOM test lead into the harness side of the connector.

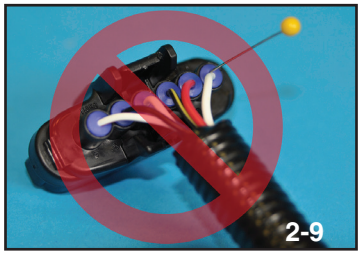


Large connectors



DVOM test lead in harness side

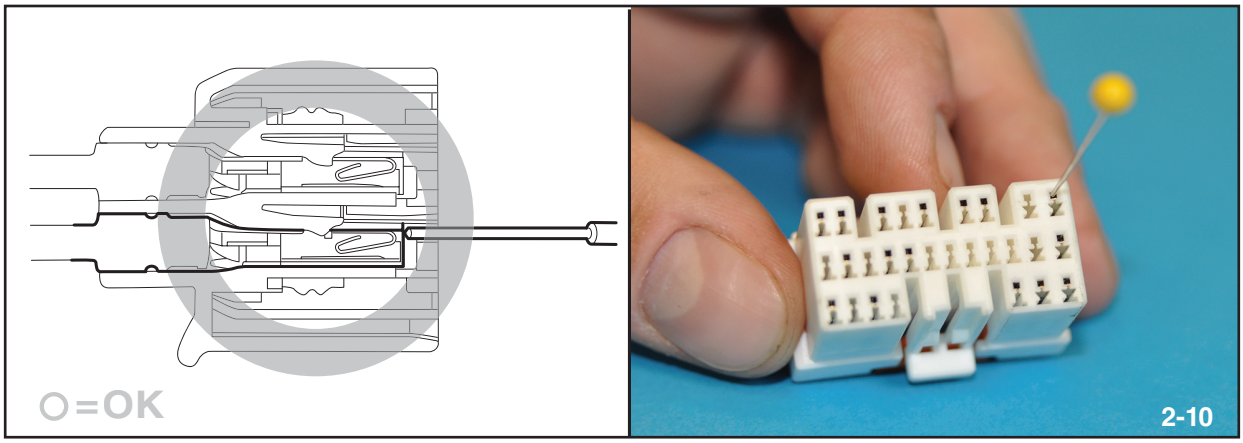
Waterproof connectors should never be probed from the harness side (back probed) as the sealing integrity may be compromised. In this circumstance, use a tapered pin to gently contact the tip of the exposed terminal in the front of the connector (Front probing). Under no circumstances should a lead be fully inserted into a female terminal as damage resulting in poor contact may occur. Similarly, be cautious not to deform, bend, or damage male terminals.



Probing from the harness side (Weatherproof)

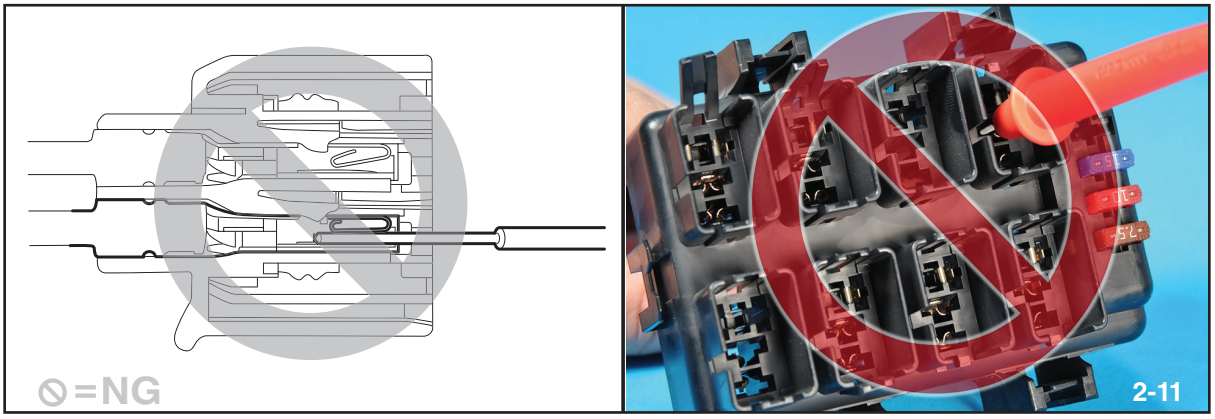
Connector Side Probing (Front Probing)

Performing electrical measurements from the connector side of the connector is typically referred to as “front probing”.



Front probing (Acceptable)

Front probing requires an increased amount of care and consideration since the insertion of a large probing pin into a female terminal may create poor contact when reassembled



Front probing (Unacceptable)

Use of the replacement leads from the Terminal Repair Kit (SST J-47606) may make connector front probing easier.

Replacement leads

Six-Step Troubleshooting Method

Diagnosis of electrical related failures are among the most challenging on modern vehicles. The use of a methodical approach can greatly reduce time spent identifying a root cause and prevent misdiagnosis. Subaru encourages the use of a Six-Step Troubleshooting method to guide vehicle diagnostics.

Step 1. Verify the Problem

- Distinguish legitimate failures from normal operation/customer misunderstandings. In some cases, customers may misinterpret a new system or function as a failure. Always refer to Service Manual “Mechanism and Function” and “Diagnosis with Phenomenon” related sections for helpful information concerning normal and abnormal operation.

Step 2. Determine Related Symptoms

- Observe related systems or functions that may exhibit problems. Many systems share common elements such as fuses and ground sources. Identifying logical common points can minimize inspection points.
- Identify related DTCs

Step 3. Isolate the Problem

- Create a simplified sketch of the suspect circuit and identify critical components and construction type (ie. Series, Parallel, Series-Parallel).
- Use the Split-Half technique (Electrical Diagnosis flow chart)

Step 4. Identify the Cause

- Open Circuits
- Short Circuits
- High Resistance/Voltage Drop
- Load Device/Component

Step 5. Repair the Problem

- Wiring Repair/Harness Replacement
- Component replacement

Step 6. Verify the Operation

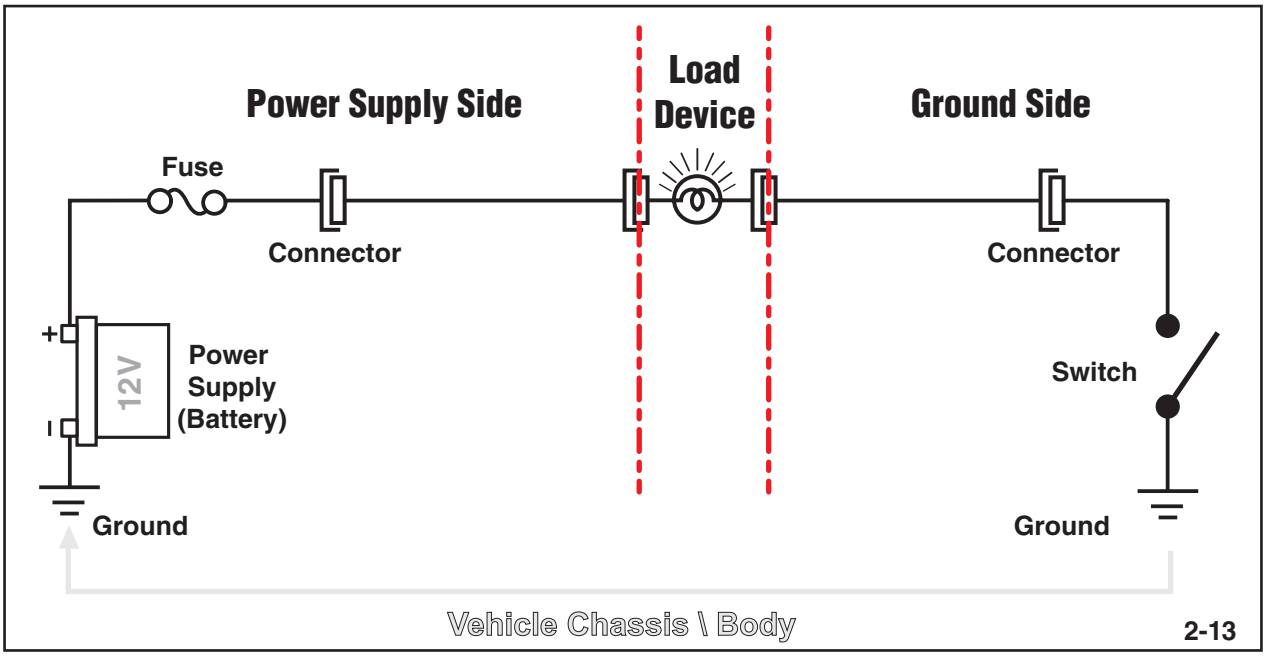
- Thoroughly inspect that the repair has been accurately performed and the electrical failure will not return. This step is critical in ensuring customer satisfaction through “fixed right the first time” measurements.

Split-Half Technique

Isolating the problem is the most difficult step in the Six-Step Troubleshooting method. However, use of the split-half technique provides a logical step by step approach to quickly and accurately locate the root cause of an electrical symptom.

While there are many varieties of circuit configurations, most can be broken down into 3 distinct segments.

- Power Supply Side
- Ground Side
- Load device (ie. Light Bulb, Motor, Solenoid)

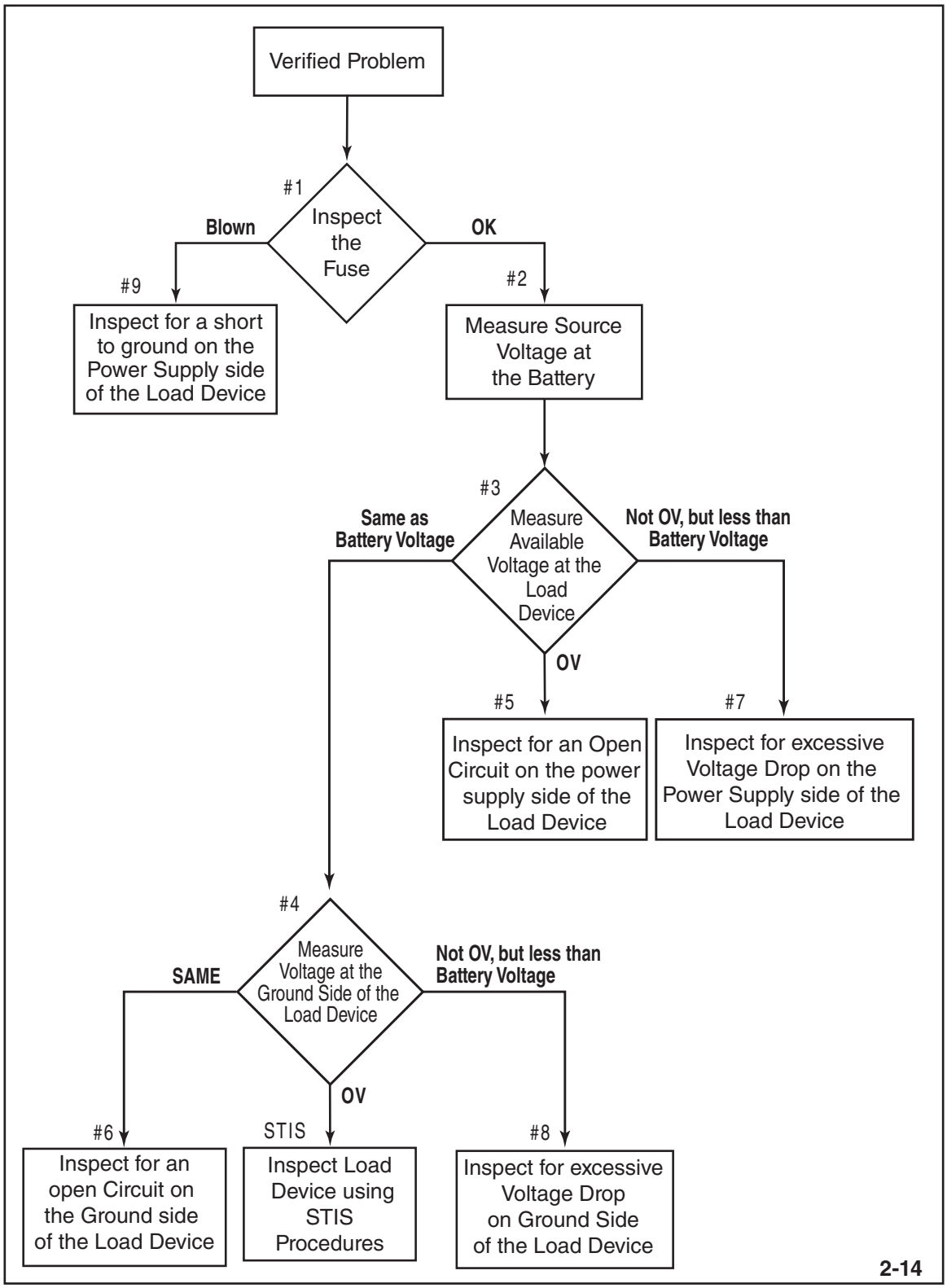


Example circuit

Electrical circuit failures can be generally classified into 3 categories:

- Open Circuits
  - ◊ An open fault is an unwanted break in a circuit. Open faults can be caused by a break in a wire, a disconnected wire or connector, or anything that opens the circuit.
- Short Circuits
  - ◊ A short circuit fault is a condition where current flows through an alternate path rather than the intended path. Short circuits are caused when two conductors unintentionally make contact and provide a path for current flow. Shorts can occur to a ground path or power supply.
- High Resistance/Voltage Drop
  - ◊ High-resistance faults are defined as circuits that have unwanted additional resistance. Corrosion, loose connections, partially broken wires, and incorrect wire sizes can cause high resistance faults within a circuit.

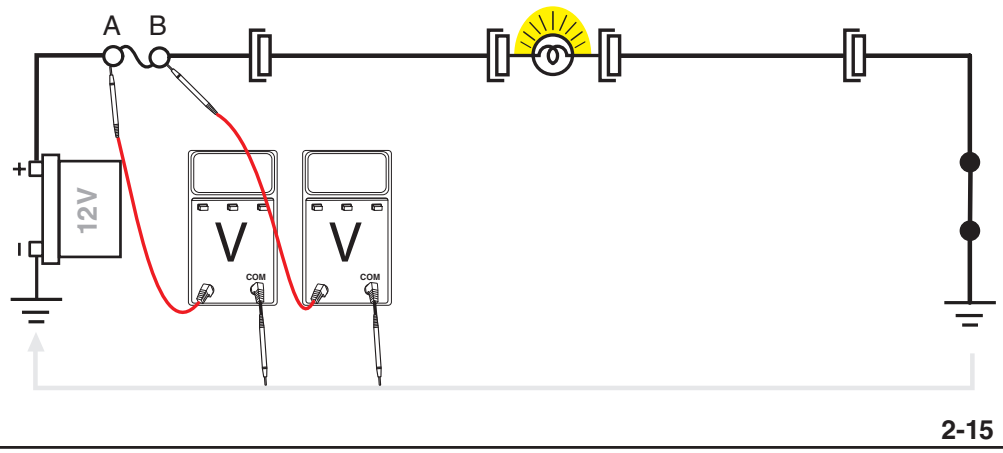
Adhering to a methodical step-by-step process can aid in isolating the cause of the problem.



Electrical diagnosis flow chart

Step 1 Inspect the Fuse

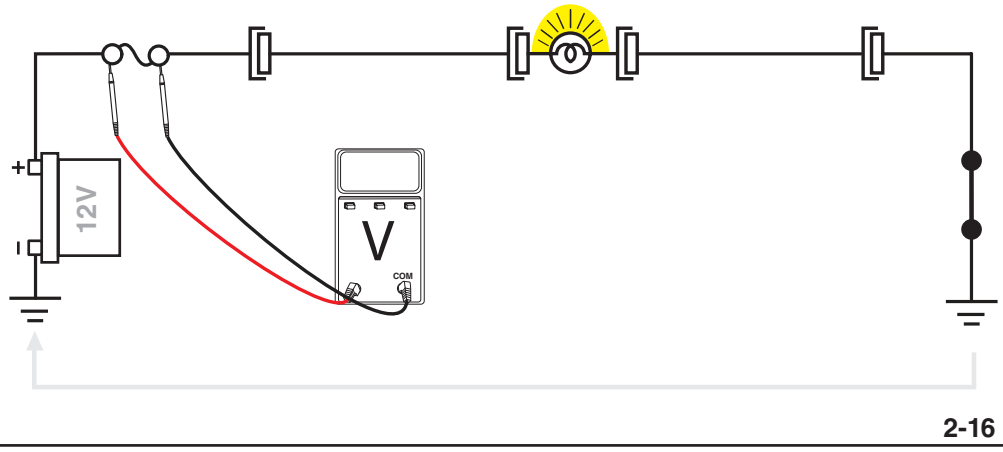
While the circuit is energized, measure both sides of the fuse from the exposed inspection contacts to the body/chassis ground.

Expected Voltage @ A: **Fuse Good** _____ **Fuse Blown** _____ **Expected Voltage @ B:** **Fuse Good** _____ **Fuse Blown** _____	

Potential voltage comparison

OR

While the circuit is energized, measure across both sides of the fuse from the exposed inspection contacts.

Expected Voltage: **Fuse Good** _____ **Fuse Blown** _____	

Voltage drop across the fuse

- If the fuse is **not** blown then no short to ground exists on the power supply side of the circuit. *Proceed to Step 2.*
- If the fuse **is** blown, then a short to ground may exist on the power supply side of the circuit. *Proceed to Step 9.*

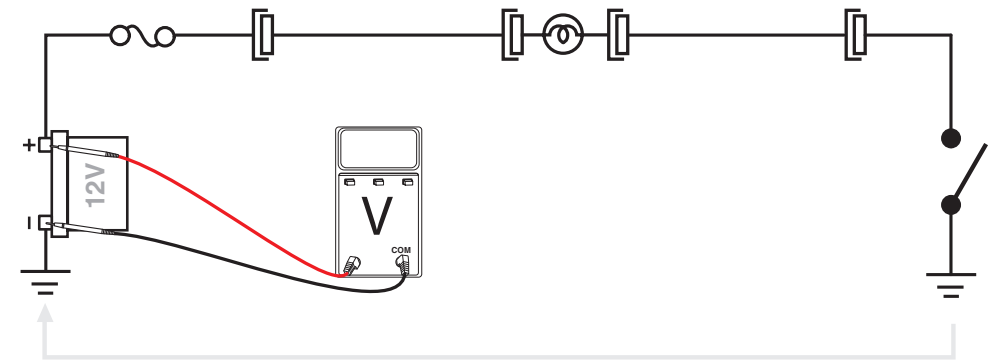
Step 2 Measure “Source Voltage” at the battery

Measure Power Supply voltage across the positive and negative terminals of the Vehicle’s battery.

- This measurement is used as a basis of comparison for power supply voltage at other points in the circuit. Proceed to Step 3.

Standard automotive battery voltage:

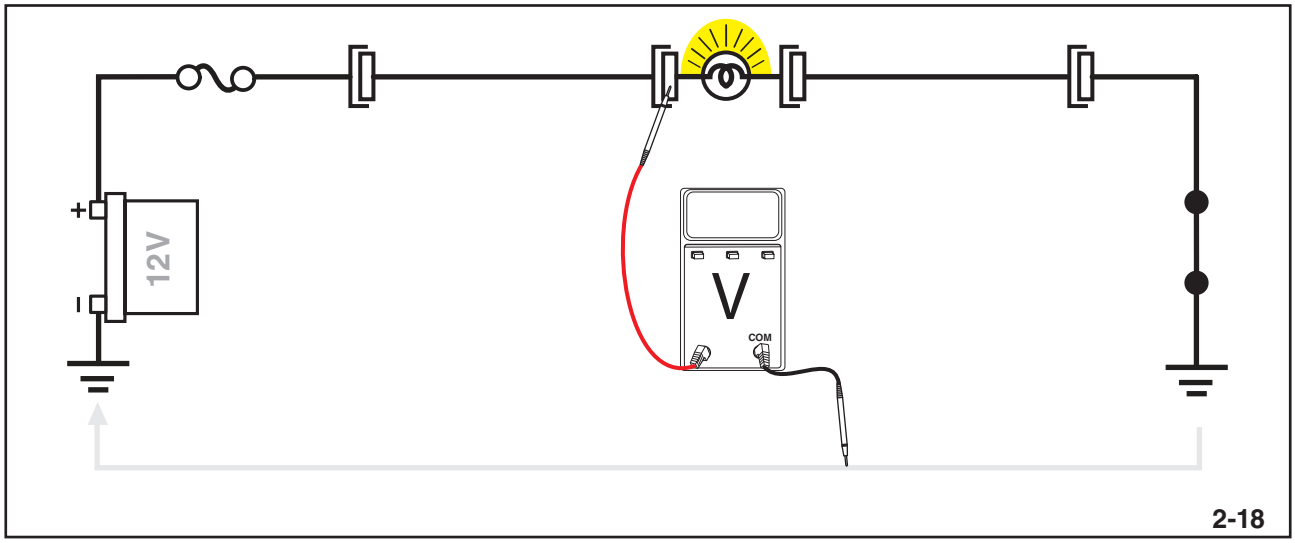
_____ V



Source voltage

Step 3: Measure "Available Voltage" at the load device

While the circuit is energized, measure available voltage between the power supply and the body/chassis ground.



Available voltage before the load device

- If the measured voltage is **within** 0.2V of the power supply/battery voltage, the power supply side is normal. Proceed to Step 4.
- If the measured voltage is 0V then an open circuit may exist on the power supply side. Proceed to Step 5.
- If the measured voltage is greater than 0.2V less than power supply/battery voltage then excessive voltage drop may be present on the power supply side. *Proceed to Step 7.*

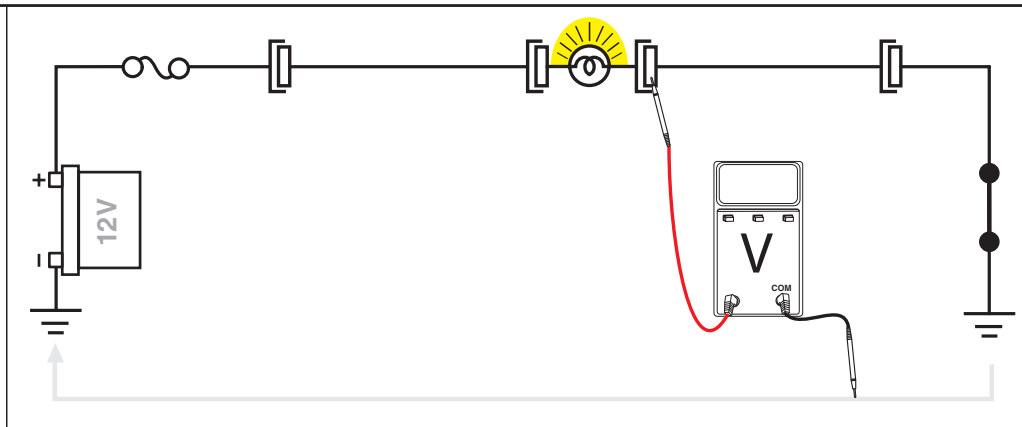
Note: When using Service Manual diagnostic trouble trees, the technician may be asked "is the voltage 10V or more?" This is often a minimum operating voltage for circuits. However, actual measured voltage should be similar to that measured at the battery power supply.

Step 4: Measure Voltage at the Ground Side of the Load Device

While the circuit is energized, measure voltage between the ground side of the load device and the body/ chassis ground.

Expected Voltage:

_____



Voltage after the load device

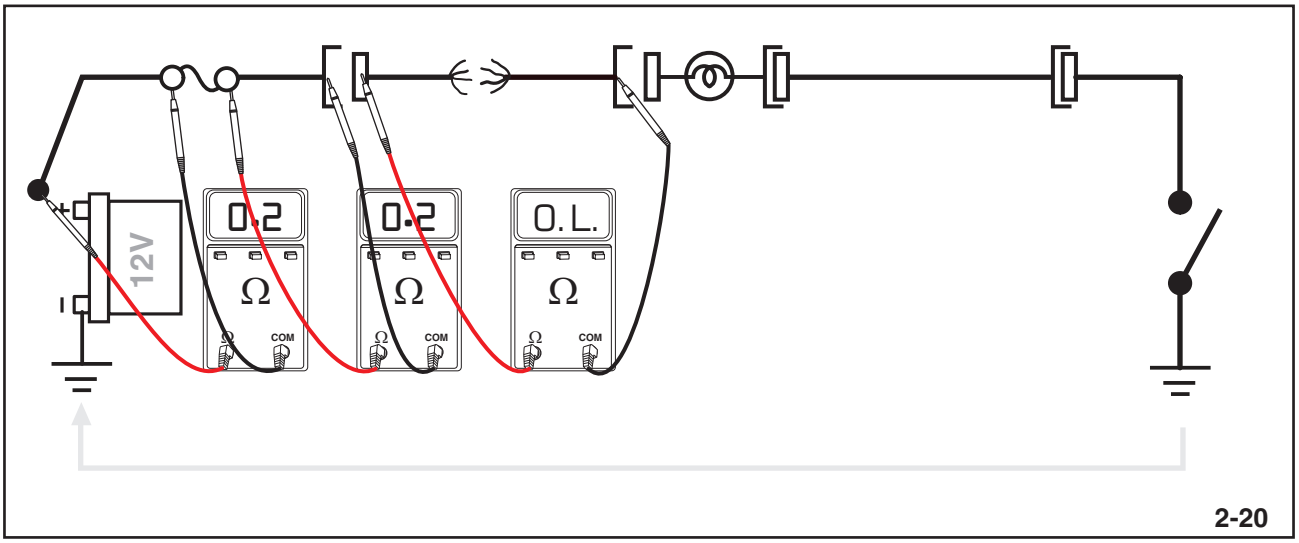
- If the measured voltage is 0.2V or less, then the total voltage drop across the load device is the same as source voltage. The ground side of the circuit is normal. If a symptom still exists please consult STIS for individual load device inspections.

NOTE: Amperage Diagnostics may also be used to identify a load device that is creating an excessive or below normal amperage draw.

- If the measured voltage is the same as the power supply/battery voltage, then an open may exist on the Ground Side. Proceed to Step 6.
- If the measured voltage is more than 0.2V then excessive Voltage Drop/high resistance may exist on the Ground Side of the circuit. *Proceed to Step 8.*

Step 5: Inspect for an Open Circuit on the Power Supply side of the Load Device/Fuse

After disconnecting the Power Supply, (Isolate the circuit) measure resistance between each segment of the Power Supply side of the circuit.

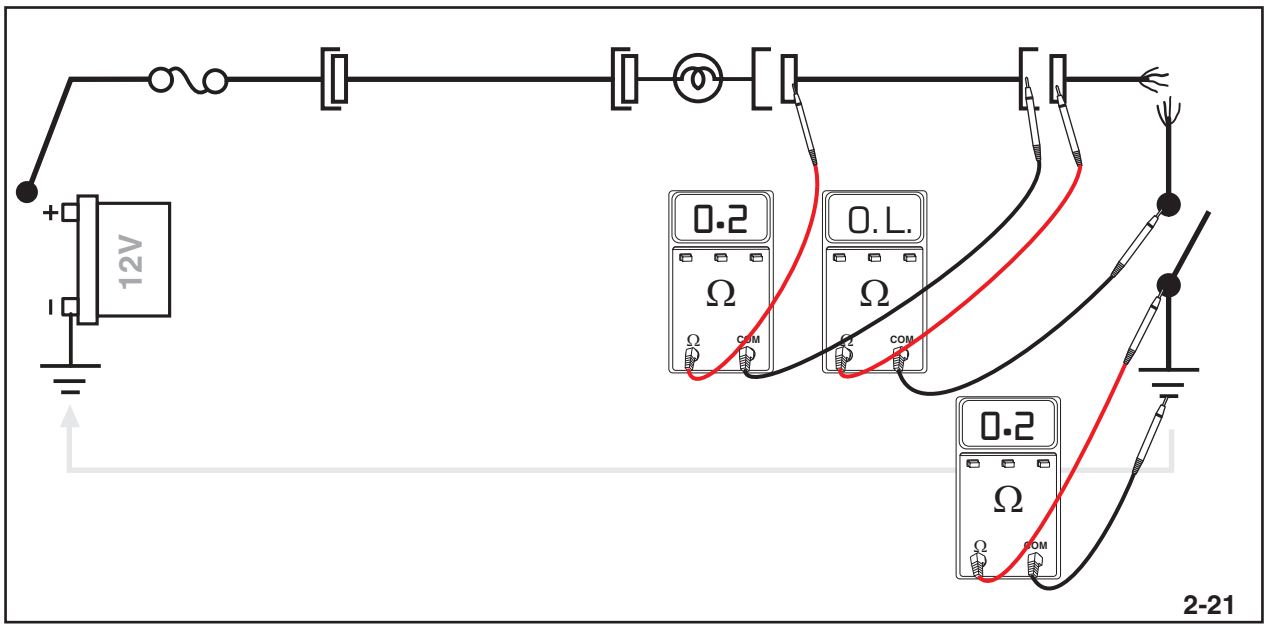


Continuity measurements (Power side)

- If the measured resistance is less than 1Ω, the segment is normal.
- If the measured resistance is “infinite” or greater than 1MΩ (O.L.), the segment is considered open. Repair or replace the segment as necessary.
- If the measured resistance is greater than 1Ω, but less than 1MΩ, the circuit is considered to have poor contact or excessive voltage drop. Repair or replace the segment as necessary.

Step 6: Inspect for an Open Circuit on the Ground Side of the Load Device

After disconnecting the Power Supply, (Isolate the circuit) measure the resistance between each segment of the Ground side of the circuit.

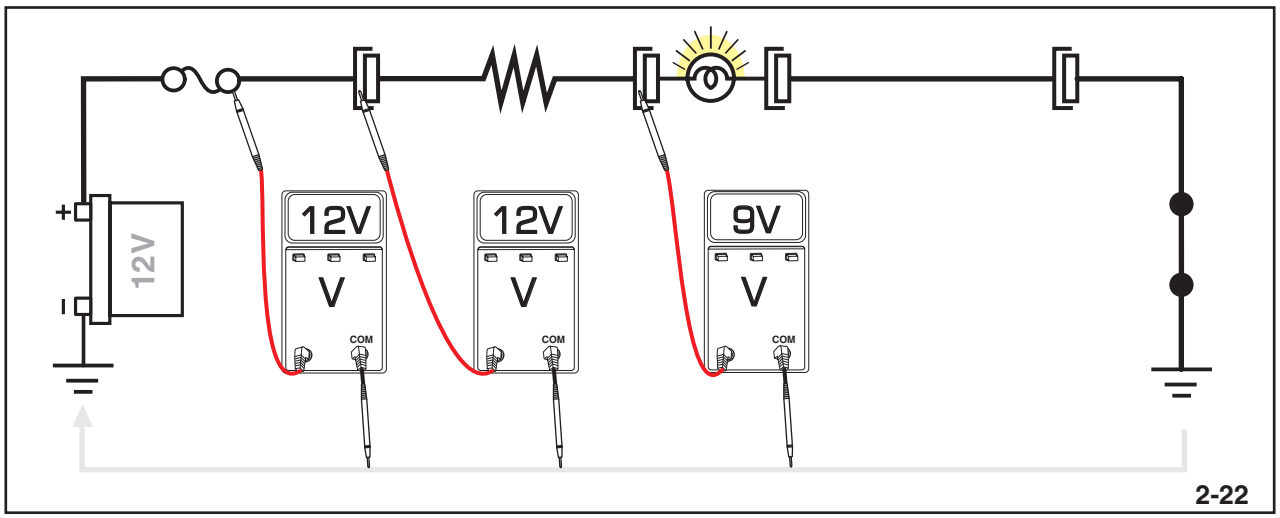


Continuity measurements (Ground side)

- If the measured resistance is infinite/greater than 1 MΩ (O.L.), the circuit is considered to be open. Repair or replace the segment as necessary.
- If the measured resistance is greater than 1Ω, but less than 1MΩ, the circuit is considered to have poor contact or excessive voltage drop. Repair or replace the segment as necessary.

Step 7: Inspect for an excessive Voltage Drop on the Power Supply side of the Load Device

While the circuit is energized, measure voltage from each segment of the Power Supply side of the circuit to the body/chassis ground.

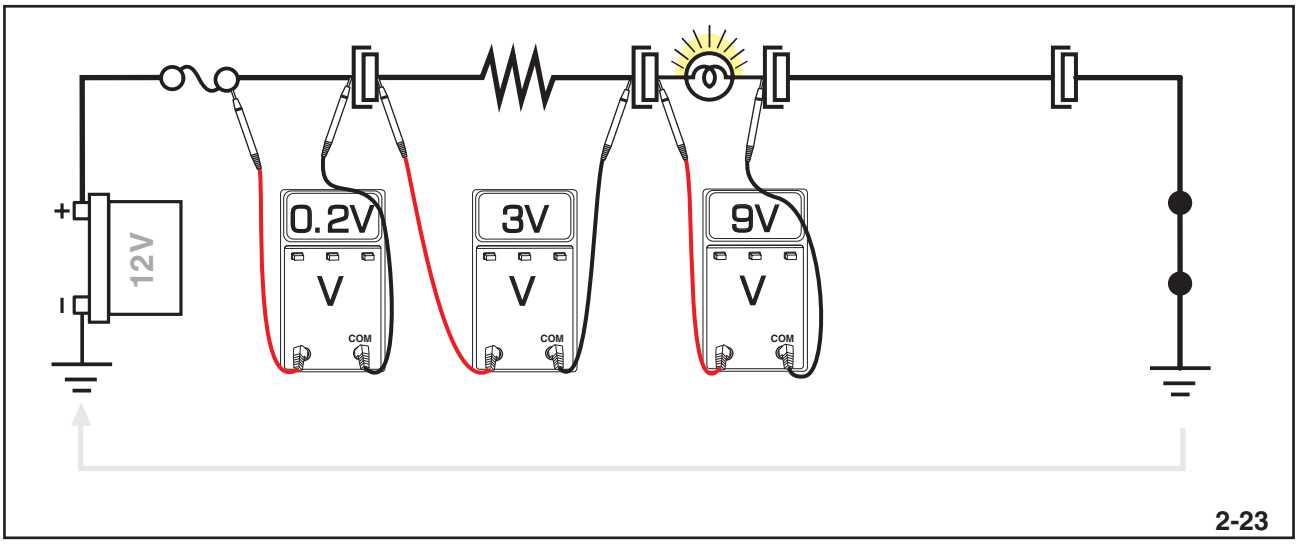


Voltage drop pressure to ground (Powerside)

- A failure exists in the segment where the measured voltage drops more than 0.2V below the supply/battery voltage. *Repair or replace the segment as necessary.*

OR

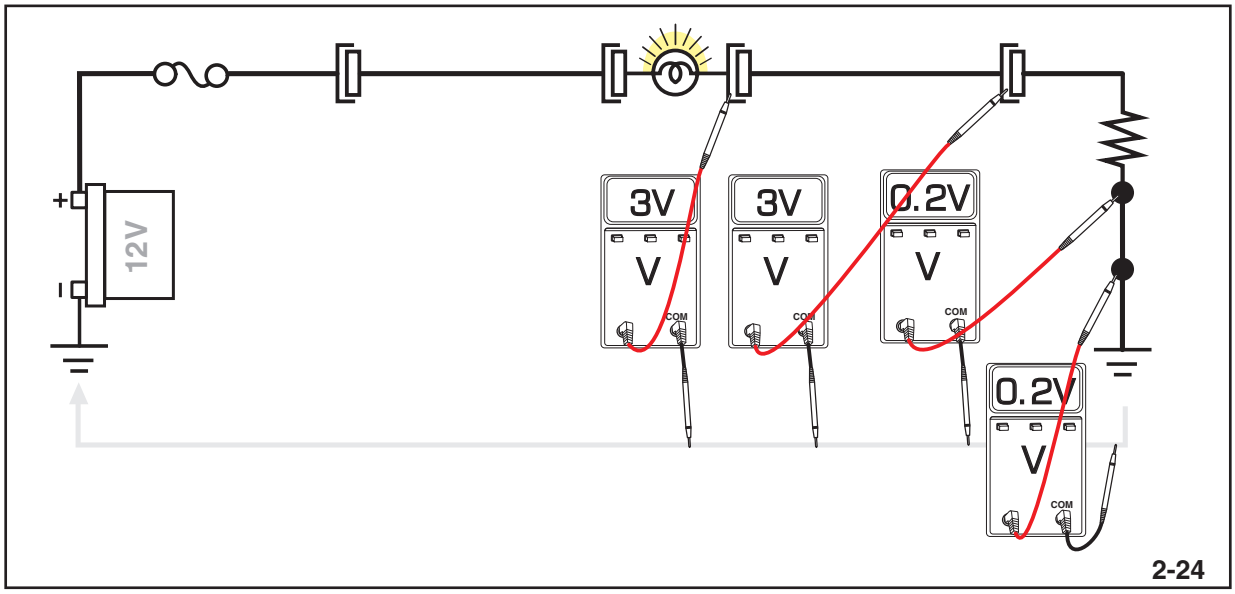
While the circuit is energized, measure the voltage **Across** each segment of the Power Supply side of circuit



Voltage drop across Power supply

Step 8: Inspect for excessive Voltage Drop on the Ground side of the Load Device

While the circuit is energized, measure voltage from each segment of the Ground side of the circuit to the body/chassis ground.

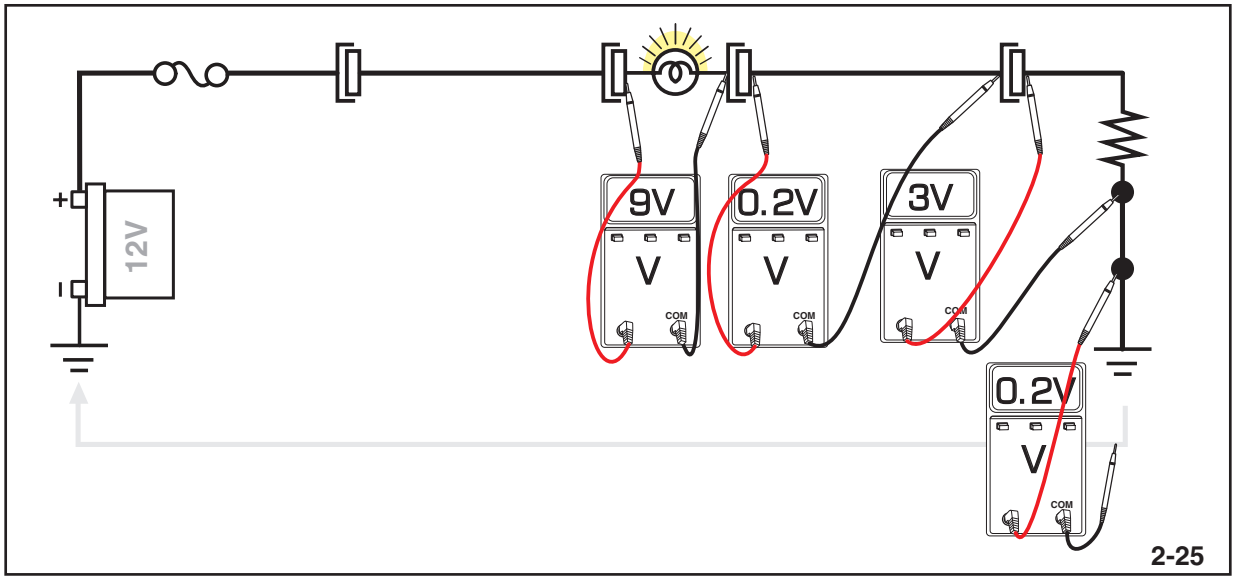


Voltage drop measuerment (Ground side)

- A failure exists in the segment where the measured voltage drops to 0.2V. Repair or replace the segment as necessary.

OR

While the circuit is energized, measure the voltage **Across** each segment of the Power Supply side of circuit

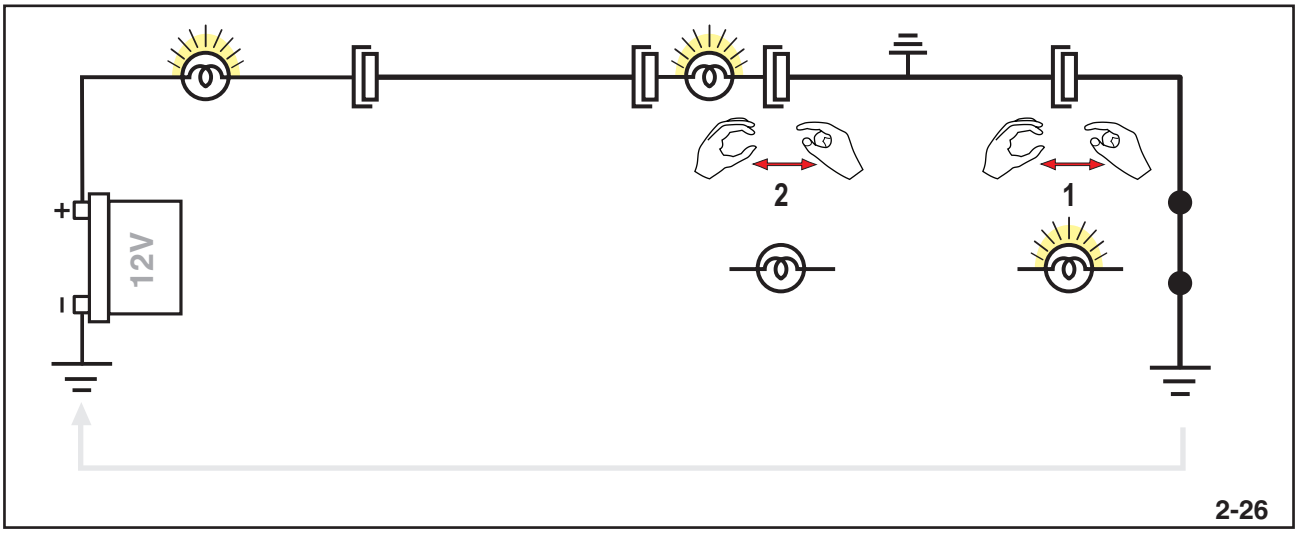


Voltage drop measuerment (Power side)

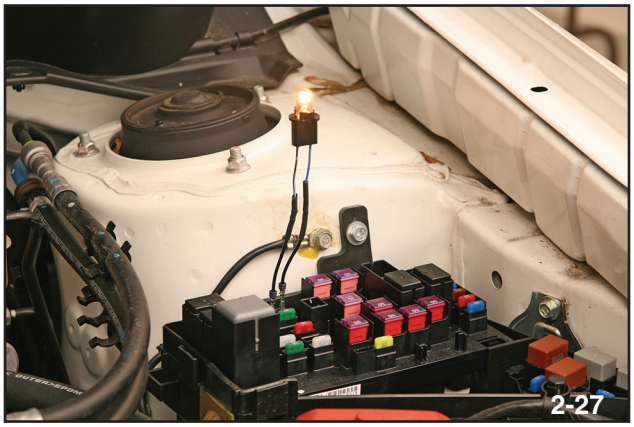
Step 9: Inspect for a Short to Ground on the Power Supply Side of the Load Device

Using a 3 Watt Light Bulb (For circuits with conventional load devices)

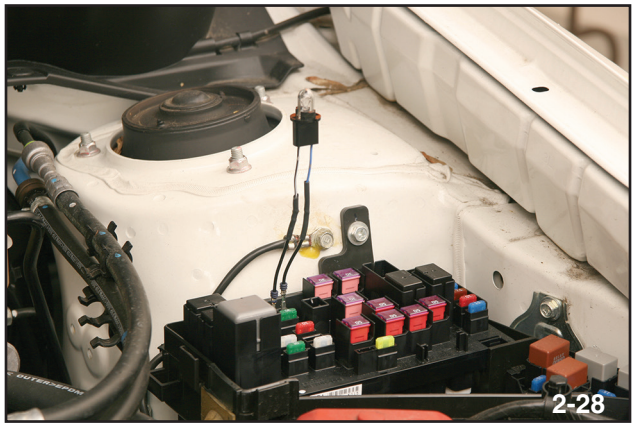
Connect a 3 Watt light bulb in place of a blown fuse to allow current to flow through the circuit. Disconnect one connector at a time beginning with the connector furthest from the power supply.



Short to ground inspection (Conventional loads)



3 watt bulb illuminated



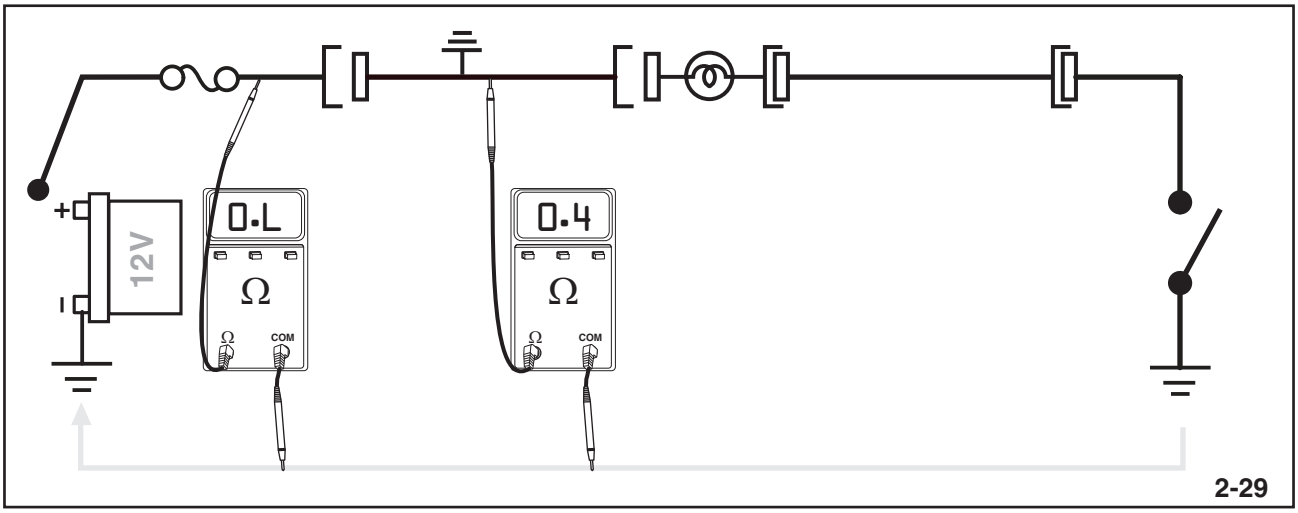
3 watt bulb off

- If the 3 Watt light bulb goes out when a connector is disconnected, then a ground path exists in that segment of the circuit.

OR

Using resistance measurements (For circuits with delicate load devices)

After disconnecting the Power Supply, measure the resistance between each segment of the Ground side of the circuit and the body/ chassis ground.



Short to ground (Delicate loads)

- If the measured resistance is infinite / Greater than 1MΩ (O.L.), the circuit has no path to a ground source and is considered normal.
- If the measured resistance is less than 1Ω, then an untended path to ground exists. Repair or replace the segment as necessary.

Intermittent Faults

Intermittent faults can be extremely difficult to locate even when employing the Split-half technique. A detailed account of the conditions surrounding the failure should always be documented from the customer.

Items such as switches, connectors, and solid state devices (modules) may be susceptible to temperature, vibration, or vehicle movement fluctuations. Extreme temperatures may cause expansion or contraction of critical internal components. Marginal connections may be compromised by mechanical influences such as suspension jouncing or other vehicle movements. Any of these conditions may produce opens, shorts, or high resistance. In these circumstances, the employment of the following strategies maybe beneficial.

- Use a heat gun or hair dryer to gently heat a component or connection to simulate a severe environmental condition.
- Mist water on a malfunctioning component to create a cooling effect.

  NOTE: Do not mist components that are not waterproofed as damage may occur.

- Use a component cooler to cool solid state devices (modules).

  NOTE: Do not use refrigerant or other harmful chemicals to cool components.

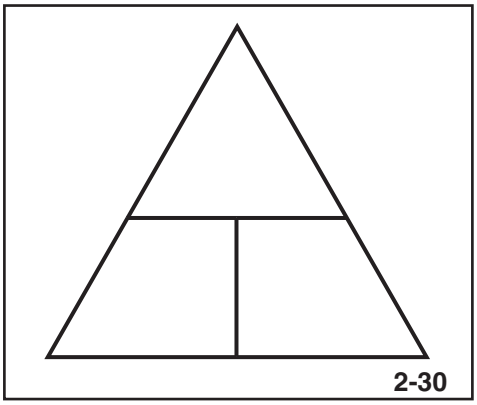
- Use jumper leads to bypass segments of a circuit to eliminate mechanical movements.

  NOTE: Never bypass fuses or circuit breakers.

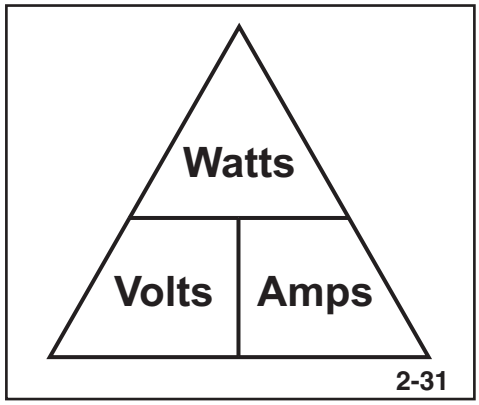
Amperage Diagnostics

Using amperage measurements can serve as an efficient diagnostic technique when paired with the principles of Ohms' and Watt's Laws. Whereas most voltage and resistance based diagnostics require the subject circuit to be de energized, amperage measurements provide a dynamic evaluation of a circuits ability to operate.

Activity: Recall Ohms law:



Ohm's law



Watt's law

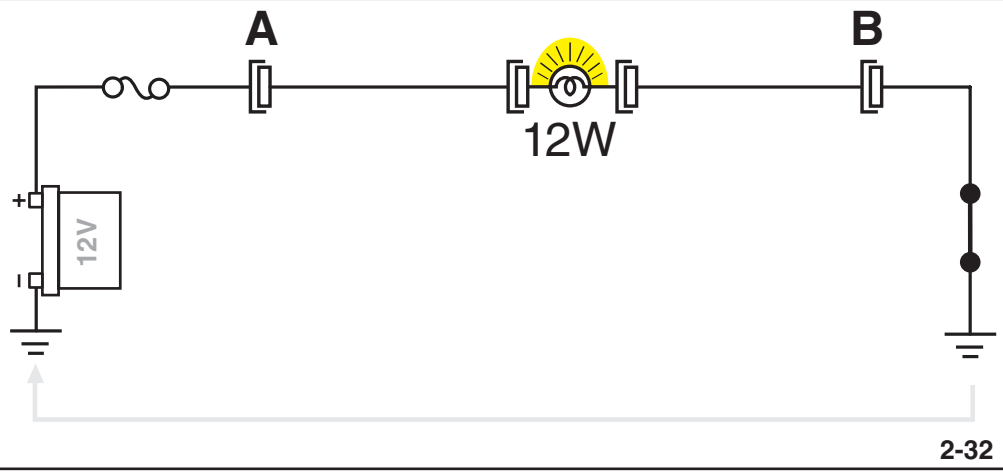
One of the first steps in using amperage measurements to diagnose a circuit is to calculate or estimate the expected amperage in the circuit.

Activity: Calculate the amperage values at the points below:

Expected Amperage:

Point A: _____

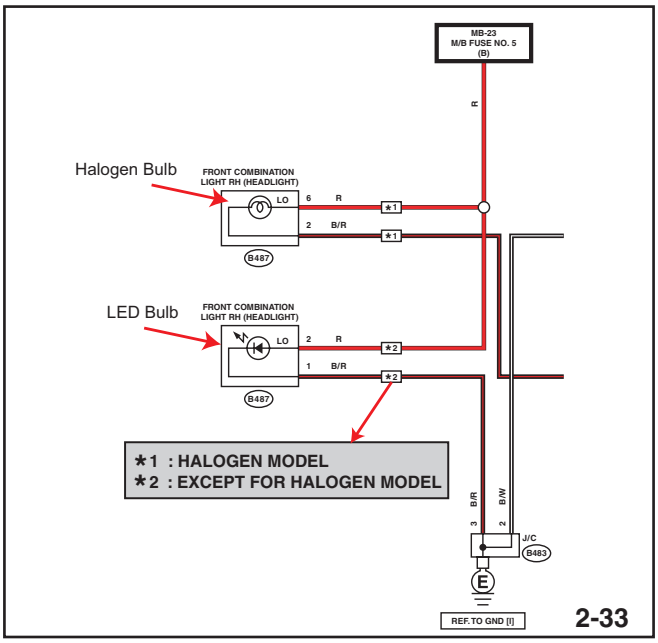
Point B: _____



Amperage calculation

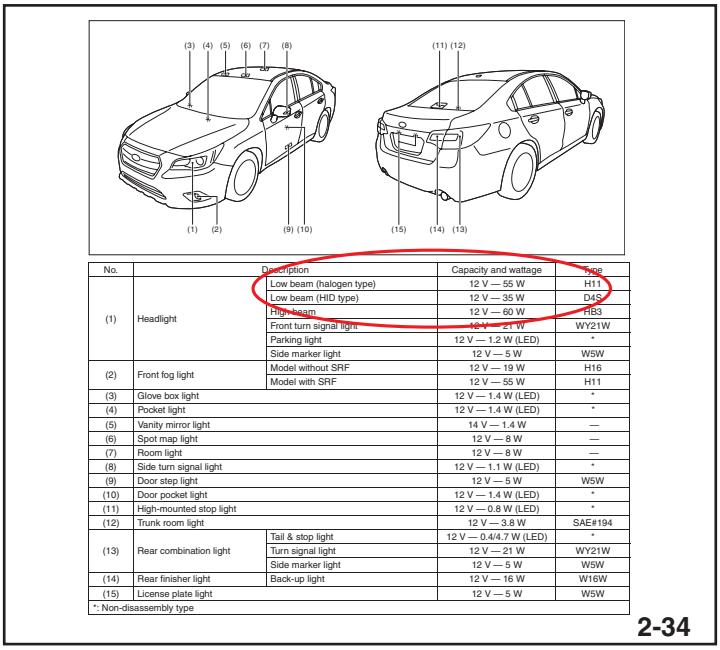
When inspecting amperage it is important to correctly identify the type of load device being diagnosed. In this example, a technician is attempting to diagnose a Front Combination Light RH (Headlight).

Note: Always pay attention to the *1 and *2 as they relate to comments on the bottom of the wiring diagram page. Additionally, the symbols for each in the diagram are reflective of the type of bulb used.



Headlight bulb circuit

Information about type of bulb found in the wiring diagram can be cross referenced for the capacity and wattage. This is found in the Lighting System section of the Subaru Service Manual.



No.		Description	Capacity and wattage	Type
(1)	Headlight	Low beam (halogen type)	12 V — 55 W	H11
		Low beam (HID type)	12 V — 35 W	D4S
		High beam	12 V — 60 W	HB3
		Front turn signal light	12 V — 21 W	WY21W
		Parking light	12 V — 1.2 W (LED)	*
		Side marker light	12 V — 5 W	W5W
(2)	Front fog light	Model without SRF	12 V — 19 W	H16
		Model with SRF	12 V — 55 W	H11
(3)	Glove box light		12 V — 1.4 W (LED)	*
(4)	Pocket light		12 V — 1.4 W (LED)	*
(5)	Vanity mirror light		14 V — 1.4 W	—
(6)	Spot map light		12 V — 8 W	—
(7)	Room light		12 V — 8 W	—
(8)	Side turn signal light		12 V — 1.1 W (LED)	*
(9)	Door step light		12 V — 5 W	W5W
(10)	Door pocket light		12 V — 1.4 W (LED)	*
(11)	High-mounted stop light		12 V — 0.8 W (LED)	*
(12)	Trunk room light		12 V — 3.8 W	SAE#194
(13)	Rear combination light	Tail & stop light	12 V — 0.4/4.7 W (LED)	*
		Turn signal light	12 V — 21 W	WY21W
		Side marker light	12 V — 5 W	W5W
(14)	Rear finisher light	Back-up light	12 V — 16 W	W16W
(15)	License plate light		12 V — 5 W	W5W

*: Non-disassembly type

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Bulb reference chart

Activity: **Calculate the amperage for the Halogen type bulb circuit below:**

Source Voltage:

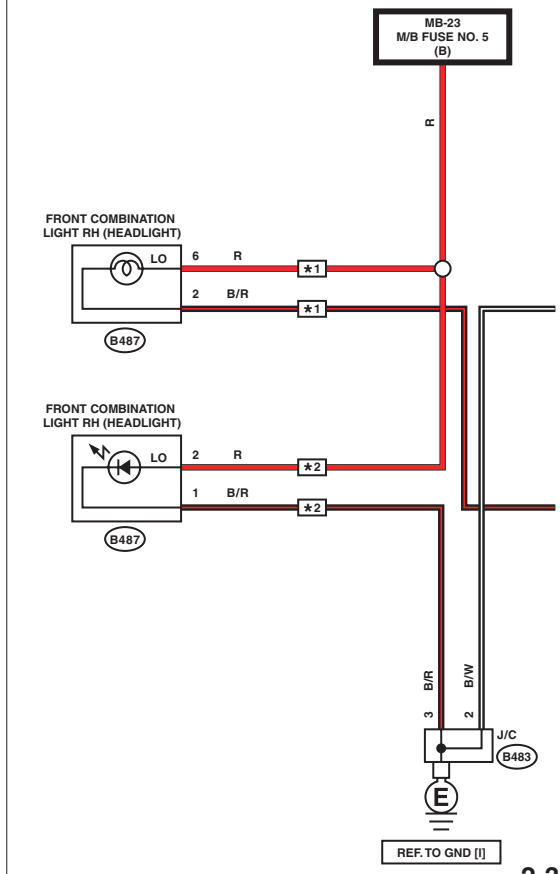
_____

Blub Wattage:

_____

Expected Amperage:

_____



Headlight bulb amperage calculation

If the wattage of a component is not provided it is still possible to estimate a circuit's amperage using a resistance value or comparison circuit. As per Ohm's Law, if voltage remains constant and resistance increases then the amount of amperage that flows through the circuit will decrease.

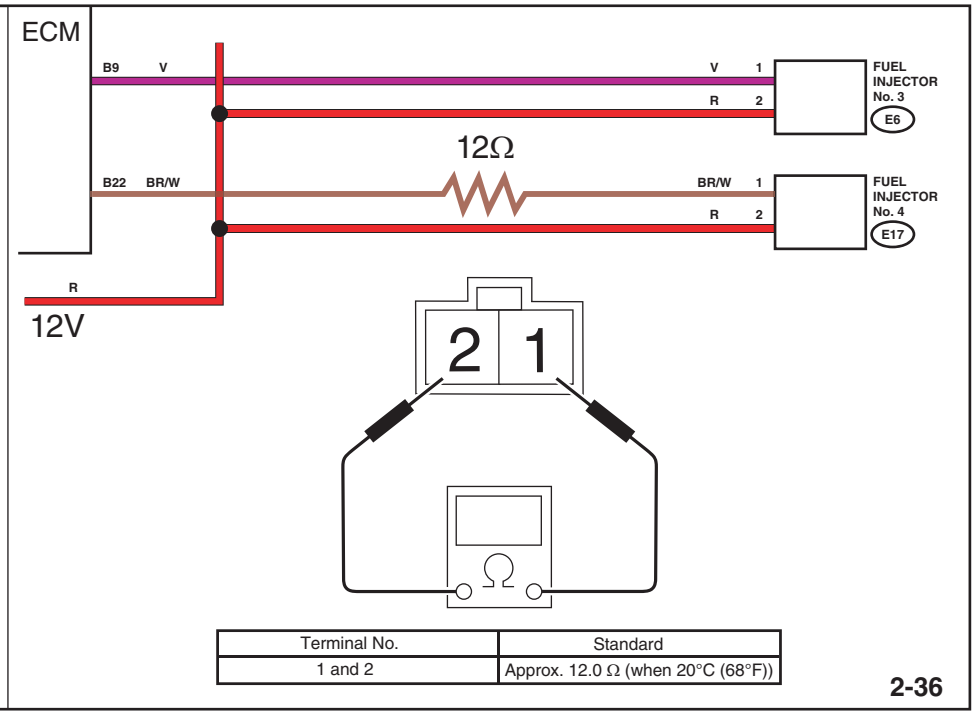
Activity: Calculate the amperage for the injector circuits below:

Injector No. 3 circuit amperage:

_____

Injector No. 4 circuit amperage:

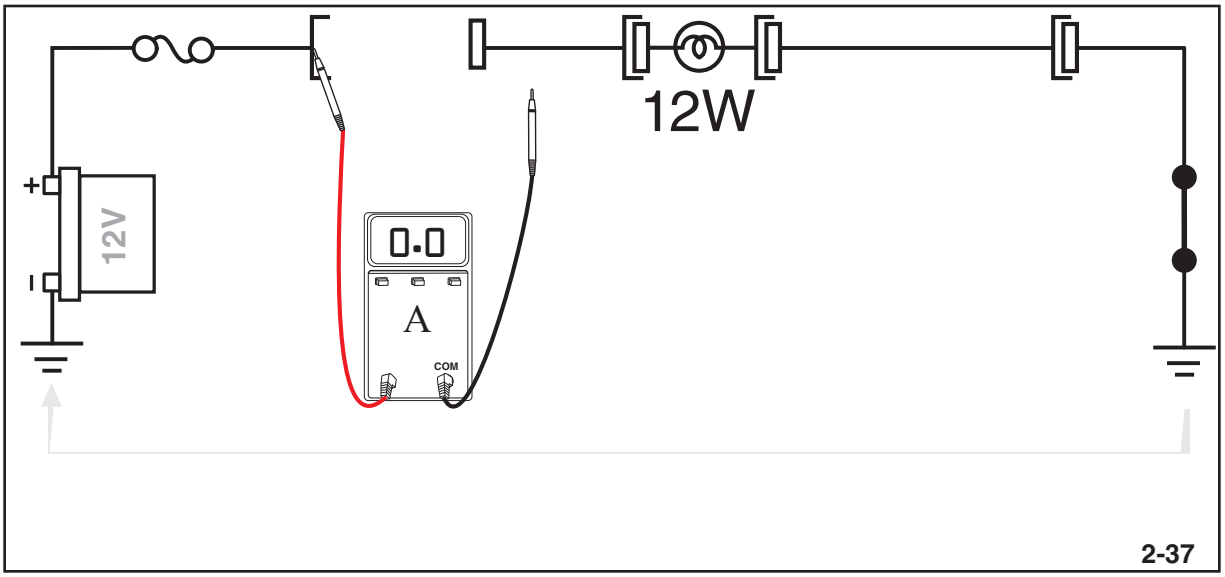
_____



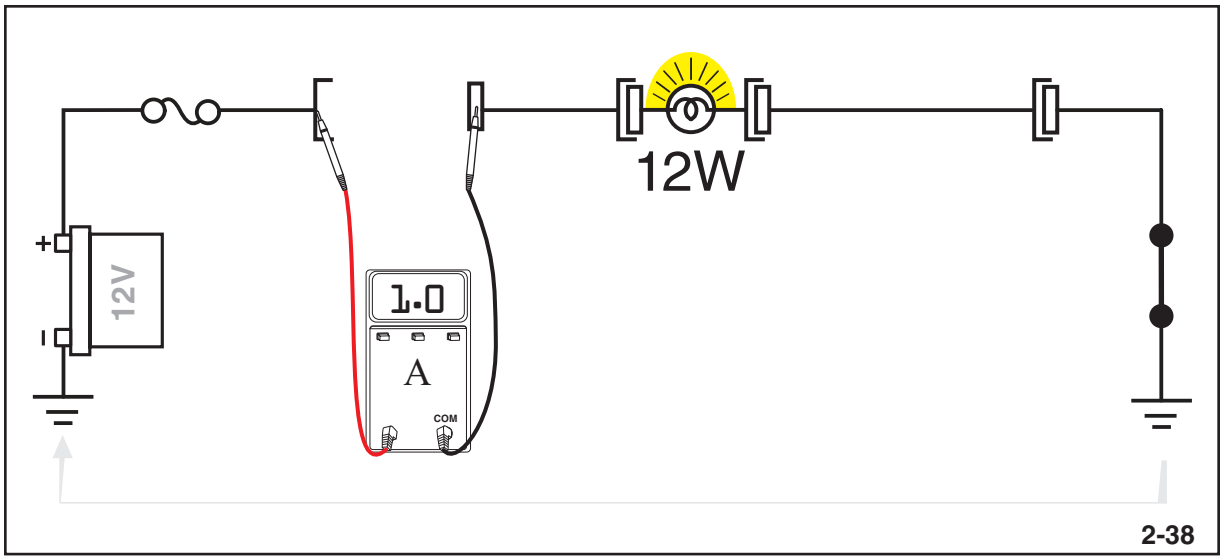
Injector circuit amperage calculation

Inductive Amperage Clamp (Amp Clamp)

The challenge when performing amperage measurements is the necessity to connect an ammeter in series with the subject circuit.



Circuit prepared for amperage measurement

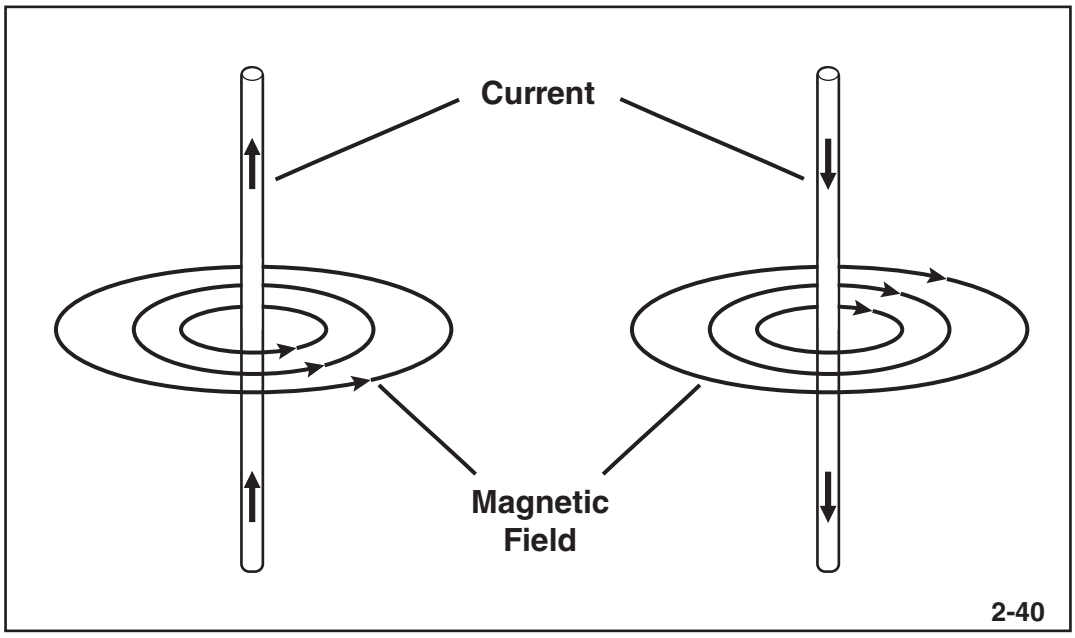


Conventional ammeter connection

While this may be possible on simpler circuits, most circuits are routed through larger connectors with numerous terminals. This makes creating a clean break in the circuit without affecting other systems extremely difficult. In these instances, an inductive amperage clamp provides a convenient solution.

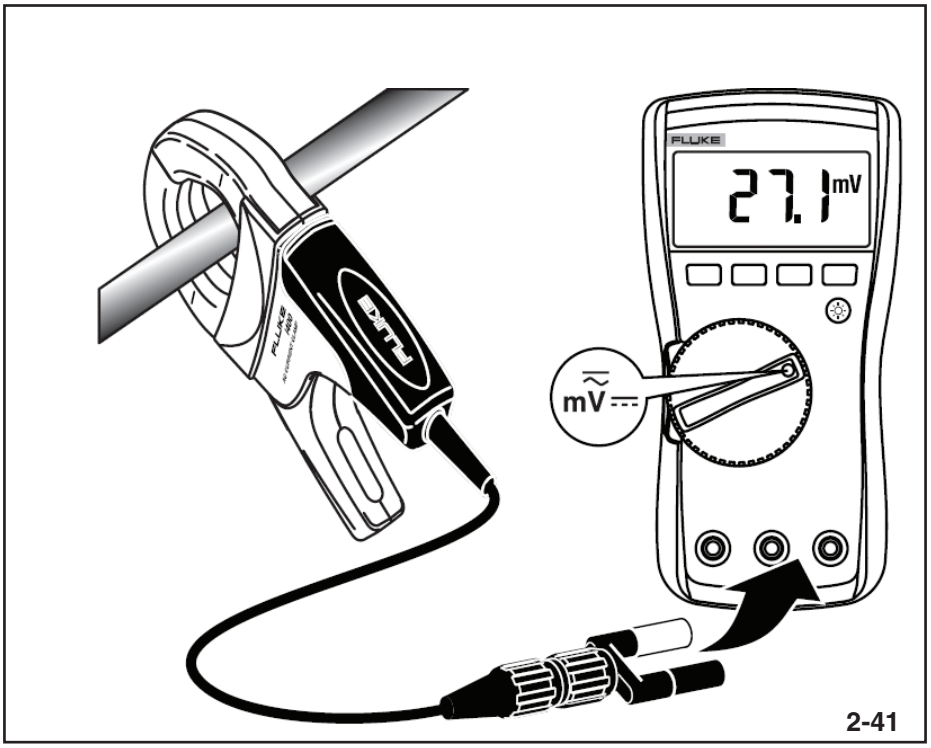
Inductive amperage clamp

An inductive amperage clamp measures the magnetic field created around a conductor as current flows. As amperage flow increases through the conductor, the magnetic field becomes more intense. Additionally, the direction of current flow dictates the direction of the induced magnetic field. This is critical in obtaining an accurate reading as most inductive amperage clamps have an arrow that must coincide with the direction of current flow.



Magnetic field direction in relation to current flow

The inductive amperage clamp measures the intensity of the generated magnetic field and converts in into a voltage output. This output can be measured using a DVOM. Always verify the amperage to voltage conversion on the amp clamp in use as many varieties exist.



Inductive amperage clamp conversion

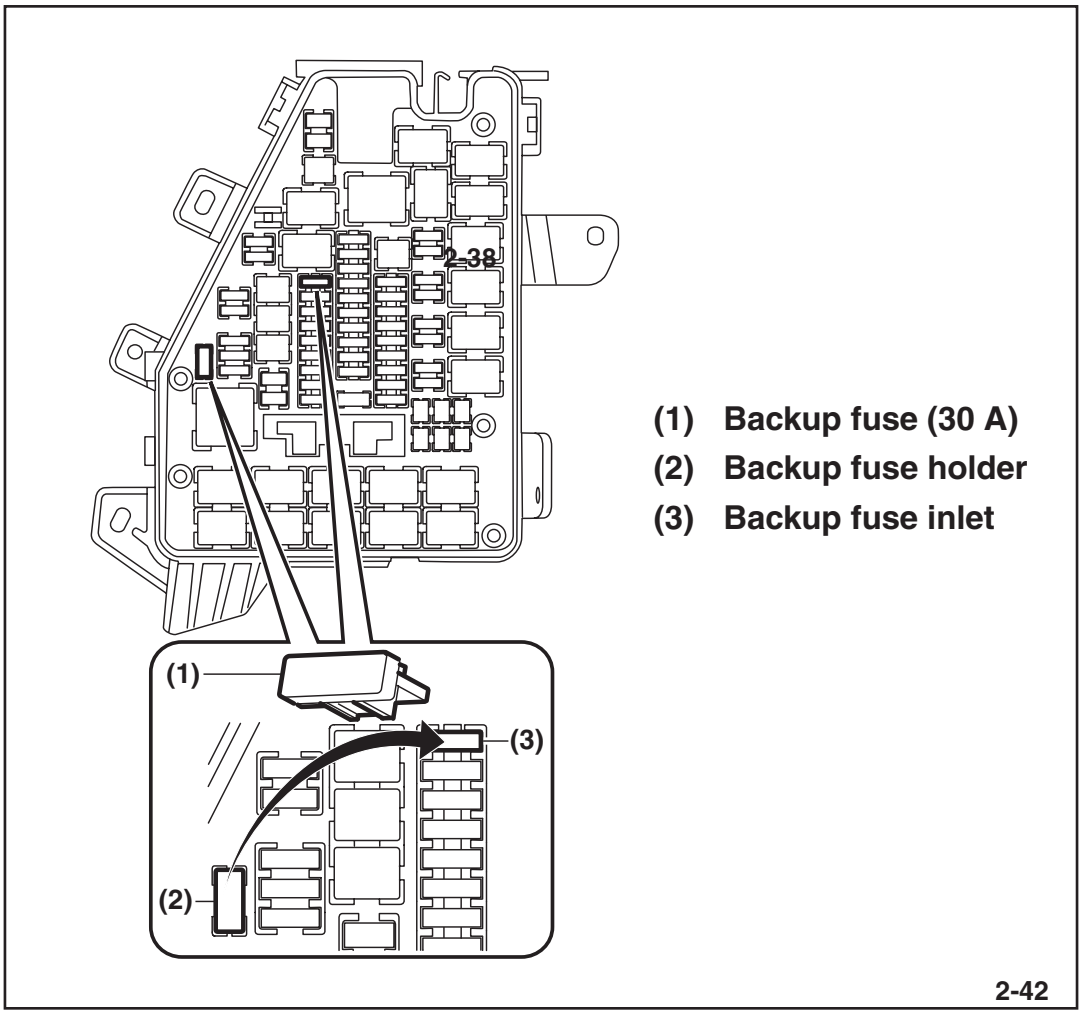
Dark Current (Parasitic Draw) Diagnostics

Amperage diagnostics can also be used to identify dark current (also referred to as parasitic draw) on the vehicle. Dark current occurs when components or circuits on the vehicle create unintentional and excessive amperage draws when the vehicle is not in operation. Over time this excessive draw can cause a low battery charge resulting in no-start conditions.

Dark Current Test Preparation

In preparation for a dark current inspection the following should be performed/confirmed;

1. Ensure the vehicle battery is fully charged. Connect the GR8 to the battery if charging is required or replace if found necessary.
2. The battery terminals are free of corrosion, dirt, or sealing products.
3. Record all radio pre-sets and navigation system favorites (if applicable). Under no circumstances should an aftermarket memory retention device be used.
4. Inspect for any non-Subaru genuine electrical accessories that may be installed in the vehicle.
5. Install the back-up power supply fuse and using the Subaru Select Monitor ensure the Body Integrated Unit (BIU) is set to “Market Mode”.



Back-up fuse installation

6. **Start the engine**, and then set each of the listed systems to the positions shown below;

System	Position
Headlight	ON or Auto
Fog light	ON
Wiper (front and rear)	ON or Low speed
Audio and navigation system	ON
Rear defogger	ON
Room light	DOOR
Luggage light	DOOR
Map light	OFF
Auto A/C	ON (AUTO)
Manual A/C	ON (Speed 1)
Electronic parking brake	ON
Electrical parts other than listed above (electrical parts that users can confirm the operation with the key removed)	OFF

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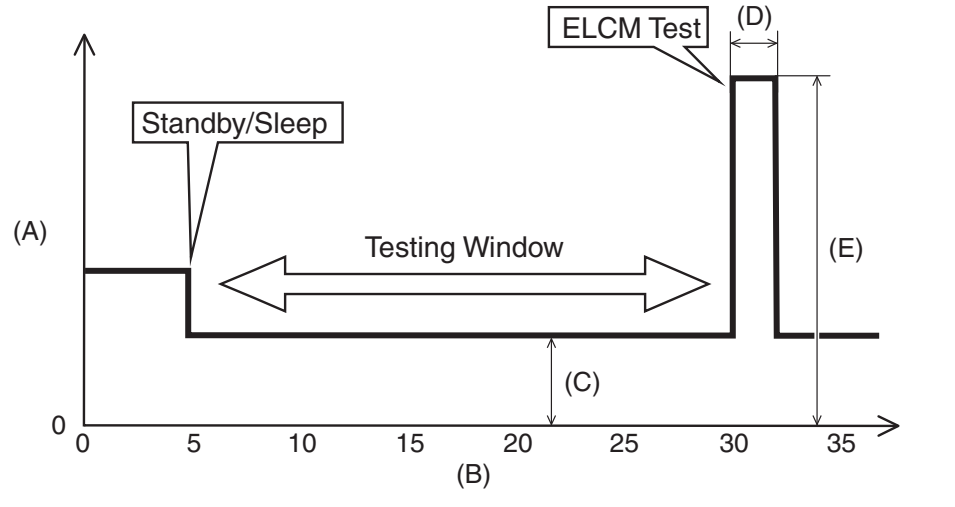
System preparations

7. Turn the ignition switch to the OFF position
8. Open the hood
9. Close all doors (including the rear gate or trunk lid) and then lock the doors (security system)
   a. On Keyless Access Control (KAC) vehicles, the immobilizer key must be placed at least 10 feet from the vehicle until testing is completed
10. Allow 5 minutes for the electrical system to stabilize (standby/sleep)

Note: Testing must be performed within 20 minutes of the vehicle entering standby/sleep mode. After approximately 20 minutes, the Evaporative Leak Check Module (ELCM, if equipped) may begin testing and will cause invalid results.



(A) Current/mA
(B) Time/min
(C) Less than 70 mA
(D) 5 seconds (system operation
(E) 300 mA or more

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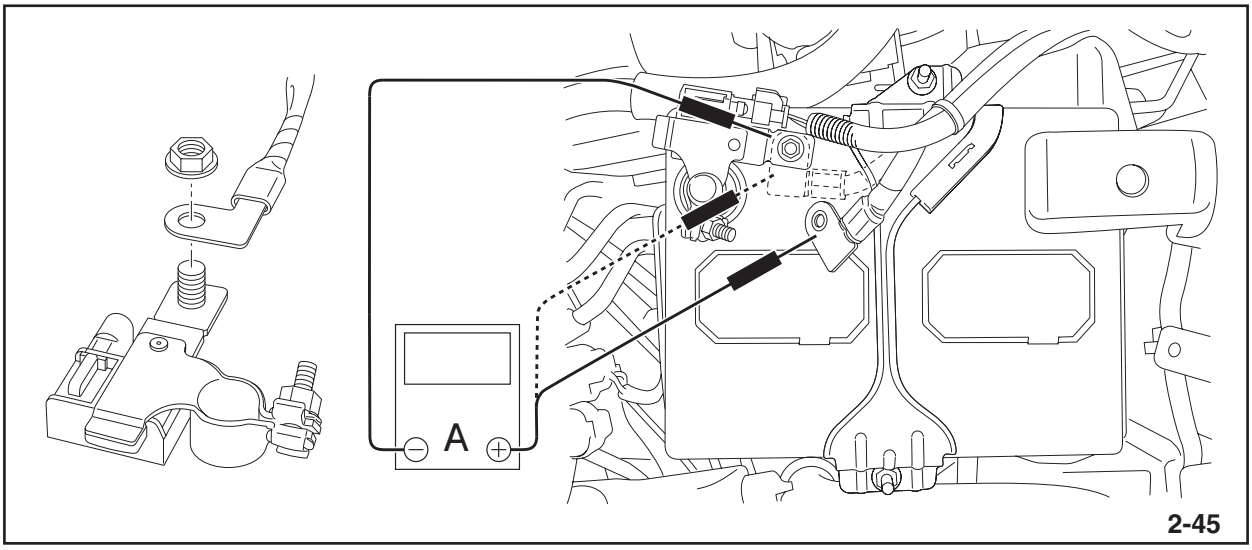
Dark current testing window

Performing the Dark Current Test

Performing a dark current measurement requires the use a DVOM than can detect 1 mA or less. The ammeter must be connected in series with the negative battery cable and the battery negative terminal while maintaining constant circuit integrity. Therefore, always connect the DVOM first before removing the negative battery cable from the battery negative terminal.



Dark current measurement

Depending on the vehicle dark current should not exceed 70-150 mA. If dark current is found to be above 70-150 mA, systematically remove fuses to isolate individual circuits. If a drastic drop in amperage is observed normal electrical diagnostic technniques should be employed.

NOTES:

NOTES:

Electrical Repairs

Wiring Repair

Electrical wiring repairs may be necessary to correct defects located as a result of a diagnostic procedure. The recommended repairs method on Subaru vehicles is to create wire unions using a solder joint. Solder is an alloy that is capable of being melted at relatively low temperatures (appx. 370°F) that can bond metal conductors. The solder is heated with a soldering iron to achieve the melting point and allow the alloy to flow into the conductor creating a solid bond when cooled.

Solders are identified by their percentages of formulation. The most commonly used for automotive repairs is a 60% Tin, 40% Lead mixture. Most solders also feature an integral Flux or Rosin core. The purpose of these chemical agents is to reduce dirt, oil, or other impurities at the site of the solder joint.

NOTE: Always consult STIS for details on prohibited repairs including, but not limited to SRS and High Voltage HEV systems.

Wiring repairs should not be attempted on any shielded, twisted, or coaxial type wires. In the event wires of these types are damaged, the replacement of the associated harness must be performed. Refer to section 8.4.19 Electrical Wiring Repairs of the Subaru Claims Policy and Procedure Manual for details pertaining to warranty eligibility and recommended repairs.

Common wiring repair tools

For most wiring repairs the following tools will be necessary:

1. Wire stripping tool
2. 30 watt minimum soldering iron with 1/8” – 5/32” (3-4mm) tip
3. 60/40 (tin/lead) rosin core solder with diameter of approximately 0.040” (1mm)
4. Heat-Shrink tubing of various sizes depending on wire gauge
5. Heat gun, variable temperature

Precautions

1. Work in a well-ventilated area.
2. Wear proper eye and skin protection.
3. Ensure battery negative cable is disconnected before attempting any electrical repairs.
4. Keep hot irons and heat guns away from combustible materials.

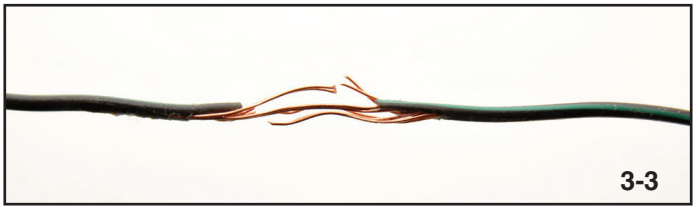
Wiring Repair Procedure

Inspect connectors and terminals for:

- Loose, bent, or broken terminals
- Cracked or damaged connector housings/locks
- Missing or torn seals/water proofing
- Corrosion

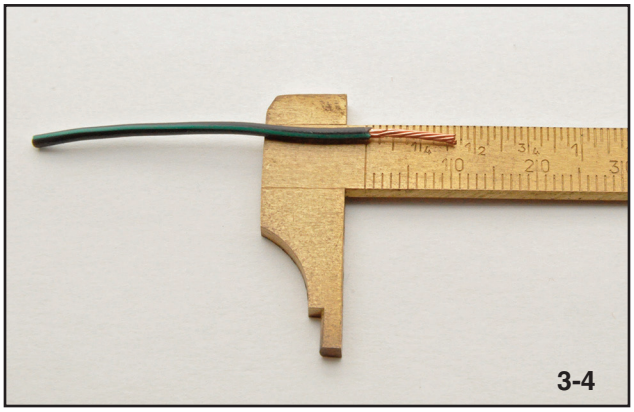
In the event that a damaged terminal is identified, please utilize repair terminals from the Harness Repair Kit (Part # J-47606).

1. Locate defective wiring using the Six-step trouble shooting method.

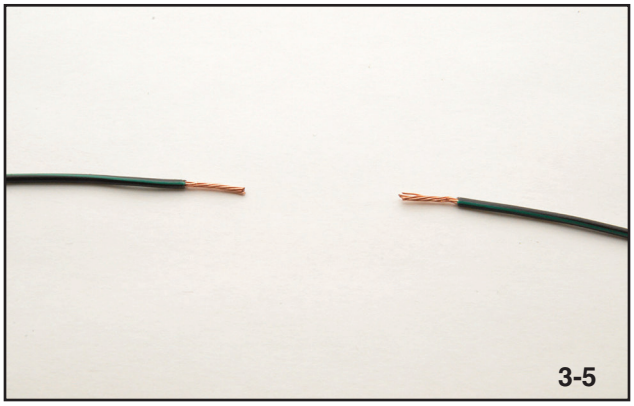


Defective wiring

2. Remove the damaged segment of wire minimizing wire length loss. Strip and remove 10mm of the protective sheathing from each side of the remaining harness. Twist the exposed conductor strands.

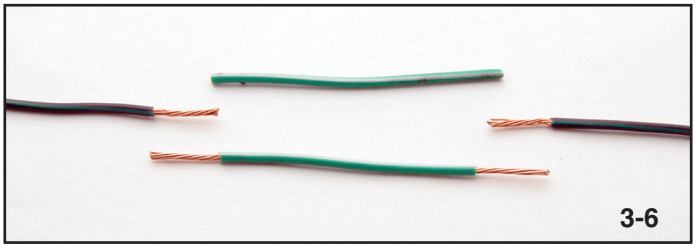


10mm stripped



Prepared wiring

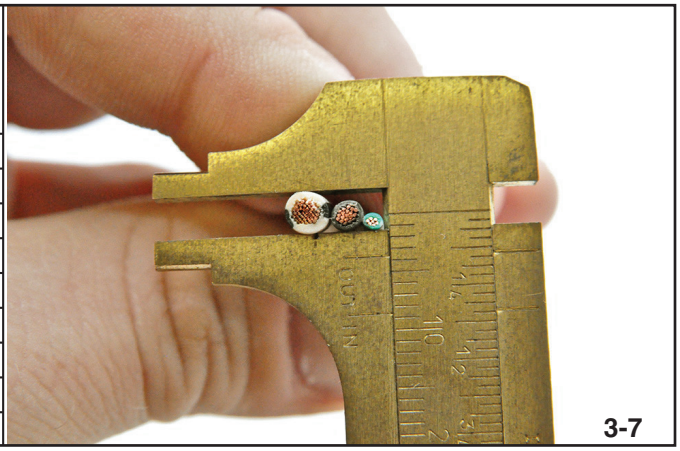
3. Create a replacement segment from generic automotive wire that is 20mm longer than the removed section. Strip and remove 10mm of the protective sheathing from each side of the replacement segment. Twist the exposed conductor strands.



Replacement segment

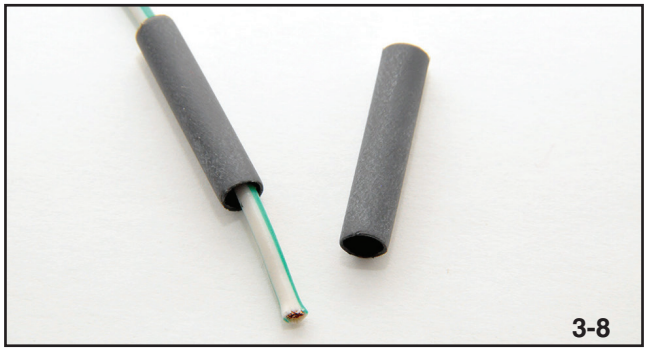
Note: Ensure the replacement segment is the same gauge (AWG) as the removed section as to not exceed allowable amperage ratings.

Nominal sectional area mm^2	No. of strands/ strand diameter	Outside diameter of wiring mm	Allowable current Amps/ 40°C (104°F)
0.3	7/0.26	1.8	7
0.5	7/0.32	2.2 (or 2.0)	12
0.75	30/0.18	2.6 (or 2.4)	16
0.85	11/0.32	2.4 (or 2.2)	16
1.25	16/0.32	2.7 (or 2.5)	21
2	26/0.32	3.1 (or 2.29)	28
3	41/0.32	3.8 (or 3.6)	38
5	65/0.32	4.6 (or 4.4)	51
8	50/0.45	5.5	67



Wire gauges

4. Prepare 20mm segments of shrink tube for each joint to be repaired and place over the original wire.

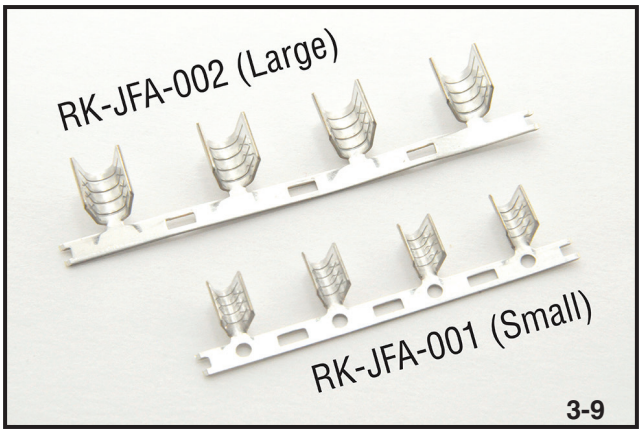


Shrink tube

5. Join the original harness with the replacement segment using one of 2 methods.

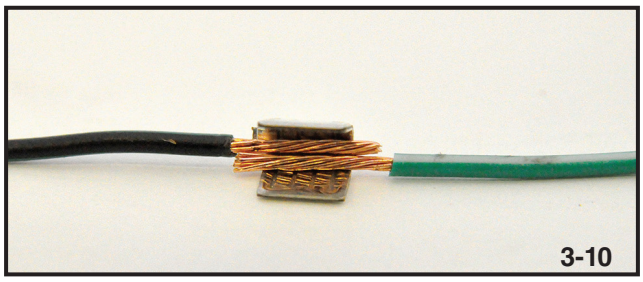
Method 1 – Crimping

1) Crimp the exposed conductors using joint pieces from the Terminal Repair Kit. Two joint piece sizes are available.

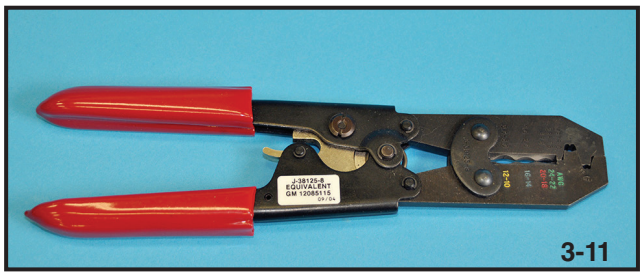


Crimp joints

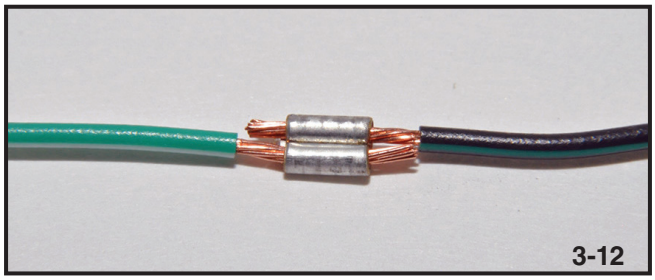
2) Crimp the 2 exposed conductors using the supplied crimping pliers from the Terminal Repair Kit.



Exposed conductors



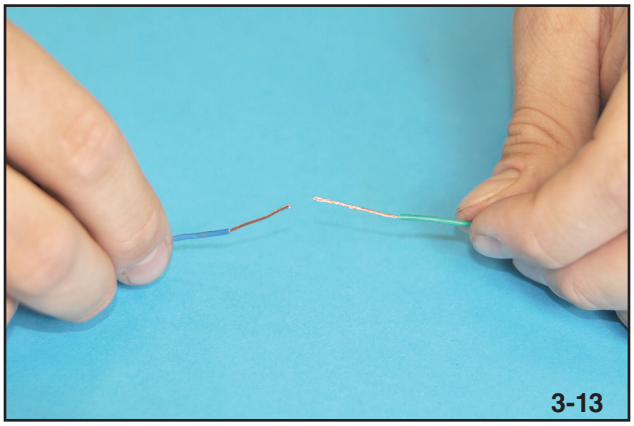
Crimping pliers



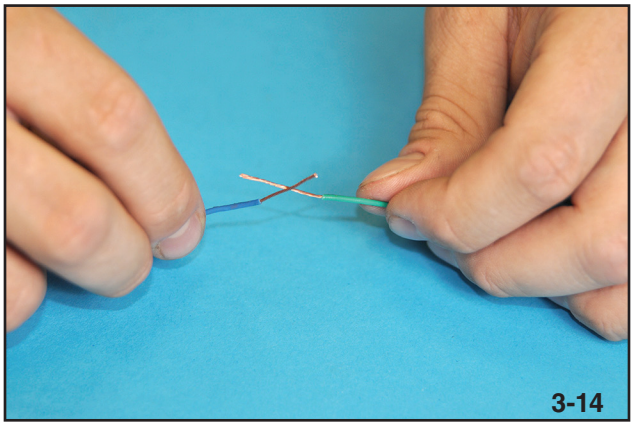
Crimping completed

Method 2 – Union Splice

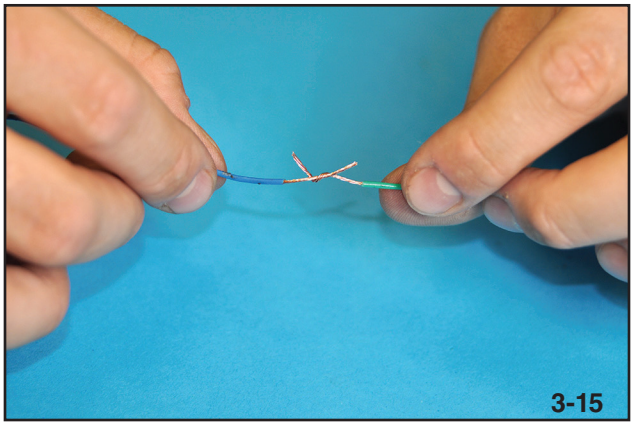
1) Twist the two exposed conductors together using a union splice.



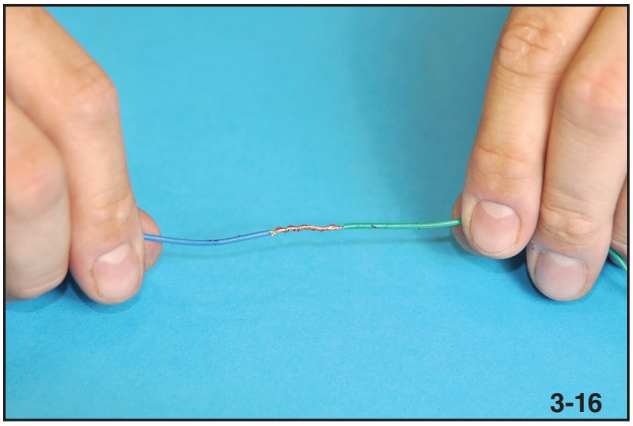
Exposed wires



Wires crossed



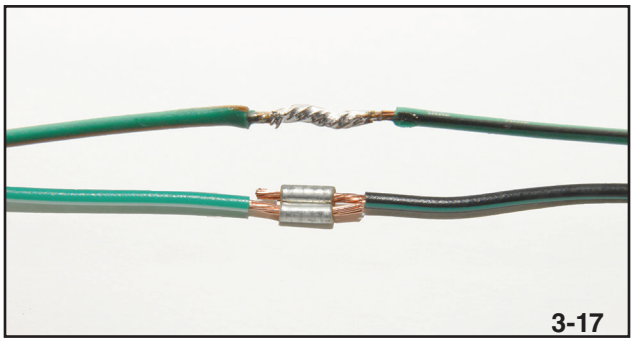
Start of twist



Completed wire splice

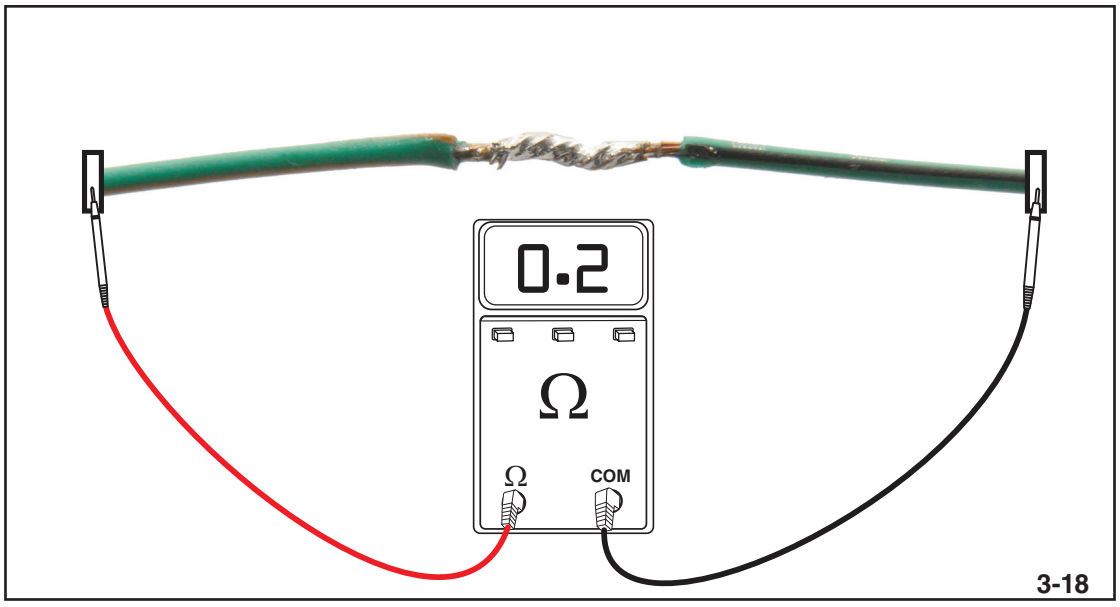
6. Using a fully warmed soldering iron, apply a small amount of 60/40 solder to the splice point. Use the minimum amount of heat to ensure full penetration of the solder into the conductor strands. Do not heat the wire to the point of melting the insulation.

NOTE: Ensure the shrink tubing is far enough away from the joint being repaired as to not begin the shrinking process.



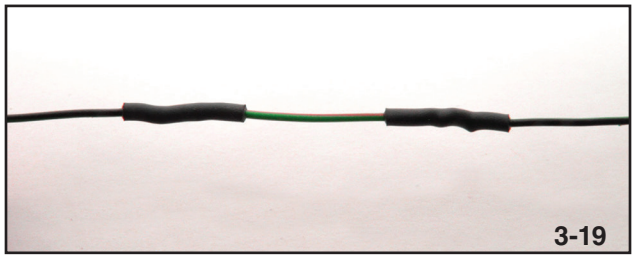
Solder vs crimping

7. Verify the integrity of the solder splice by measuring the continuity of the repaired harness with a DVOM. Resistance should not increase as a result of the performed repair.



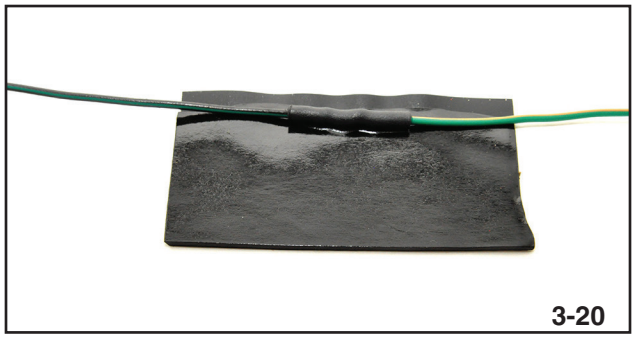
Repair inspection

8. Center the shrink tubing over the repaired joints. Using an adjustable heat gun, slowly heat the shrink tubing until it has securely covered the repaired joints.



Shrink tubing applied

9. In areas that are exposed to moisture, humidity, dust, or other environmental conditions, apply waterproof adhesive (RK-BFA-003) from the terminal repair kit. During application, ensure the adhesive is fully fastened by firmly squeezing from the center of the joint outward.



Weather proof adhesive

Weather proof adhesive applied

10. Verify the operation of the repaired component or system prior to customer delivery.

Connector Repair

Occasionally, electrical repairs may involve the replacement of connector terminals. Subaru Special Tool J-47606 (Harness Repair Kit) provides replacement terminal leads for many of the connectors located on a Subaru vehicle.

Terminal repair kit (Upper)

Terminal repair kit (Lower)

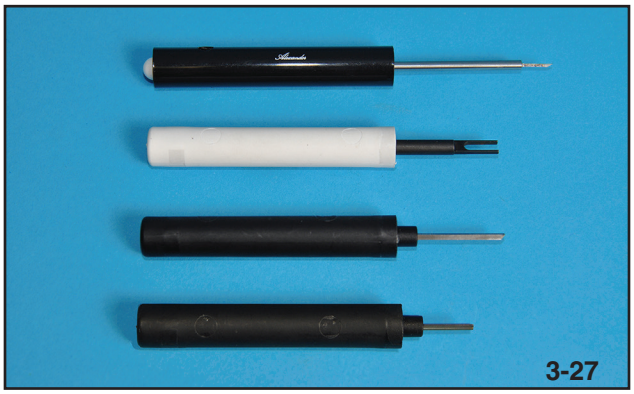
The top of the Terminal Repair Kit contains an assortment terminal replacement leads. Male/Female and waterproof/non-waterproof varieties are included.

Terminal repair kit (Top)

Replacement leads

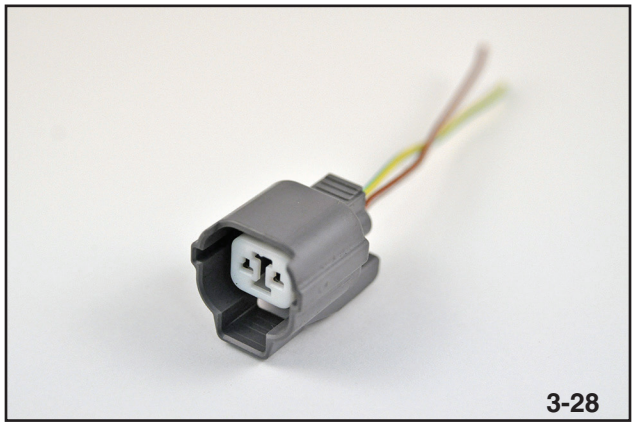
The base of the Terminal Repair Kit contains repair tools such as crimping pliers and joints, terminal removal tools, shrink wrapping, waterproofing tape.

Terminal repair kit (Lower)

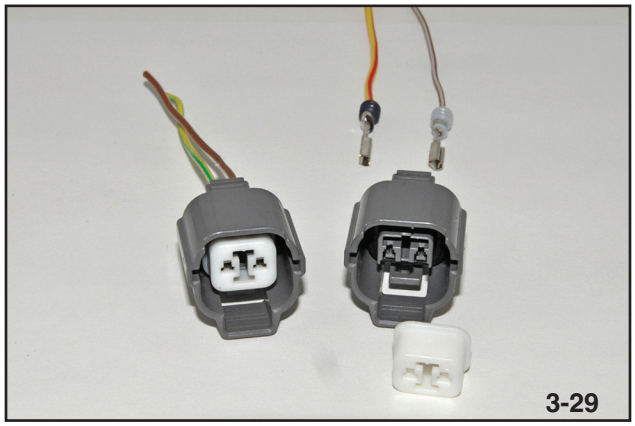


Terminal removal tools

Removing a damaged terminal require care not to damage the connector body. In some cases, the connector contains a lock for the terminals. This lock may be a simple latch or an entirely removal able piece. Most locks are identifiable by their differing color from the main body of the connector.

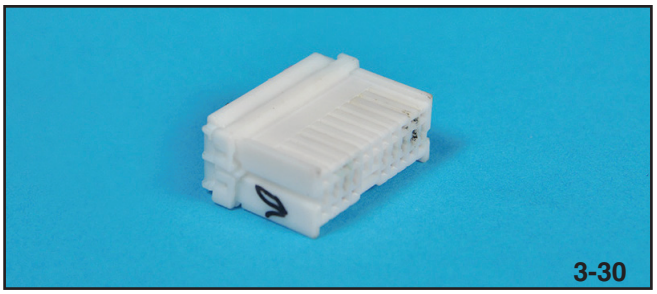


Connector lock

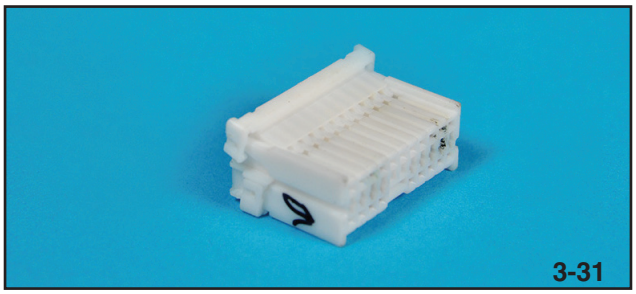


Connector lock removed

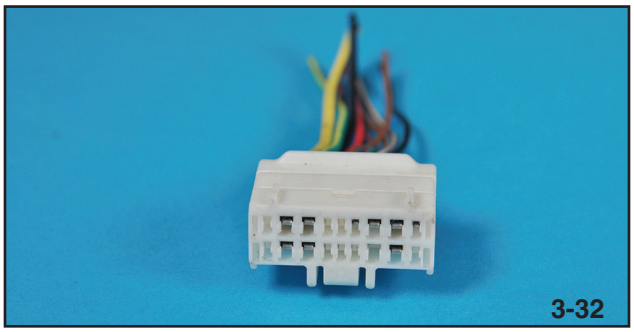
Connector Lock Examples



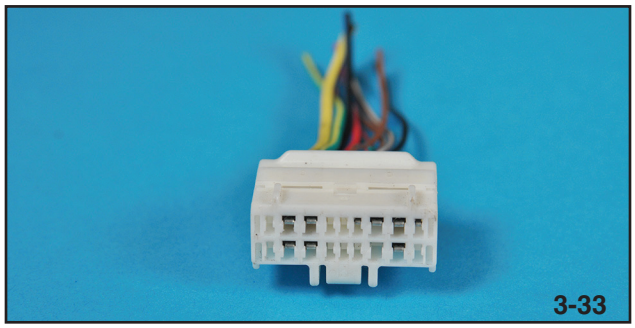
Connector **A** *locked*



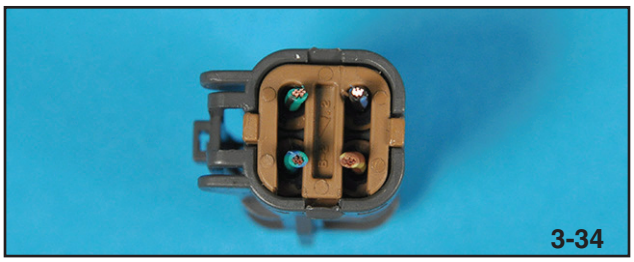
Connector **A** *unlocked*



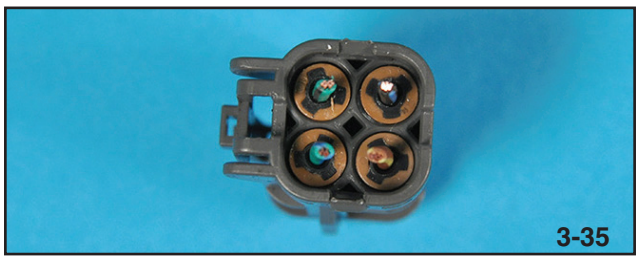
Connector **B** *locked*



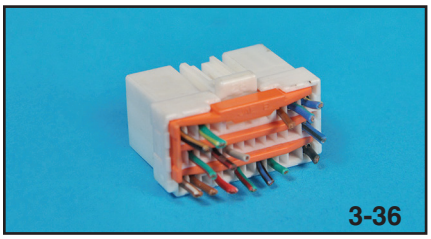
Connector **B** *unlocked*



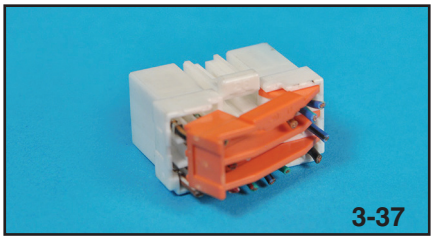
Connector **C** *locked*



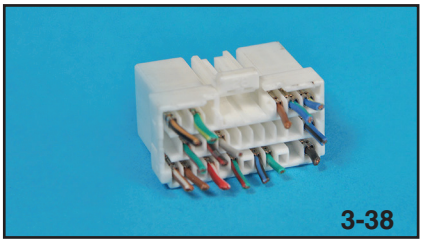
Connector **C** *unlocked*



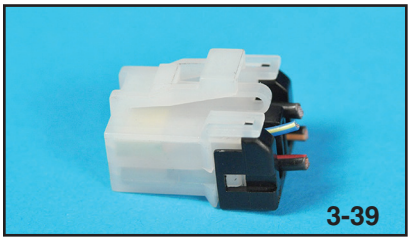
Connector **D** *locked*



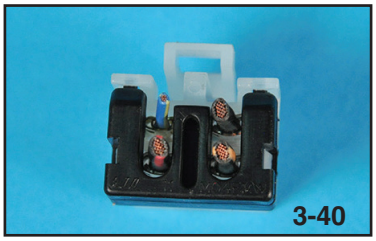
Connector **D** *half removed*



Connector **D** *unlocked*



Connector **E** *Side View*

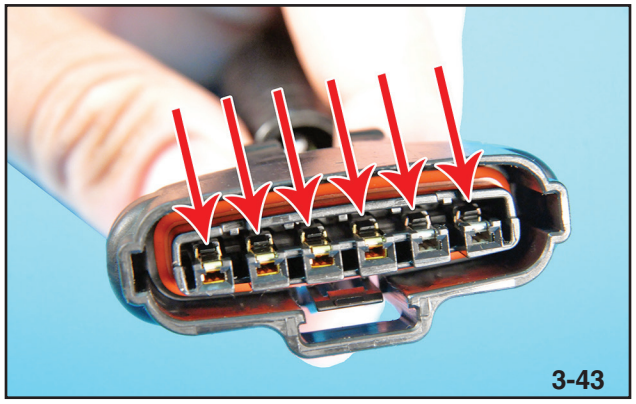


Connector **E** *Loaded*

Connector **E** *Unlocked*

Once the connector lock has been removed, the release tabs for the terminal locks should be visible.

Connector lock installed

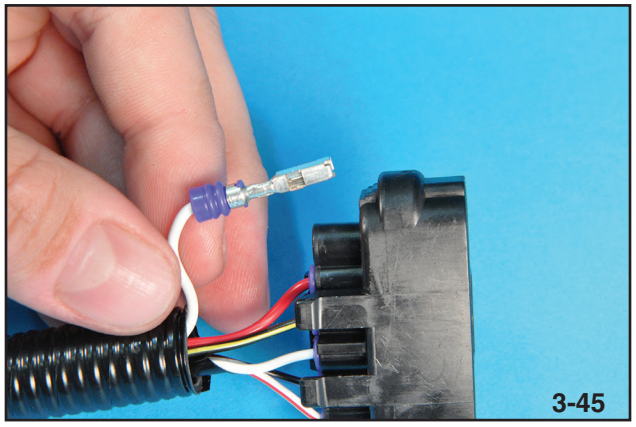


Terminal locks

Using the most suitable terminal removal tool, lift or depress the lock while gently pulling on the wire terminal. Insert the new terminal until a click is heard or felt and re-seat the connector lock.

Note: Take care not to damage the connector lock by using a tool that is too large. It may be easier to use a small pin on smaller connectors.

Terminal removal tools



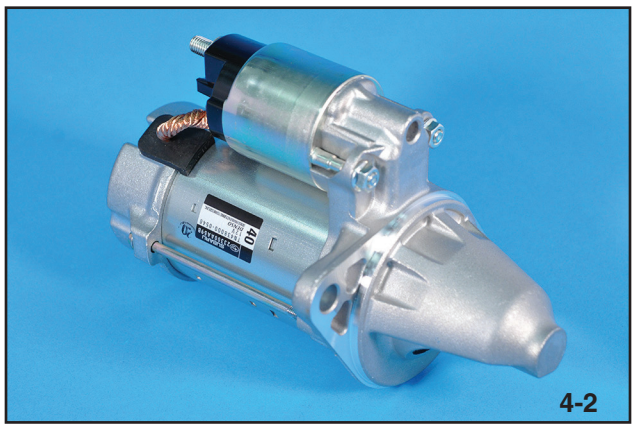
Terminal removal

NOTES

Starting System

Introduction

The Starting System provides the necessary initial turning force to begin the 4 cycles of an internal combustion engine. This initial turning force is referred to as engine "cranking". Engine cranking is provided by a powerful electric motor that drives the engine through a pinion gear that engages with a toothed ring gear on the flywheel or flex plate. The starter motor can drive the engine between 200 and 800 RPM depending on the load conditions. During cranking the fuel injection and ignition systems operate to create engine combustion. Once the engine establishes combustion the starter motor is disengaged from the ring gear. Other components in starting system include the Ignition Switch, Starter Relay Inhibitor or Clutch Switch, Starter Magnet Switch and Starter Motor.



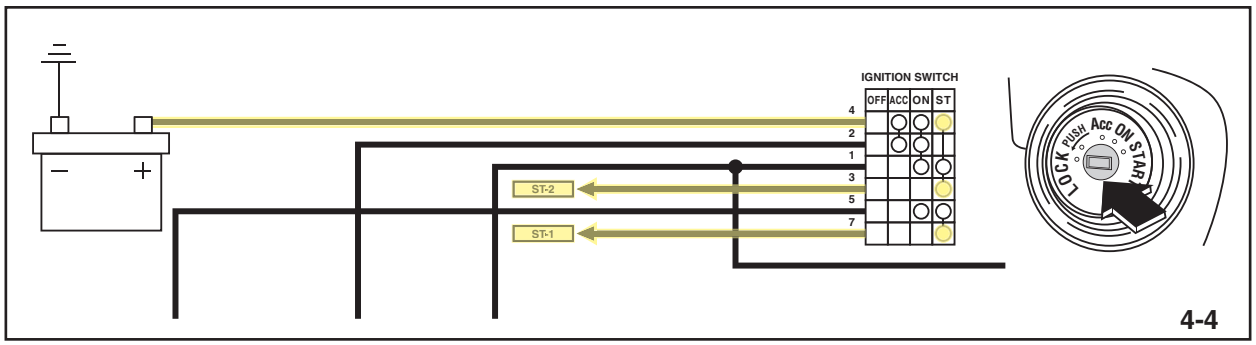
Starter motor

Flex plate ring gear

Starting System Construction

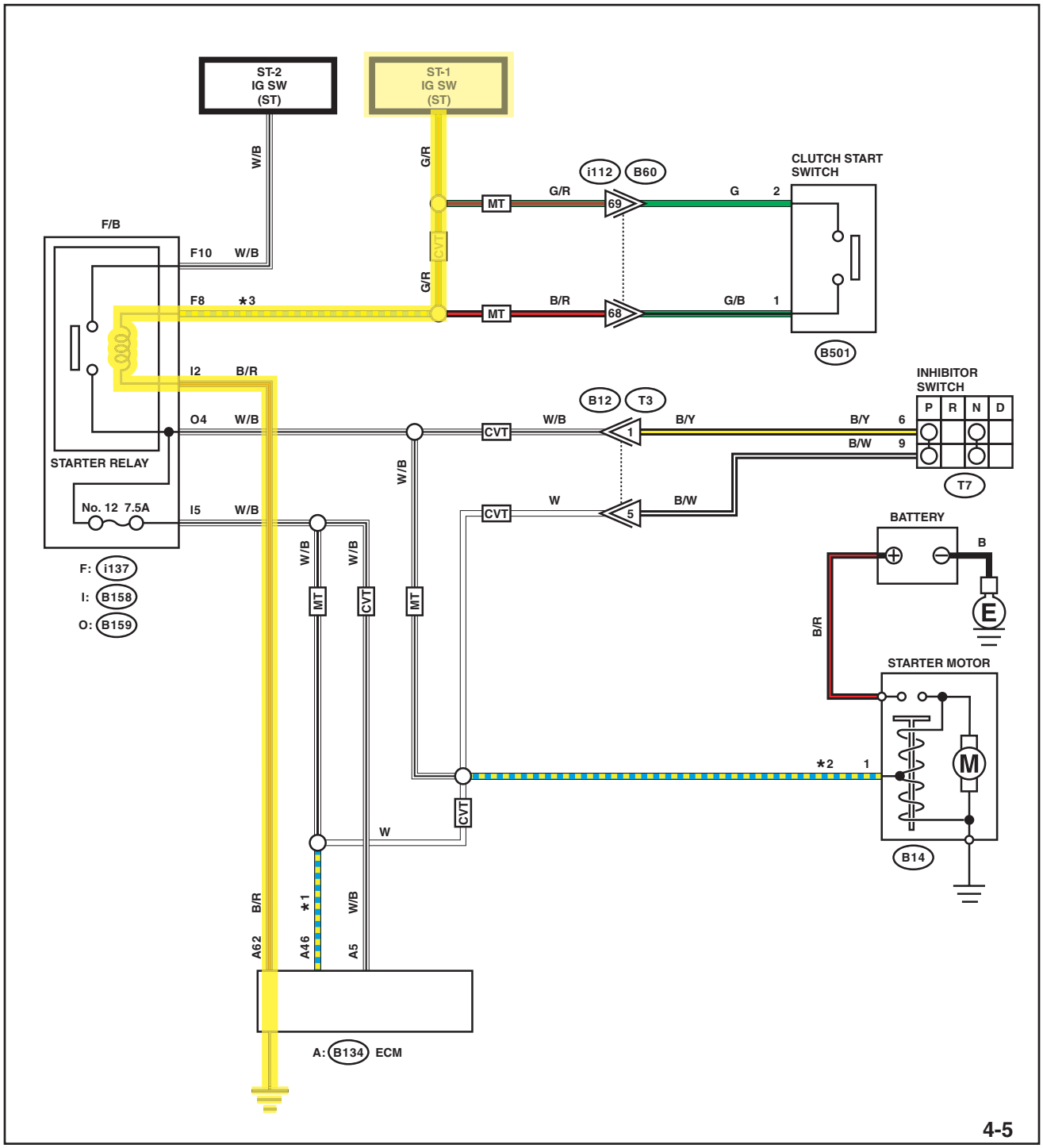
The engine starting sequence begins when the Ignition Switch is turned to the START (ST) position and battery voltage is supplied to the Starter Relay. The Starter Relay provides an energizing current to the Starter Magnet switch. The Starter Magnet Switch completes a power supply path to the Starter Motor, engaging the motor to provided rotation to the engine flywheel and crankshaft.

In this example, the Ignition switch is turned to the START (ST) position and voltage from the battery is supplied to the ST-1 and ST-2 circuits.



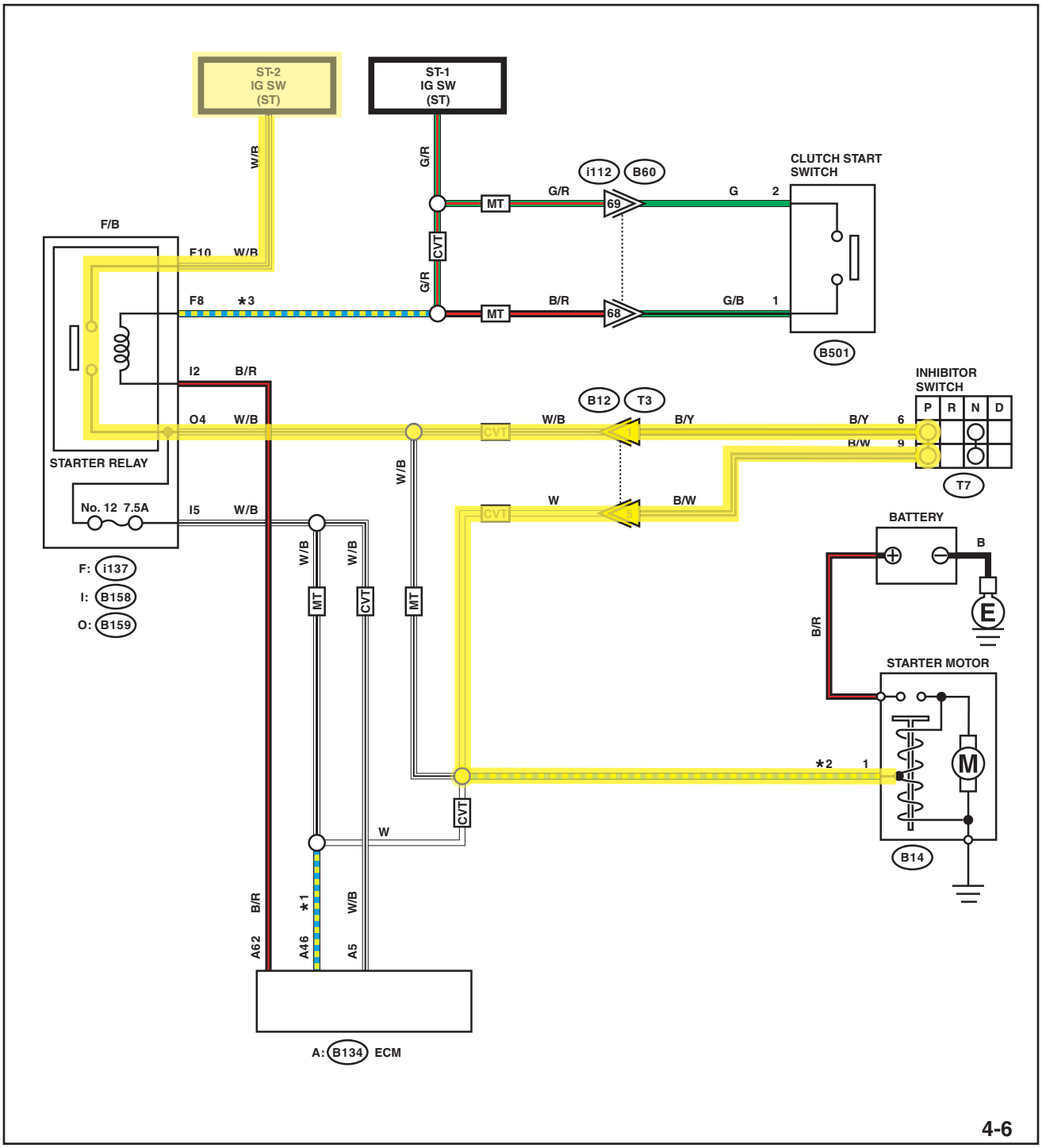
Ignition switch "START" position

The Starter Relay is controlled by a ground signal from the Engine Control Module (ECM). Power is supplied to the Starter Relay coil from the ST-1 circuit.



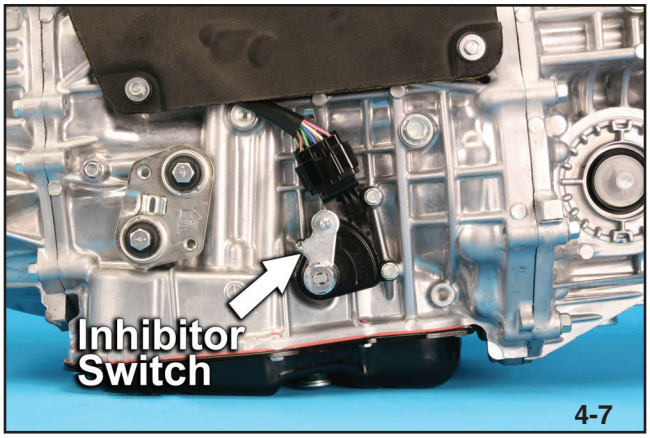
ST-1 circuit

When the Starter Relay coil is energized, the internal contacts allow current from the ST-2 circuit to flow to the Starter Magnet Switch.

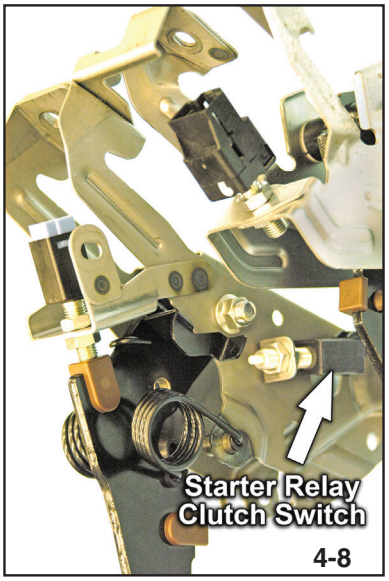


ST-2 circuit

Depending on the transmission type equipped, an Inhibitor Switch or Clutch Start Switch may be incorporated as a preventative measure. In this example, the normally-open Clutch Start Switch prevents voltage supply to Starter Relay 1 until the clutch pedal is depressed. This applies only to the Manual Transmission (MT) models. Conversely, on Automatic Transmission (CVT) models the Inhibitor Switch prevents voltage supply from the Starter Relay from reaching the Starter Magnet Switch



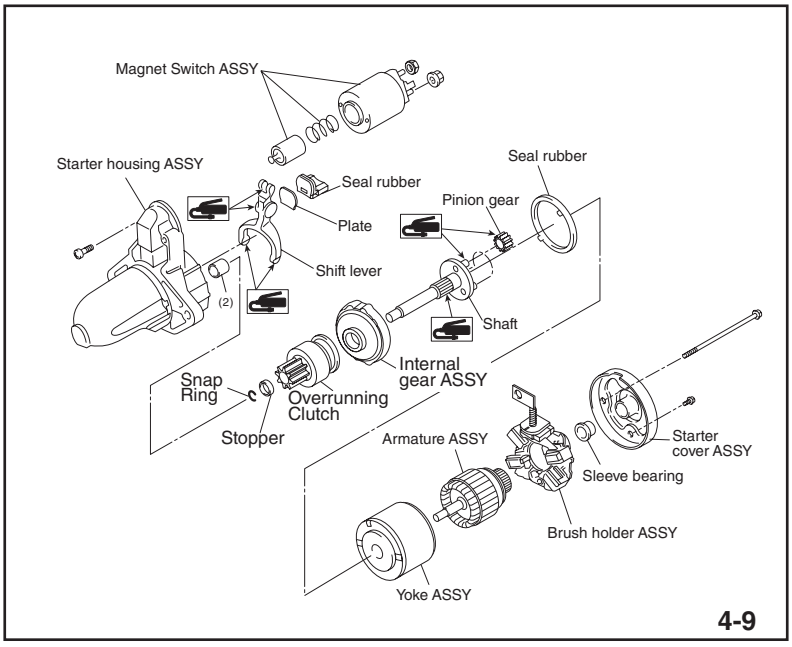
Inhibitor switch



Clutch switch

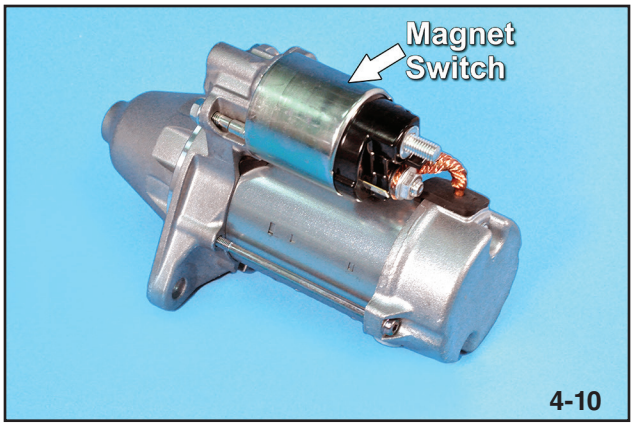
Starter Motor Construction

Major components of the starter motor include the Yoke assembly, Armature assembly, Brush holder, Reduction gear assembly, Overrunning clutch, Shift lever, and Magnet switch. These components work in unison to deliver the rotational torque to crank the internal combustion engine.

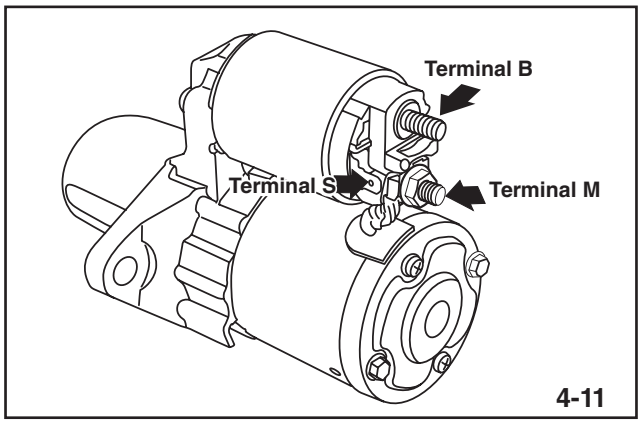


Starter motor exploded view

Magnet Switch Operation

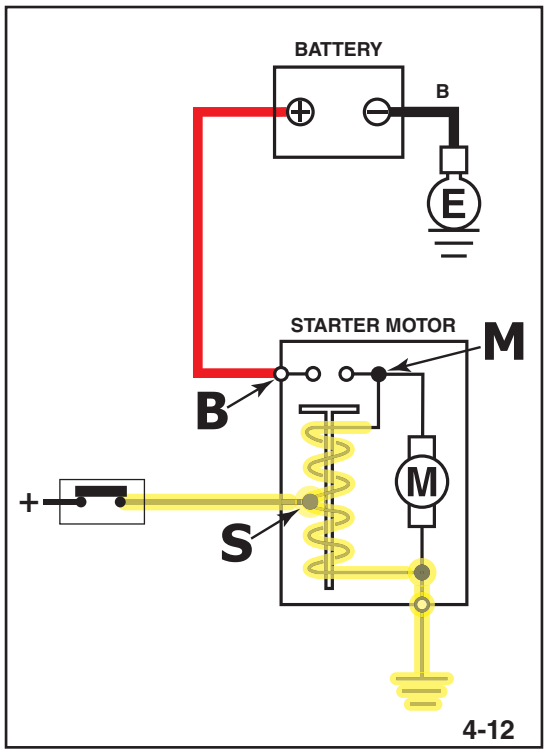


Magnet switch

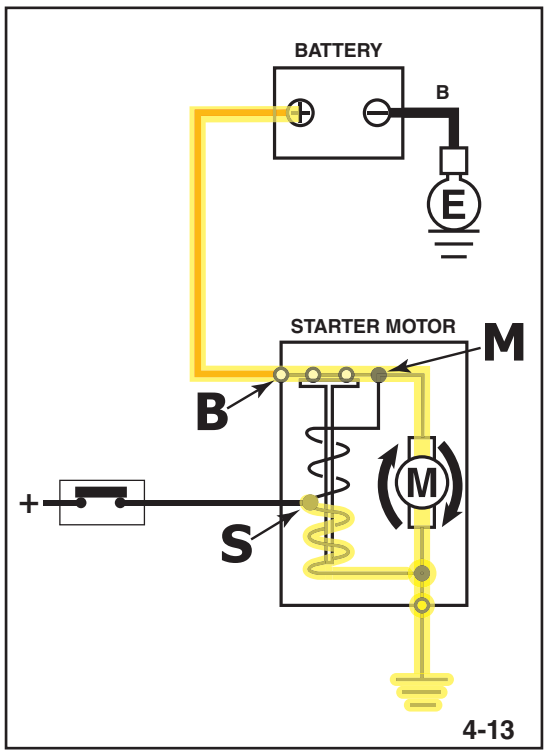


Magnet switch terminals

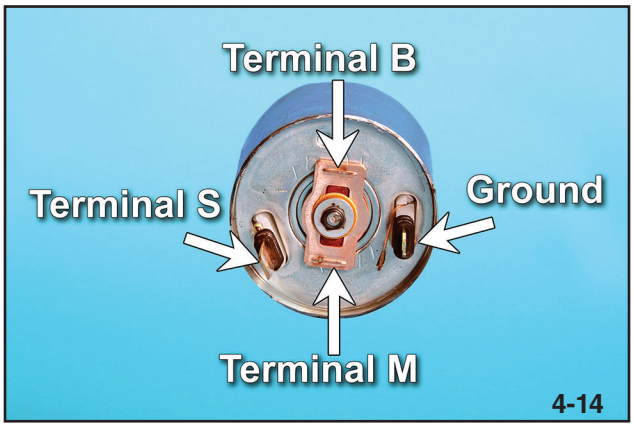
The Starter Relay (ST-2) energizes Terminal S on the Magnet switch to connect the starter motor (Terminal M) directly battery current (Terminal B). Both of these currents flow through the starter case as a ground path.



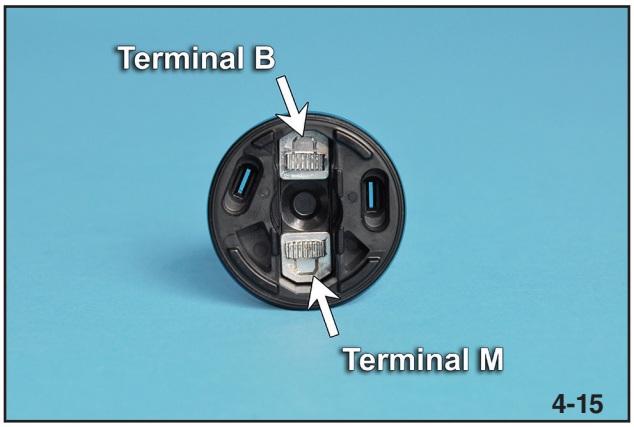
Magnet switch energized



Starter motor energized

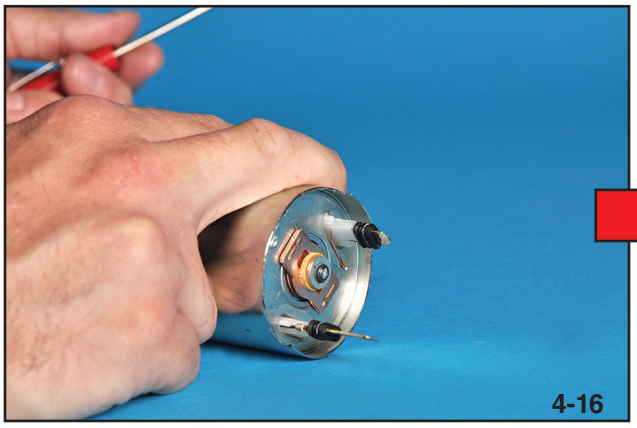


Magnet switch terminals (Switch side)

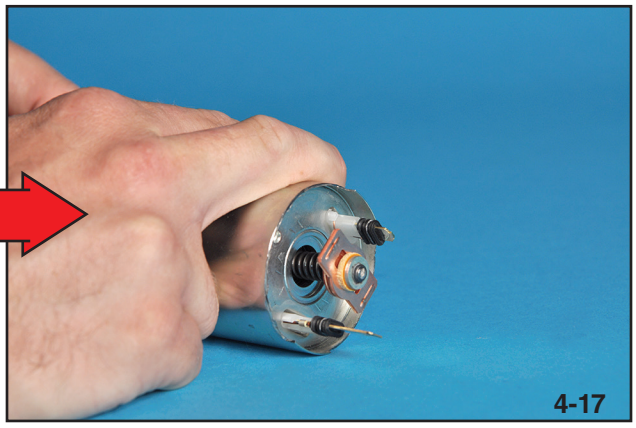


Magnet switch terminals (Contact side)

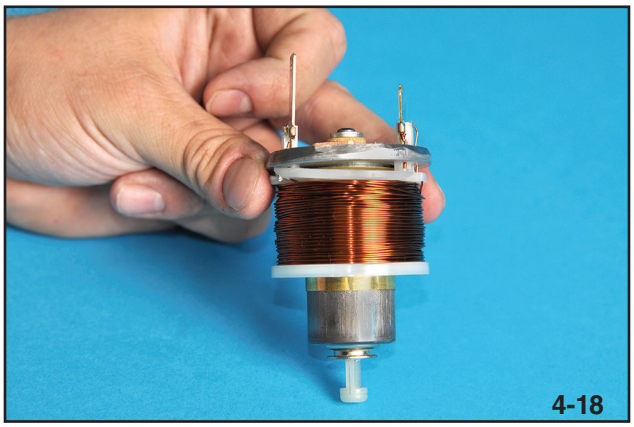
Energizing Terminal S allows current to flow through the Magnetic switch coil windings creating a magnetic field strong enough to overcome the return spring pressure.



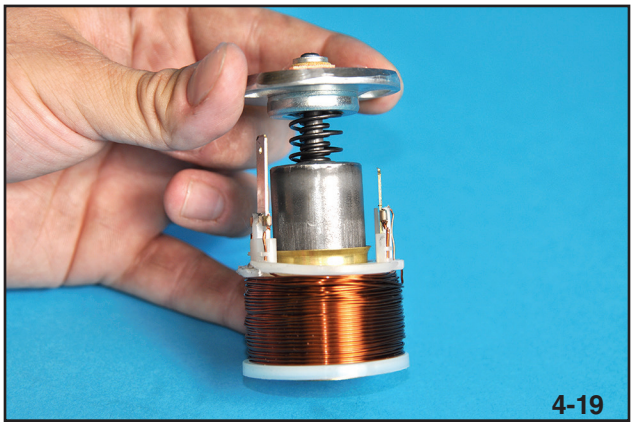
Magnet switch de-energized



Magnet switch energized



Magnet switch coil winding

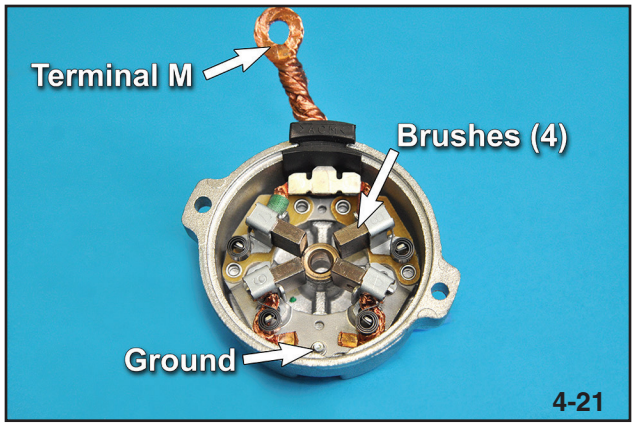


Magnet switch internal

Starter Motor Operation

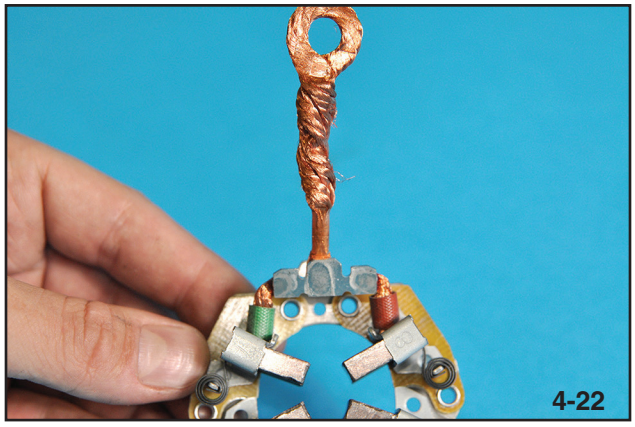
Once energized, the M terminal provides a path from the battery positive terminal to the brush holder assembly. The brush holder contains 4 brushes that supply power and ground to the conductor.

Terminal M

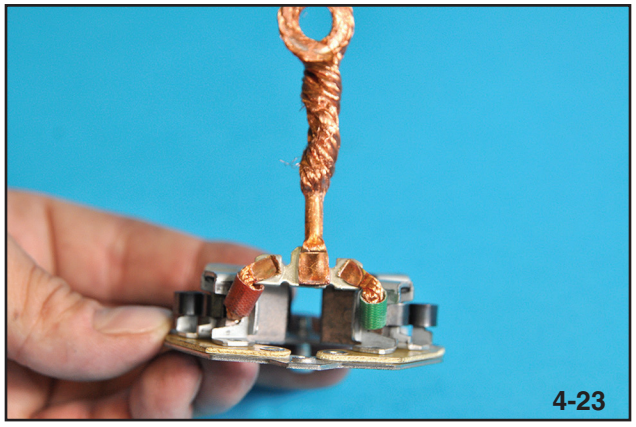


Brush holder

In this orientation, the top 2 brushes are where power enters the brush assembly from Terminal M.

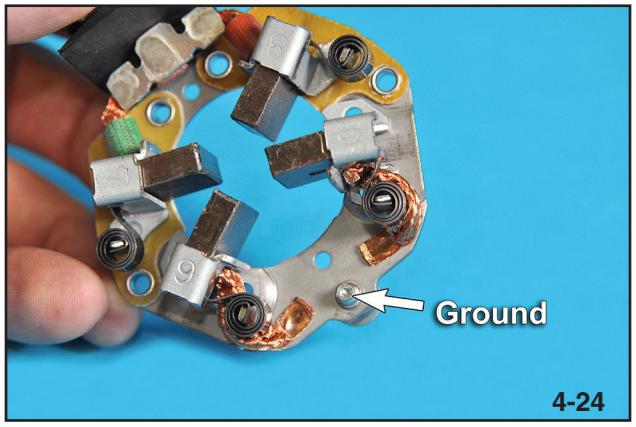


Terminal M brushes (Power supply)



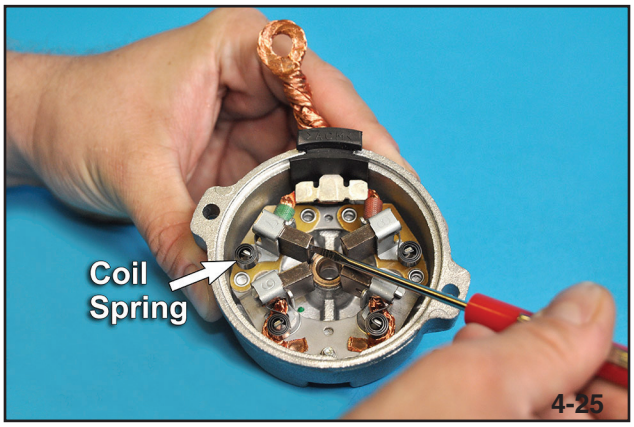
Terminal M brush connection point

The lower 2 brushes provide a path to ground through a bolt in the starter case.

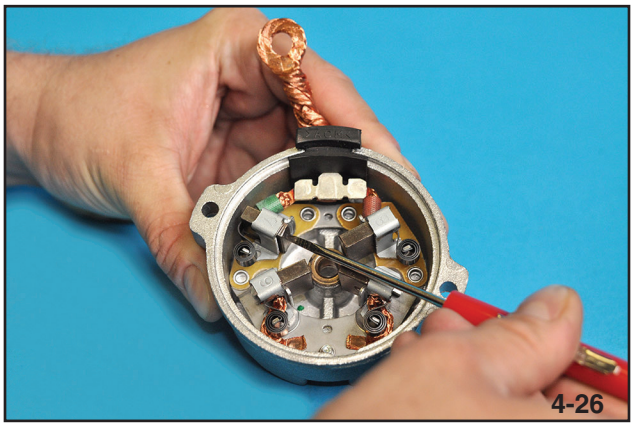


Ground brushes

Each brush maintains constant contact with the commutator using coil springs. This ensures reliable operation as wear occurs to the brushes.

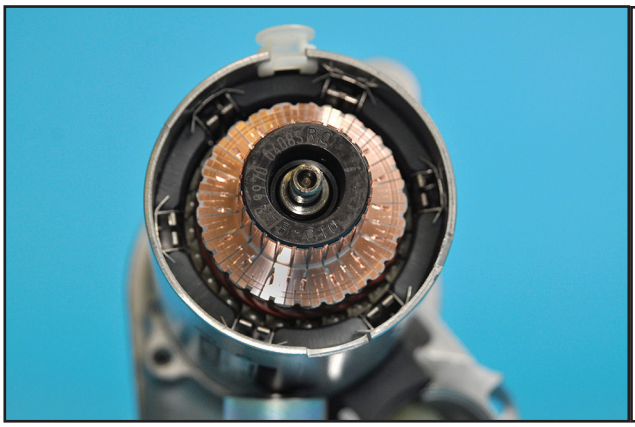


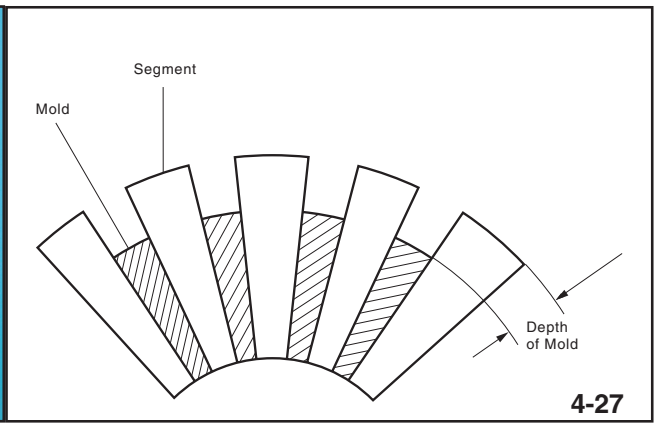
Brush spring released



Brush spring compressed

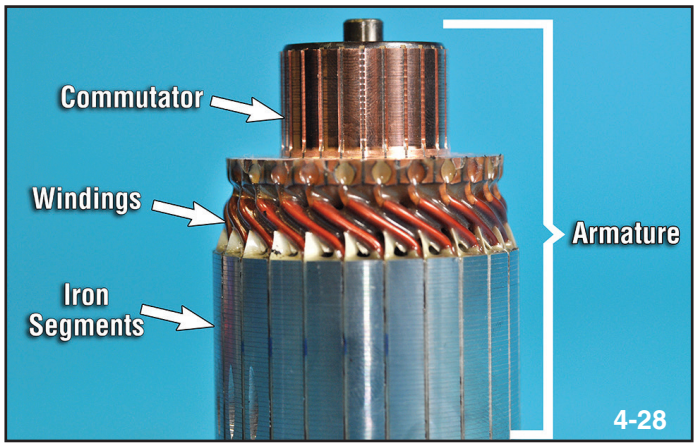
Each brush makes contact with the individual segments of the commutator.





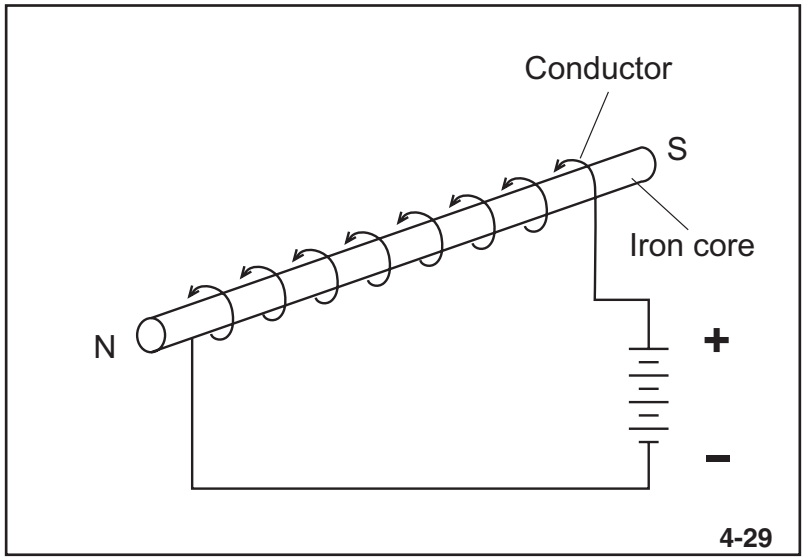
Commutator segments

Current flows from the brushes to the commutator. Each commutator segment is connected to a winding that is routed through a corresponding Iron segment. The assembly of windings and iron segments is referred to as the armature.



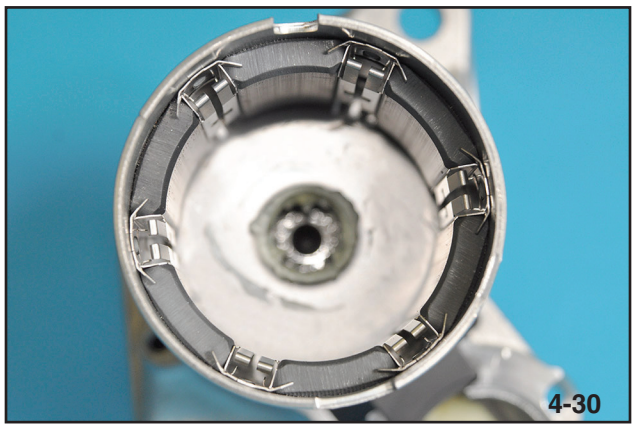
Armature assembly

As current flows through each winding the corresponding iron segments becomes a magnet. Polarity of the magnet is determined by the direction of current flow through the brushes and commutator.



Armature theory

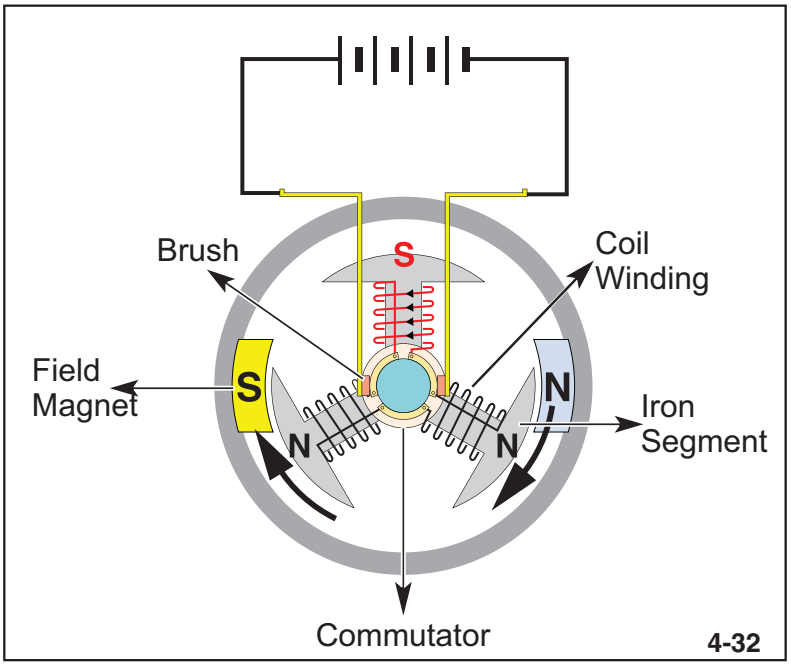
Once energized, the armature rotates inside of the starter housing which contains a series of permanent magnets (field magnets). These permanent magnets form the Yoke of the starter motor assembly. The Yoke provides mechanical strength for the motor and carries the magnetic flux (field) produced by the armature.



Field magnets installed

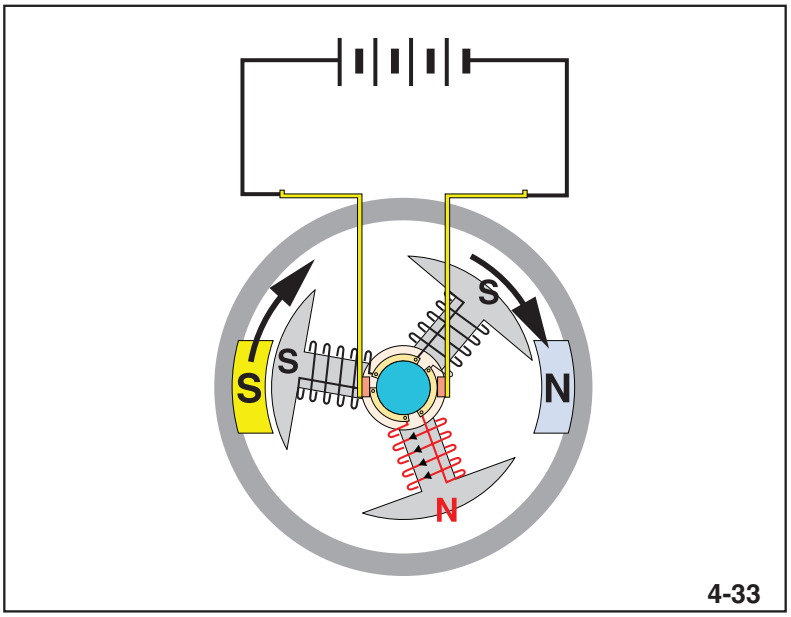
Individual field magnet

In this example, when current is flowing through the brushes and commutator and into the upper coil, the iron segment that the coil is wrapped around becomes magnetized as an “S” pole. This causes an attraction to the “N” field magnet and repulsion to the “S” field magnet. As a result the armature assembly to rotate clockwise



DC motor theory 1

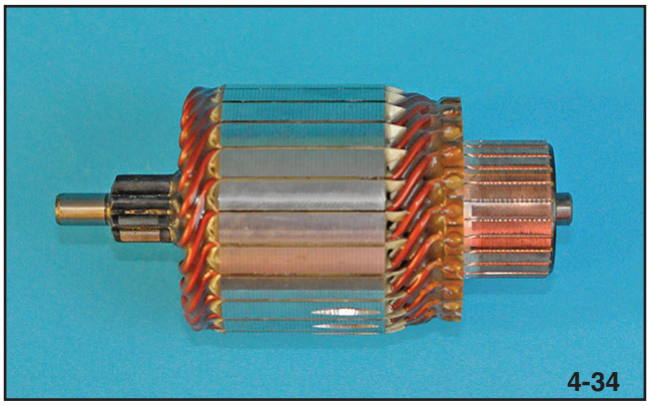
As the armature assembly rotates so does the commutator. As the commutator rotates, contact with the next brush is made changing the current flow to the next winding. In this example, contact to the pole that was energized as an “S” pole is cut and the lower coil is now energized as an “N” pole. This causes an attraction to the next “S” field magnet and repulsion to the “N” field magnet again rotating the armature clockwise.



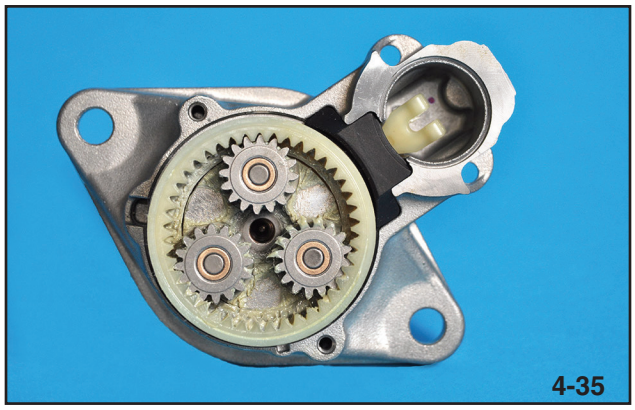
DC motor theory 2

Starter Engagement Operation

Opposite of the commutator on the armature assembly is drive gear. The drive gear engages a gear reduction assembly which multiplies the torque output of the armature rotation.

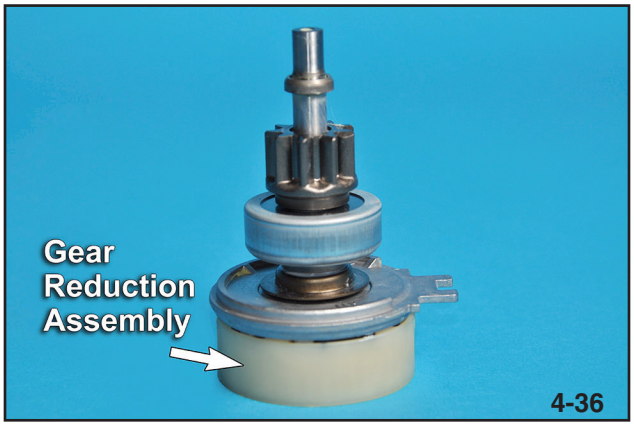


Armature assembly

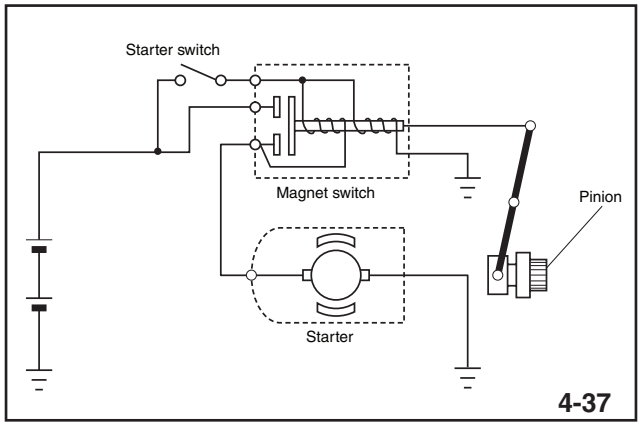


Gear reduction assembly

The gear reduction assembly is fitted to the shaft of the Overrunning clutch (Pinion) assembly. This assembly is also commonly referred to as the starter Bendix drive.



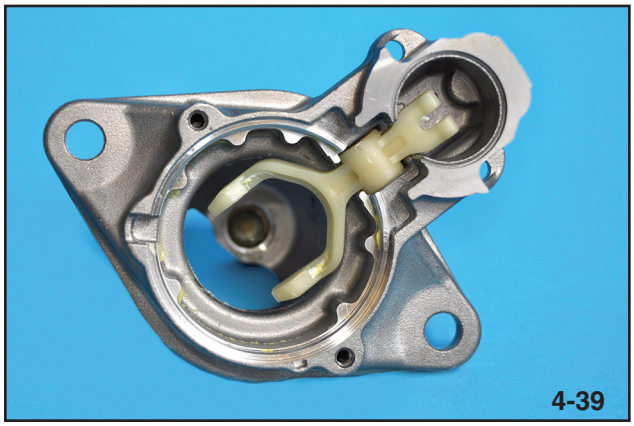
Overrunning clutch assembly



Starter engagement (Artwork)

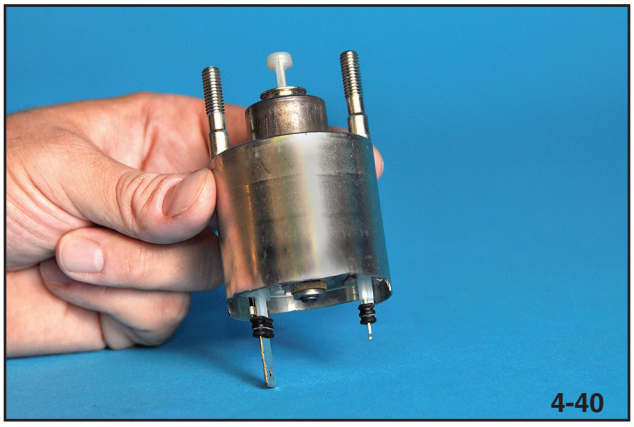
The overrunning clutch assembly is engaged by a shift lever.

Shift lever

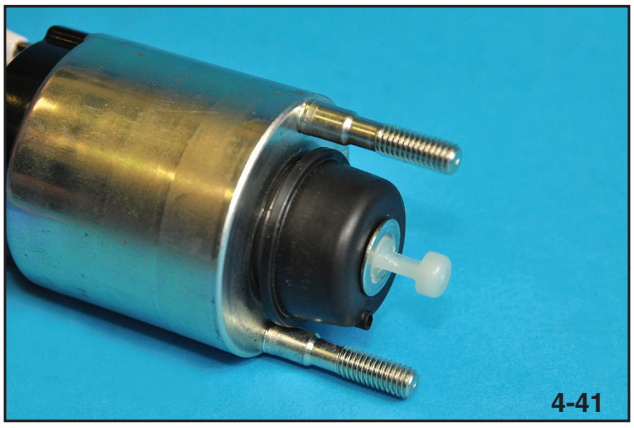


Shift lever pivot point

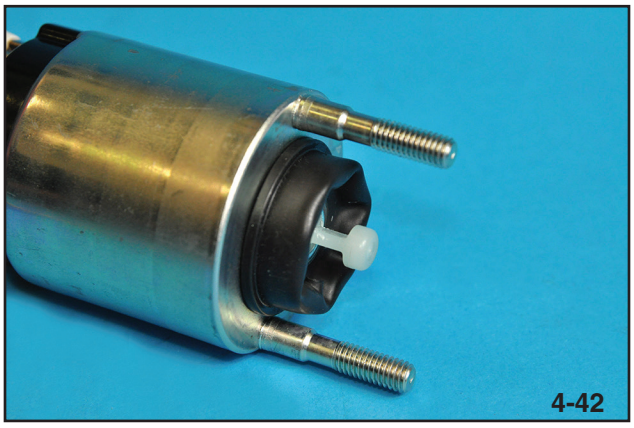
Energizing the Magnet switch causes the Shift Lever to pivot inside the starter housing. The shift lever is connected to the Overrunning clutch which contains a pinion gear that meshes with the flywheel or flex plate ring gear.



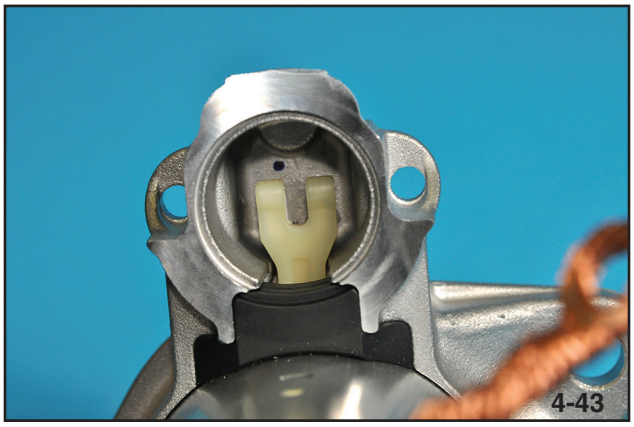
Magnet switch



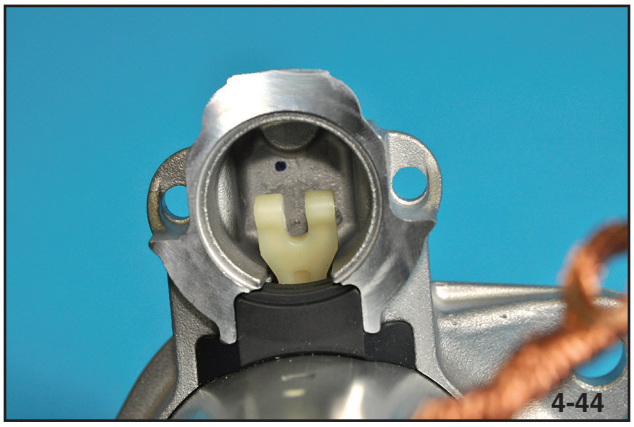
Magnet switch OFF



Magnet switch ON

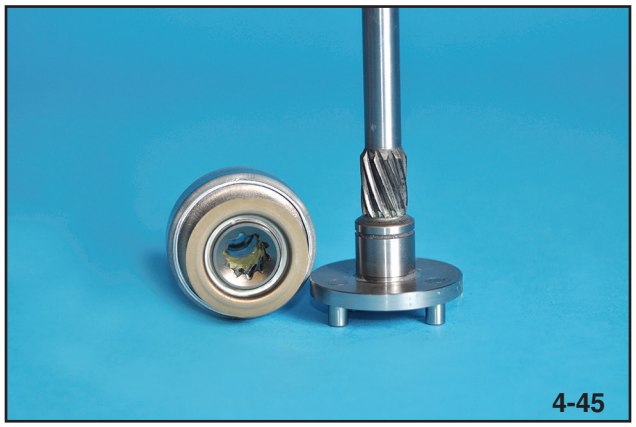


Shift lever disengaged

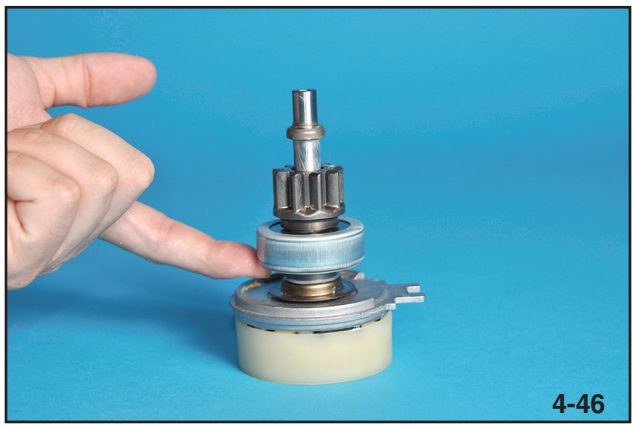


Shift lever engaged

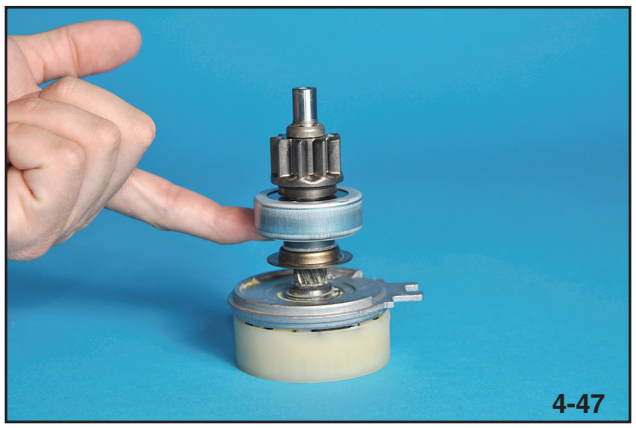
The Overrunning clutch and pinion gear assembly moves along a helical shaft that creates a small amount of rotation to ease engagement of the pinion gear with the flywheel or flex plate ring gear.



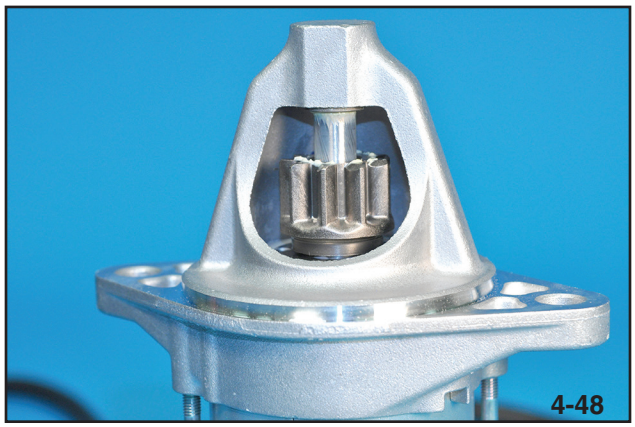
Pinion gear and helical shaft



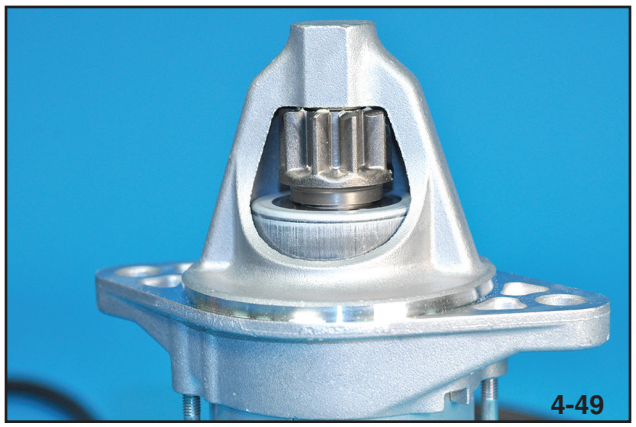
Pinion gear disengaged



Pinion gear engaged

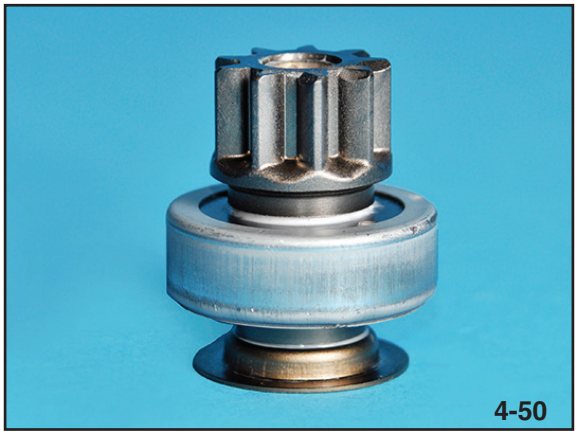


Pinion gear disengaged (In housing)

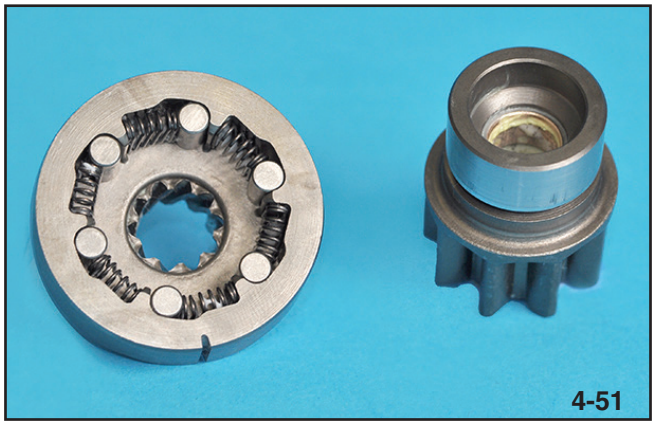


Pinion gear engaged (In housing)

The Overrunning clutch houses a series of rollers and springs. The rollers and springs are configured in such a way as to allow rotation in one direction only. This allows the starter motor to transmit torque to the flywheel or flex plate ring gear, but prevents the ring gear from transferring torque to the starter motor. This prevents damage to the starter armature.

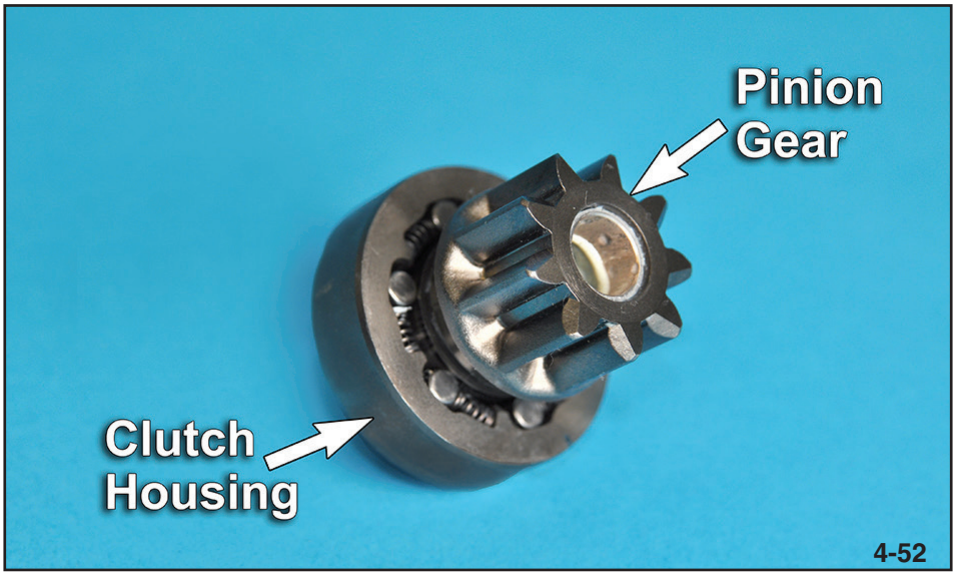


Overrunning clutch assembly



Overrunning clutch disassembled

When torque is transmitted through the starter armature and reduction gears, the spring loaded rollers are forced into the small ends of the tapered slots. This locks the pinion gear to the clutch housing allowing torque to be transmitted to the flywheel or flex plate ring gear. When the engine begins to rotate under combustion power and RPMs increase above the starter's normal speed, the rollers unload and the pinion gear is allowed to spin freely.



Overrunning clutch components

Starting System Diagnostics

Starter system diagnostics can be performed using a variety of methods and tools. Regardless of the method chosen, always ensure the correct specifications and characteristics are referenced to ensure accurate results. The General Description section of the Subaru Service manual contains detailed information concerning the individual specifications for each model and type.

Note: In many cases, the specification for Automatic and Manual transmission models will differ.

Performance Specifications

Item			Specifications	
Vehicle model			CVT	MT
Starter	Type		Reduction type	
	Model		M000T38571ZC	M000T33176ZC
	Manufacturer		Mitsubishi Electric	
	Voltage and output		12 V — 1.2 kW	12 V — 1.0 kW
	Direction of rotation		Counterclockwise (when observed from pinion)	
	Number of pinion teeth		9	8
	Armature commutator runout	Standard	0.05 mm (0.0020 in)	
		Limit	0.10 mm (0.0039 in)	
	Armature depth of segment mold	Standard	0.5 mm (0.020 in)	
	Brush length	Standard	12.3 mm (0.484 in)	
		Limit	7.0 mm (0.276 in)	
	Brush spring force	Standard	15.9 — 19.5 N (1.62 — 1.99 kgf, 3.57 — 4.38 lbf)	
		Limit	2.5 N (0.25 kgf, 0.56 lbf)	
	No-load characteristics	Voltage	11 V	
		Current	90 A or less	95 A or less
		Rotating speed	2,370 r/min or more	2,500 r/min or more
	Load characteristics	Voltage	7.5 V	7.5 V
		Current	300 A	300 A
		Torque	10.65 N·m (1.1 kgf-m, 7.8 ft-lb) or more	8.84 N·m (0.9 kgf-m, 6.5 ft-lb) or more
		Rotating speed	840 r/min or more	870 r/min or more
	Lock characteristics	Voltage	4 V	4 V
		Current	780 A or less	680 A or less
		Torque	20 N·m (2.0 kgf-m, 14.8 ft-lb) or more	17 N·m (1.7 kgf-m, 12.5 ft-lb) or more

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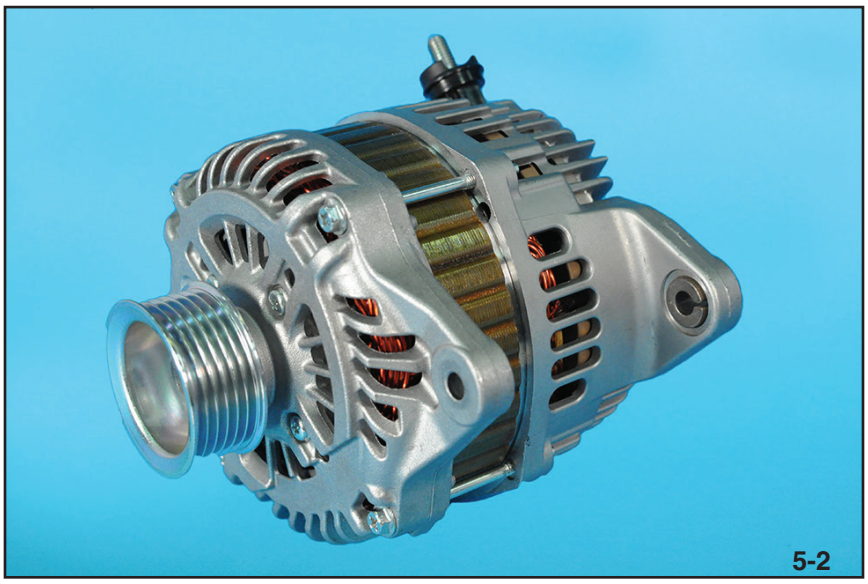
Starting system general description

NOTES:

Charging System

Introduction

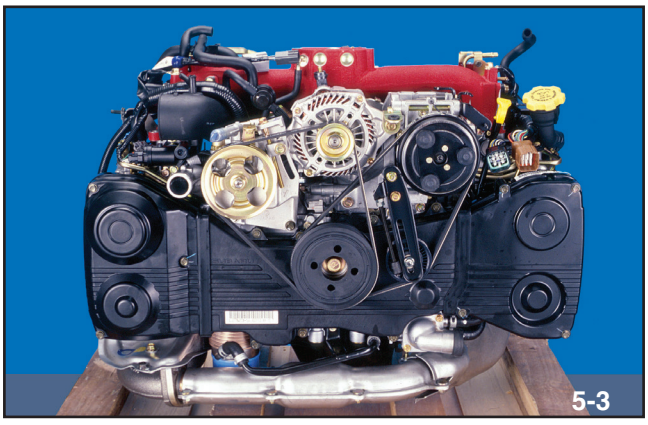
The Charging System generates the electricity needed to continuously power vehicle systems. At the center of the charging system is the Alternator (sometimes referred to as the generator) which is driven by the engine crankshaft via a drive belt. The alternator takes the mechanical energy from the engine and converts it into electrical energy for the various vehicle systems.



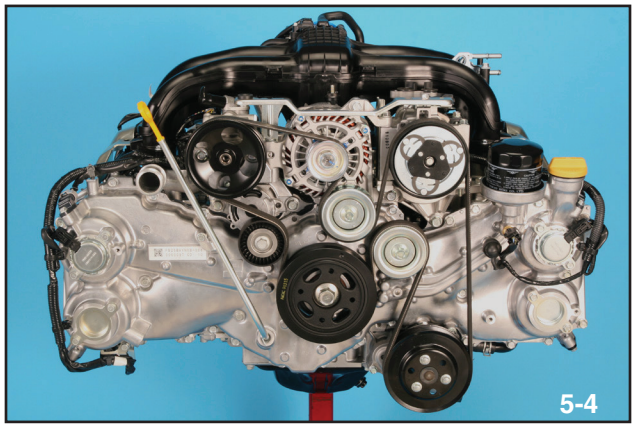
Alternator

Drive Belt and Pulley

The drive belt (sometimes referred to as the V-Belt) is critical in transferring the mechanical energy from the engine crankshaft to the alternator pulley. Drive belts should be regularly inspected as they are a wearable component. Damage, wear, or contamination may cause inefficient drive of the alternator causing abnormal charging conditions. Earlier Subaru models used two independent belts to drive the various accessories. Most current models (except STI) have transitioned to a single serpentine style belt configuration.



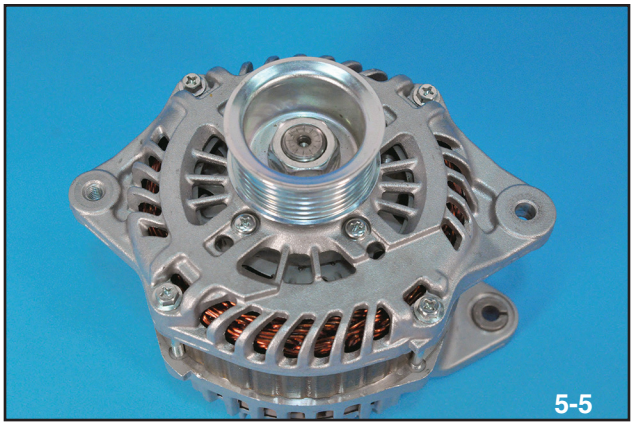
Multiple drive belts



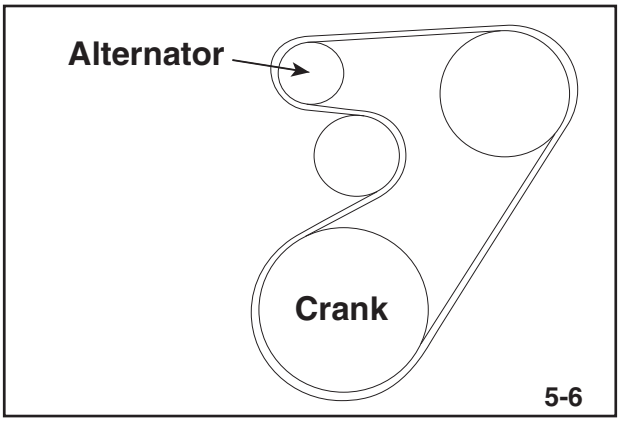
Single serpentine drive belt

Alternator Pulley

The internal rotor of the alternator is connected to an accessory pulley via a shaft and nut. Since the diameter of the crank pulley is several times larger than the alternator pulley, the rotational speed of the alternator rotor is much higher than engine crankshaft.



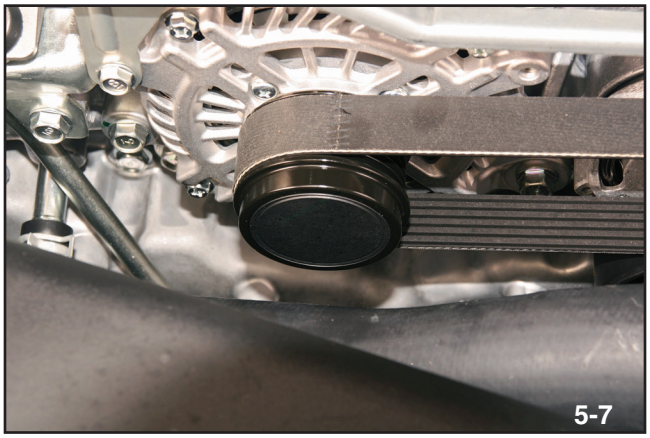
Alternator accessory pulley



Accessory pulley size differences

Alternator De-Coupler

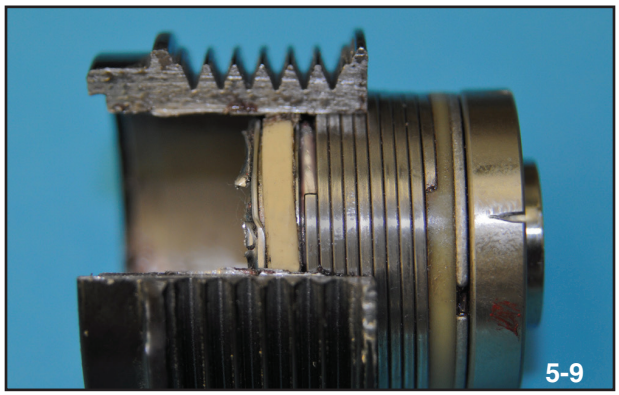
Beginning with 2014 MY Forester, some Subaru engines may be equipped with a de-coupling alternator pulley. Engines with the de-coupler are easily identified by the black cover cap that protects the pulley nut. This pulley functions as an overrunning-clutch when engine speed drastically decreases as compared to alternator speed. In doing so, the de-coupler allows the alternator to continue rotating thus reducing unwanted noise and sensations from the powertrain and marginally improving fuel economy.



Alternator De-coupler (Front)

Alternator De-coupler (Removed)

Internally, the de-coupler contains a wound coil spring. When the spring is loosened its diameter increases and locks the inner housing to the outer housing. Conversely, when the spring tightens, the diameter decreases creating a gap between the inner and outer housings allowing them to rotate independently.

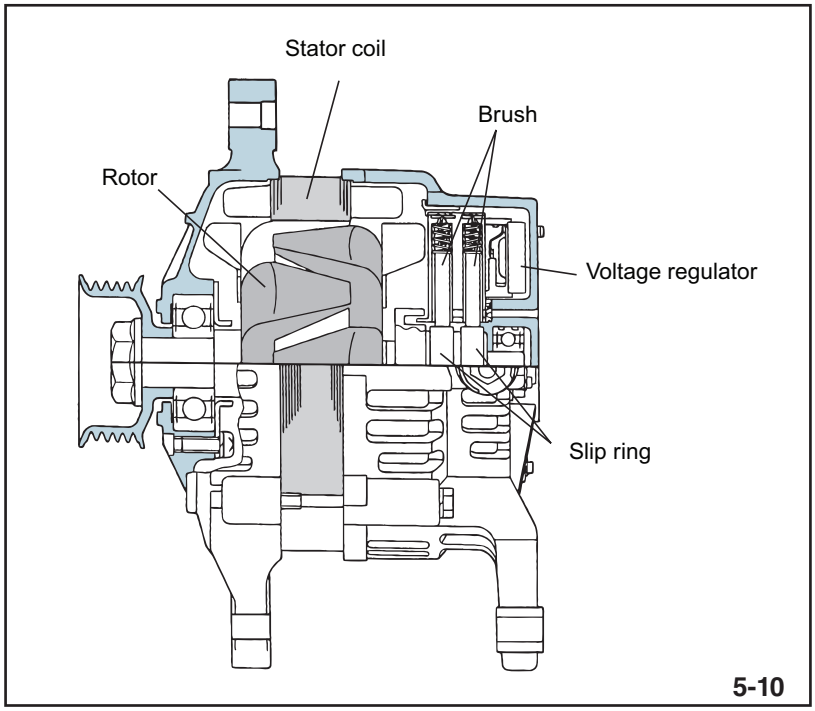


Alternator De-coupler (Cut-away)

Alternator Construction and Operation

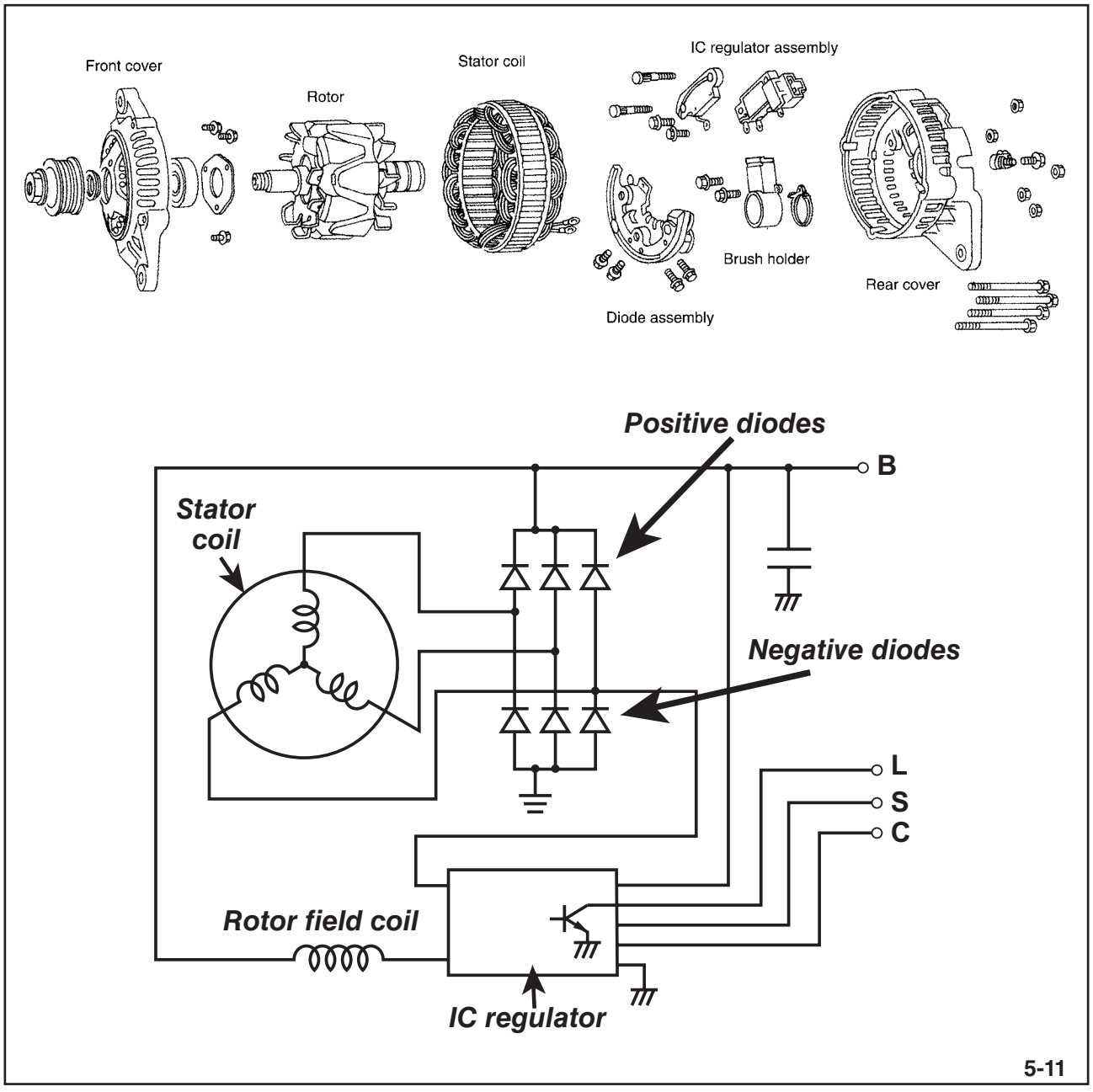
The alternator contains six major components.

- Rotor
- Stator coil
- Brush holder
- Slip rings
- Voltage regulator
- Alternator case



Alternator components

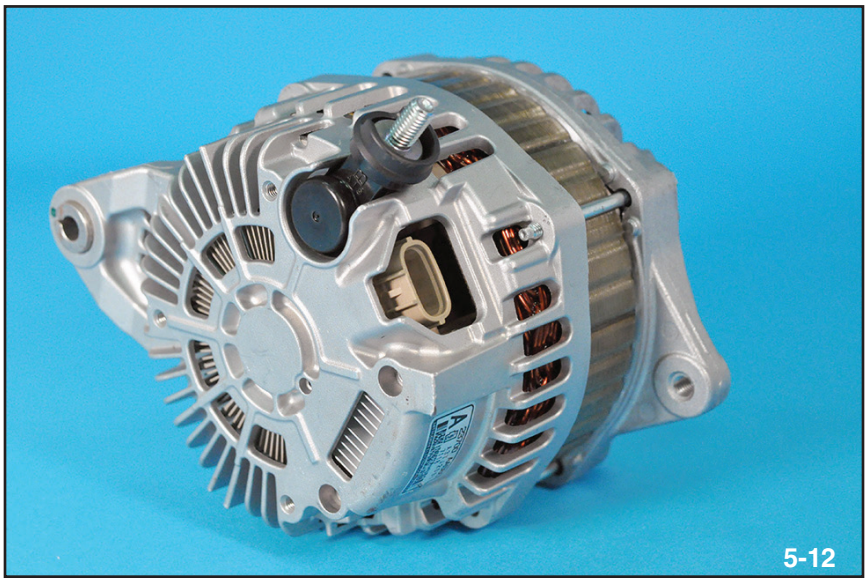
The rotor rotates via the drive belt and pulley which induces electromagnetism in the stator coil. The raw electromagnetic force produced is AC (alternating current) voltage. However, AC voltage is not directly usable by the components on the vehicle. As a result the AC voltage must pass through a diode assembly. The diode assembly "rectifies" the AC voltage into DC (direct current) voltage. Following the diode assembly the voltage is rectified, but unregulated. Too much or too little voltage can damage the battery or other electrical components. To control the voltage output from the alternator, a voltage regulator is used. The voltage regulator works by controlling the current supplied to the rotor field coil. Increasing the current to the rotor field coil intensifies the electromagnetic field created by the rotor. Conversely, reducing the current to the field coil reduces the overall output of the alternator. Constant contact to the rotor field coil is maintained through a pair of brushes and slip rings.



Alternator system overview

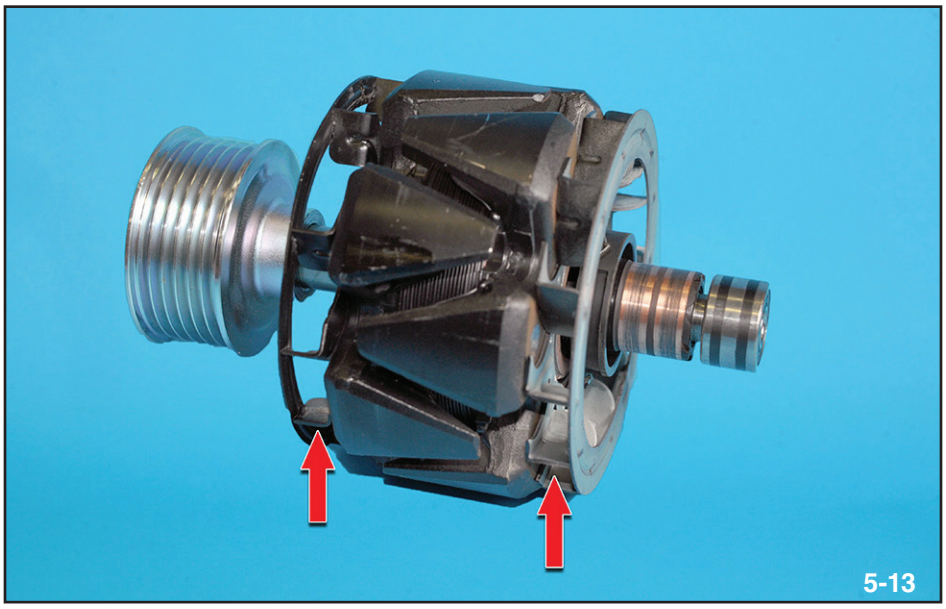
Alternator Case

The alternator case is constructed of aluminum since it dissipates heat well and does not magnetize. Numerous areas of ventilation are also incorporated in the case design to improve cooling characteristics.



Alternator case (Rear)

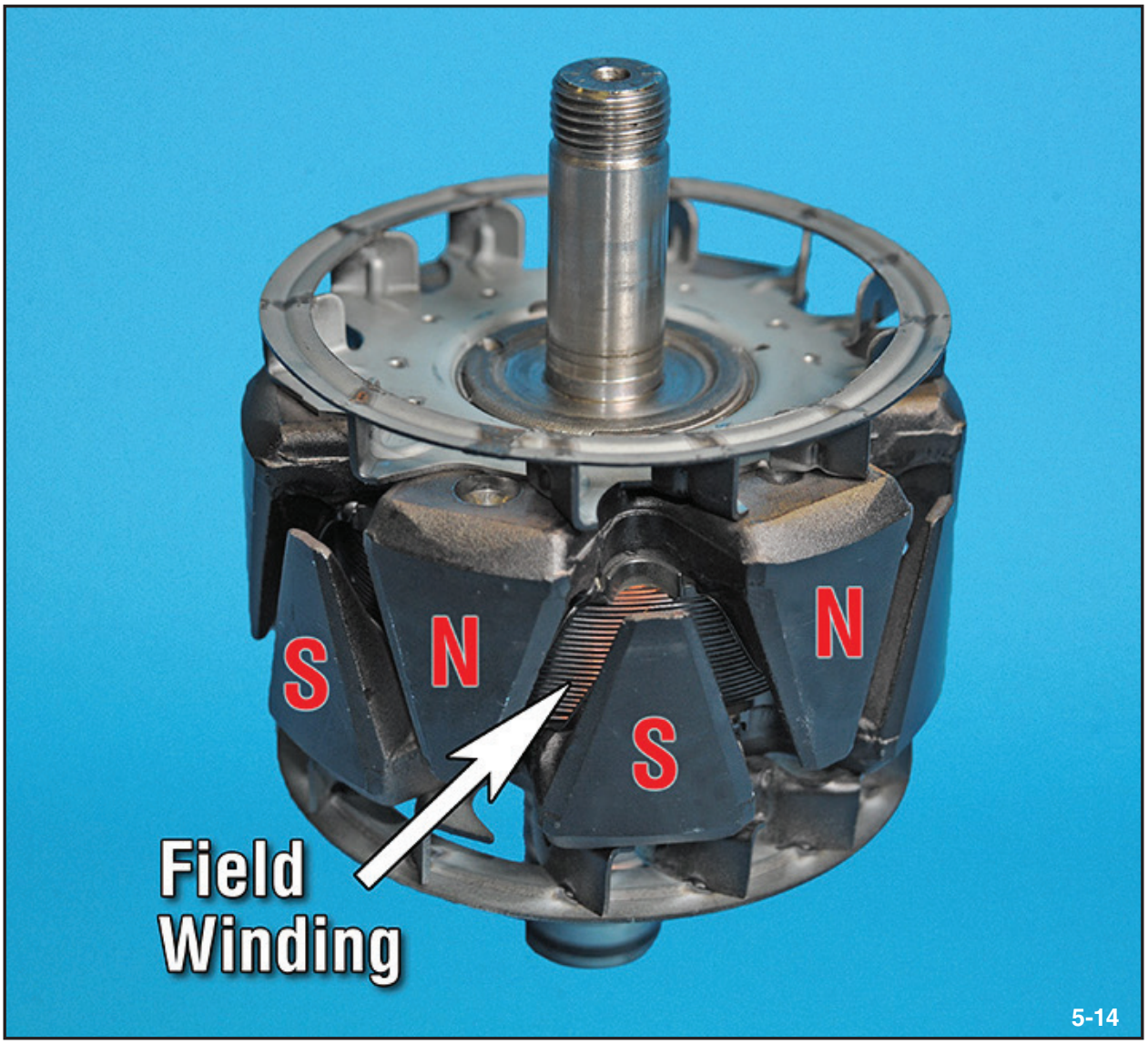
Fan blades are attached to the rotor assembly inside the front and rear of the alternator case. As the rotor rotates, air flows across the internal components to increase heat dissipation.



Alternator cooling fans

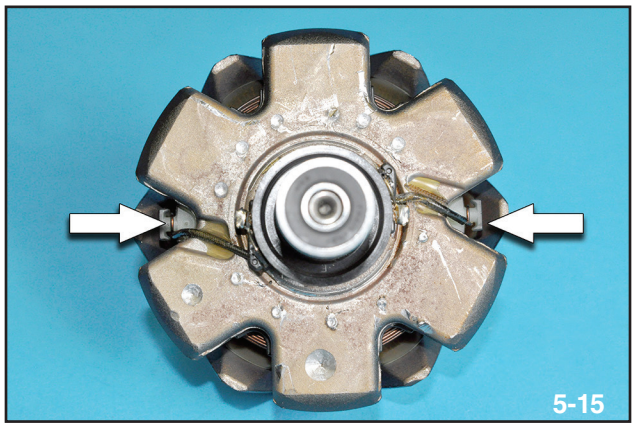
Rotor Assembly

At the center of the alternator is the rotor assembly. The rotor is secured to the alternator pulley and consequently driven by the engine drive belt. The rotor is constructed of alternating, triangle shaped, north and south magnets and an internal field winding (copper coil). These components work together to act as an electromagnet. As the rotor rotates, the alternating magnets induce an electromagnetic voltage into the stator windings. When current is applied to the field winding, the magnetic field coming from the north and south poles is intensified, increasing the induced voltage.

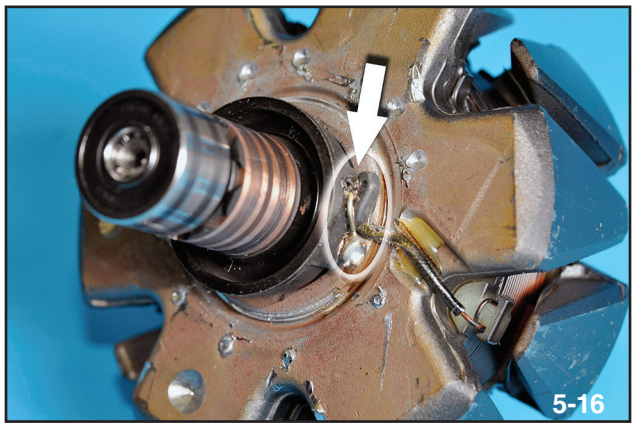


Rotor construction

The stator winding receives a power supply and ground path through a pair of slip rings and brushes.

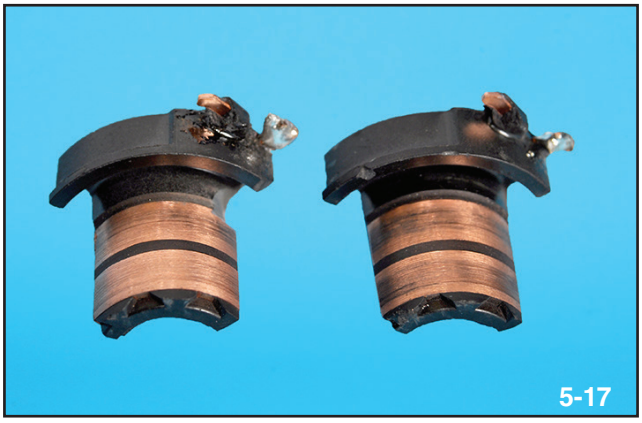


Field winding connection points



Slip ring connection point

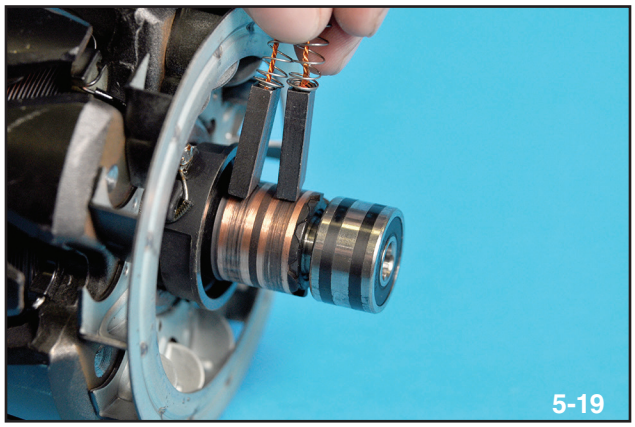
The slip rings allow the rotor to rotate while maintaining constant contact with the brushes.



Slip rings

Slip rings (Cutaway)

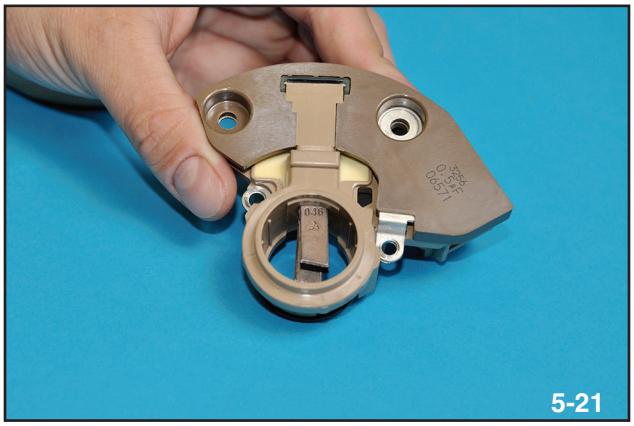
Each slip ring has a corresponding brush that gently rides along the conductive surface. Brushes are made of a soft carbon material that will slowly wear overtime. As a result, each brush is fitted with a spring to maintain constant contact with the slip ring.



Slip rings to brush contact

Individual brushes

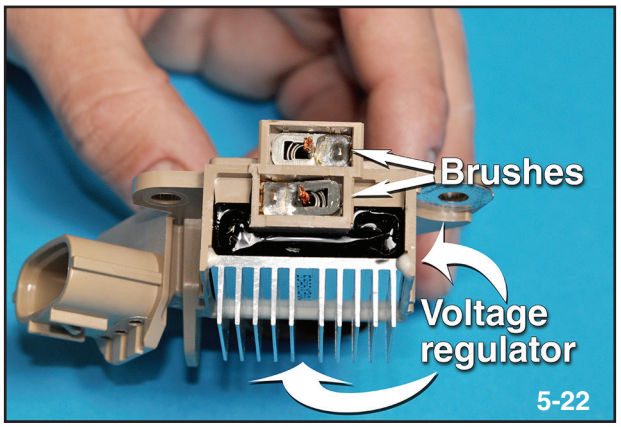
The brushes are fitted in a holder that allows their attached springs to maintain constant contact with the slip rings.



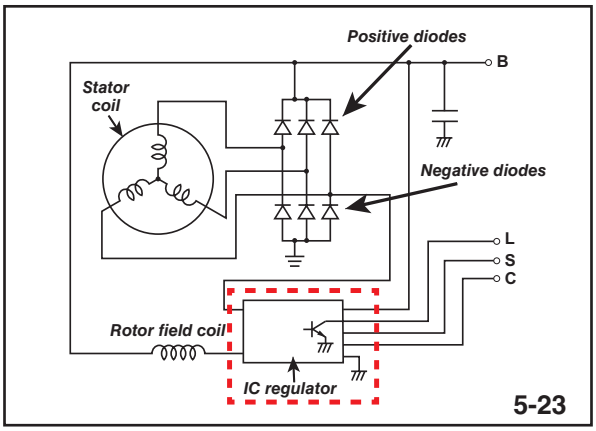
Brush holder

Voltage Regulator and Integrated Circuit

The brush holder also serves as the voltage regulator and integrated circuit (IC). The brushes are connected to the voltage regulator at the top of the brush holder. The voltage regulator controls the voltage applied to the field winding and regulates the final output of the alternator assembly.



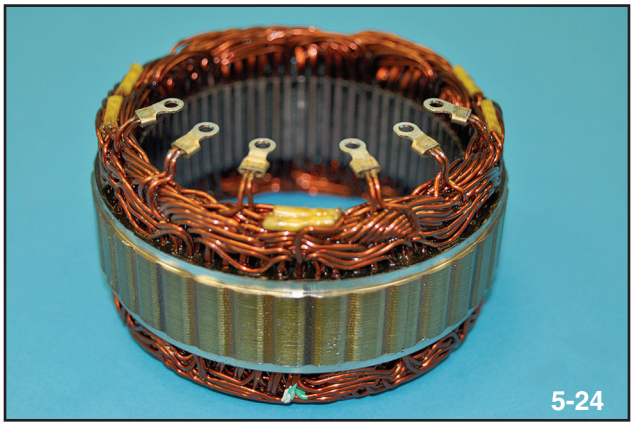
Voltage regulator



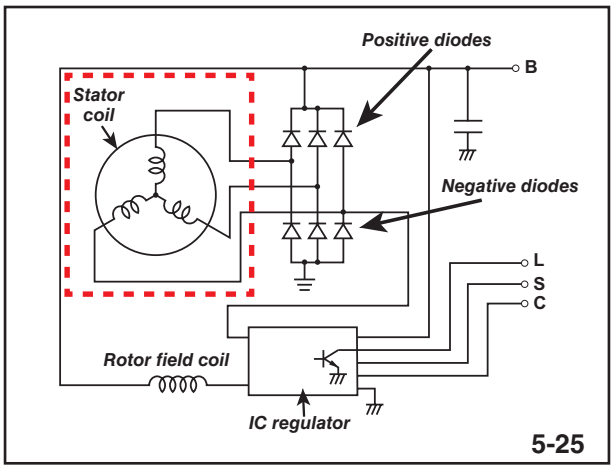
Voltage regulator and IC

Stator Assembly

The magnetic field generated from the rotor is induced into the stator assembly. The stator contains three separate coils (Sometimes referred to as phases) supported by steel frame in the center.



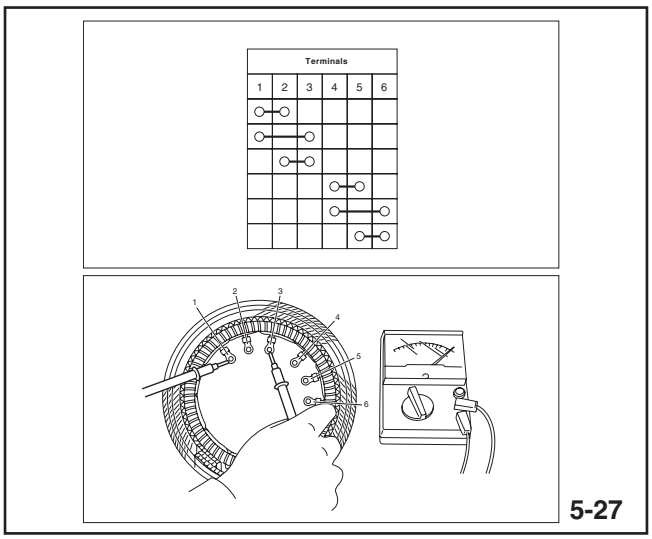
Stator assembly



Stator assembly

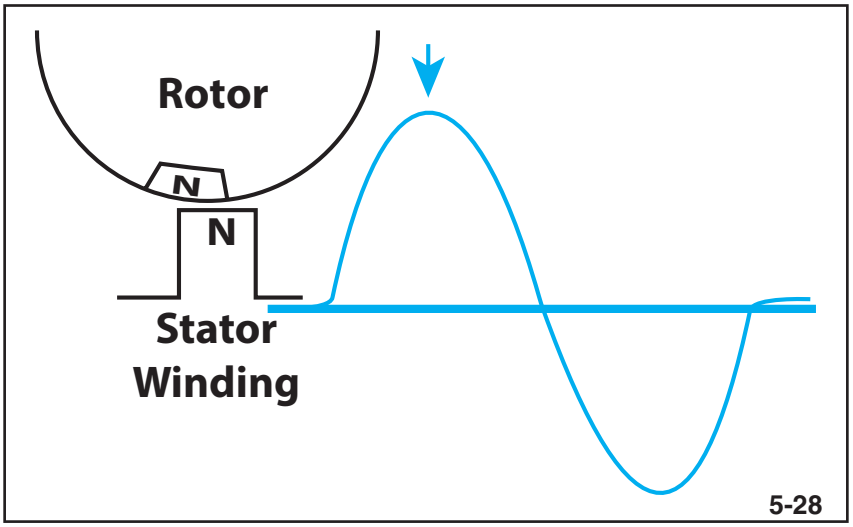
The three coils wound around the stator support terminate at six contact points on the rear side of the stator assembly. Using the inspection procedure found in the service manual, the relationship between the three sets of windings can be seen.

Stator connection points

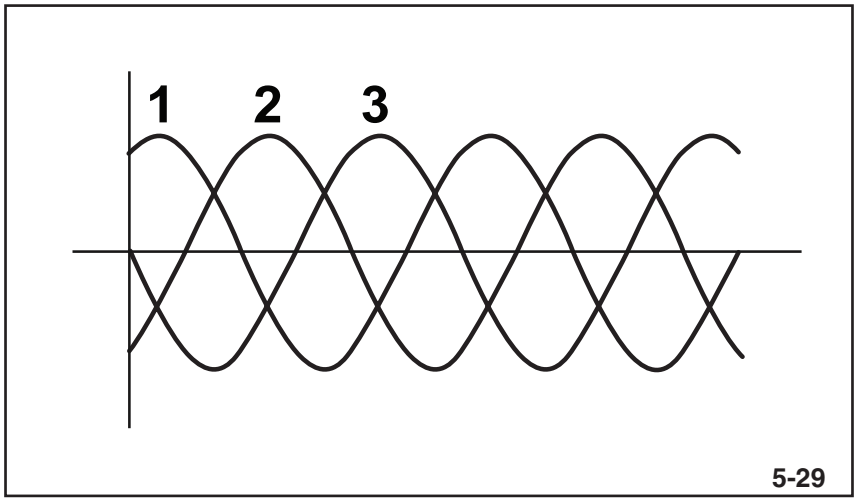


Stator inspection

As the rotor rotates the magnetic field produced is induced into the stator windings in the form of an AC current. Since the Stator has three independent sets of windings, three independent phases of AC current are generated.



A/C voltage - Single phase

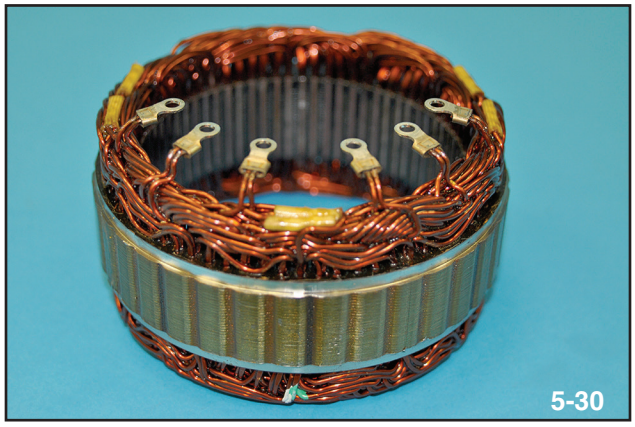


A/C voltage - Three phase

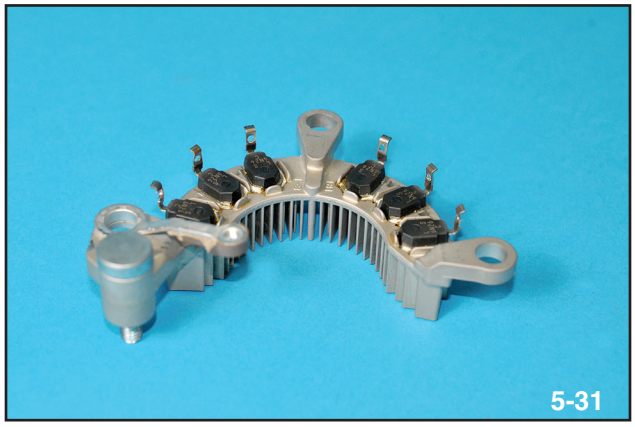
NOTES:

Diode Assembly (Rectifier)

The diode assembly contains six diodes fitted to an aluminum frame with cooling fins to dissipate heat.

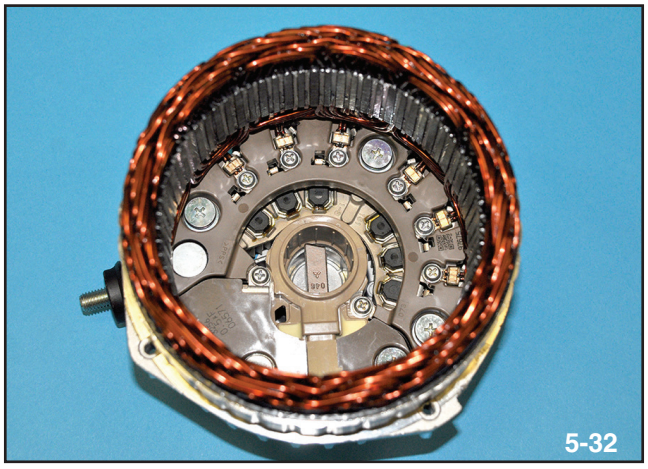


Diode assembly encased

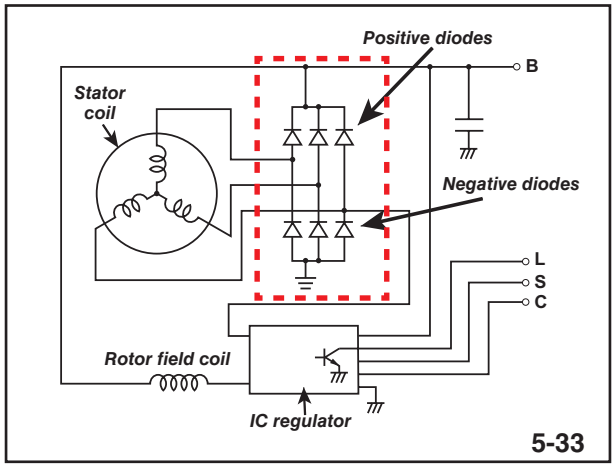


Diode assemble casing removed

Since the voltage induced in the Stator assembly is AC, it cannot be readily used by the vehicle until it has been converted or “rectified” into DC voltage. AC voltage rectification is accomplished by the diode assembly.

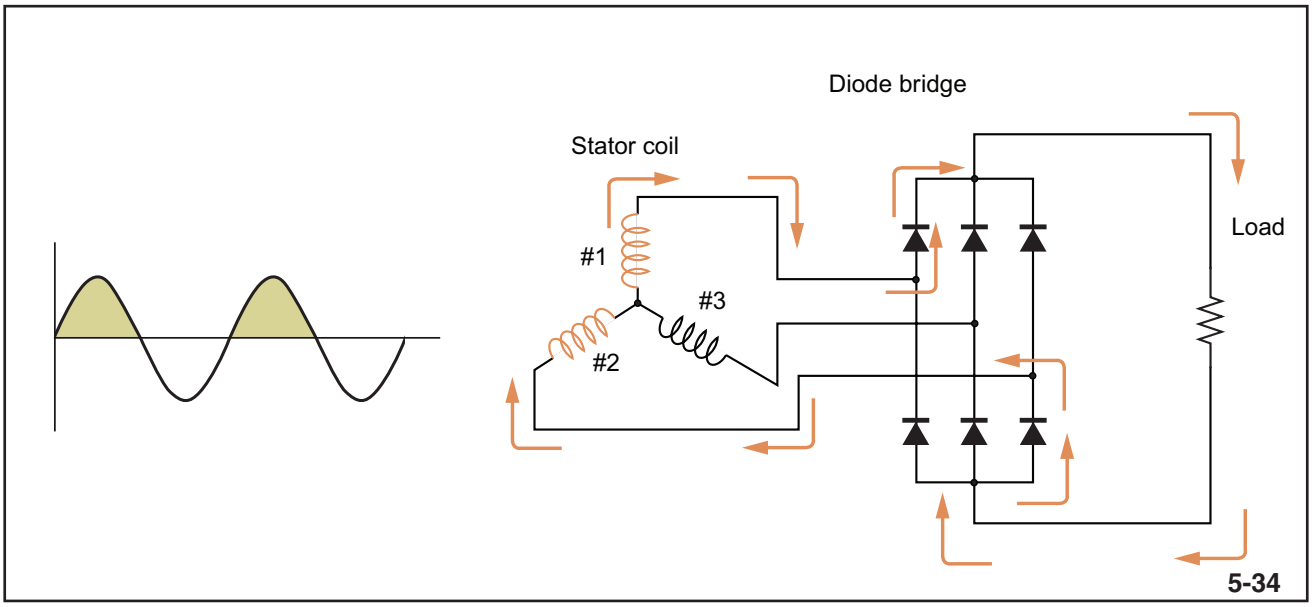


Diode assembly



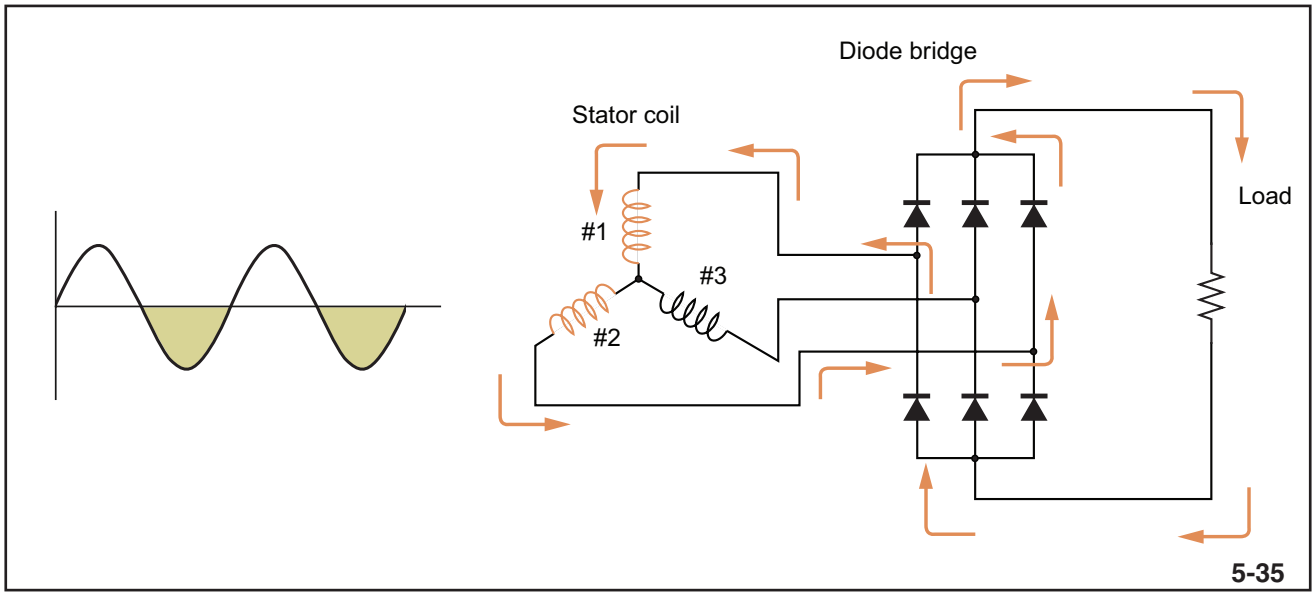
Diode assembly

When positive voltage is generated through the stator assembly, it flows through the three positive diodes as shown in the image below. There is one positive diode for each stator winding.



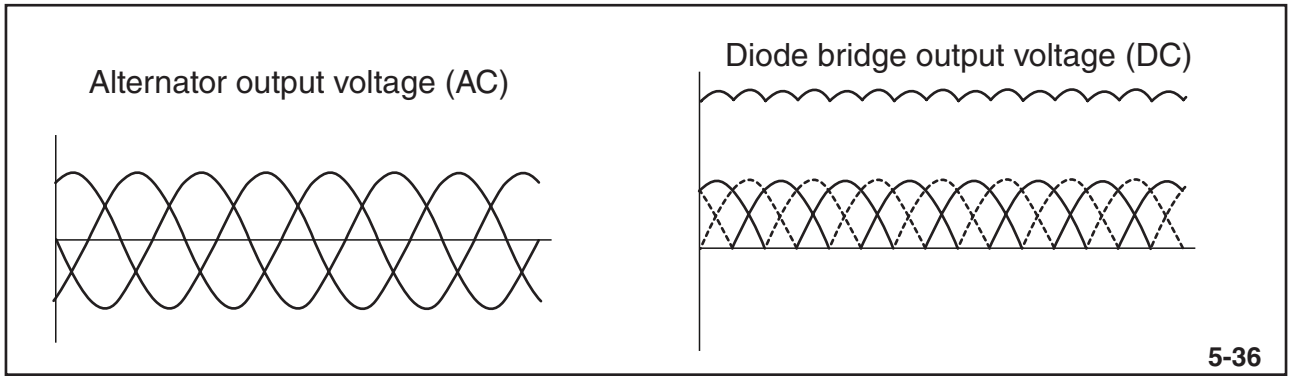
Positive voltage flow

When negative voltage is generated through the stator assembly, it flows through the three negative diodes as shown in the image below. There is one negative diode for each stator winding.



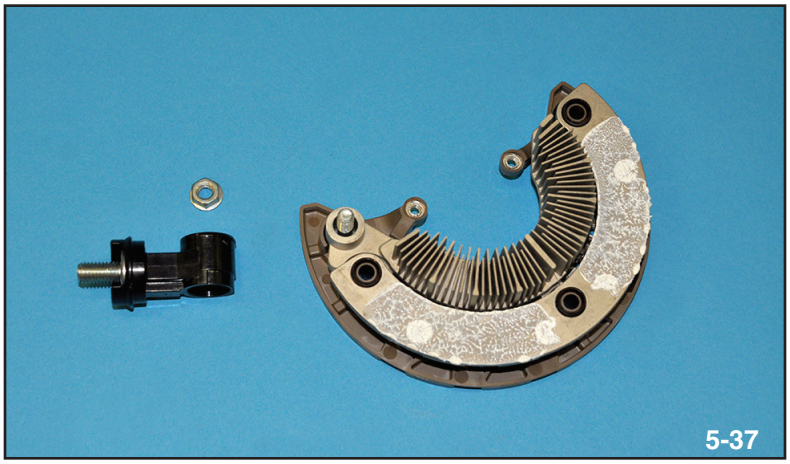
Negative voltage flow

The resulting rectified voltage is DC and usable for conventional vehicle systems.

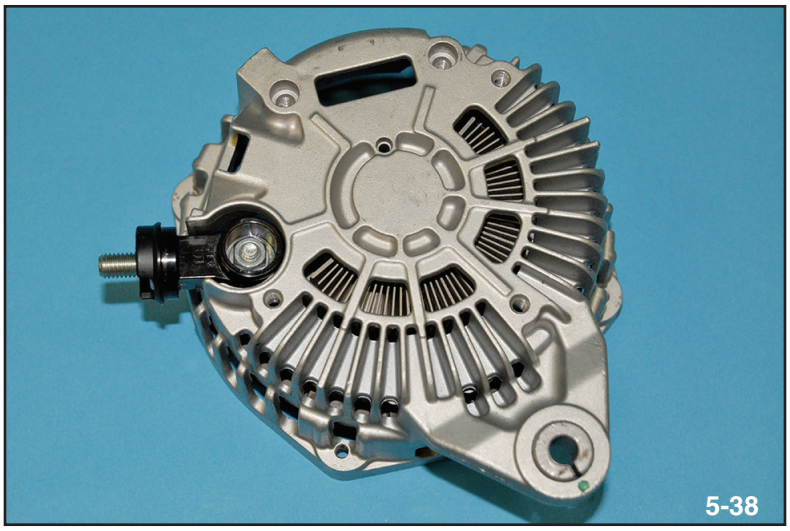


Voltage rectification results

The rectified voltage outputs to the “B” Terminal. The insulated “B” terminal then protrudes through the alternator case and connects to the power supply circuit.



B terminal connection (Case removed)

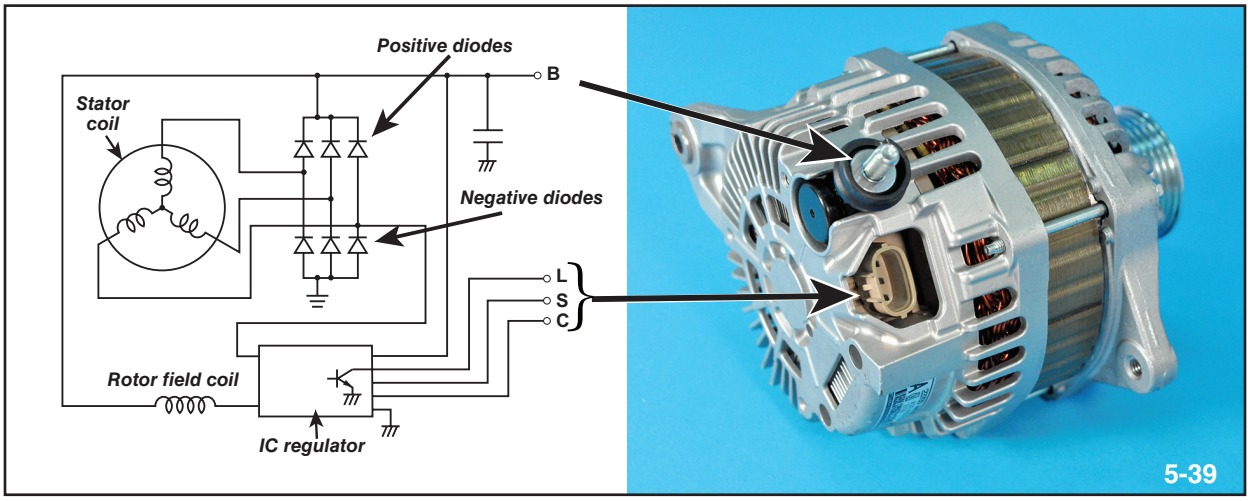


B terminal connection (Case installed)

Alternator Circuit Construction

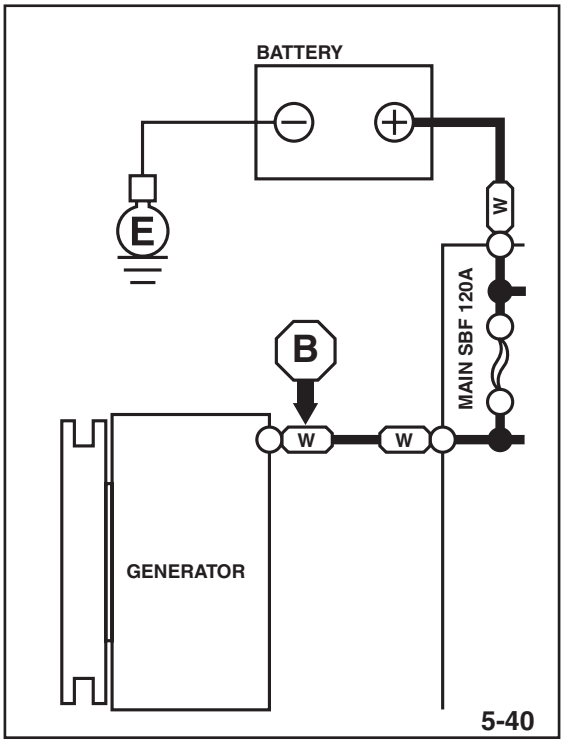
The alternator will contain 2 or 4 connection points depending on model and generation.

- **B** (Battery) – Main alternator output terminal. Connected to the battery
- **L** (Lamp) – Warning lamp control. Connects to the combination meter
- **S** (Sensing) – Voltage regulator terminal. Connects to the main fuse box
- **C** (Control) – Duty control for the voltage regulator. Signal comes from engine control Module (late model vehicles).



Alternator connection points

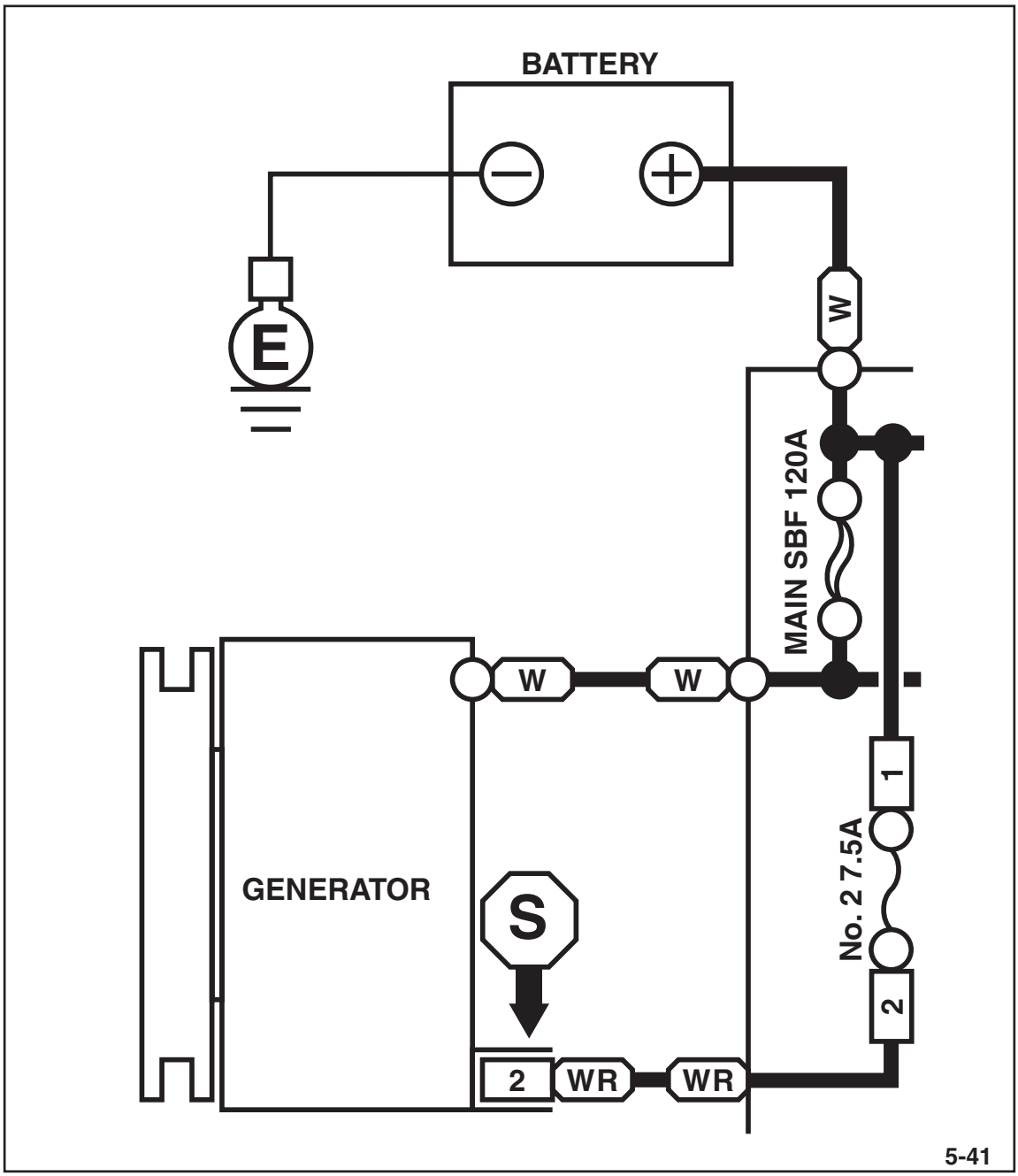
The “B” Terminal is the main output from the alternator and connects to the battery through the Main Fuse.



“B” Terminal circuit

The “S” Terminal senses voltage from the battery circuit through the main fuse box. The voltage sensed is constantly compared to the voltage at the “B” terminal and allows the voltage regulator to provide the proper level of voltage at all times.

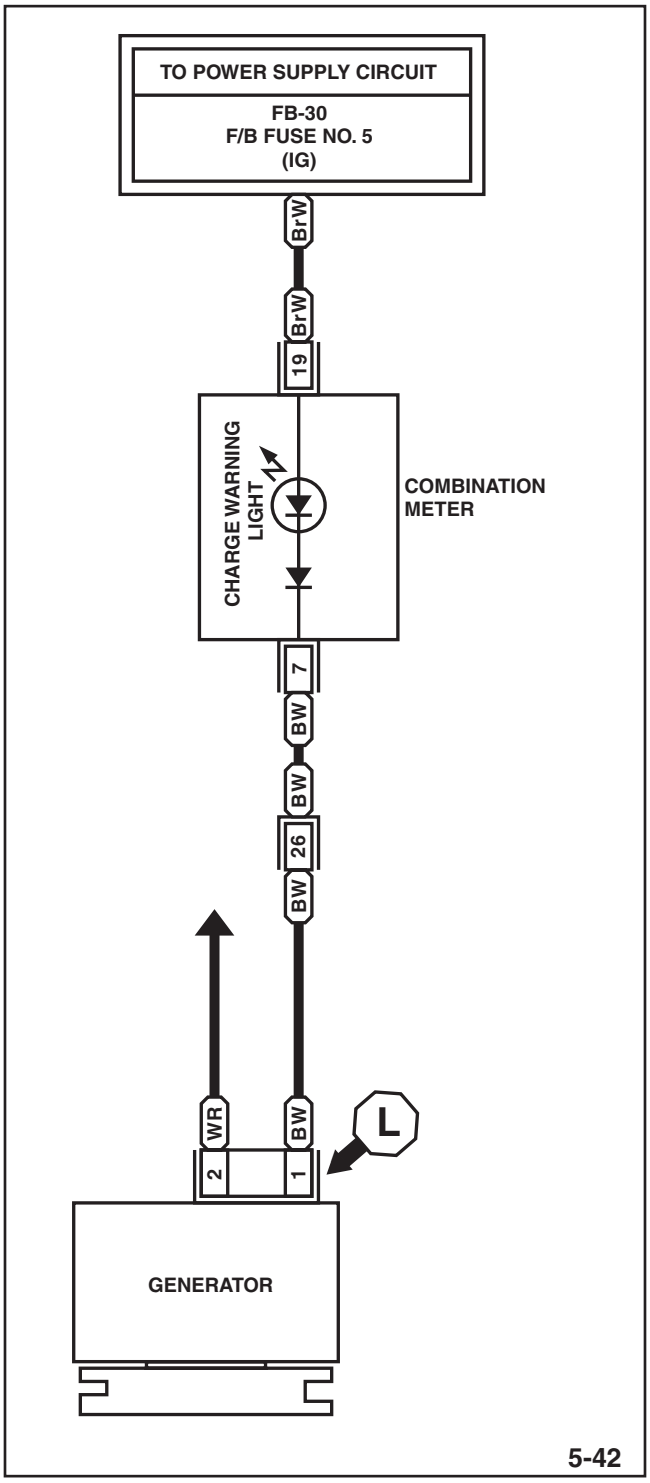
Note: A fuse is installed in the “S” terminal path to the battery circuit. Should this fuse be removed or become blown/damaged overcharging may result; however, voltage will still be regulated to prevent the battery from being damaged.



“S” Terminal circuit

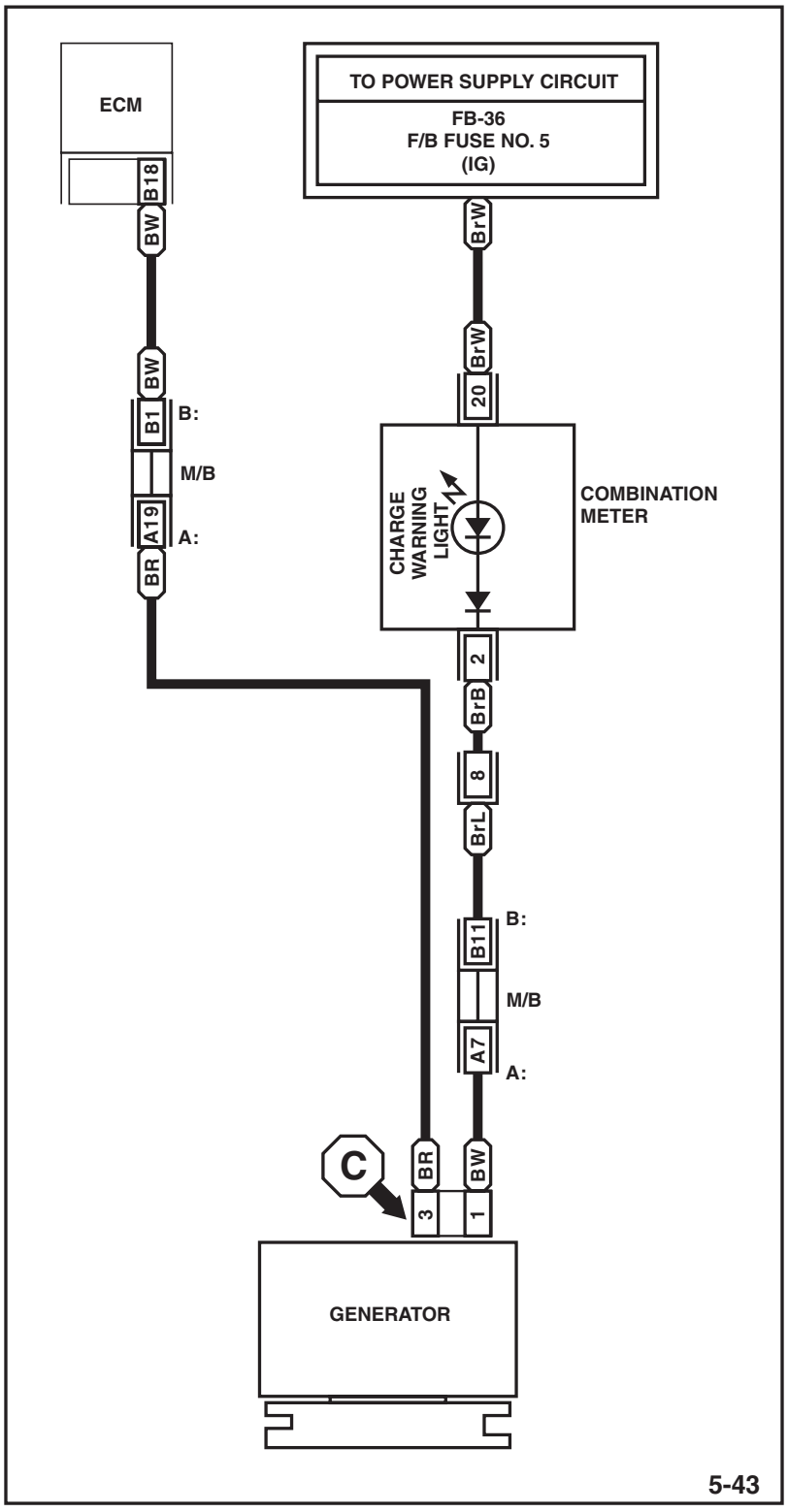
The "L" Terminal controls a ground signal to the LED located in the combination meter. The integrated circuit (IC) in the voltage regulator will complete a ground path for the LED in the following instances;

1. No voltage output
2. Excessive voltage output
3. Terminal "B" is disconnected
4. Terminal "S" is disconnected



"L" Terminal circuit

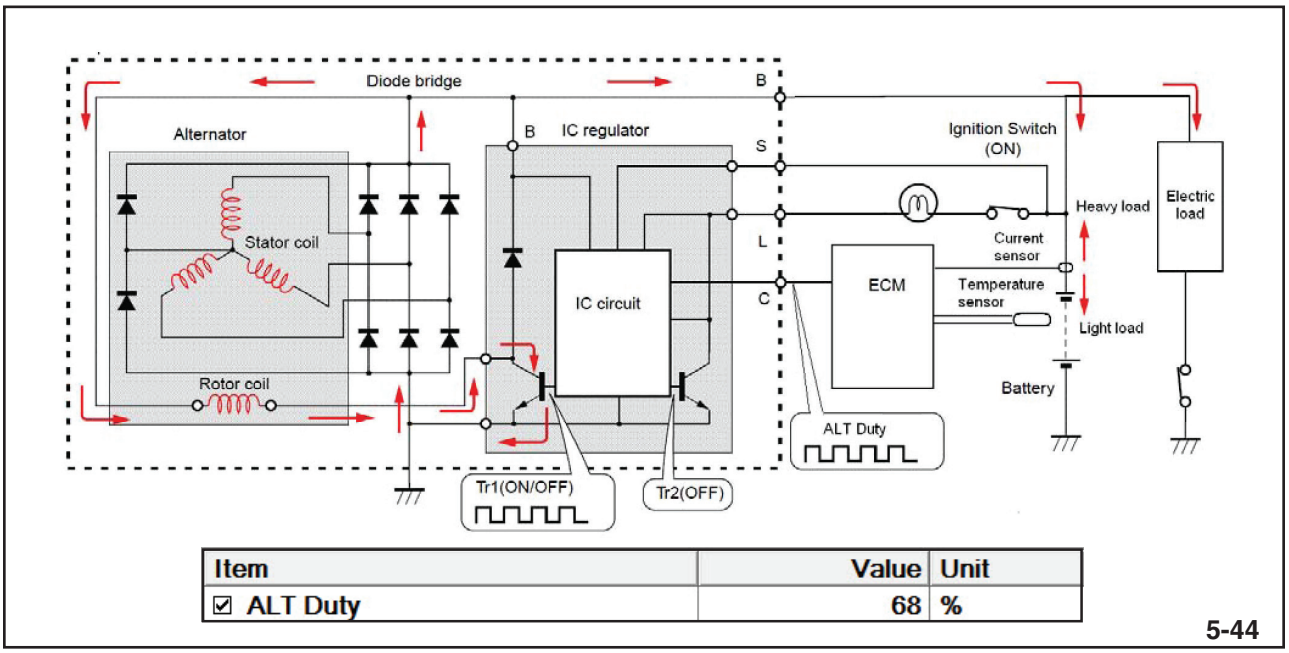
The “C” Terminal is the control signal for vehicles with enhanced charging control systems. Introduced with the 2012 Impreza, the Engine Control Module (ECM) outputs a duty signal to the voltage regulator to more precisely control alternator output. The ECM utilizes information from the battery current and temperature sensor to determine the most suitable level of alternator output.



“C” Terminal circuit

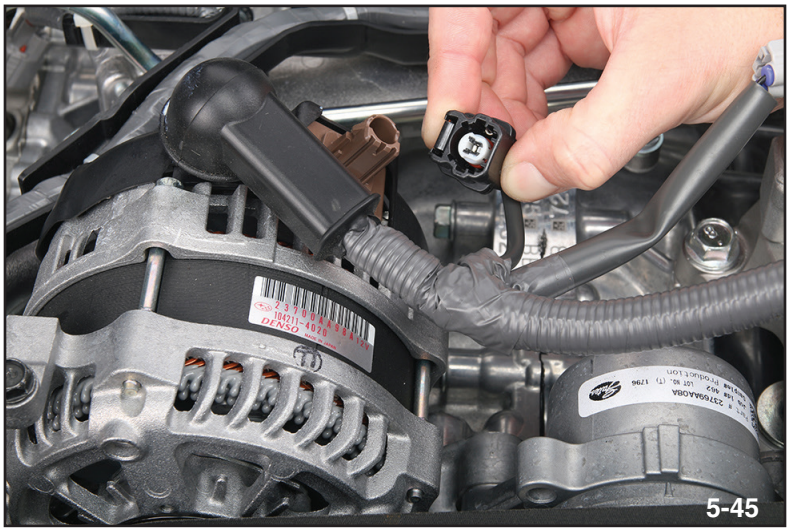
Charging control begins with a duty signal originated from the ECM. The IC regulator interpreters the signal and in turn controls the Tr1 transistor base. The transistor controls the rotor coil (field winding) current flow and consequently the amount of electromagnetism induced into the stator coil. A reduced duty signal to the Tr1 transistor will weaken the magnetic field from the rotor and reduce alternator output.

Note: Tr2 represents the control for the charge warning light located on the combination meter.

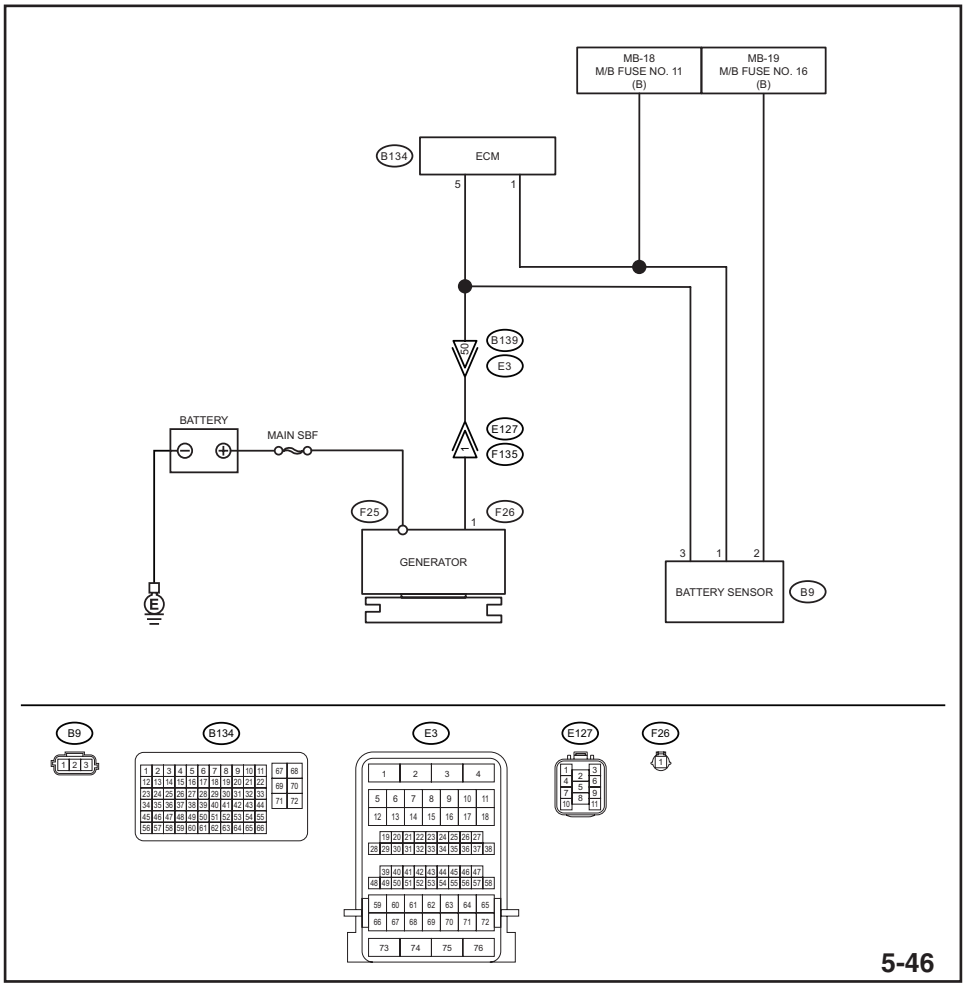


Alternator duty control signal

Beginning with certain 2017MY vehicles, the alternator charging control circuit has been reduced to a singular wire. The single wire connection provides a LIN communication from the ECM for charging control.



LIN Communication (Connector)

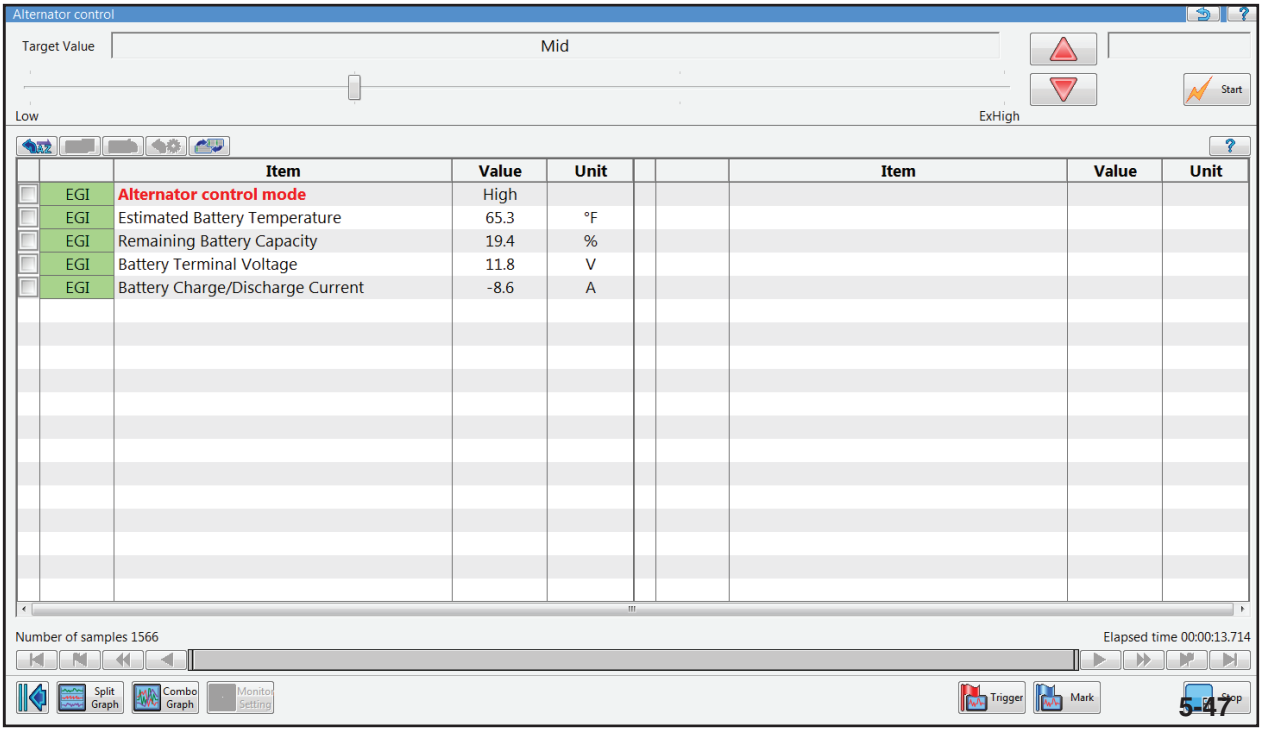


Charging System Wiring Diagram

The ECM commands alternator output in three or four modes depending on the model year;

- Low
- Middle
- High
- ExHigh (Extra High, added in later model years)

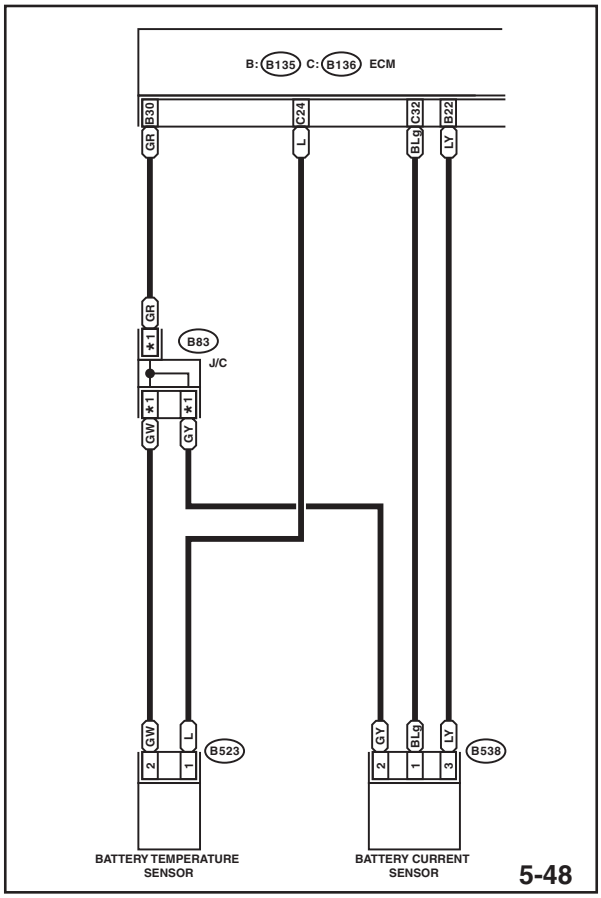
Users can monitor and control the output of each of these modes using the System Operation Check Mode function on the Subaru Select Monitor.



Alternator control system operation check mode

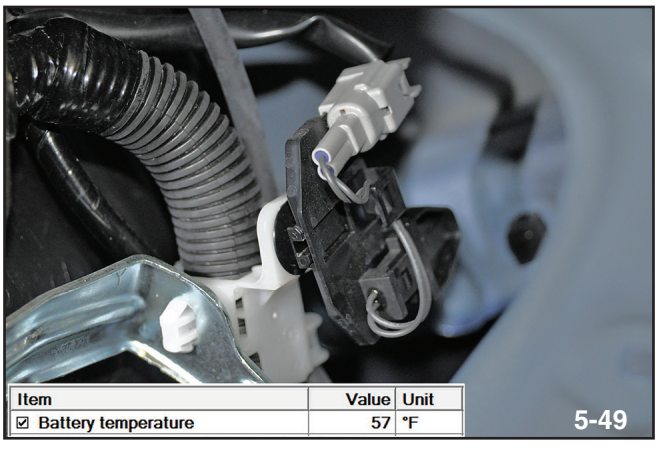
Battery Current and Temperature Sensors

Coinciding with the 2012MY Impreza enhanced charging control system, battery current and temperature sensors were added to improve the accuracy of the charging control system.



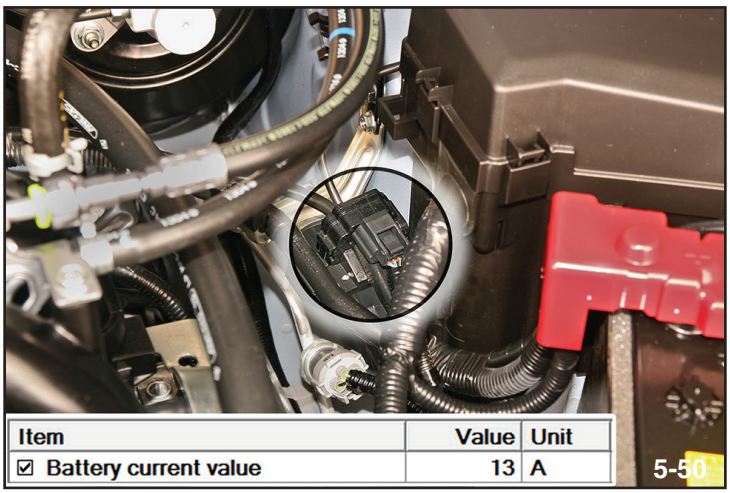
Charging control system sensor diagram

A battery temperature sensor was installed next to the battery case to measure the surrounding temperature of the battery. This provided the ECM with the information to estimate the battery's ability to accept a charge based on the principal that a warmer battery accepts a high rate of charge more efficiently.



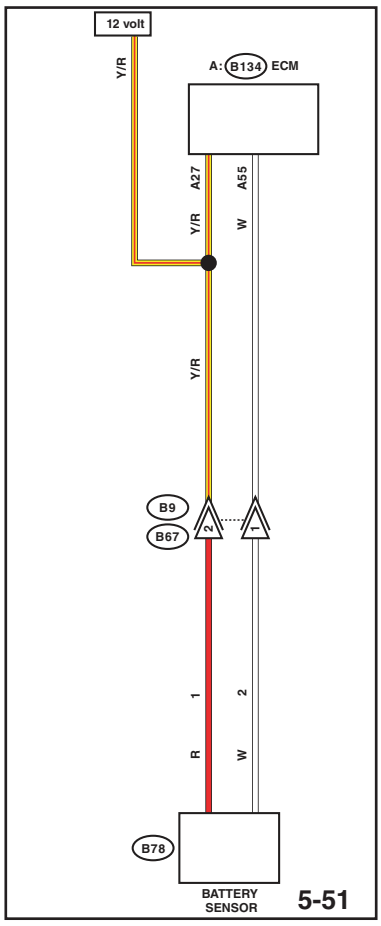
Battery Temperature sensor

An inductive battery current sensor was installed around the battery negative cable to measure the intensity of the magnetic field surrounding the cable.



Inductive battery current sensor

Beginning with some 2013 MY vehicles the functions of the battery current sensor and temperature sensor were incorporated into a singular battery sensor. The sensor receives 12v power supply through normal power distribution and outputs a LIN (Local Interconnect Network) communication signal to the ECM. The battery negative terminal is used as a ground for the sensor.



Improved battery sensor wiring

The battery sensor features improved current sensing ability by means of a shunt type resistor. This improvement provides more accurate charging system measurements and expands the information provided when using the Subaru Select Monitor.

		Item	Value	Unit
☐	EGI	Estimated Battery Temperature	70.7	°F
☐	EGI	Remaining Battery Capacity	15.3	%
☐	EGI	Battery Terminal Voltage	11.7	V
☐	EGI	Battery Charge/Discharge Current	-8.6	A
☐	EGI	Alternator control mode	High	5-52

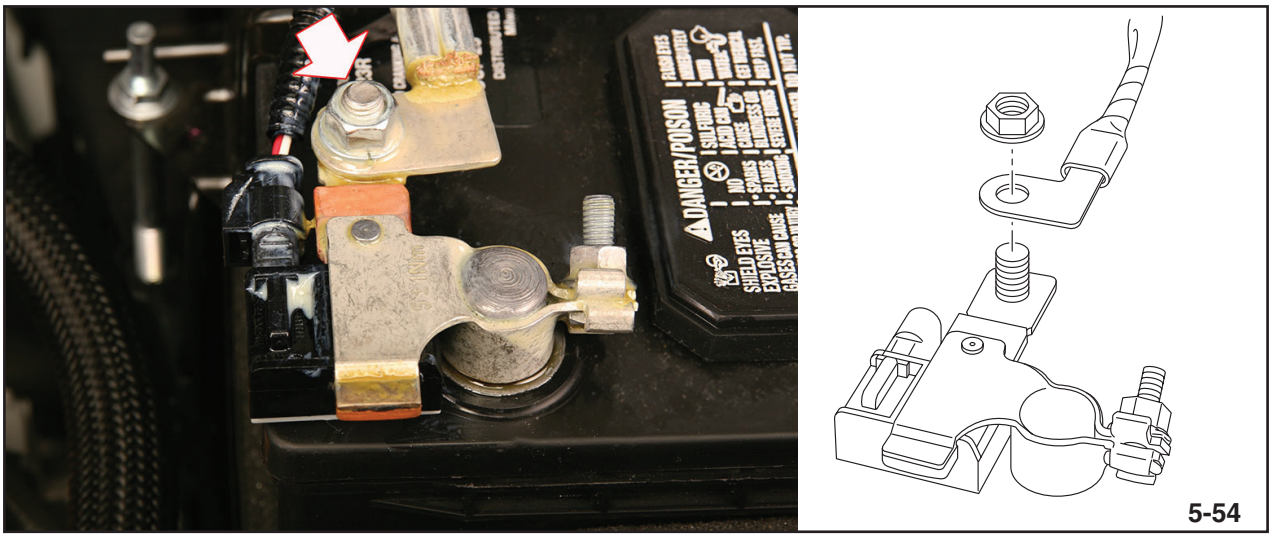
Charging control system SSM data

Beginning with some 2017MY vehicles, a new style battery sensor was adopted. These sensors utilize a “Pulse Discharge Current” method (as opposed to shunt type) to more accurately measure the battery state of charge. The new sensor has improved Ignition ON/Engine OFF monitoring abilities to interact with retained power features of corresponding models.

Battery Sensor

Battery Sensor Service

When disconnecting the negative battery cable for service, always remove the larger 12mm nut from the sensor. Avoid removing the 10mm nut on the battery terminal as poor contact due to loss of tension may occur after re-installation.



Battery sensor service

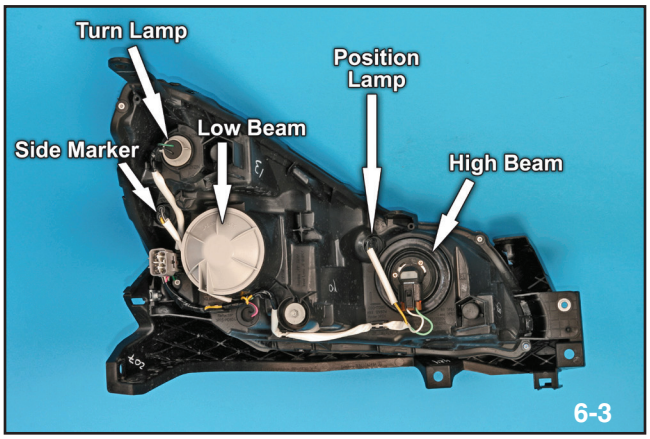
NOTES:

Headlight Systems

Halogen

Most Subaru vehicles use conventional halogen lamps to provide the necessary illumination when driving in low light conditions or using signals.

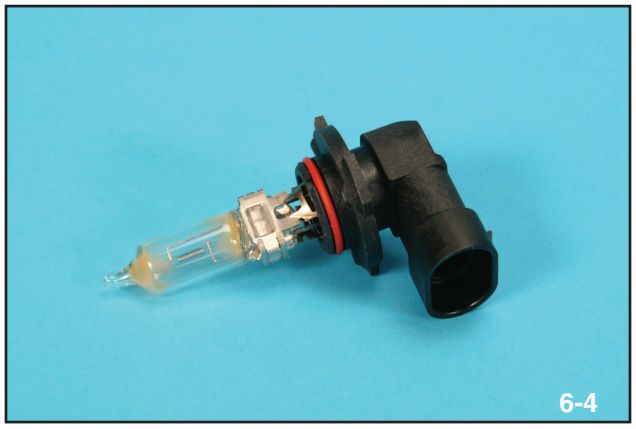
Conventional Headlight



Bulb Locations

Halogen lamps offer reliable performance at a low cost and do not use hazardous materials.

Caution: Avoid direct contact with the glass bulb housing as contamination may lead to premature bulb failure.



Halogen headlight lamp

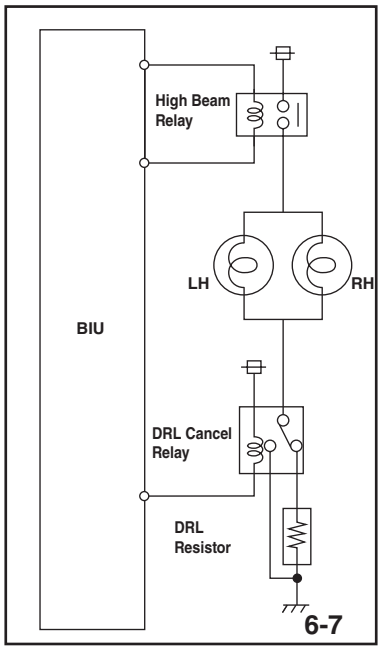
Daytime Running Lamps

Subaru's Daytime Running Lamp (DRL) system uses the high beam lamps at a reduced output to provide daytime visibility to other vehicles on the road.

DRLs OFF

DRLs ON

When the low beams are in the OFF position, the high beam relay is energized allowing current to flow to the high beam lamps. The ground side of the high beam lamps contains a "DRL Cancel Relay" and a "DRL Resistor". During DRL operation the DRL cancel relay is de-energized causing the current to flow through the DRL resistor before reaching a ground source. This creates a significant voltage drop in the circuit reducing the available voltage for the high beam lamp. When full high beam operation is required, the DRL cancel relay will be energized allowing current to bypass the DRL resistor. This allows the high beam lamp to utilize full source voltage for illumination.



DRL circuit

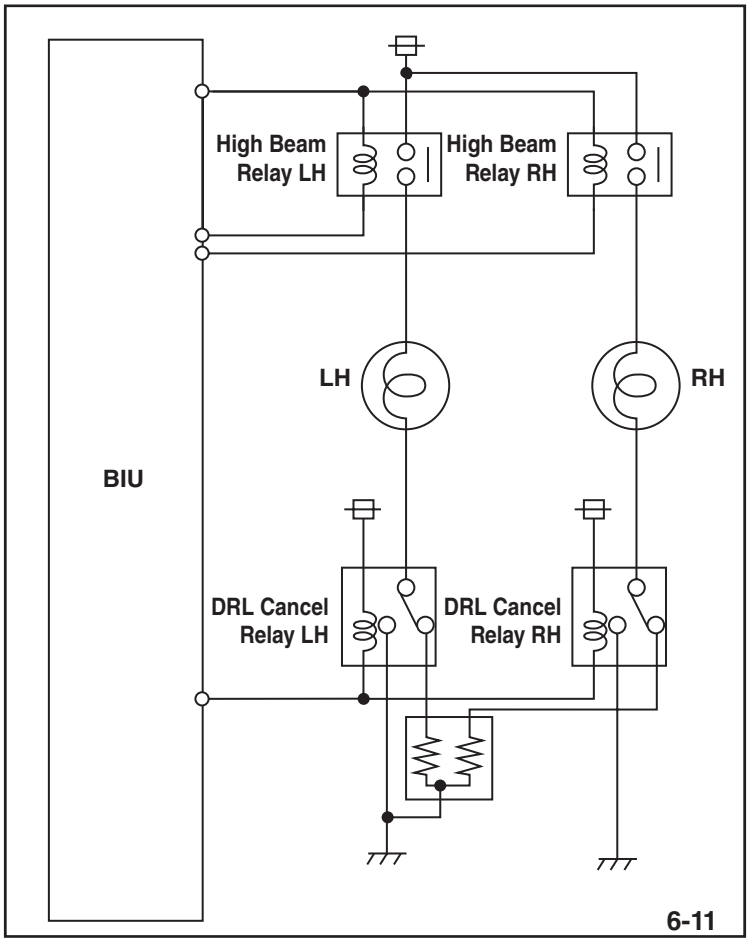
DRL resistor

Beginning with 2015 Legacy and Outback models, the DRL system has been expanded to provide better turn signal visibility for surrounding vehicles and pedestrians. This is accomplished by disabling the low beam on the side of turn signal activation.

DRLs ON

Left turn signal ON

In order to achieve this function, an additional DRL cancel relay, High Beam relay, and DRL resistor have been added. This effectively creates 2 independent high beam control circuits allowing independent function.



DRL cancel circuit

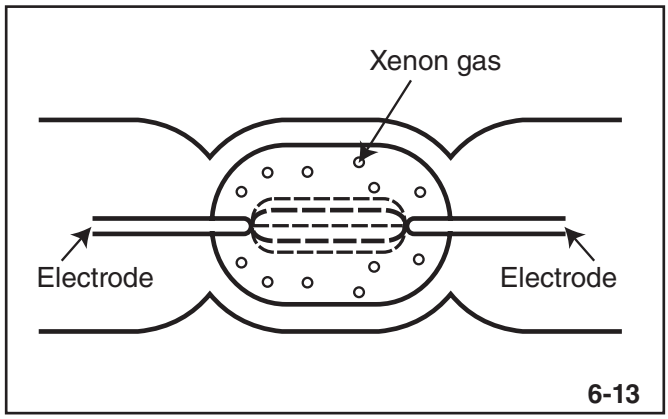
High Intensity Discharge (HID)

Beginning with the 2004 Impreza WRX STi, some Subaru models may be optionally equipped with High Intensity Discharge low beam headlights for improved visibility.

HID headlight

HID headlights operate by applying a high electrical charge through two electrodes that are surrounded by a xenon and mercury gas in a sealed glass tube. The gas emits light as it is heated by the electrical current.

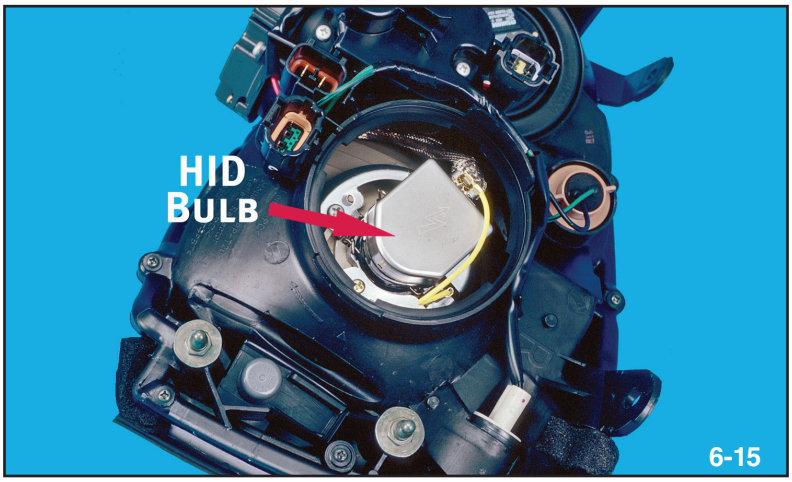
Note: HID headlights contain mercury. For that reason, it is necessary to remove HID headlights before vehicle disposal. Once removed, please recycle or dispose of the headlights as hazardous waste in accordance with applicable state laws.



HID internal function

HID Bulb (Low beam)

The HID headlight bulb is fitted into the normal location for the low beam and sealed with a protective cover.

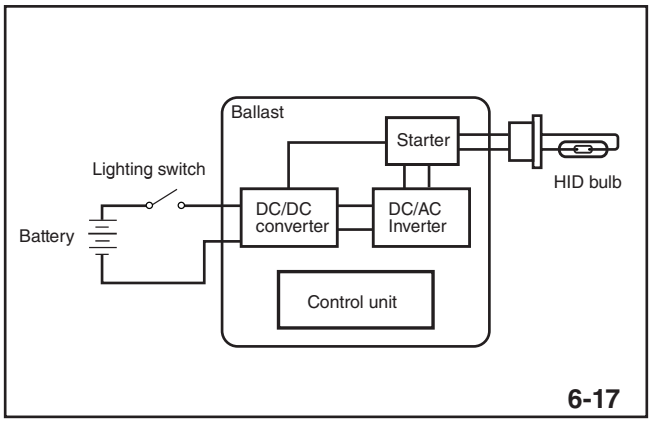


HID bulb

In order to achieve the intense light emission from the xenon gas, a large voltage supply is required. An HID ballast containing a control unit, DC/DC convertor, DC/AC inverter, and starter is fitted to each HID headlight. When an HID headlight is first turned on the starter in the HID ballast will provide nearly 23,000 volts AC. After the initial spike, the DC/DC convertor will raise the 12.6 volt supply to around 85 volts DC. The 85 volts DC is then inverted to 85 volts AC for sustained operation of the HID headlight.

- Warning: Do not attempt to disconnect the HID headlight assembly or related components with the headlights in the ON position.

HID ballast



HID schematic

Due to the high voltage and high heat generation, always exercise caution and read warning labels before attempting any service of the HID headlight system.

HID warning label

Light Emitting Diode (LED)

Beginning with the 2015 WRX and STI, light emitting diode (LED) low beam and parking lamps have been added for improved reliability and reduced power consumption.

Note: The LED low beam and parking lamps are not serviceable. The entire headlight assembly must be replaced if an internal failure occurs. However, the halogen high beam lamp is still individually serviceable.

LED parking lamp

LED low beam

The LED headlight system is equipped with a warning message in the event an LED failure occurs.

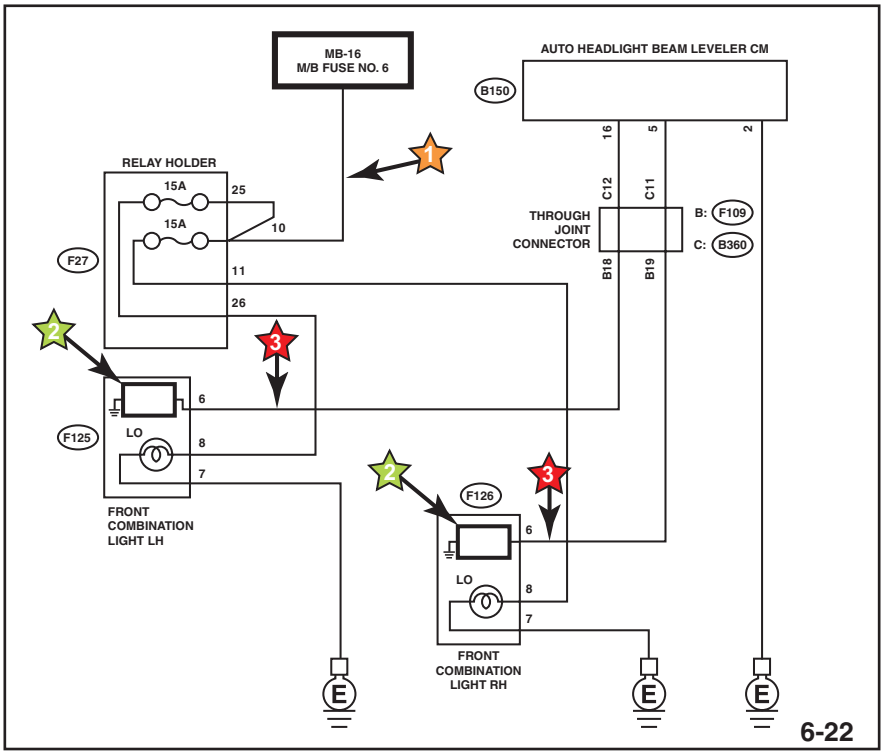
LED headlight disabled warning

The Automatic Headlight Leveling Control Module (AHLCM) monitors the power supply to the LED low beam. During normal operation, the LED headlights illuminate when power is received from MB-16 (Orange star 1) Parallel circuits at the Relay Holder provide independently fused circuits to each headlight assembly.

As each headlight operates the supply power is monitored by voltage check modules (Green star 2) that are located inside the headlight assembly.

When the circuit is operating normally, the voltage at terminal 6 (Red star 3) of F125 and F126 is 0 volts. If power is lost on one or both headlights, the voltage at terminal 6 becomes 5 volts and a DTC (82905 LED HEADLAMP LEFTHAND ERROR or DTC 82904 LED HEADLAMP RIGHTHAND ERROR) is set.

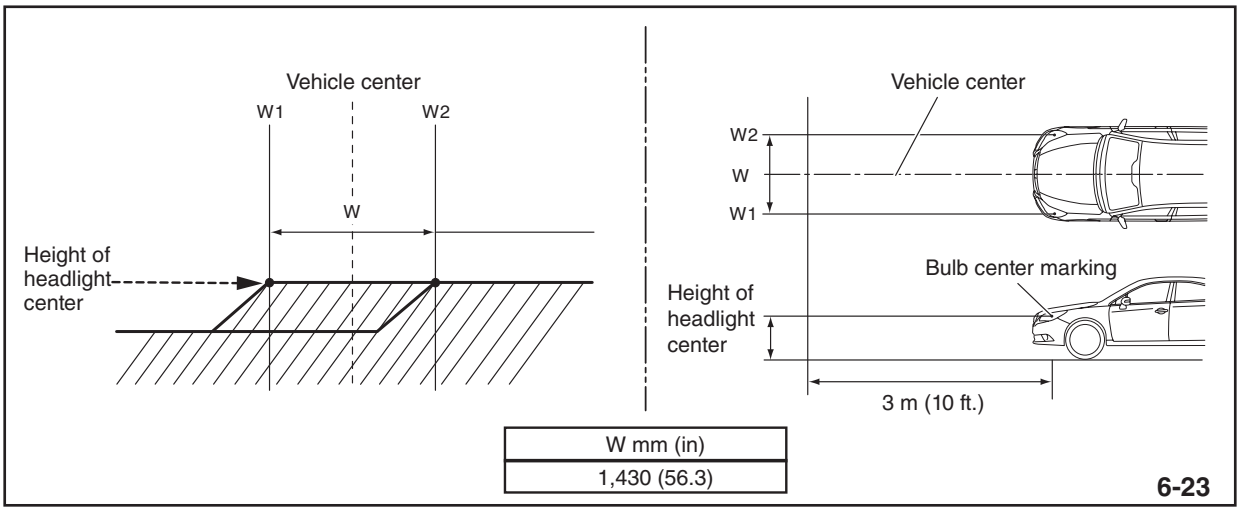
Note: The actual construction and internal wiring of the LED headlights is not represented in this drawing A set of high strength light emitting diodes are wired in series and use a DC to DC converter to amplify the battery voltage The amplification is required due to the voltage drop that occurs at each LED.



LED headlight circuit

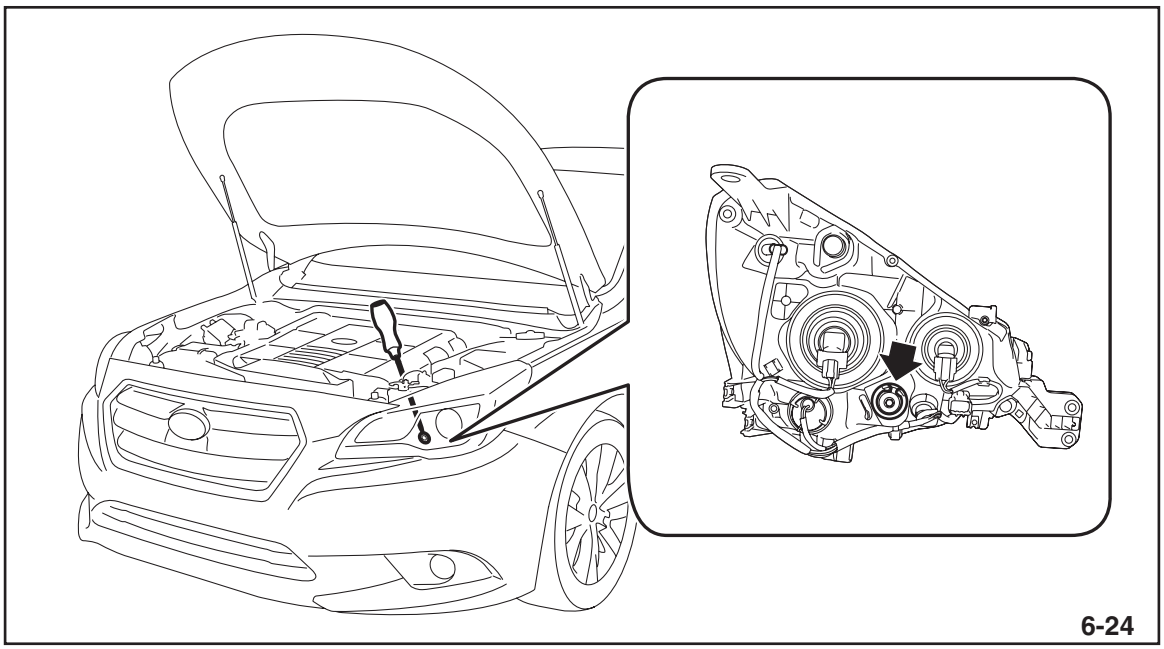
Adjustments and Levelers

Proper headlight aiming is critical for good visibility and safety. Following any headlight related services always ensure the headlights are properly aimed and adjusted.



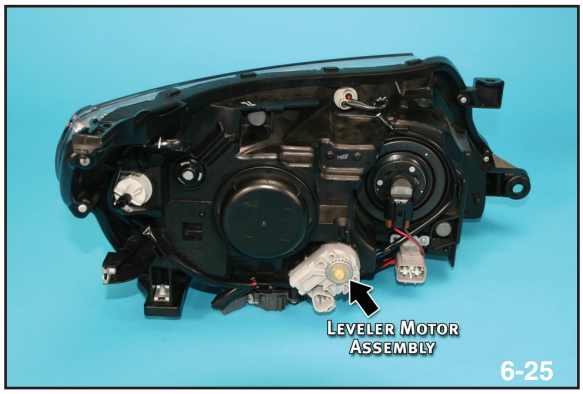
Headlight Aiming

For conventional headlights, aiming is accomplished by turning the adjustment screw fitted to the rear of the headlight assembly. Consult STIS for the location and access of the adjustment screw.



Manual Adjustment

Some Subaru models are fitted with on-board headlight leveler systems. These systems use a leveler motor to adjust the vertical axis of the low beam lamps.

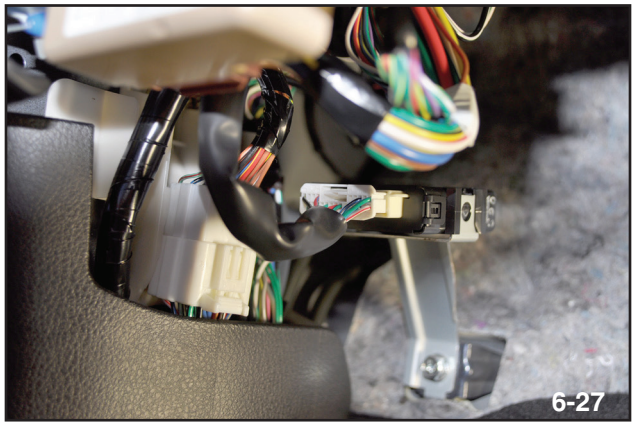


Leveler Motor

Some headlight leveler systems are actuated by console mounted switches. These systems are commonly referred to as manual leveler systems.

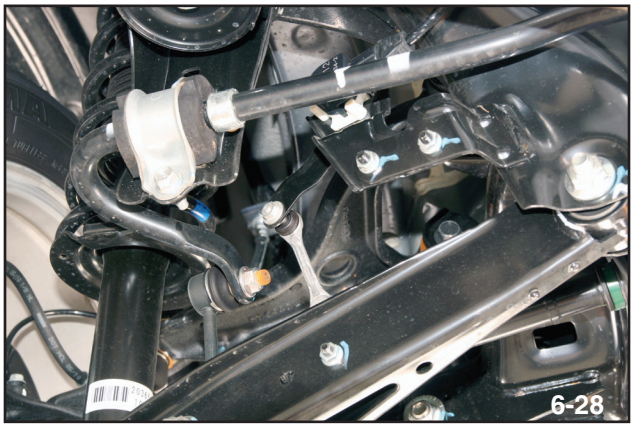
Headlight Leveler Switch

Other headlight leveler systems are equipped with automatic adjustment functions. These systems utilize information received from a rear height sensor to adjust the vertical axis of the headlights. An Automatic Headlight Lever Control Module (AHLCM) interpreters the information from the rear height sensor and controls the headlight leveler adjustment.



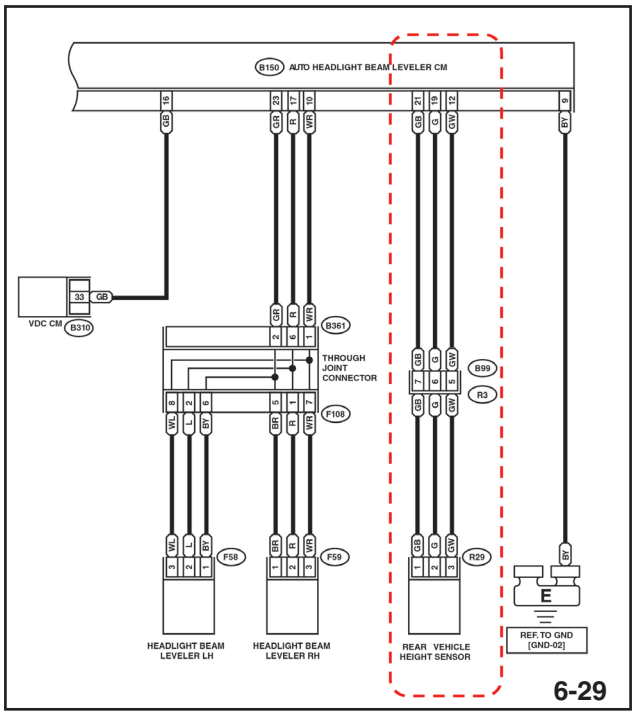
Automatic Headlight Leveler Control Module (AHLCM)

The rear vehicle height sensor is mounted to the rear subframe and arm. As weight is added or subtracted the vehicle ride height will fluctuate. Generally, a weight increase will cause the rear suspension to sink to a lower level. This will cause the front suspension to have a more upward angle resulting in an undesirable headlight angle.

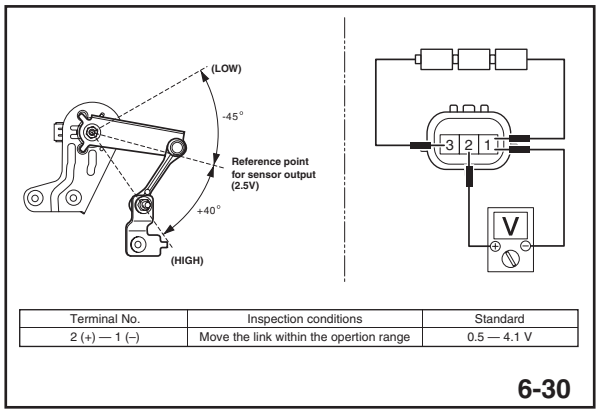


Rear height sensor

The rear vehicle height sensor is connected to the Auto Headlight Beam Leveler CM with 3 wires. Those 3 wires represent a 5 volt reference, ground, and signal voltage. The sensor may be inspected by measuring the voltage between the connector terminals when the sensor link is removed from the suspension arm.



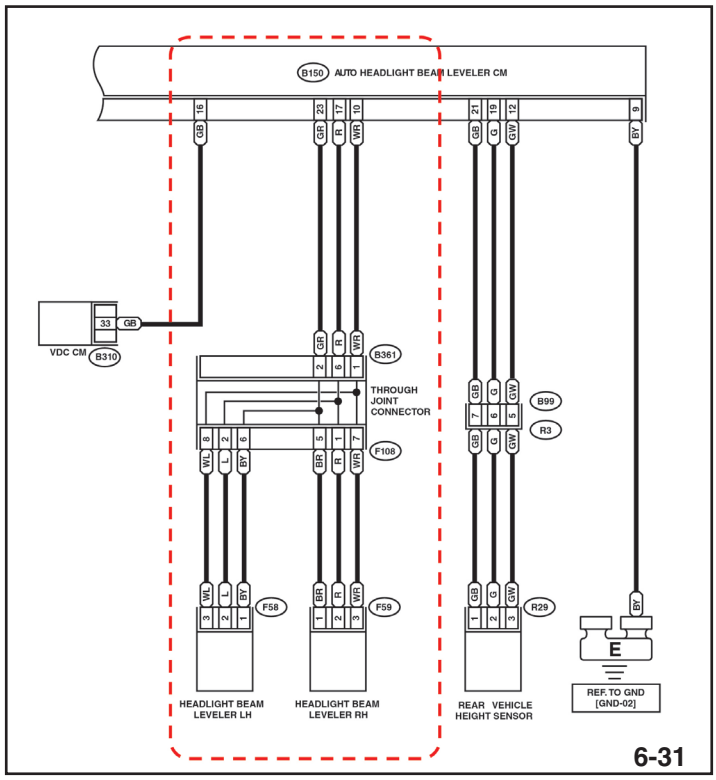
Rear height sensor circuit



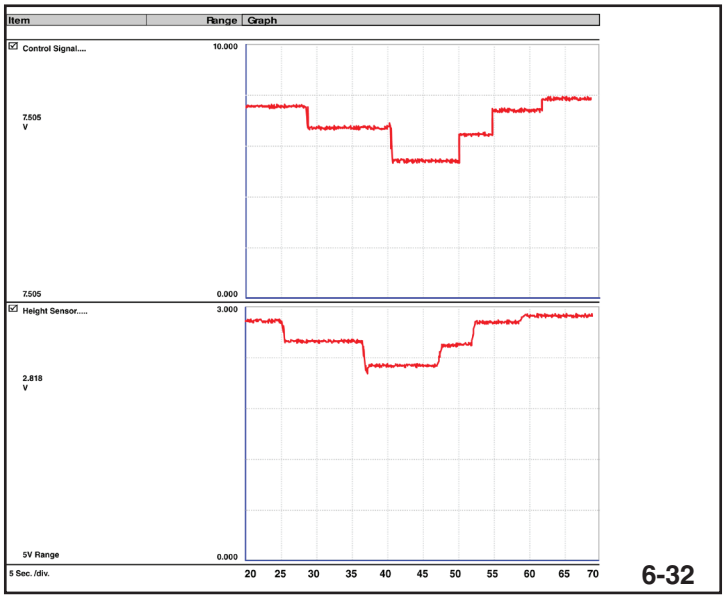
Rear height sensor inspection

In response to the rear vehicle height sensor input, the AHBLCM will command both the left and right leveler motor assemblies to move up or down as needed. The AHBLCM provides supply voltage, ground, and an actuating signal to the headlight levelers.

Note: Weight changes in the front seats may cause headlight adjustment, but since they are located close to the center of the vehicle the effect on the rear height sensor and headlight adjustment is minimal.

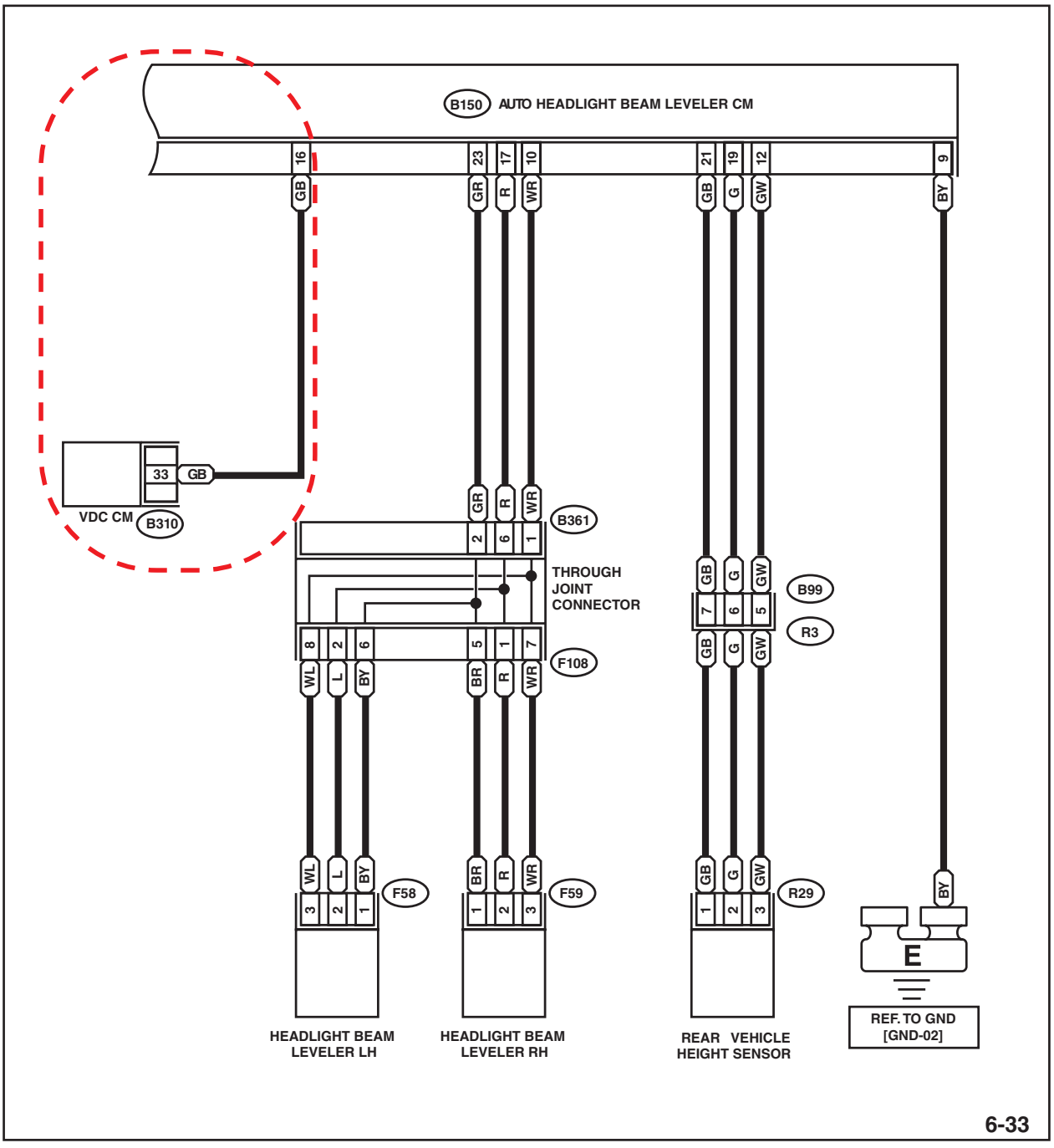


Leveler motor circuit



Leveler motor operation

The AHBLCM receives one signal wire from the Vehicle Dynamics Control (VDC) CM to monitor vehicle speed. High frequency input from the rear height sensor is compared with the current vehicle speed. When the vehicle speed is above 19 mph (30 km) the headlight leveler system will have altered parameters to prevent excessive adjustment.



VDC communication circuit

There are two different service procedures that must be performed when parts are removed or replaced from the system. Always consult STIS for the proper procedures.

Before attempting either of these service procedures always ensure the following conditions have been met;

- The vehicle is parked on a level surface
- Tire inflation is correct
- Cargo is unloaded from the vehicle
- The fuel tank is fully filled

Initialization	When the auto headlight beam leveler CM was replaced with a new module.
Reinitialization	• When the auto headlight beam leveler CM was replaced with a part from another vehicle. • When suspension parts have been removed or replaced. (Crossmember, front arm, sub frame, lateral link, housing, strut etc.) • When the vehicle height sensor has been replaced or removed.

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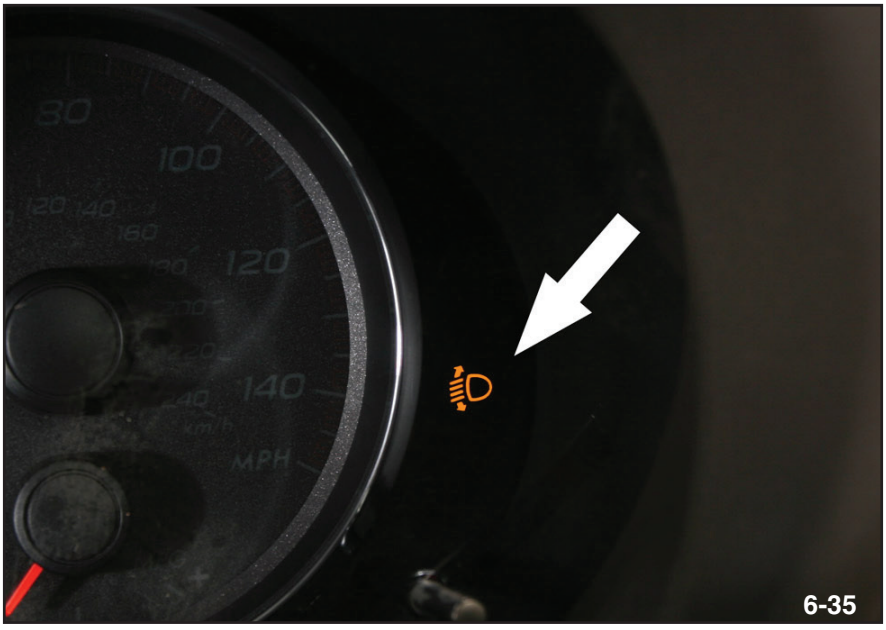
Auto headlight service procedures

During the service procedures, the headlight leveler lamp will illuminate to provide feedback. This lamp is only used for the initialization and re-initialization service procedures. It will not illuminate if a fault has occurred in the system.

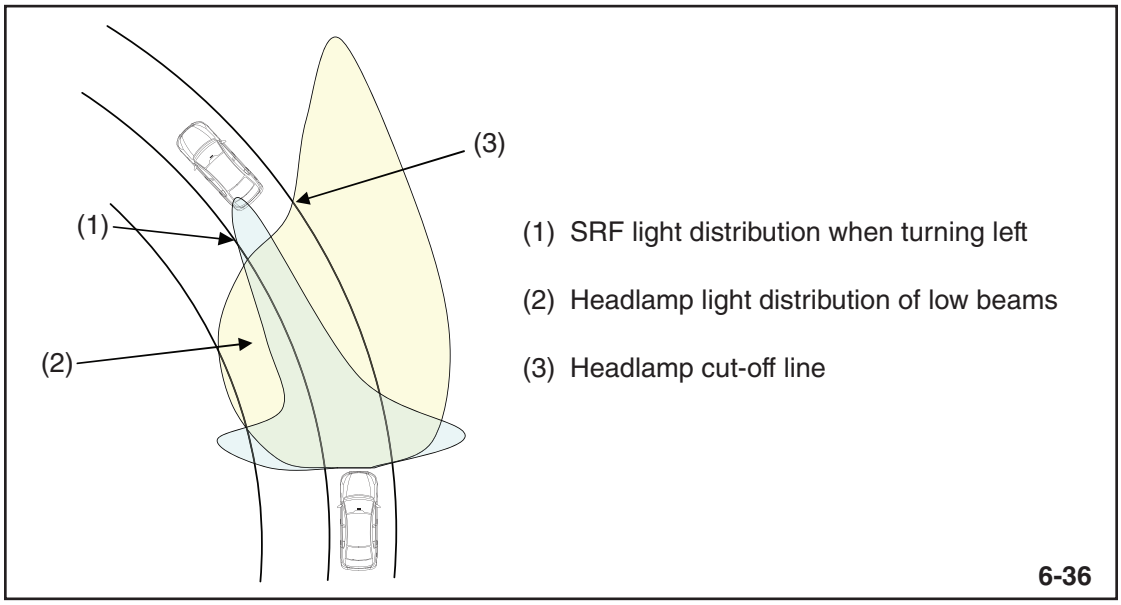


6-35

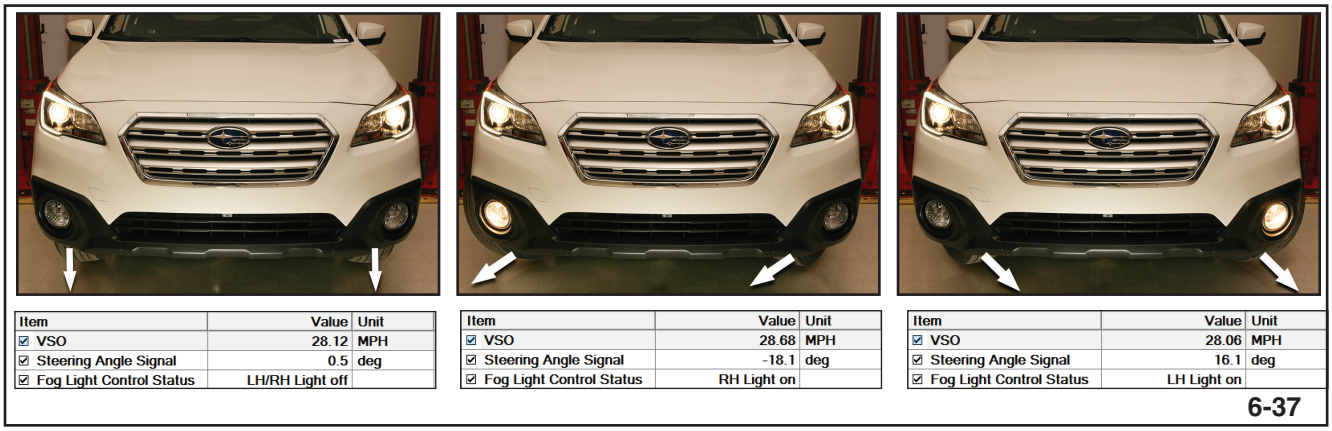
Headlight leveler lamp

Steering Responsive Fog Lights (SRF)

Beginning with the 2015 Legacy and Outback models, a new Steering Responsive Fog Light (SRF) system was optionally equipped to provide enhanced visibility in the direction of a turn. The SRF system communicates with the vehicle CAN circuit to monitor vehicle speed and steering angle and controls the on and off functions of the fog lights accordingly.



SRF light distribution



Fog lights OFF *Right turn, Fog light ON* *Left turn, Fog light ON*

In order for the system to function the following conditions must be met;

Low beam light	ON
Fog lamp	OFF
Shift position	Except “R”
SRF OFF switch	OFF
Vehicle speed & Steering angle condition is satisfied **6-38**	

SRF conditions

The SRF system can be temporarily disabled by pressing the “SRF OFF” button located on the lower left instrument panel.

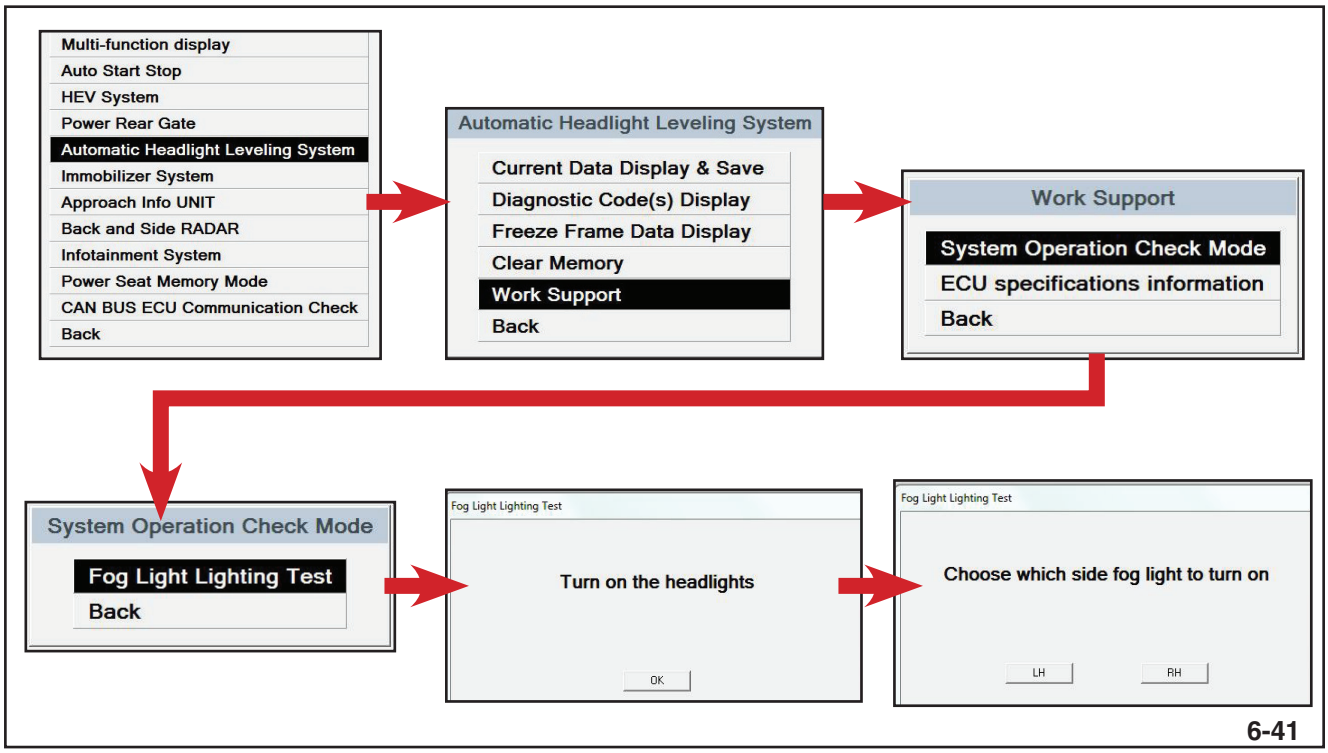
Note: The SRF system is defaulted to the ON position after cycling the ignition.

SRF OFF switch

If equipped, the SRF system may share the same control unit as the Automatic Headlight Leveler system.

Lighting control unit

Inspection of the SRF system can be performed using the Subaru Select Monitor.



Inspection of the SRF system with SSMIII

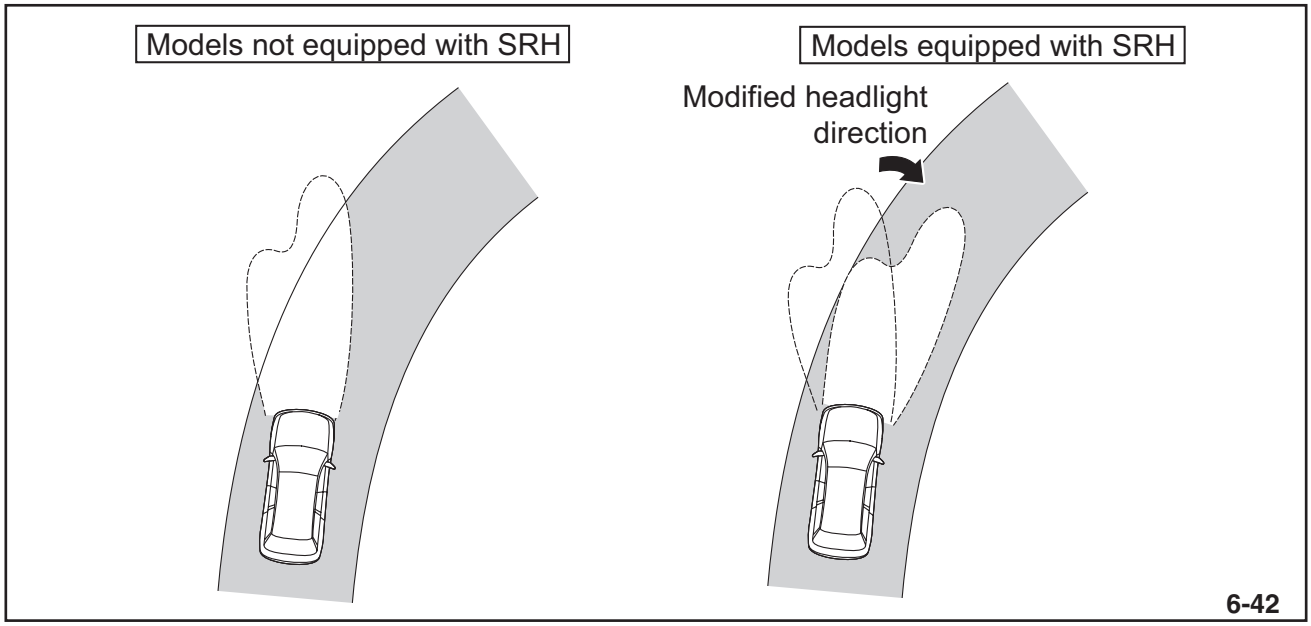
NOTES:

Steering Responsive Headlights

Introduced with certain 2017MY vehicles, Steering Responsive Headlights (SRH) are designed to improve driving illumination while cornering the vehicle by moving the headlight beams in the direction of steering wheel movement.

The SRH functions with the low beam and high beam headlight settings through the use of a non-serviceable Swivel Actuator in the headlight assembly, a serviceable dash mounted SRH OFF switch, and the CAN network. All SRH systems include Automatic Headlight Leveling functions. Both systems are controlled through the Automatic Headlight Leveling Control Module (AHLCM).

Note: The SRH system will remain off while the Daytime Running lights are operating.



Illumination with and without SRH

Basic Operation

The SRH system is defaulted to the on setting each time the ignition is turned to the on position and performs an initialization process to test the operation of the system.

Center

Maximum Inside

Maximum Outside

A successful completion of this process is required to allow SRH operation. During the initialization process the headlights move from the center position to the inside, back to center, and then to the outside and finally back to the center position. This is performed each time the engine is started, regardless to the headlight switch setting.

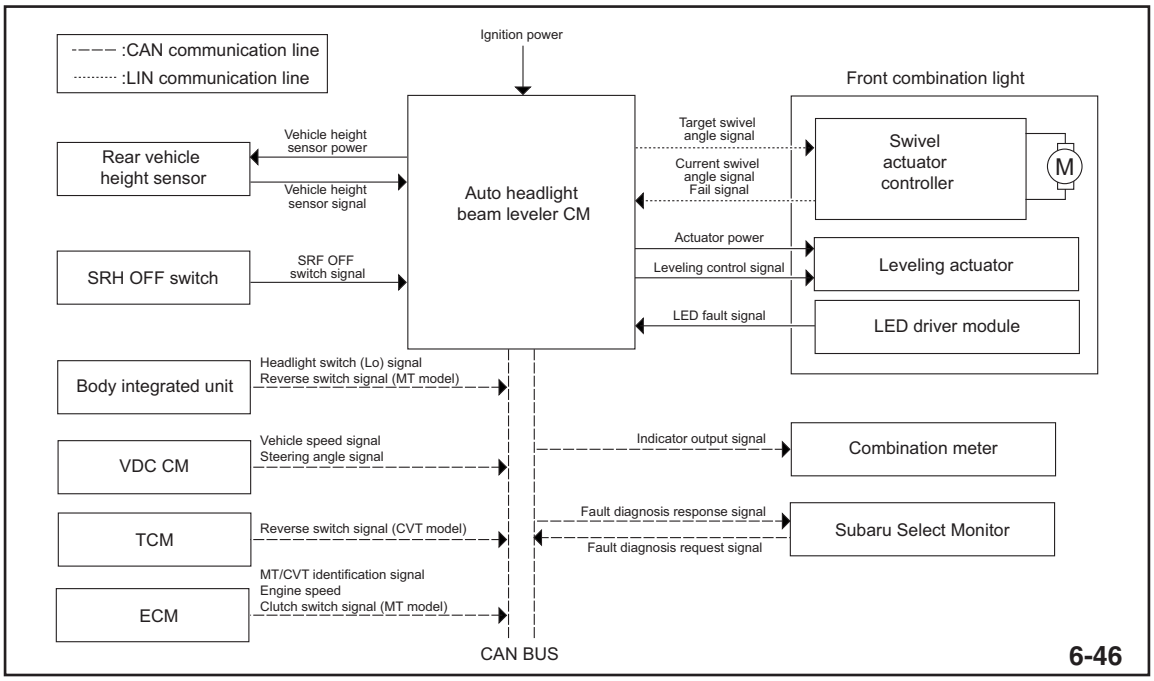
Required vehicle conditions for SRH operation:

- Successful completion of the initialization process
- Headlight Switch is on (or Automatic)
- The vehicle is traveling forward
- Vehicle speed is at least 5 m.p.h. (8 km/h)
- SRH OFF switch has not been activated
- Manual transmission vehicles must be in the 2nd gear range or higher

Note: SRH operation on manual transmission vehicles will continue to operate after the vehicle has been shifted down to 1st gear, until the vehicle comes to a complete stop. At that time the SRH operation will not return until the vehicle has been upshifted to at least 2nd gear.

When the headlights are turned on, the AHLCM checks the vehicle speed and steering angle and computes the size of the curve. It then controls the swivel actuators via LIN communication.

The AHLCM uses the following CAN and LIN signals to control the swivel actuator:



CAN and LIN

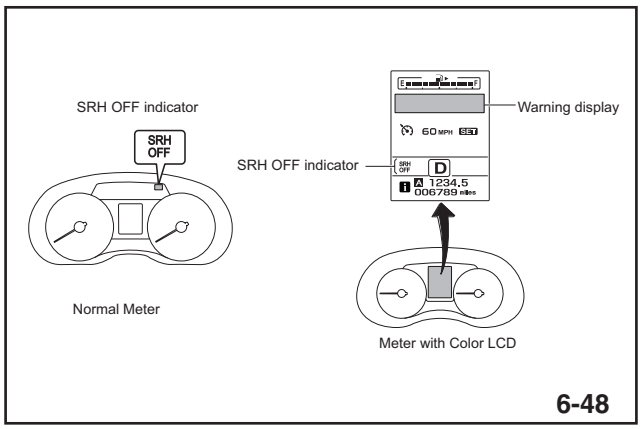
The Driver can turn off the SRH system using the SRH OFF button located on the dash, left of the steering wheel.

The SRH OFF indicator light will illuminate in the combination meter or on the Multi-Function Display to indicate the switch has been activated and the system has been turned off. This light will flash if there is a malfunction with the system.

The angle of movement of each headlight is independently controlled. The only time the two headlights are at the same angle is at 0 degree steering angle.

Note: Steering left produces a negative steering angle and steering right produces a positive steering angle.

SRH OFF Button



SRH OFF Indicator

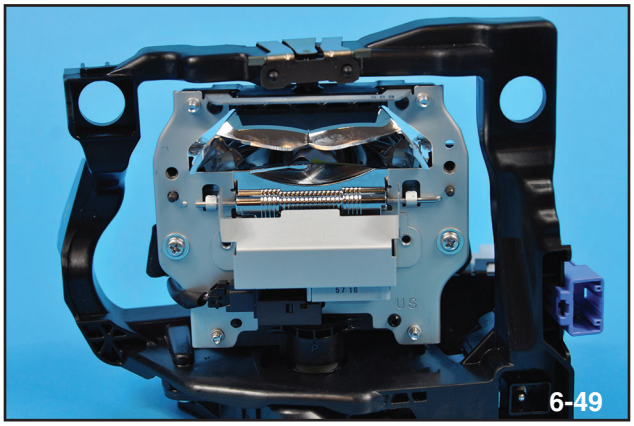
During a left hand turn the inside headlight (left) will move a maximum of -18 degrees to the left. The outside headlight (right) will move a maximum of -5 degrees to the left.

During a right hand turn the inside headlight (right) will move a maximum of 18 degrees to the right. The outside headlight (left) will move a maximum of 5 degrees to the right.

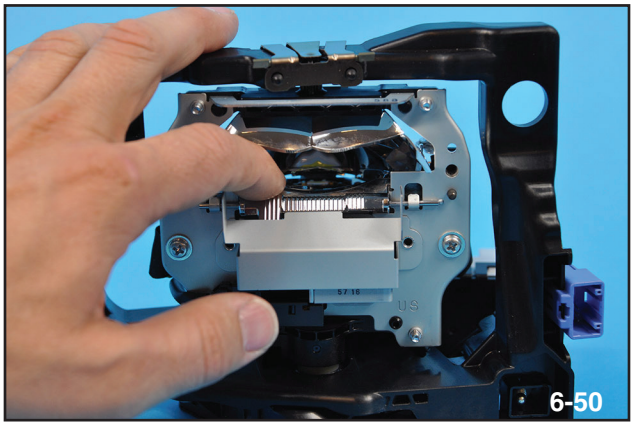
This operating logic provides for optimal illumination for the area directly in front of the vehicle and into the intended path of travel.

Note: The operating logic for the headlights is not adjustable.

During turns in either direction, the degree of movement of the headlights is controlled by the steering angle sensor input and vehicle speed.

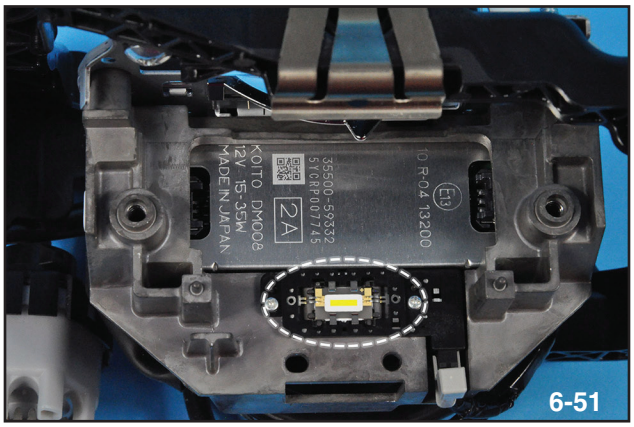


Shutter Door Low Beam

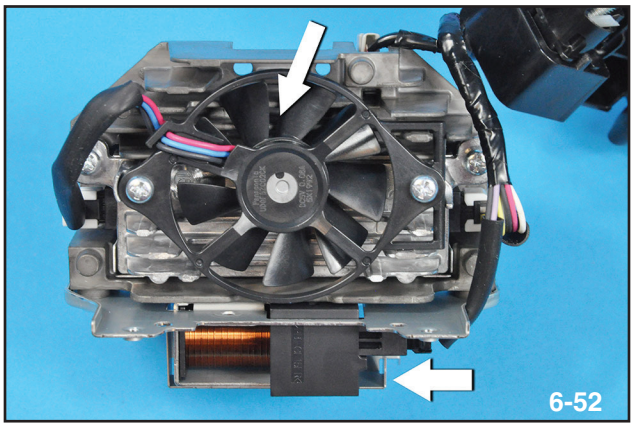


Shutter Door High Beam

The shutter door of the SRH system controls the high and low beam headlight operations by shading the illumination from the headlight assembly. A single LED assembly turns on for headlight light operation, operating at a constant current value. A solenoid activates the shutter door.



LED



Shutter Door High Beam Solenoid and Cooling Fan

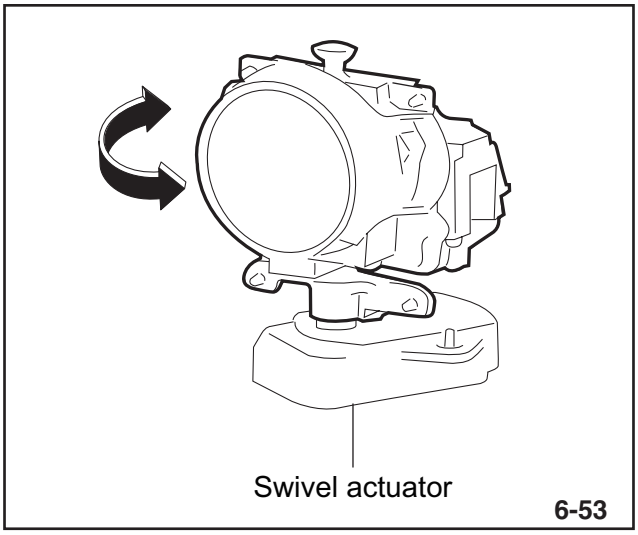
Electrical Operation

The heat sink for the LED assembly and the LIN transceiver are cooled by a fan with a brushless 5- volt DC motor. The fan is in operation any time the headlights are operating.

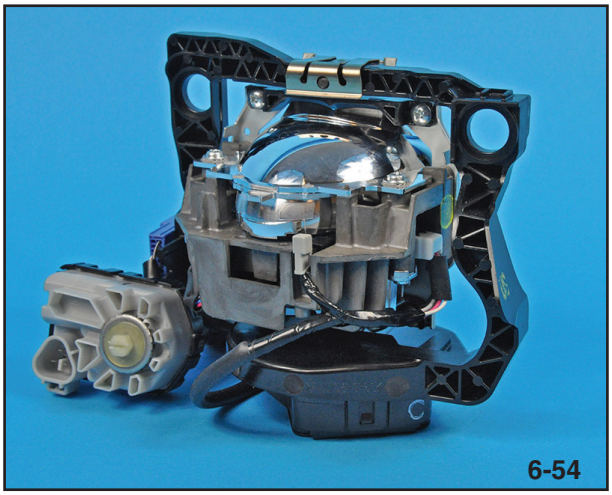
The SRH swivel actuator performs all left and right movements of the projector lens of the headlight assembly. The actuator is wired with an ignition power supply, body ground, LIN communication, and malfunction signal circuits.

All commands and position signals are sent and received through the LIN communication wires from the headlight assembly to the Automatic Headlight Leveler Control Module (AHLCM). This includes left and right movements, and high/ low beam settings of the shutter doors. A failure with the LED assembly, shutter door, or swivel actuator requires replacement of the headlight assembly. The swivel actuator is non-serviceable. Replace the headlight assembly if the swivel actuator has failed.

Note: The Headlight Beam Leveler is wired independently to the AHLCM. Headlight assembly replacement is required for a Headlight Leveler Failure.



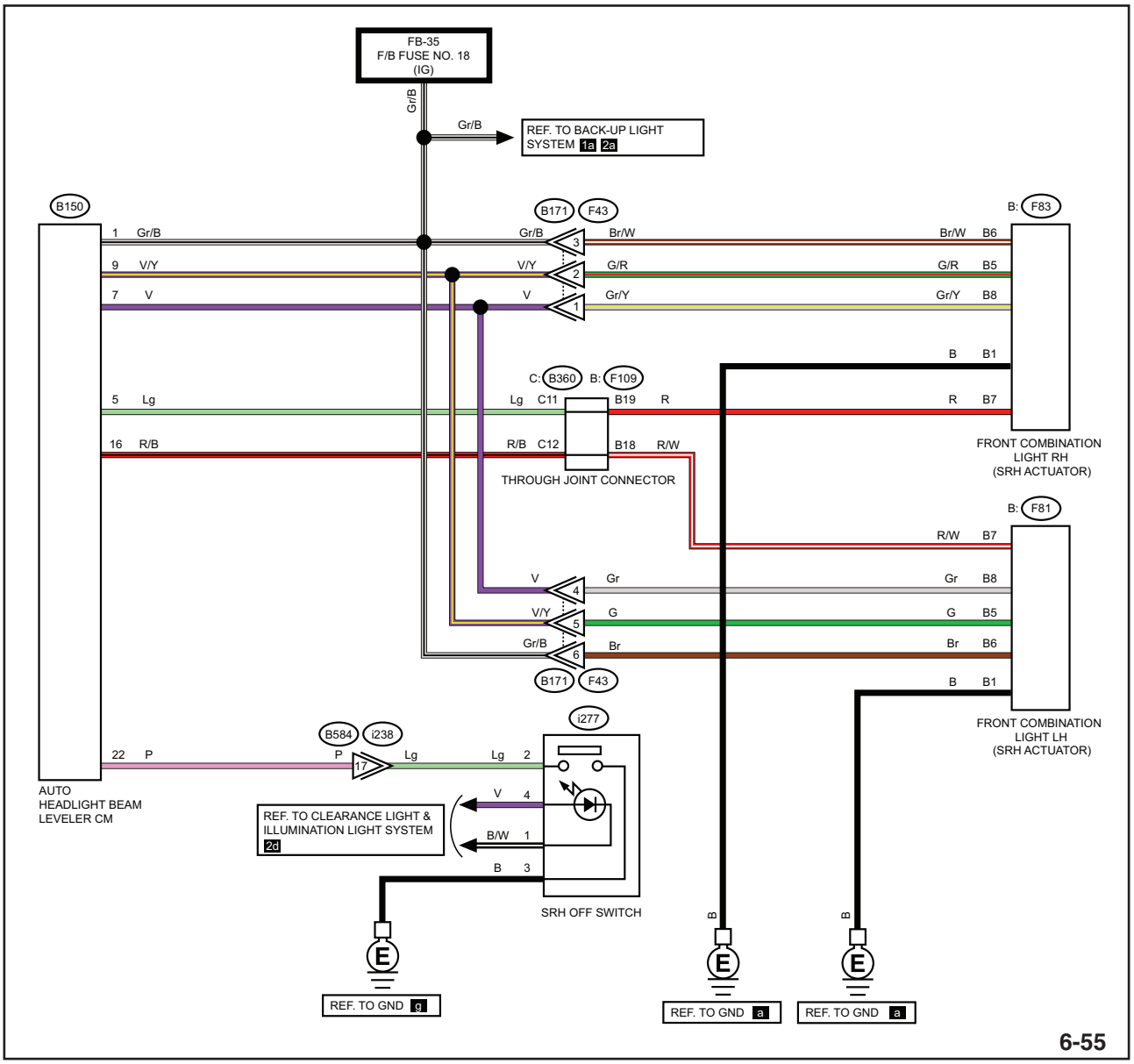
Swivel Actuator



Headlight Beam Leveler

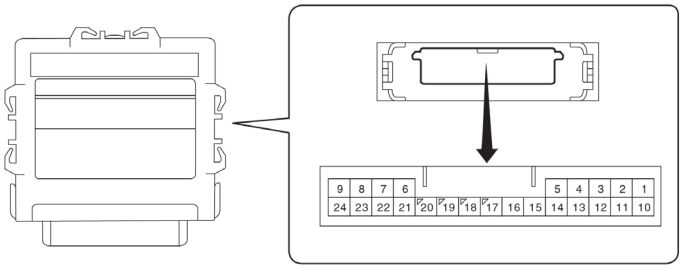
Wiring Diagram

The swivel actuator of the SRH system contains a LIN bus transceiver, control circuits for the actuator motor, shutter door, shutter door solenoids, and a head light position sensor. The transceiver receives target swivel angle and head light leveling target setting commands from the AHLCM and directs the control circuits to operate the actuator motor and shutter door solenoid. The headlight position sensor communicates the current headlight positions back to the AHLCM through the LIN communications wire.



SRH Wiring Schematic

Input/output Chart



Terminal No.	Content	Measuring condition	Standard
1 ←→ Chassis ground	IG power supply	Ignition switch ON	8 — 16 V
2 ←→ Chassis ground	GND	Always	Less than 1 Ω
3 ←→ Chassis ground	Rr vehicle height sensor GND	Always	Less than 1 Ω
4	Not used	—	—
5 ←→ Chassis ground	RH headlight malfunction signal	Always	1 MΩ or more
6	Not used	—	—
7 ←→ Chassis ground	SRH signal (LIN)	Always	1 MΩ or more
8	Not used	—	—
9 ←→ Chassis ground	SRH GND	Always	Less than 1 Ω
10 ←→ Chassis ground	Leveling actuator power supply	Ignition switch ON	10 — 16 V
11 ←→ Chassis ground	Leveling actuator GND	Always	Less than 1 Ω
12 ←→ 3	Rr vehicle height sensor power supply	Ignition switch ON	4.75 — 5.25 V
13	Not used	—	—
14	Not used	—	—
15	Not used	—	—
16 ←→ Chassis ground	LH headlight malfunction signal	Always	1 MΩ or more
17 ←→ Chassis ground	Leveling actuator signal	Headlight off → on	Less than 1 V →1.0 — 14.4 V (for 17 seconds)
		Headlight on, no vehicle height change → change and hold vehicle height for 3 seconds or more	
18	Not used	—	—
19 ←→ Chassis ground	Rr sensor signal	IG ON (with no passenger, no load and vehicle stopped)	Approx. 2.5 V (changes according to vehicle condition)
20	Not used	—	—
21	Not used	—	—
22 ←→ Chassis ground	SRH OFF switch	Switch OFF → ON (at SRH OFF)	1 MΩ or more → less than 1 Ω
23	CAN-H	Always	1 MΩ or more
24	CAN-L	Always	1 MΩ or more

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I/O Chart

Service and Diagnostics

Basic Diagnostic Procedure

Customer Interview

When performing diagnostics on the headlight system, start with the customer interview check list. The headlight diagnostics includes two check lists. The first one is for the Automatic Headlight Leveler system and the second is for the Steering Responsive Headlights. The second check list contains all of the questions of the first check list and additional, more detailed questions. It is recommended to start with the second check list.

Note: The functions of the headlight system are intermixed with many operations of illumination control which may lead to customer difficulty in isolating a complaint.

Steering • Responsive • Headlight Check List for Interview Vehicle is Received Year Month Day			Date the
Customer's name		Registration No.	Initial year of registration Year Month Date
		Vehicle model	Frame number
Interviewer	Inspector	Engine type	Odometer reading
Customer specified content • • •			
Date and time when the trouble occurred		Frequency of trouble occurrence	Always occurs Sometimes occurs (times per day, times per month)
Condition of trouble occurrence (How the trouble occurs)		Weather	Fine • Cloudy • Rainy • Snowy • Others ( )
		Temperature	°C (°F) — °C (°F)
Road conditions			
Accessory installation condition			
Confirmation of trouble condition			
Curve of trouble occurrence	❑ Right-hand curve ❑ Left-hand curve ❑ Both		
Information on curve of trouble occurrence Note: Check the location and curve on the map.	❑ Specific location ❑ Gentle curve ❑ Sharp curve ❑ Uphill ❑ Downhill ❑ Other		
Vehicle speed at trouble occurrence	Approximately km/h (MPH)		
SRH OFF indicator status	❑ Light OFF ❑ Light ON ❑ Blink		
Headlight switch operation	❑ Lo-Hi switch available ❑ Lo-Hi switch unavailable		
Range inspection for CVT vehicle	❑ Shift indicator operates according to the shift position ❑ Shift indicator does not operate according to the shift position		
❑ Diagnostic Trouble Code			

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Customer Interview Sheet

Function Check (Initialization)

Basic diagnostics of the Headlight systems includes a function check of SRH operation. This is referred to "as the initialization function".

1. Stop the vehicle at approximately 1 m (3.3ft) away and perpendicular to the wall.
2. Make the vehicle vicinity dark.
3. Set the vehicle headlight switch to ON.
4. Make sure that both headlights' cut lines move immediately after the engine has started. (Together towards the inside (8 degrees) back to center and then to the outside (13 degrees)).

Diagnostics by Phenomenon

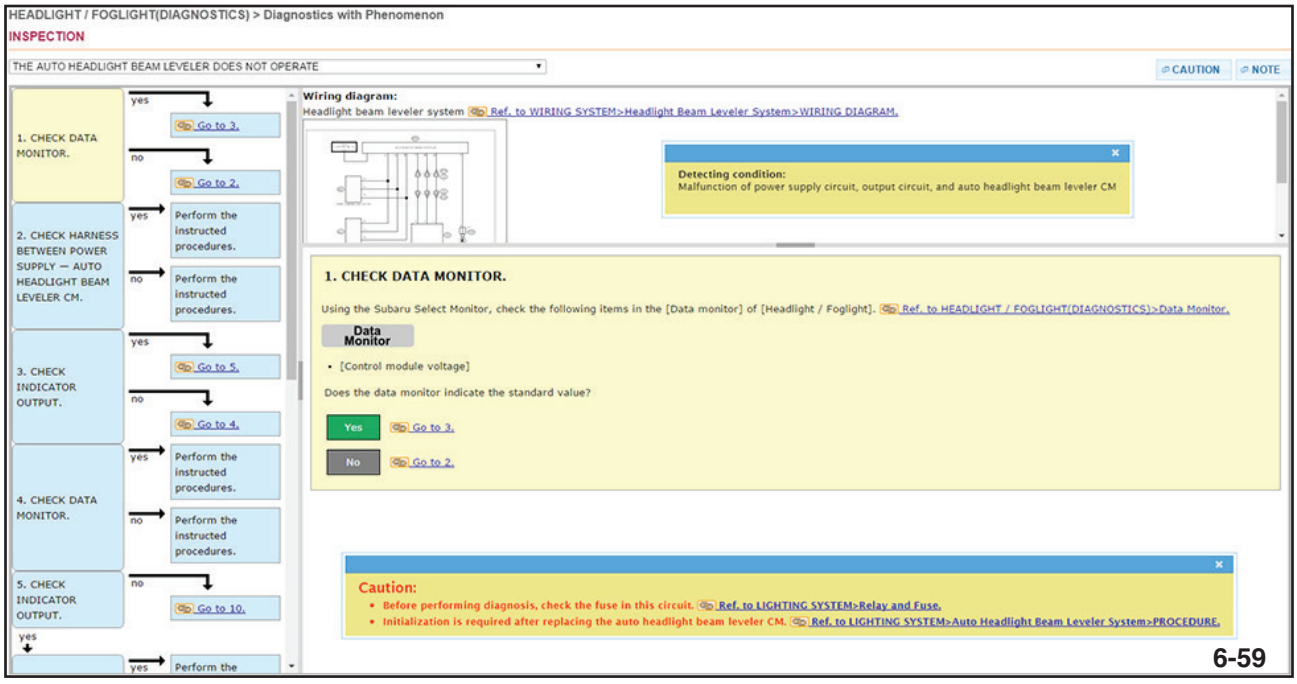
If no diagnostic trouble codes have been created, diagnose the vehicle according to the chart below and the accompanying instructions in the service manual.

Symptoms
1. The auto headlight beam leveler does not operate.
2. The steering responsive headlight does not operate.
3. The steering responsive headlight operates in a direction different from the target.

6-58

Service Manual Chart

Utilizing the diagnostic procedure, basic inspections of the system should be performed in the event DTCs are not present. Diagnostics by phenomenon may lead to mechanical issues, such as severe vehicle alignment issues.



Diagnostics with Phenomenon

Subaru Select Monitor (SSM)

Diagnostic Trouble Codes

Four new diagnostic trouble codes have been added to the headlight system. Follow the diagnostics with trouble codes procedures in the service manual to make accurate and timely repairs.

DTC	Description	Diagnostic details
B2908	SRH actuator error (RH)	Internal actuator error
B2909	SRH actuator error (LH)	
B2910	SRH actuator LIN communication error (RH)	LIN data from the actuator is not received or erroneous
B2911	SRH actuator LIN communication error (LH)	

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SRH DTCs

Data Monitor

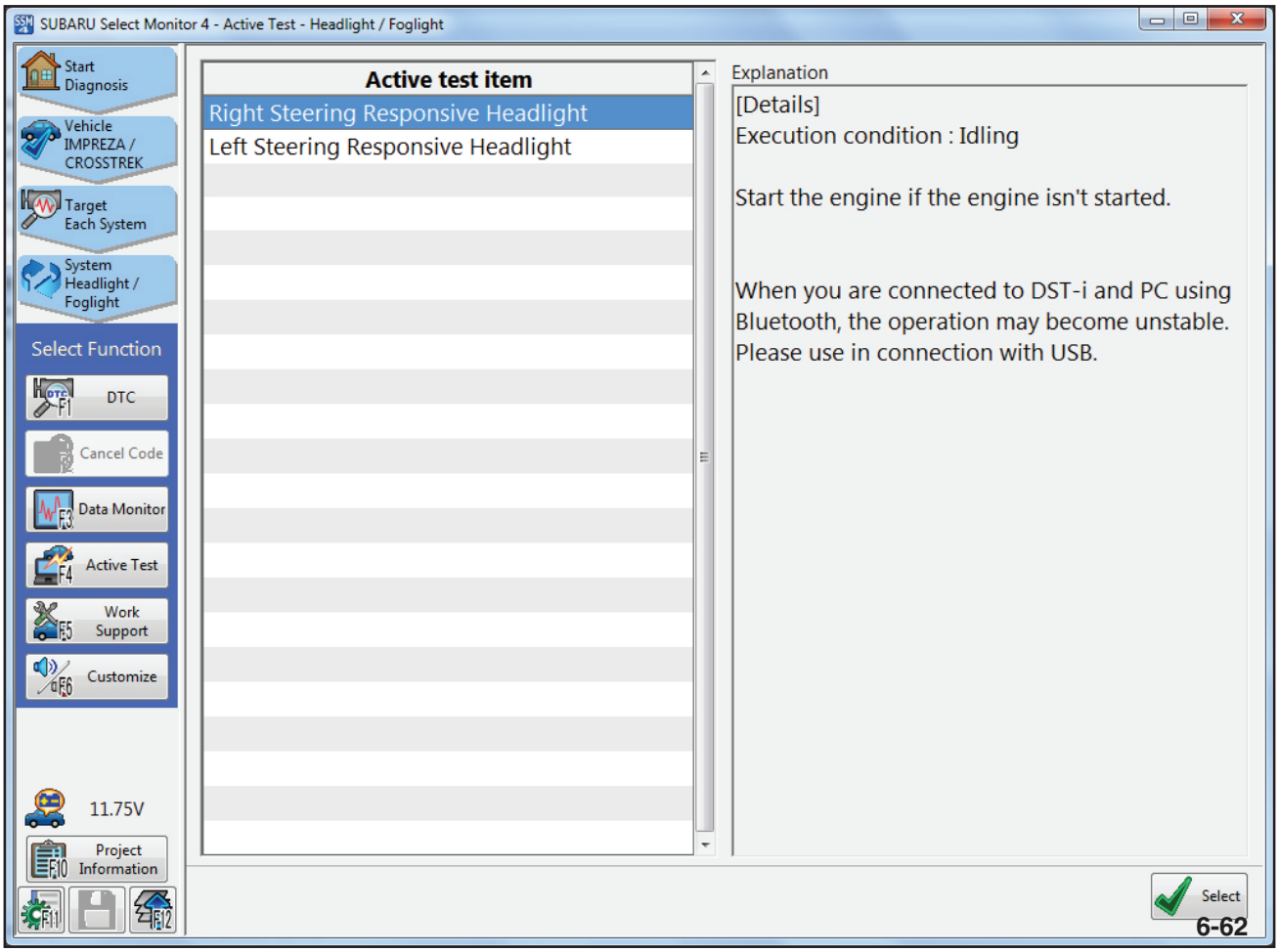
Basic Information related to SRH can be found using the Data Monitor function within the Headlight/ Foglight Menu of the SSM.

	Item	Value	Unit
LT	Shift Position Signal	"P"	
LT	Trip Count	2118	Time
LT	Count	Common	
LT	Time Count	802200	ms
LT	R Sensor Signal	2.43	V
LT	Actuator Signal	0.0	%
LT	ECU ACC	13.94	V
LT	Vehicle Speed Signal	0.00	MPH
LT	H/L Lo Signal	ON	
LT	LED HEADLAMP(LH) error Signal	OFF	
LT	LED HEADLAMP(RH) error Signal	OFF	
LT	Steering Angle Signal	-32.8	deg
LT	MT Reverse SW	OFF	
LT	SRH-OFF SW	ON	
LT	Engine Speed	837	rpm
LT	Left Steering Responsive Headlight Current Angle	0.0	deg
LT	Right Steering Responsive Headlight Current Angle	0.0	deg
LT	Left Steering Responsive Headlight Target Angle	0.0	deg
LT	Right Steering Responsive Headlight Target Angle	0.0	deg
LT	Left Steering Responsive Headlight Power Supply Failure	Normal	
LT	Right Steering Responsive Headlight Power Supply Failure	Normal	
LT	Left Steering Responsive Headlight Motor Failure	Normal	
LT	Right Steering Responsive Headlight Motor Failure	Normal	
LT	Left Steering Responsive Headlight Sensor Failure	Normal	
LT	Right Steering Responsive Headlight Sensor Failure	Normal	
LT	SRH/ADB Setup Status	ON	**6-61**

SSM4 SRH System Data

Active Test

Active Test in the Headlight/Foglight menu allows for individual testing of each headlight assembly. Performing the active test allows the user to monitor the Target Angle and the Current Angle to determine if the assembly is performing correctly.



SSM – Active Test

NOTES:

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