

General

A brief description of the principal parts of the electrical system is presented here. Also covered here are basic electrical system troubleshooting tips.

See also ⇒ [121 Battery, Alternator, Starter](#).

Electrical test equipment

Many electrical tests described in this manual call for measuring voltage, current, or resistance using a digital multimeter. Digital meters are preferred for precise measurements and for electronics work because they are generally more accurate than analog meters. An analog meter (swing-needle) may draw enough current to damage sensitive electronic components.

An LED test light is a safe, inexpensive tool that can be used to perform many simple electrical tests that would otherwise require a digital multimeter. The LED indicates when voltage is present between any two test-points in a circuit.

The integrated safety, comfort, security and handling systems on E46 cars are designed with self-diagnostic capabilities. The quickest way to diagnose many problems is to start out with a scan tool read out of Diagnostic Trouble Codes (DTCs). See ⇒ [OBD On Board Diagnostics](#) at rear of manual.

Special Tools

A

➤ Automotive digital multimeter Fluke 87

B

➤ LED tester with thin spade probes
Baum 1115 (Source: Baum Tools
Unlimited)

C

➤ Scan tools BMW DIS/MoDiC

D

➤ Aftermarket scan tool Baum CS2000
(Source: Baum Tools Unlimited)

E46 Electrical System

E46 cars are electrically complex. Many vehicle systems and subsystems are interconnected or integrated. In addition, the requirements of second generation On-Board Diagnostics (OBD II) are such that there are now many more circuits and wires in the vehicle than ever before. The components must exchange large volumes of data with one another in order to perform their various functions.

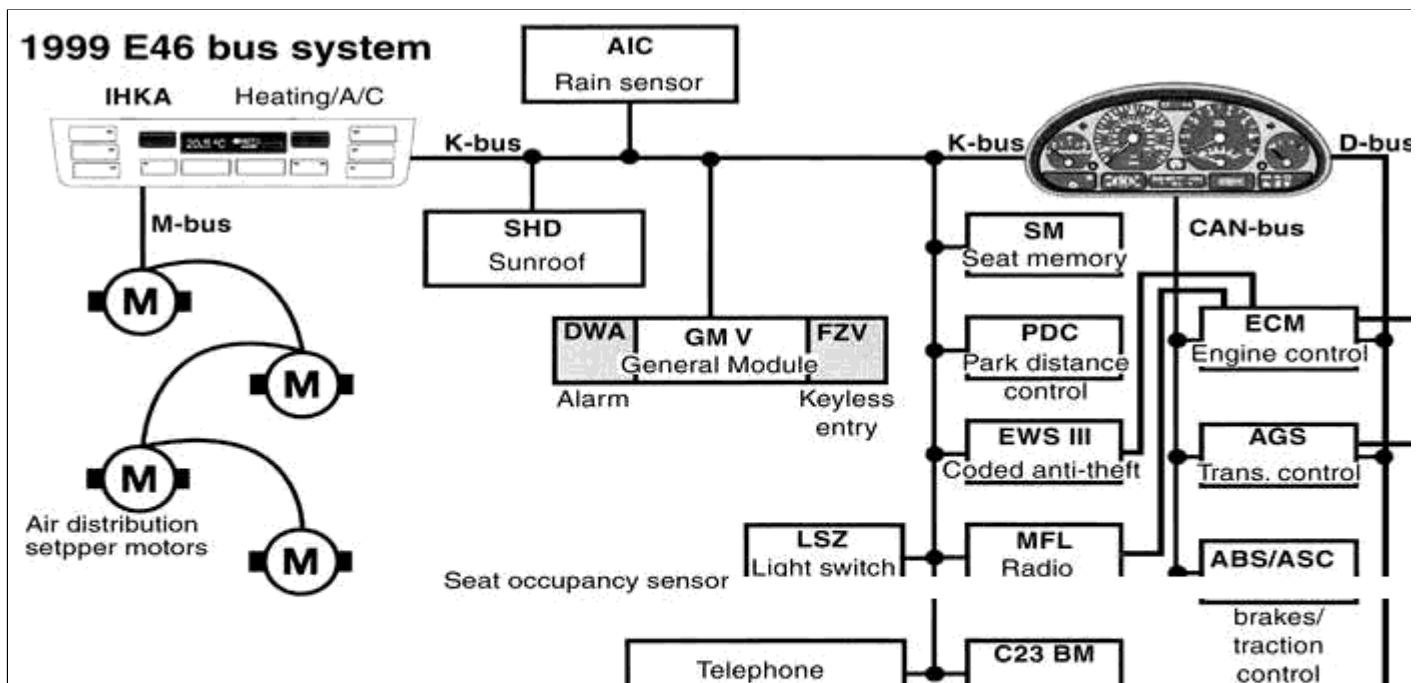
The use of dedicated data lines for each link in the system has reached the limits of its capabilities. On the one hand, wiring harnesses now must be so complex that they become unmanageable. In addition, the finite number of pins on conventional connectors becomes a limiting factor in electronic control module development.

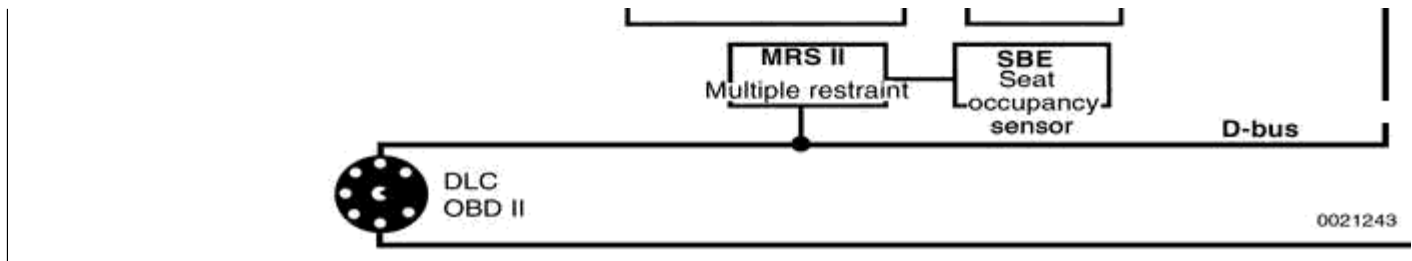
The solution has been found in the use of specialized, vehicle compatible serial bus systems. The E46 bus system is summarized in ⇒ [Table a.](#)

Table a. E46 busses	
Bus	Circuits covered
K-bus	Driver information systems (instrument cluster, Check Control, on-board computer) Central Body Electronics (ZKE V) General Module (GM V) Seat memory (SM) Sunroof (SHD) Rain sensor (AIC) Telephone and sound system Headlight module (LSZ)

Table a. E46 busses	
Bus	Circuits covered
	Coded anti-theft (EWS III) and anti-theft (DWA) Remote entry (FZV) Park distance control (PDC)
M-bus	Heating and air conditioning (IHKA) components
CAN-bus	Engine management system (DME) Transmission control (AGS) Antilock brakes (ABS) Traction control (ASC) Dynamic stability control (DSC)
D-bus	Data link connector (DLC) OBD II connector Multiple restraint system (MRS II)

1999 E46 bus system, diagram





Voltage and polarity

The vehicle electrical system is a 12-volt direct current (DC) negative-ground system. A voltage regulator controls system voltage at approximately 12-volts. All circuits are grounded by direct or indirect connection to the negative (-) terminal of the battery. A number of ground connections throughout the car connect the wiring harness to chassis ground. These circuits are completed by the battery cable or ground strap between the body and the battery negative (-) terminal.

Wiring, fuses and relays

Electrical components connect using one of the following:

- ◆ Heavy cables with lug-type connectors (battery and starter)
- ◆ Electrical harnesses with keyed, push-on connectors that lock into place
- ◆ Busses with modular connectors



- ◀ With the exception of the starter and the charging system, most electrical power is routed from the ignition switch or the battery through the main relay panel in back of the glove compartment or the



main fuse box (**arrow**) above the glove compartment. Fuses are color coded to indicate current capacities.

The relays and control modules are mounted in various places throughout the vehicle. See ⇒ [610 Electrical Component Locations](#).

Central Body Electronics (ZKE V)

E46 vehicles are equipped with an integrated complex of electronic modules connected mostly via K-bus. This system, called ZKE V, is primarily controlled by the General Module (GM V).

These functions are controlled directly by the GM V:

- ◆ Windshield wiper/washer system, with optional Rain Sensor Interface. See ⇒ [611 Wipers and Washers](#).
- ◆ Central locking, power trunk release, keyless entry (FZV). See ⇒ [515 Central Locking and Anti-theft](#).
- ◆ Power window control. See ⇒ [512 Door Windows](#).
- ◆ Car Memory/Key Memory. See ⇒ [515 Central Locking and Anti-theft](#).
- ◆ Interior lighting. See ⇒ [612 Switches](#).
- ◆ Alarm system (DWA). See ⇒ [515 Central Locking and Anti-theft](#).
- ◆ Electronic consumer sleep mode, described later in this section

Other functions are not directly controlled by the GM V but interconnected:

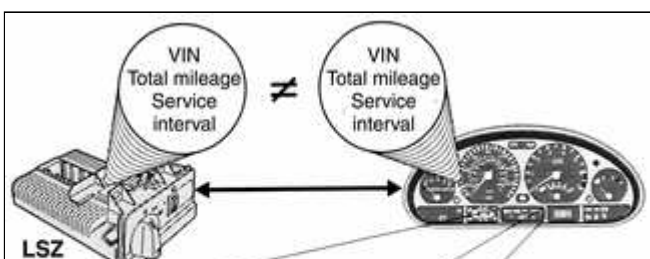
- ◆ Rain sensor (AIC). See ⇒ [611 Wipers and Washers](#).
- ◆ Sunroof operation (SHD). See ⇒ [540 Sunroof](#).
- ◆ Seat memory (SM) and electrical operation. See ⇒ [520 Seats](#).
- ◆ Outside rear-view mirror control and heating. See ⇒ [510 Exterior Trim, Bumpers](#).
- ◆ Windshield washer jet heating. See ⇒ [611 Wipers and Washers](#).

Redundant data storage

The following vehicle information is stored redundantly in the instrument cluster and the light switch module:

- ◆ Vehicle identification number (VIN)
- ◆ Total mileage
- ◆ Service interval data

This redundancy means that the instrument cluster or light module may be replaced without loss of stored data.



The data between the two units is compared each time the ignition is switched on (KL 15 on). If the data does not match the tamper warning dot (**arrow**) in the mileage display will be illuminated. Under certain circumstances



a fault code (DTC) will be set.

Resetting and resynchronizing of codes and data requires the use of BMW scan tools DIS or MoDiC.

Car Memory/Key Memory

A number of features and functions can be customized to the driver(s) preference. The identity of the vehicle user is provided by a signal from the keyless entry system (FZV).

Car Memory and Key Memory are actually two separate functions, although they are marketed as a combined feature. See ⇒ [515 Central Locking and Anti-theft](#) for further details.

Electrical consumer sleep mode

Central body electronics (ZKE V) is designed to bring the vehicle electrical consumers into "sleep mode" after 16 minutes of inactivity.

In order to test sleep mode:

- ◆ Switch ignition off.
- ◆ Close all doors, trunk and hood.
- ◆ Lock vehicle using central locking.
- ◆ Wait 16 minutes.

If one of a number of inputs into the General Module (GM V) is activated before the vehicle is in sleep mode, the 16 minute cycle starts again. Once the vehicle is in sleep mode, the GM V will "wake up" if it receives a change of signal from one of the following sensors:

- ◆ K-bus
- ◆ Door jamb sensors
- ◆ Trunk lid lock cylinder microswitch
- ◆ Interior trunk lid release push-button microswitch
- ◆ Central locking button
- ◆ Engine hood latch microswitch
- ◆ Trunk key position switch
- ◆ Interior light switch
- ◆ Internal motion sensor
- ◆ Tilt sensor
- ◆ Driver's door lock sensors

Note:

If an interior light is accidentally left on, the GM V will override the signal from it after 16 minutes and implement sleep mode.

Electrical system safety precautions

Please read the warnings and cautions in this section before doing any work on your electrical system.

WARNING!

- ♦ *An airbag unit houses an explosive powerful charge. Making repairs without the proper knowledge and special test equipment may cause serious personal injury. See ⇒ [721 Airbag System \(SRS\)](#).*
- ♦ *The ignition system of the car operates at lethal voltages. People with pacemakers or weak hearts should not expose themselves to the ignition system electric currents. Extra caution must be taken when working on the ignition system or when servicing the engine while it is running or the key is on. See ⇒ [120 Ignition System](#) for additional ignition system warnings and cautions.*
- ♦ *Keep hands, clothing and other objects clear of the electric radiator cooling fan when working on a warm engine. The fan may start at any time, even when the ignition is switched off.*

CAUTION!

- ♦ *Always turn off the engine and disconnect the negative (-) cable from the battery before removing any electrical components. Disconnecting the battery may erase fault code(s) stored in control module memory. Check for fault codes using special BMW diagnostic equipment.*
- ♦ *Prior to disconnecting the battery, read the battery disconnection cautions given at*

the front of this manual on page viii.

- ♦ *Connect and disconnect ignition system wires, multiple connectors and ignition test equipment leads only while the ignition is off.*
- ♦ *Do not disconnect the battery with the engine running.*
- ♦ *Do not quick-charge the battery (for boost starting) for longer than one minute, and do not exceed 16.5 volts at the battery with the boosting cables attached. Wait at least one minute before boosting the battery a second time.*
- ♦ *Do not use an analog meter. Use only a digital multimeter.*
- ♦ *Many of the solid-state modules are static sensitive. Static discharge will permanently damage them. Always handle the modules using proper static prevention equipment and techniques.*
- ♦ *To avoid damaging harness connectors or relay panel sockets, use jumper wires with flat-blade connectors that are the same size as the connector or relay terminals.*
- ♦ *Always switch a digital multimeter to the appropriate function and range before making test connections.*

- ♦ *Do not try to start the engine of a car which has been heated above 176F/80C, (for example, in a paint drying booth). Allow it to cool to normal temperature.*
- ♦ *Disconnect the battery before doing any electric welding on the car.*
- ♦ *Do not wash the engine while it is running, or anytime the ignition is switched on.*
- ♦ *Choose test equipment carefully. Use a digital multimeter with at least 10 megaohm input impedance, or an LED test light. An analog meter (swing-needle) or a test light with a normal incandescent bulb may draw enough current to damage sensitive electronic components.*
- ♦ *An ohmmeter must not be used to measure resistance on solid state components such as control units or time delay relays.*
- ♦ *Always disconnect the battery before making resistance (ohm) measurements on the circuit.*

Wiring Diagrams

The wiring diagrams shown in Electrical Wiring Diagrams have been specially designed to enable quick and efficient diagnosis and troubleshooting of electrical malfunctions.

Wiring codes and abbreviations

A lot of information is included in each wiring diagram if you know how to read them. Wire colors in the diagrams are abbreviated. Combined color codes indicate a multi-colored wire. For example the code BLU/RED indicates a blue wire with a red stripe.

Many electrical components, connectors, fuses, and ground locations are identified using a unique number. Each of these numbers corresponds to a particular part in the circuit commonly found in Electrical Wiring Diagrams.

Note:

Sometimes the color of an installed wire may be different than the one on the wiring diagram. Don't be concerned. Just be sure to confirm that the wire connects to the proper terminals.

Table b. Wire color codes		
German code	English code	Color
SW	BLK	Black
BL	BLU	Blue
BR	BRN	Brown
GN	GRN	Green

Table b. Wire color codes		
German code	English code	Color
GR	GRY	Grey
	ORG	Orange
RT	RED	Red
VI	VIO	Violet
WS	WHT	White
GE	YEL	Yellow

Most terminals are identified by numbers on components and harness connectors. Terminal numbers for major electrical connections are shown in the diagrams. Though many terminal numbers appear only once, several other numbers appear in numerous places throughout the electrical system and identify certain types of circuits. Some common circuit numbers are listed below in ⇒ [Table c.](#)

Table c. Terminal and circuit numbers	
Number	Circuit description
1	Low voltage switched terminal of coil
4	High voltage center terminal of coil
+X	Originates at ignition switch. Supplies power when the ignition switch is in the PARK, RUN, or START position
15	Originates at ignition switch. Supplies power when ignition switch is in RUN or START position

Table c. Terminal and circuit numbers	
Number	Circuit description
30	Battery positive (+) voltage. Supplies power whenever battery is connected. (Not dependent on ignition switch position, unfused)
31	Ground, battery negative (-) terminal
50	Supplies power from battery to starter solenoid when ignition switch is in START position only
+54	Originates at ignition switch. Supplies power when ignition switch is in the RUN position only
85	Ground side (-) of relay coil
86	Power-in side (+) of relay coil
87	Relay actuated contact
D	Alternator warning light and field energizing circuit

Additional abbreviations shown in the wiring diagrams are given below.

Table d. Common E46 abbreviation

Abbreviation	Component or system	Abbreviation	Component or system
ABS	antilock brakes	KL 50	ignition switch start position
A/C	air conditioning	LDP	fuel tank leak diagnosis pump (DME MS 42.0)

Abbreviation	Component or system	Abbreviation	Component or system
ADB, ADB-X	automatic differential lock	LEV	low emission vehicle
AGS	adaptive transmission control	LSZ	light switch module
AIC	rain sensor	MAF	mass air flow sensor
ASC	traction control	MBC	maximum braking control
AUC	automatic air recirculation	MFL	multifunction steering wheel
BST	Battery safety terminal	MRS	multiple restraint system
CAN	Controller Area Network (BUS)	NLEV	national low emission vehicle program
CBC	cornering brake control	NTC	negative temperature coefficient resistor
DBC	dynamic brake control	OBC	on board computer
DK	throttle valve	OBD II	second generation on-board diagnostics
DLC	diagnostic link connector	ORVR	on-board refueling vapor recovery
DME	digital motor electronics	PDC	park distance control (optional)
DMTL	diagnosis module-tank leakage (DME MS 43.0)	PWG	pedal position sensor
DSC III	dynamic stability control	RAM	random access memory
DTC	diagnostic trouble code	RDC	tire pressure control (optional)
DWA	anti-theft alarm system	RPS	rollover protection system
E-box	electronics box under engine hood	RXD	receive data line
ECM	engine control module	SBE	front passenger seat sensor
EGS	electronic transmission control	SGS	seat integrated belt system
EPROM	erasable/programmable read-only memory	SHD	sunroof module
EWS	electronic immobilizer	SII	service interval indicator
FZV	keyless entry	SM	seat memory module

Abbreviation	Component or system	Abbreviation	Component or system
GM	general module (see ZKE)	SRS	supplemental restraint system-airbag
HPS	head protection system	TCM	transmission control module
IHKA	automatic heating and air conditioning system	TDC	top dead center
IHKR	manual heating and air conditioning system	TLEV	transitional low emissions vehicle
ITS	head protection system	TXD	transmit data line
KL 15	battery positive, ignition switch on "run"	UIS	ultrasonic interior protection
KL 30	battery positive "hot" all the time	ULEV	ultra low emissions vehicle
KL 31	battery/chassis ground	ZKE	central body electronics

Electrical Troubleshooting

Four things are required for current to flow in any electrical circuit: a voltage source, wires or connections to transport the voltage, a load or device that uses the electricity, and a connection to ground.

Most problems can be found using a digital multimeter (volt/ohm/amp meter) to check the following:

- ◆ Voltage supply
- ◆ Breaks in the wiring (infinite resistance/no continuity)
- ◆ A path to ground that completes the circuit.

Electric current is logical in its flow, always moving from the voltage source toward ground. Electrical faults can usually be located through a process of elimination. When troubleshooting a complex circuit, separate the circuit into smaller parts. General tests outlined below may be helpful in finding electrical problems. The information is most helpful when used with wiring diagrams.

Be sure to analyze the problem. Use wiring diagrams to determine the most likely cause. Get an understanding of how the circuit works by following the circuit from ground back to the power source.

When making test connections at connectors and components, use care to avoid spreading or damaging the connectors or terminals. Some tests may require jumper wires to bypass

components or connections in the wiring harness. When connecting jumper wires, use blade connectors at the wire ends that match the size of the terminal being tested. The small internal contacts are easily spread apart, and this can cause intermittent or faulty connections that can lead to more problems.

Voltage and voltage drops

Wires, connectors, and switches that carry current are designed with very low resistance so that current flows with a minimum loss of voltage. A voltage drop is caused by higher than normal resistance in a circuit. This additional resistance actually decreases or stops the flow of current. A voltage drop can be noticed by problems ranging from dim headlights to sluggish wipers. Some common sources of voltage drops are corroded or dirty switches, dirty or corroded connections or contacts, and loose or corroded ground wires and ground connections.

A voltage drop test is a good test to make if current is flowing through the circuit, but the circuit is not operating correctly. A voltage drop test will help to pinpoint a corroded ground strap or a faulty switch. Normally, there should be less than 1 volt drop across most wires or closed switches. A voltage drop across a connector or short cable should not exceed 0.5 volts.

Note:

- ◆ *A voltage drop test is generally more accurate than a simple resistance check because the resistances involved are often too small to measure with most ohmmeters. For example, a*

resistance as small as 0.02 ohms would results in a 3 volt drop in a typical 150 amp starter circuit. (150 amps x 0.02 ohms =3 volts).

- ◆ Keep in mind that voltage with the key on and voltage with the engine running are not the same. With the ignition on and the engine off (battery voltage), voltage should be approximately 12.6 volts. With the engine running (charging voltage), voltage should be approximately 14.0 volts. Measure voltage at the battery with the ignition on and then with the engine running to get exact measurements.

Voltage, measuring

- ✦ Connect digital multimeter negative lead to a reliable ground point on car.

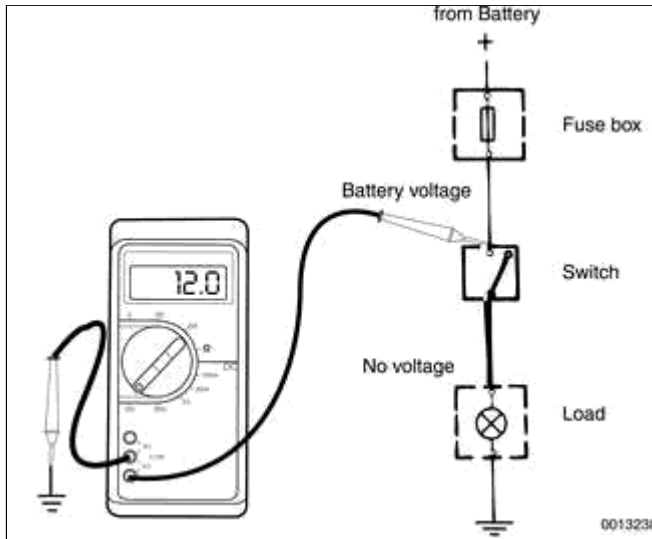
Note:

The negative (-) battery terminal is always a good ground point.

- Connect digital multimeter positive lead to point in circuit you wish to measure.
- ◆ If a reading is obtained, current is flowing through circuit.

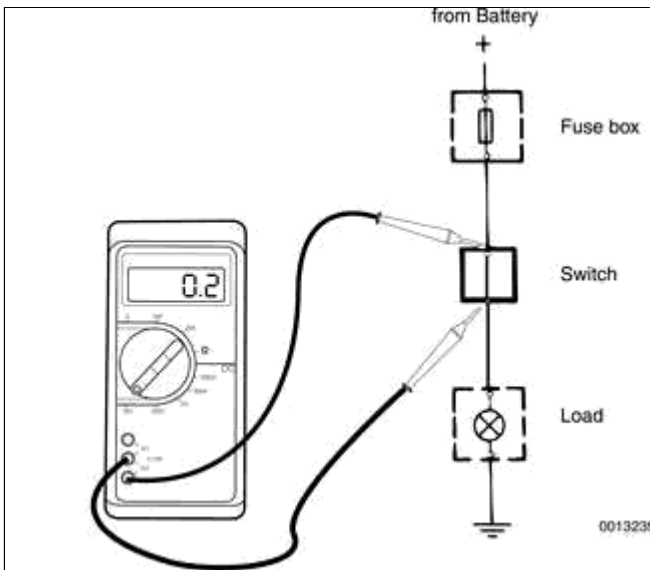
Note:

The voltage reading should not deviate more than 1 volt from voltage at the battery. If voltage drop is more than this, check for a corroded connector or loose ground wire.



Voltage drop, testing

Voltage drop can only be checked when there is a load on the circuit, such as when operating the starter motor or turning on the headlights. A digital multimeter should be used to ensure accurate readings.



Connect digital multimeter positive lead to positive (+) battery terminal or a positive power supply close to battery source.

- Connect digital multimeter negative lead to other end of cable or switch being tested.
- With power on and circuit working, meter shows voltage drop (difference between two points). This value should not exceed 1 volt.

Note:

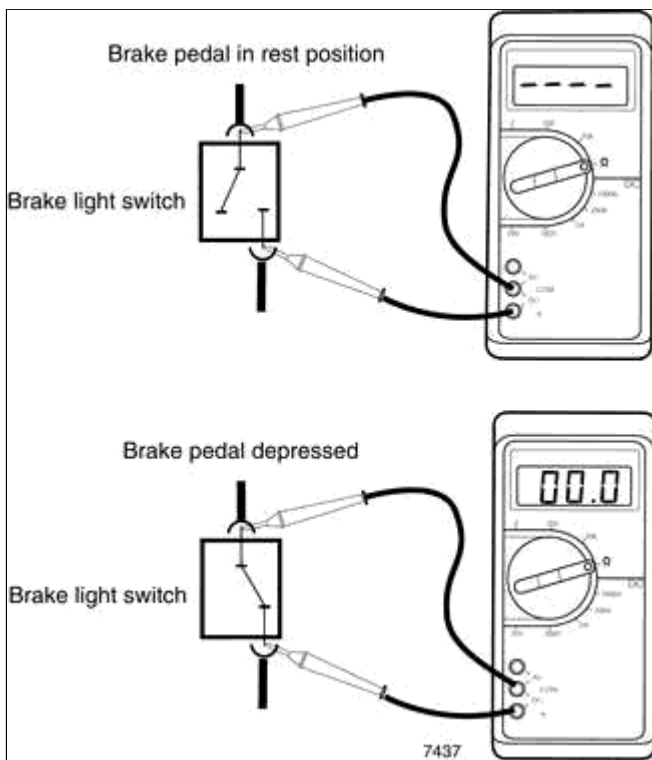
The maximum voltage drop in an automotive circuit, as recommended by the Society of Automotive Engineers (SAE), is as follows: 0 volts for small wire connections; 0.1 Volts for high current connections; 0.2 volts for high current cables; and 0.3 volts for switch or solenoid contacts. On longer wires or cables, the drop may be slightly higher. In any case, a voltage drop of more than 1.0 volt usually indicates a problem.

Continuity, checking

Continuity tests can be used to check a circuit or switch. Because most automotive circuits are designed to have little or no resistance, a circuit or part of a circuit can be easily checked

for faults using an ohmmeter. An open circuit or a circuit with high resistance will not allow current to flow. A circuit with little or no resistance allows current to flow easily.

When checking continuity, the ignition should be off. On circuits that are powered at all times, the battery should be disconnected. Using the appropriate wiring diagram, a circuit can be easily tested for faulty connections, wires, switches, relays and engine sensors by checking for continuity.



For example, to test brake light switch for continuity:

- ◆ With brake pedal in rest position (switch open) there is no continuity (infinite Ω).
- ◆ With pedal depressed (switch closed) there is continuity (0Ω).

Short circuits

Short circuits are exactly what the name implies. The circuit takes a shorter path than it was designed to take. The most common short that causes problems is a short to ground where the insulation on a positive (+) wire wears away and the metal wire is exposed. When the wire rubs against a metal part of the car or other ground source, the circuit is shorted to ground. If the exposed wire is live (positive

battery voltage), a fuse will blow and the circuit may possibly be damaged.

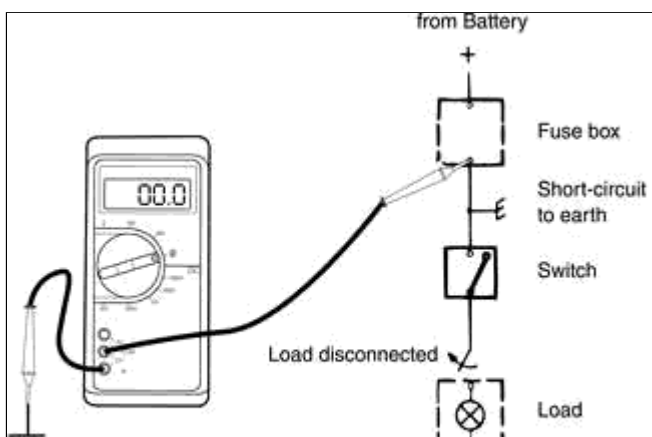
Shorts to ground can be located with a digital multimeter. Short circuits are often difficult to locate and may vary in nature. Short circuits can be found using a logical approach based on current path.

CAUTION!

- ♦ ***On circuits protected with high rating fuses (25 amp and greater), wires or circuit components may be damaged before the fuse blows. Always check for damage before replacing fuses of this rating.***
- ♦ ***When replacing blown fuses, use only fuses having the correct rating. Always confirm the correct fuse rating printed on the fuse/relay panel cover.***

Short circuit, testing with ohmmeter

- Remove blown fuse from circuit and disconnect cables from battery. Disconnect harness connector from circuit load or consumer.



- ◀ Using an ohmmeter, connect one test lead to load side of fuse terminal (terminal leading to circuit) and the other test lead to ground.
 - If there is continuity to ground, there is a short to ground.
 - If there is no continuity, work from wire harness nearest to fuse/relay



panel and move or wiggle wires while observing meter. Continue to move down harness until meter displays a reading. This is the location of short to ground.

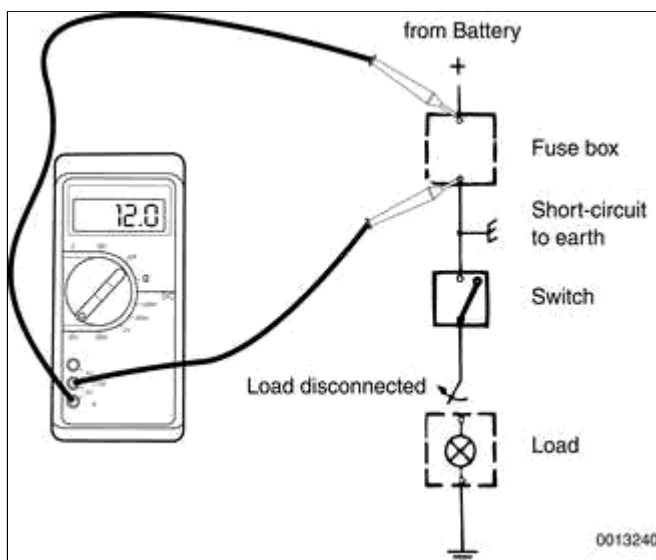
- Visually inspect wire harness at this point for any faults. If no faults are visible, carefully slice open harness cover or wire insulation for further inspection. Repair any faults found.

Short circuit, testing with voltmeter

- Remove blown fuse from circuit. Disconnect harness connector from circuit load or consumer.

Note:

Most fuses power more than one consumer. Be sure all consumers are disconnected when checking for a short circuit.



- Using a digital multimeter, connect test leads across fuse terminals. Make sure power is present in circuit. If necessary turn key on.

- If voltage is present at voltmeter, there is a short to ground.
- If voltage is not present, work from wire harness nearest to fuse/relay panel and move or wiggle wires while observing meter. Continue to move down harness until meter displays a reading. This is the location of short to ground.
- Visually inspect wire harness at

this point for any faults. If no faults are visible, carefully slice open harness cover or wire insulation for further inspection. Repair any faults found.