ISUZU E-Learning System

Module 4: Electrical

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Electricity

Electricity

Introduction

Use of electricity paved the way in improving vehicle drivability as advances in electronics made it possible in creating control systems that improved every aspect of driving a vehicle. From fuel injection systems to body control systems, all of them relied solely on electricity.

Electricity has the following functions:

1.) *Heat Generation Function* – Heat is generated as electricity passes through a resistor, such as a cigarette lighter or fuse.

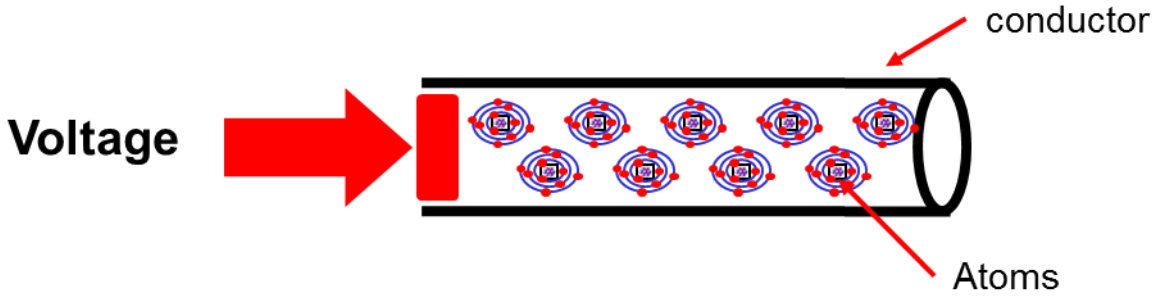
2.) *Light-emitting Function* – Light is emitted as electricity passes through a resistor such as light bulbs.

3.) *Magnetic Function* - A magnetic force is generated as electricity passes through a conductor or coil, such as an ignition coil, alternator, injector.

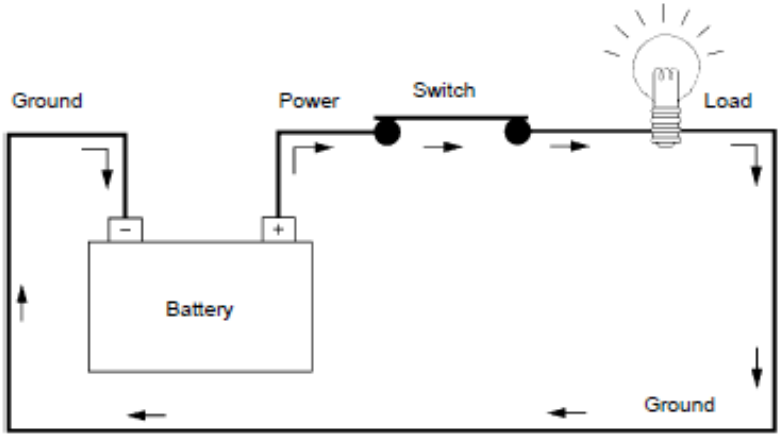
Electricity

Theory of Electricity

Electricity is the flow of electrons on a given conductor which is a material that permits flow of charged particles through it if applied with an external force called Voltage which is also called electrical pressure. Conductors are separated or protected by a material called Insulator which does not permit current flow through it.



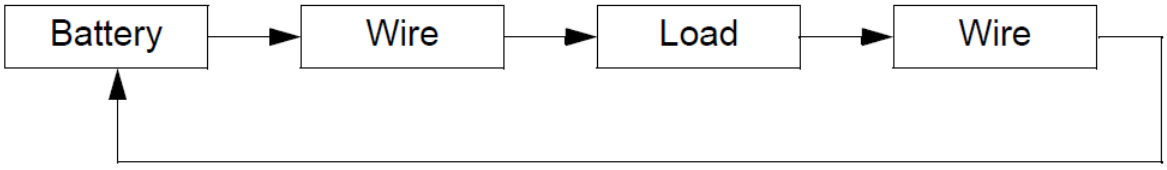
The path where electricity flows is called a Circuit. Electrical Circuits consists of wires, wire connectors, switches, relays or other electrical and electronic components.



Electricity

The three essential requirement for any circuits to operate are:

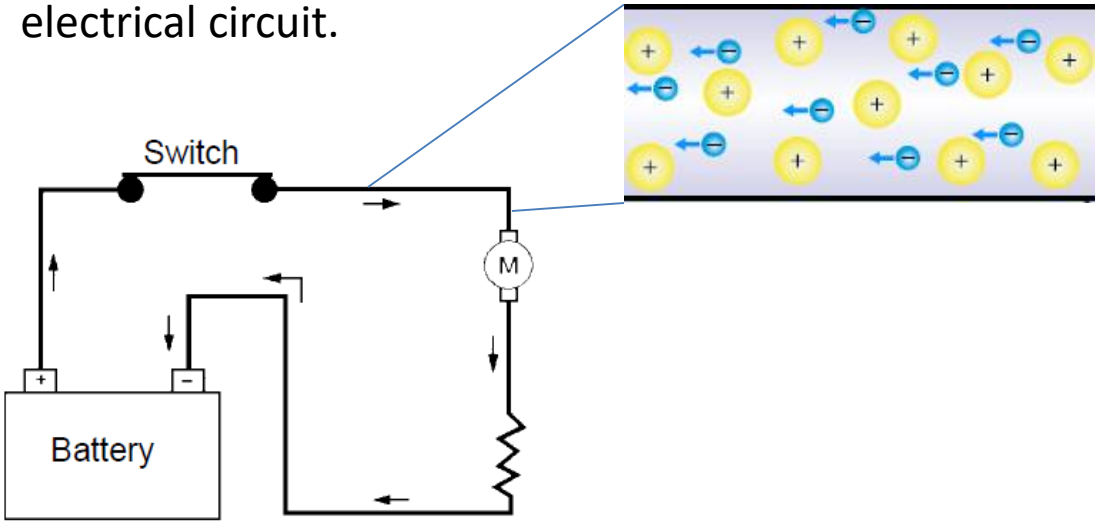
- Power (Source) – the battery and electrical path from the battery to the load (+ Positive).
- Load – Any electrical component that lights, heats or produces motion in a circuit and,
- Ground – The electrical path from the load back to the battery (- Negative).



Elements of Electricity

Electricity consists of three basic elements:

1. Current (A, Ampere) – It is the current flow through an electrical circuit.

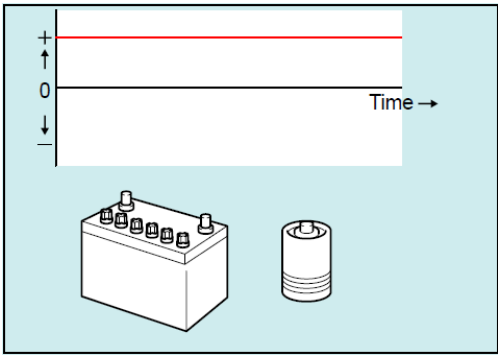


Electricity

Types of Electric Current

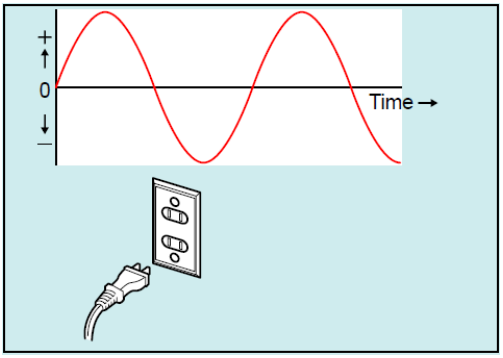
1. Direct Current

   This is a type of current that flows in a constant direction, from the positive pole to the negative pole, as in an automotive battery or a dry cell.



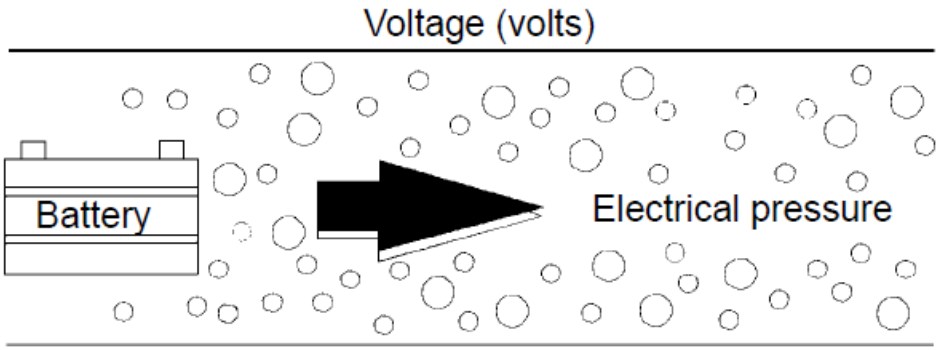
2. Alternating Current

   This is a type of current that reverses direction at regular intervals. The electricity in the household outlets or industrial three-phase power supply used in factories are some examples.

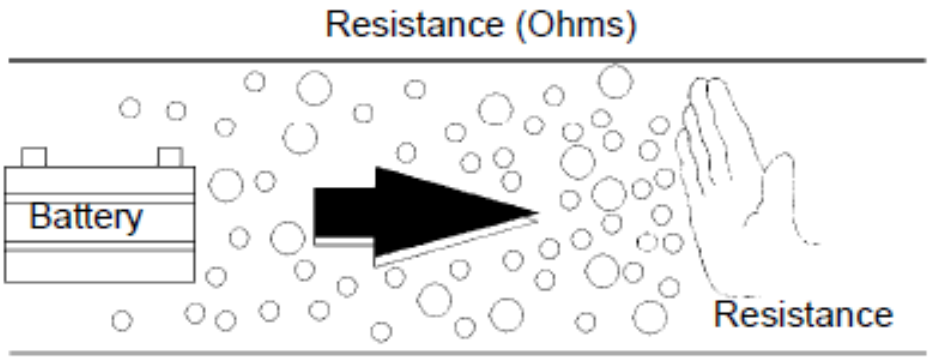


Electricity

2. Voltage (V, Volt) – It is the force of electricity that moves current through an electrical circuit. The higher the voltage, the greater the amount of current that will flow through the circuit.

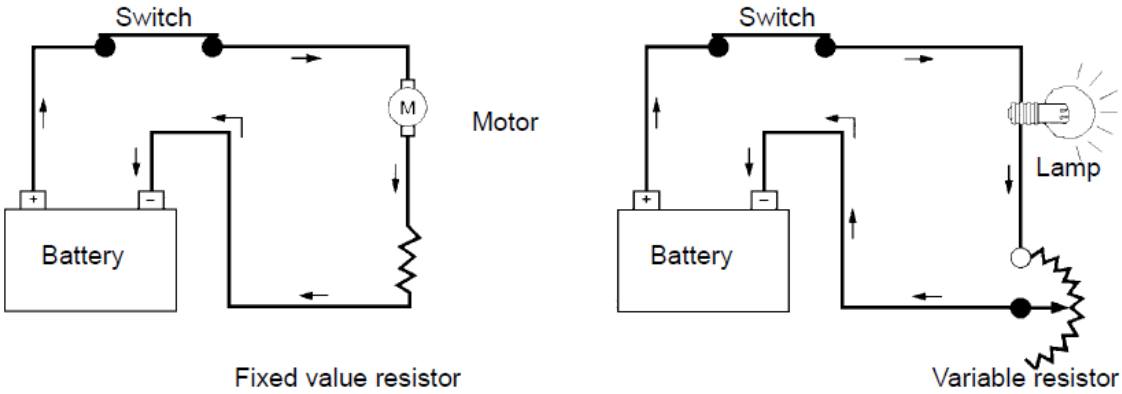


3. Resistance (Ω, Ohm) – It is the opposition to the current flow.



Electricity

In a given electrical circuit, LOAD is the resistance in a circuit that provides beat, light, motion etc. If the resistance of the LOAD as well as the values for POWER and GROUND are correct, Circuit operates as it should.



Problems for incorrect resistance:

Increased Resistance = poor or non-working electrical equipment

Decreased Resistance = Increased current flow causing Short Circuit, blown fuses and burned wires and connectors.

Electricity

Ohm's Law

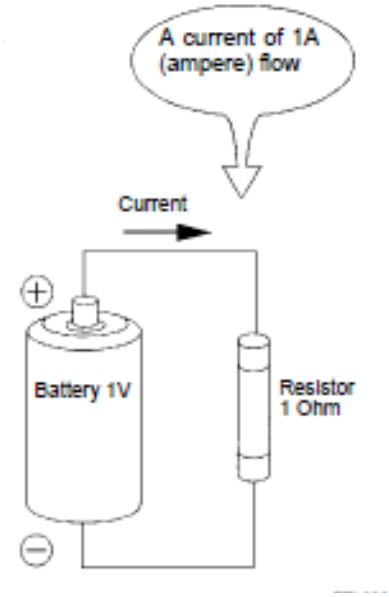
The relationship of Voltage, Current and Resistance is called Ohm's Law and it states that the current flow in a circuit is proportional to the applied voltage and inversely proportional to the resistance.

$$I = V / R \ [A]$$

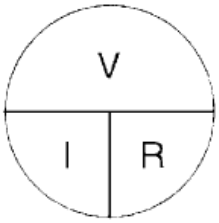
$R = V / I \ [\Omega]$

$V = I \times R \ [V]$

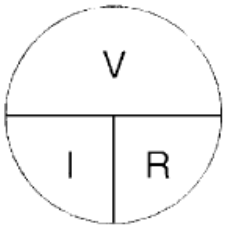
Where: I --- Current
V --- Voltage
R --- Resistance



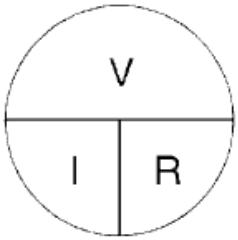
To memorize formula easily:



$$I = \frac{V}{R} \ [A]$$



$$R = \frac{V}{I} \ [\Omega]$$



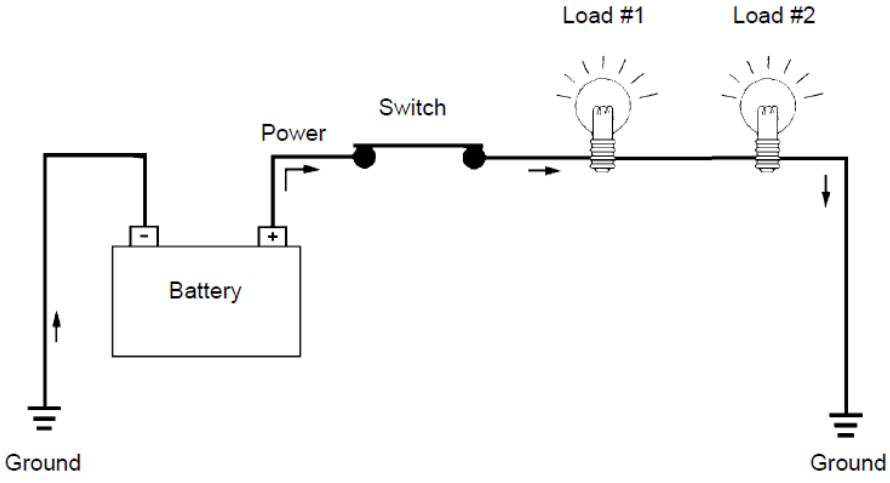
$$V = I \bullet R \ [V]$$

Electrical Circuits

Electrical Circuits

Series Circuit

Series Circuits have Power, Load and Ground arranged so that current will only take one path and it will only operate provided there is no open circuit.



Applying Ohm's Law: $I = V / R$ [A]

$V = I \times R$

$P = V \times I$

$= V2 / R$

$= I2 \times R$

Current, I:

Current flow through out the circuit is constant

$I_{total} = I_1 = I_2 = I_3$

Voltage, V:

Total voltage is equal to the sum of the voltage drops across each load or resistance.

$V_{total} = V_1 + V_2 + V_3 + \ldots + V_n$

Resistance, R:

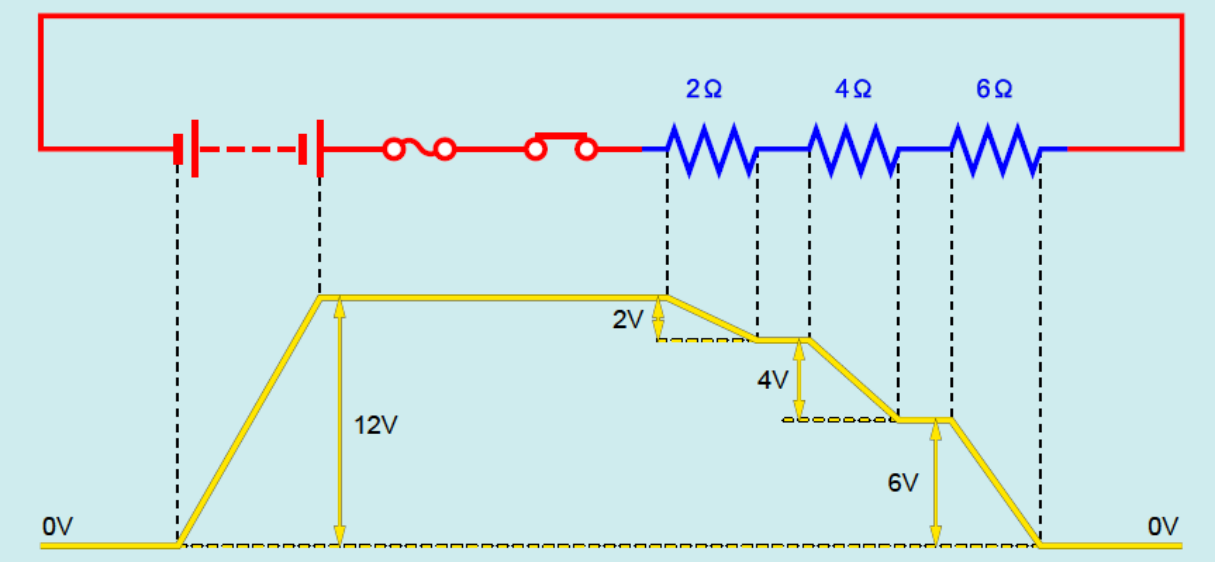
Total Resistance is equal to the sum of resistance in a circuit.

$R_{total} = R_1 + R_2 + R_3 + \ldots + R_n$

Electrical Circuits

Voltage Drop in a Series Circuit

While a current flows through a circuit, its voltage decreases each time it passes a resistor.



Example:

V= 12 V

Rtotal = R1 + R2 + R3 = 2Ω + 4Ω + 6Ω = 12Ω

I = V / Rtotal = 12V / 12Ω = 1A

V1 = I x R1 = 1A x 2Ω = 2V

V2 = I x R2 = 1A x 4Ω = 4V

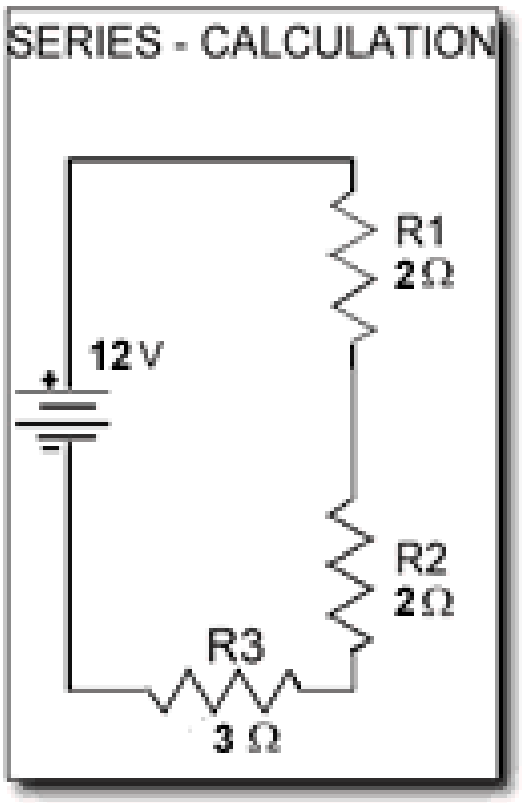
V3 = I x R3 = 1A x 6Ω = 6V

Vtotal = V1 + V2 + V3 = 2V + 4V + 6V = 12V

Electrical Circuits

Series Circuit

Sample Computation:



Ohm's Law:

V = I x R

P = V x I

= V2 / R

= I2 x R

V= 12 V

Rtotal = R1 + R2 + R3 = 2Ω + 2Ω + 3Ω = 7Ω

I = V / Rtotal = 12V / 7Ω = 1.7A

Electrical Circuits

Series Circuit

Voltage Drop Computation:

Ohm's Law: V = I x R

P = V x I

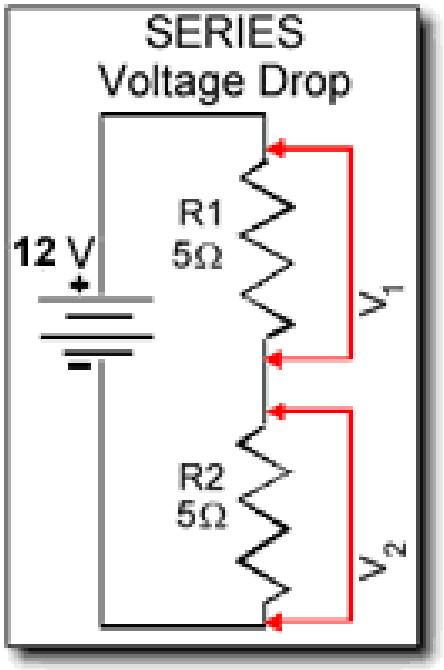
= V^2 / R

= I^2 x R

Voltage = V = V1 + V2 + V3 + … + VN

Current = I = constant

Resistance = R = R1 + R2 + R3 +…+ RN



Example:

V= 12 V

Rtotal = R1 + R2 = 5Ω + 5Ω = 10Ω

I = V / Rtotal = 12V / 10Ω = 1.2A

V1 = I x R1 = 1.2A x 5Ω = 6V

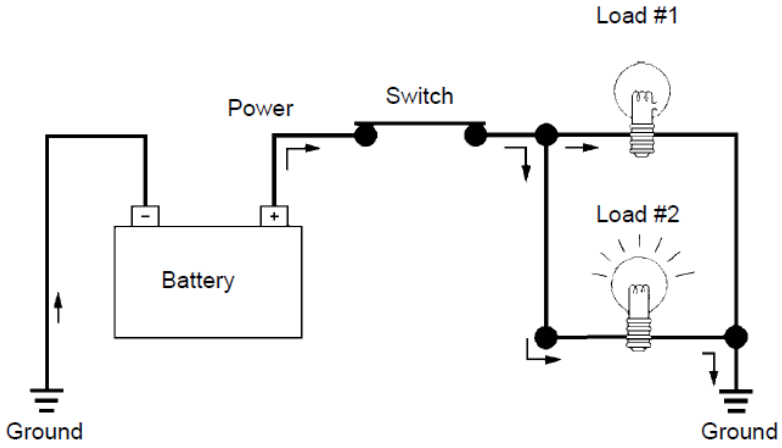
V2 = I x R2 = 1.2A x 5Ω = 6V

Vtotal = V1 + V2 = 6V + 6V = 12V

Electrical Circuits

Parallel Circuit

Parallel Circuits there are two or more current paths to flow and will allow other loads connected to it to operate should one of them fails or malfunctions.



Applying Ohm's Law:

$$I = V / R \text{ [A]}$$

$V = I \times R$

$P = V \times I$

$= V2 / R$

$= I2 \times R$

Current, I:

Total Current flow through out the circuit is equal to the sum of the individual currents of each branch.

$I_{total} = I_1 + I_2 + I_3 + \ldots + I_n$

Voltage, V:

Voltage throughout the circuit is constant.

$V_{total} = V_1 = V_2 = V_3 = \ldots = V_n$

Resistance, R:

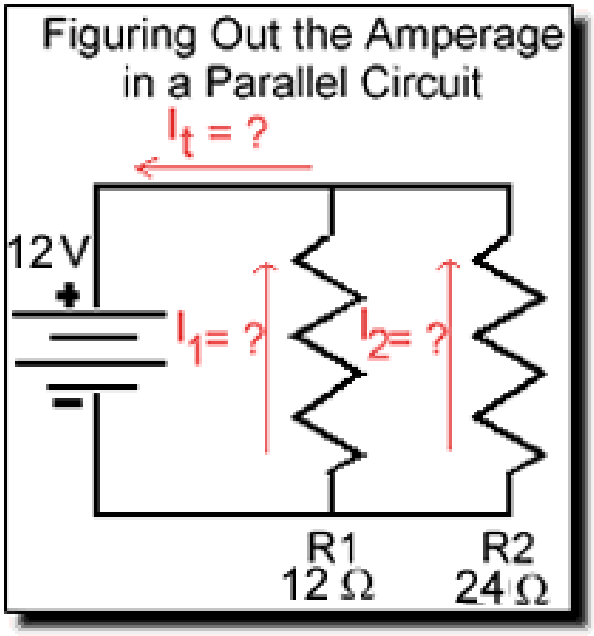
Total Resistance is in the circuit can be computed as:

$$R_{total} = \frac{1}{\frac{1}{R1}+\frac{1}{R2}+\frac{1}{R3}+\cdots+\frac{1}{RN}}$$

Electrical Circuits

Parallel Circuit

Sample Computation:



Ohm's Law:

V = I x R

P = V x I

= V2 / R

= I2 x R

V= 12 V = constant

Rtotal = $\frac{1}{\frac{1}{12\Omega}+\frac{1}{24\Omega}}$ **= 8Ω**

Itotal = V / Rtotal = 12V / 8Ω = 1.5A

I1 = 12V / 12 Ω = 1A

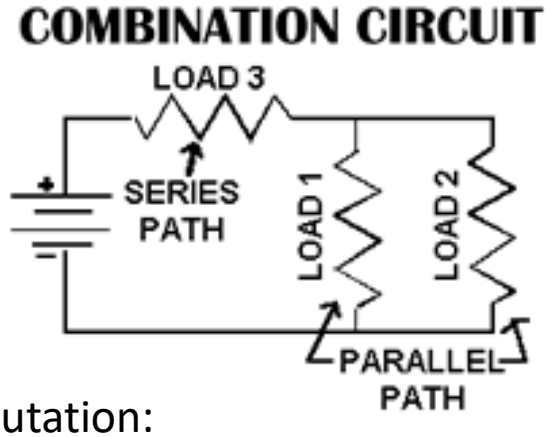
I2 = 12V / 24 Ω = 0.5A

Electrical Circuits

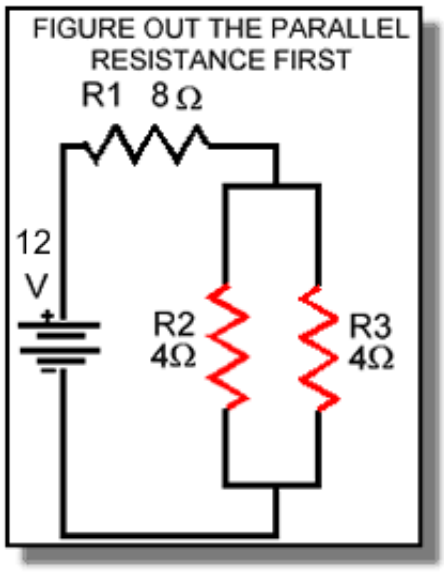
Combination Circuit

A Combination Circuit is a type of circuit wherein resistors are connected both in series and parallel in a given path.

To compute for the Total Resistance, you must compute for the total resistance of resistors in PARALLEL, then add it to the resistor which is in series.



Sample Computation:



V= 12 V = constant

R2-3 = $\frac{1}{\frac{1}{4\Omega}+\frac{1}{4\Omega}}$ = 2Ω

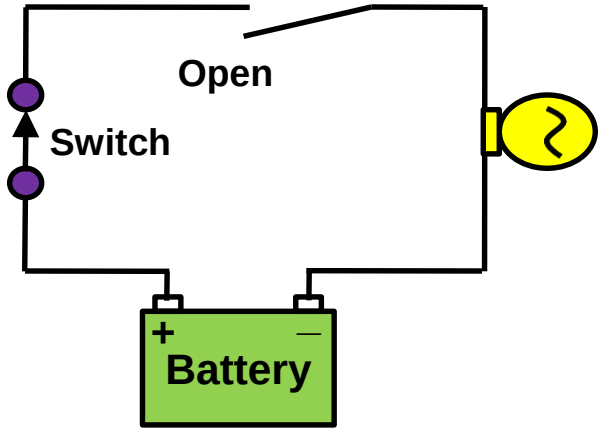
Rtotal = R1 + R2-3 = 8Ω + 2Ω = 10Ω

Electrical Circuits

Circuit Defects

Open Circuit

In this circuit, a wire has been broken or opened up. There is not a complete path for the current to flow through.



Causes of an Open Circuit

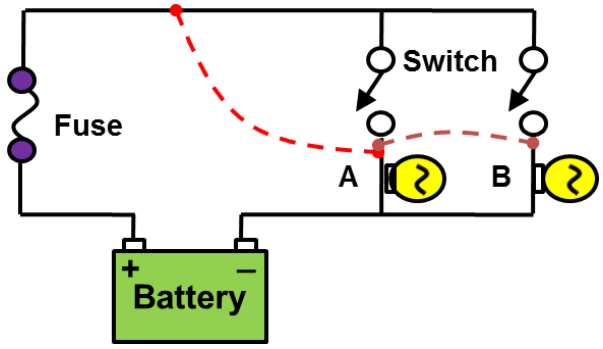
- Switch off
- Broken wire
- Burned out light bulb
- Disconnected wires and connectors
- Anything that opens the circuits (Fuses and other electrical devices)

Electrical Circuits

Circuit Defects

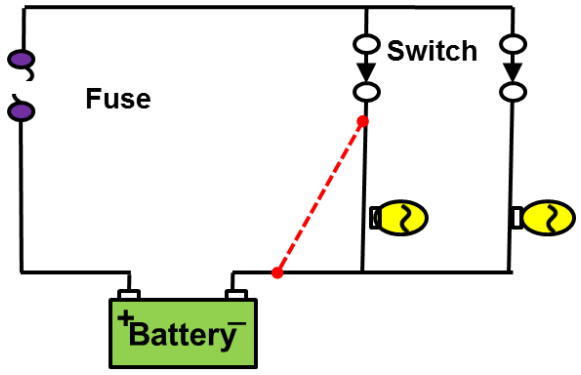
Short Circuit

In this circuit, current is allowed to flow past part of the normal path. A shorted load such as this reduces the total resistances of the load. This increases the amperage in the circuit possibly causing a fuse to blow.



Grounded Circuit

In this circuit, current is allowed to return to the battery before it has reached the load. This circuit will cause excessive current to be sent through the fuse causing the fuse to blow.



Electrical Circuits

Four Step Rule in Troubleshooting

The information below will help you plan and carry out effective repairs to electrical problems. Try to follow a logical, systematic procedure during your diagnosis and repair.

Verify

- Check to confirm the complaint is occuring.
- Is the condition described abnormal? (use owner's manual or another vehicle for verification)
- What else is not working? (Related Circuits)
- What is working?

Isolate

- Locate Schematic and wiring diagram for the year and model of vehicle you're repairing.
- Is the circuit controlled by:
  - Switch?
  - Relay?
  - ECM?
- Are components in the same parallel circuit operating correctly or not?

Electrical Circuits

Four Step Rule in Troubleshooting

- Are components in series operating or not?
- Choose test points that:
  - ❖ Can be quickly and easily accessed
  - ❖ Follow a logical process leading to a decision
- Separate the relay circuits and individually test the field coil and contact point circuits.
- "Bench Test" components – supply power and ground to check their operation.
- Remember circuit essentials:
  - ❖ POWER source with sufficient voltage
  - ❖ LOAD operating properly in good condition
  - ❖ GROUND with sufficient current capacity

Repair

- Fix the harness.
- Clean the connections.
- Replace the malfunctioning component and repair the cause of the failure.

Electrical Circuits

Four Step Rule in Troubleshooting

Recheck

- Make sure the complaint has been resolved.
- Be sure no other problem was caused during the repair
- Clean the vehicle so it is “customer ready”.

Electrical Circuits

Troubleshooting and Repair

Headlight

- **Headlights (high and low beam) do not light**

Checkpoint	Trouble Cause	Countermeasure
Ground Point Contact	Poor ground point contact	Repair the wiring
Combination Switch Continuity	Poor switch contact or faulty switch	Repair / Replace the combination switch
Lighting Relay	Poor relay contact or faulty relay	Reinstall / replace lighting relay
Voltage between ground	Open circuit between relay and switch	Repair open circuit or connector contact
Wiring continuity	Open circuit	Repair open circuit

Electrical Circuits

Troubleshooting and Repair

Headlight

- **RH (or LH) high and low beam does not light**

Checkpoint	Trouble Cause	Countermeasure
Fuse	Poor installation or blown fuse	Reinstall or replace fuse
Headlight connector continuity	Blown filament	Replace headlight bulb
Wiring continuity	Open circuit or poor connector contact	Repair or replace wire / connector

- **Passing light does not function when dimmer switch is operated**

Checkpoint	Trouble Cause	Countermeasure
Dimmer switch	Poor switch contact	Repair / replace dimmer switch
Voltage to ground	Open circuit	Repair open circuit

Electrical Circuits

Troubleshooting and Repair

Tail Light, License Plate and Clearance Light

- **All lights do not light**

Checkpoint	Trouble Cause	Countermeasure
Fuse	Poor fuse contact or blown fuse	Reinstall or replace fuse
Continuity between switch and connector	Poor switch point or connector contact	Repair or replace combination switch
Tail relay	Poor relay contact or faulty relay	Reinstall or replace tail relay

- **All lights do not light**

Checkpoint	Trouble Cause	Countermeasure
Tail light bulb continuity	Bulb burned out or poor connector contact	Replace bulb or repair connector contact
Continuity between connector	Open circuit or poor connector contact	Repair open circuit or connector contact

Electrical Circuits

Troubleshooting and Repair

Tail Light, License Plate and Clearance Light

- **Clearance or license plate light does not light**

Checkpoint	Trouble Cause	Countermeasure
Light bulb continuity	Bulb burned out	Replace bulb
Continuity between connector	Open circuit or poor connector	Repair open circuit or connector contact

Electrical Circuits

Troubleshooting and Repair

Stop Light and High Mounted Stop Light

- **One side of stoplight does not light**

Checkpoint	Trouble Cause	Countermeasure
Bulb continuity	Burned out bulb	Replace bulb
Connector continuity	Open circuit or poor connector contact	Repair open circuit or connector contact
Switch continuity	Open circuit or poor switch contact	Repair open circuit or switch contact

- **One side of stoplight does not light**

Checkpoint	Trouble Cause	Countermeasure
Fuse	Poor fuse contact or blown fuse	Reinstall or replace fuse
Stoplight switch function	Incorrect switch installation or adjustment	Adjust switch installation or position
Voltage between ground and switch	Open circuit or poor connector contact	Repair open circuit or connector contact

Electrical Circuits

Troubleshooting and Repair

Turn Signal and Hazard Warning Light

- **Turn signal light does not light on both sides**

Checkpoint	Trouble Cause	Countermeasure
Fuse	Poor fuse contact or blown fuse	Reinstall or replace fuse
Connector short circuit	Flasher unit malfunction	Replace flasher unit
Switch continuity between connector	Poor switch point contact or faulty switch	Repair or replace combination switch

- **Hazard warning light does not light**

Checkpoint	Trouble Cause	Countermeasure
Fuse	Poor fuse contact or blown fuse	Reinstall or replace fuse
Switch continuity	Hazard switch malfunction	Repair or replace hazard switch

Electrical Circuits

Troubleshooting and Repair

Turn Signal and Hazard Warning Light

- **Flashing rate too fast (one side)**

Checkpoint	Trouble Cause	Countermeasure
Bulb	Burned out bulb	Replace bulb or repair open circuit

Horn

- **Both sides of horn do not sound**

Checkpoint	Trouble Cause	Countermeasure
Fuse	Poor fuse contact or blown fuse	Reinstall or replace fuse
Grounding point	Poor ground contact	Repair grounding point
Horn switch continuity	Poor switch point contact or faulty switch	Repair or replace horn switch
Connector continuity	Open circuit or poor connector contact	Repair open circuit or connector contact

Electrical Circuits

Troubleshooting and Repair

Windshield Wiper

- **Wiper does not operate at any switch position**

Checkpoint	Trouble Cause	Countermeasure
Fuse	Poor fuse contact or blown fuse	Reinstall or replace the fuse
Voltage ground	Open circuit or poor connector contact	Repair open circuit or connector contact
Switch continuity	Switch malfunction	Replace wiper switch
Grounding point	Poor grounding point contact	Repair grounding point contact
Connector continuity	Open circuit or poor connector contact	Repair open circuit or connector contact

Electrical Circuits

Troubleshooting and Repair

Door Locks

- **All doors do not locked (or unlocked)**

Checkpoint	Trouble Cause	Countermeasure
Fuse	Poor fuse contact or blown fuse	Reinstall or replace fuse
Grounding point	Poor grounding point contact	Repair grounding point contact
Connector continuity	Open circuit or poor connector contact	Repair open circuit or connector contact
Driver's side door switch	Switch malfunction	Replace driver's side door lock switch

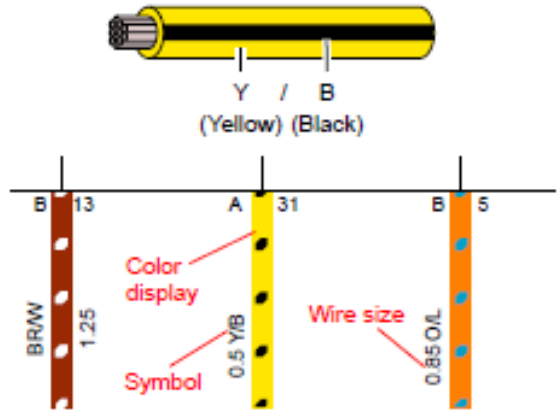
Wiring Diagram

Wiring Diagram

How to Read Wiring Diagrams

Wiring colors are identified by a code and wire sizes are identified in the wiring diagram. Below are the list of color codes and wiring sizes and how to identify it on a wire

Nominal size	Calculated area (mm^2)	Outside diameter (mm)
0.3	0.372	1.8
0.5	0.563	2.0
0.85	0.885	2.2
1.25	1.287	2.5
2	2.091	2.9
3	3.296	3.6
5	5.227	4.4
8	7.952	5.5
15	13.36	7.0
20	20.61	8.2



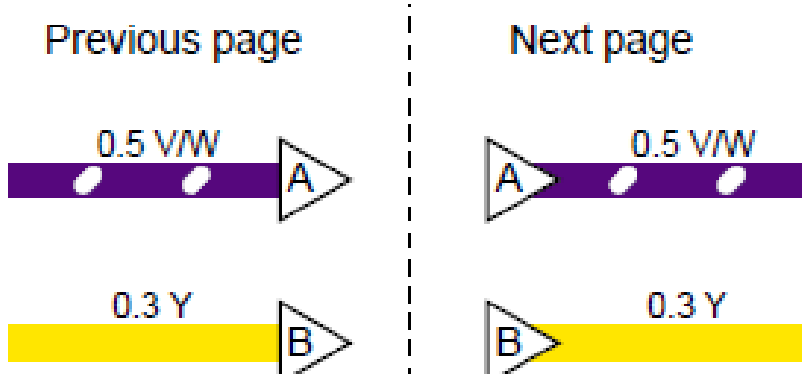
- Note: when 2 color are indicated like “Y/B” it means the wire has yellow base an and black stripe.

Symbol	Color	Symbol	Color
B	Black	BR	Brown
W	White	LG	Light green
R	Red	GY	Gray
G	Green	P	Pink
Y	Yellow	SB	Sky blue
L	Blue	V	Violet
O	Orange	T	Tan

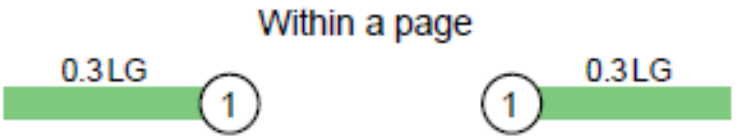
Wiring Diagram

How to Read Wiring Diagrams

Connections between pages are indicated by the symbol ▷ which connects on the line from the previous page containing the same symbol and number inside it.



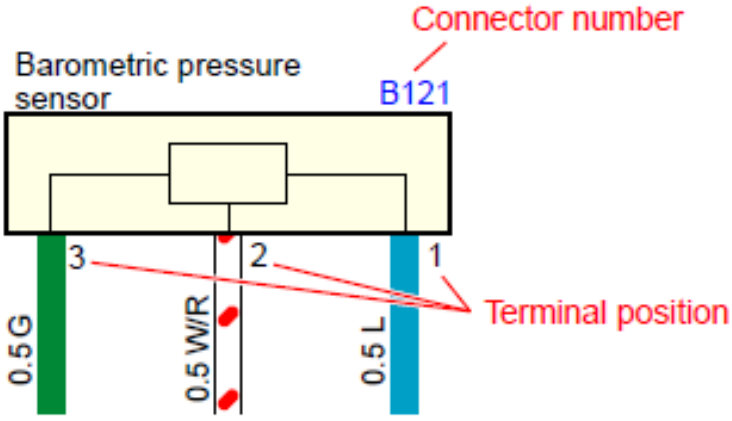
For connections on the same page, the symbol ◯ is used with a number inside it.



Wiring Diagram

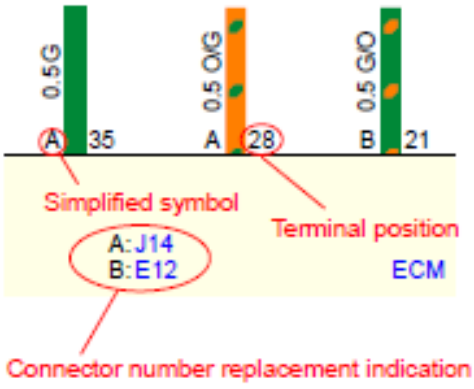
How to Read Wiring Diagrams

For Connectors with multiple wires connected on an equipment, the connector number is either on the inside or outside of the equipment and terminal number is positioned beside the wire.



- For multiple connectors connected in a component, each connector is expressed on the wiring diagram with a simplified symbol.

Example:
"A: J14" means that J14 connector is described using the simplified symbol of "A".

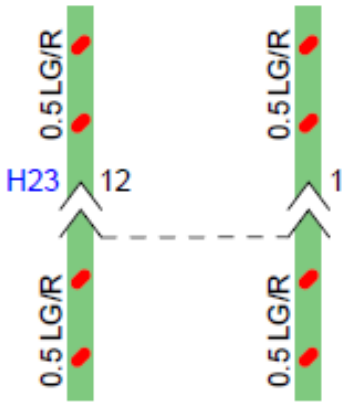


Wiring Diagram

How to Read Wiring Diagrams

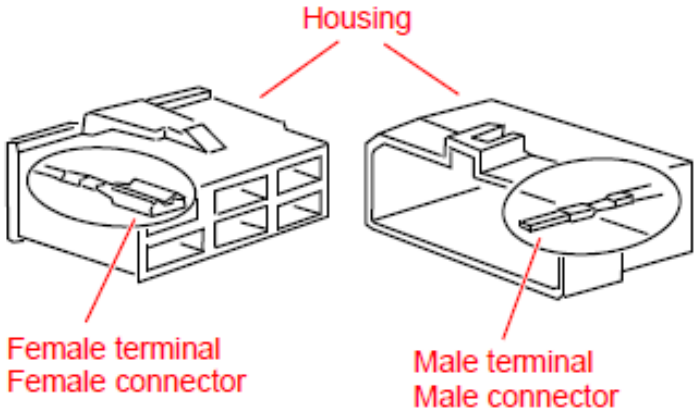
Inline connector

Connectors that are connecting wires are indicated.
" ◀ " indicates the female connector, and " ◀ " indicates the male connector.
On the wiring diagram, when connectors are linked with a dashed line (----), it means that they are the same connector.



Connector shape and terminal shape

- Female connector
  …indicates that the terminals are female.
- Male connector
  …indicates that the terminals are male.



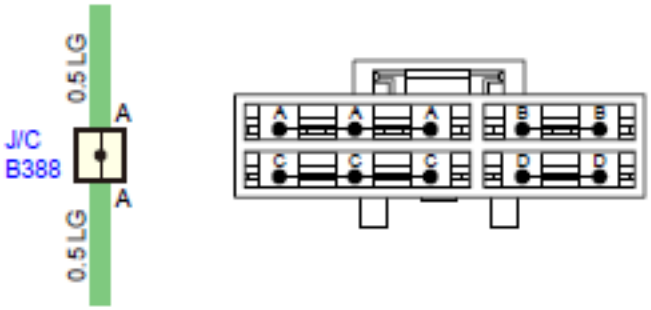
Wiring Diagram

How to Read Wiring Diagrams

Joint connector

A connector in which multiple terminals are collectively connected using joint terminals is indicated.

Alphabets indicate jointed groups (collectively connected terminals).



Ground

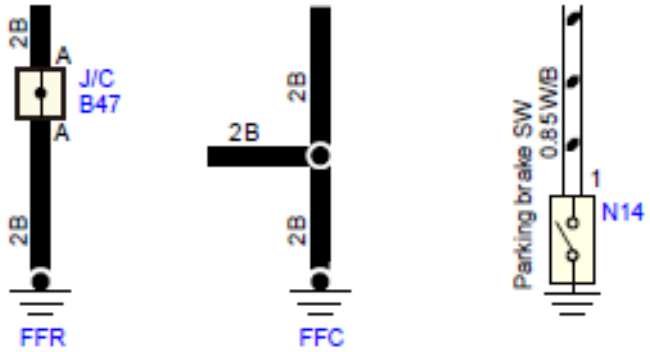
Ground positions are indicated using symbols.

Example:

FFR = Frame Front Right

FFC = Frame Front Center

For the parking brake SW, etc., it indicates that a chassis ground is used (the switch itself is connected to a ground).



Wiring Diagram

How to Read Wiring Diagrams

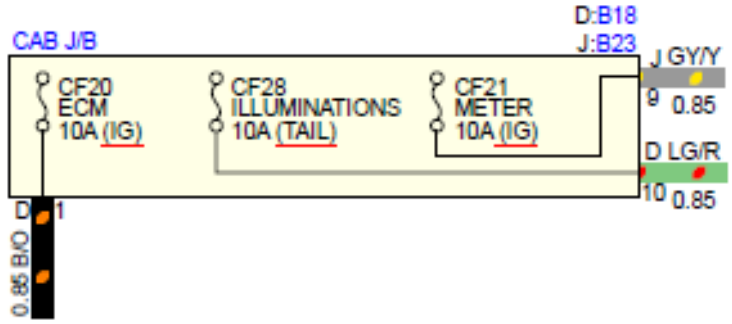
Fuse

Names, capacities and energizing conditions (in parentheses) of fuses are described.

Example:

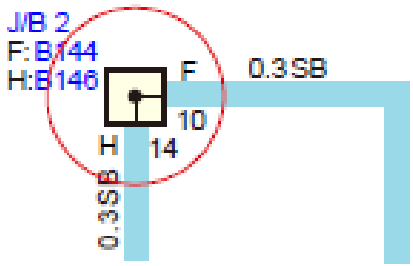
(IG) = Energized with ignition switch "ON"

(TAIL) = Energized with lighting switch "ON"



Junction block

Internal connections within a junction block which is related to each circuit are indicated.

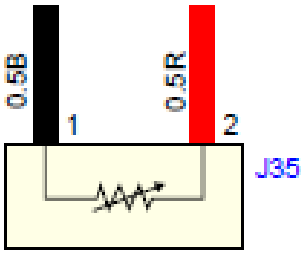


Wiring Diagram

How to Read Wiring Diagrams

Component

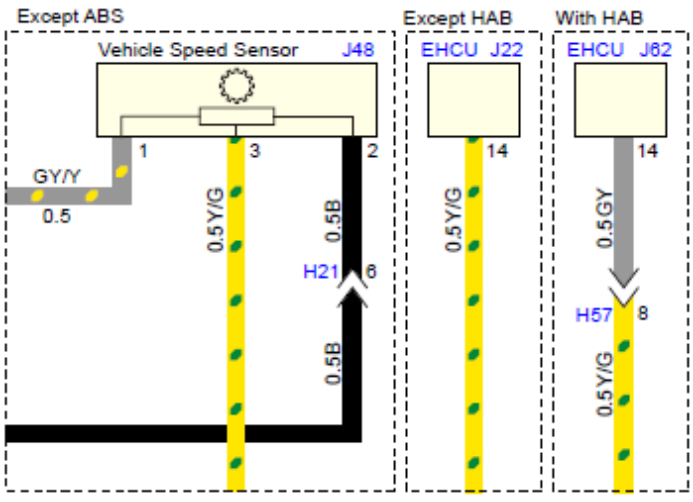
A component is represented as a frame (yellow inside), and the name of component is indicated either inside or outside the frame.



Water temperature sensor

Descriptions of specification differences

Differences in wiring diagram due to specification differences are indicated in a dashed border.

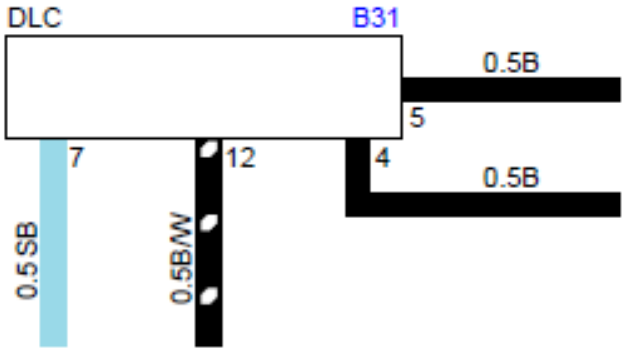


Wiring Diagram

How to Read Wiring Diagrams

External connector

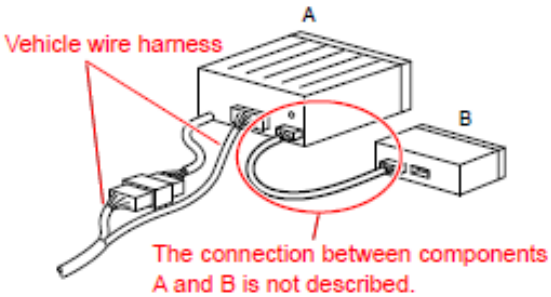
Each external connector such as DLC or option connector is represented as a frame (white inside).

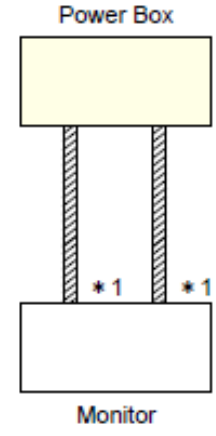


Wiring not described

This document describes connections between vehicle wire harness and each component.

Therefore, connections made between components without mediating the vehicle wire harness are not described.





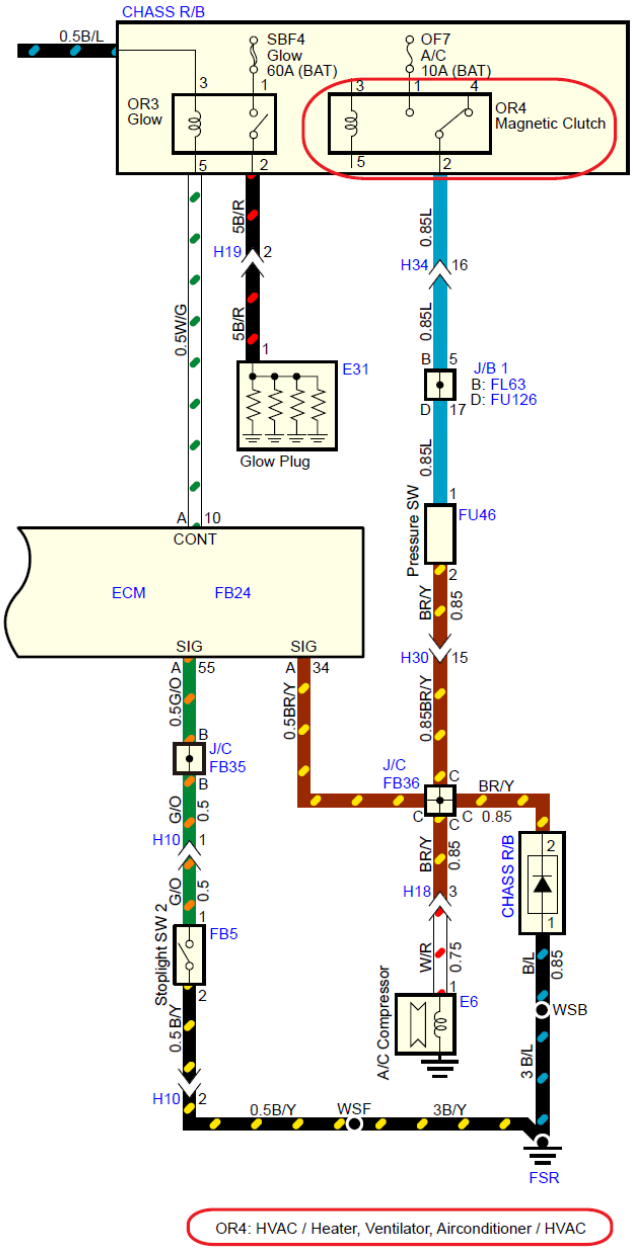
*1 : Dedicated cable

Wiring Diagram

How to Read Wiring Diagrams

Relay

Relay numbers, relay names, and relay internal circuits are indicated. If the relay is not completed in the relevant circuit, a line is added to the connection terminal and the referenced circuit names are indicated on the circuit diagram.

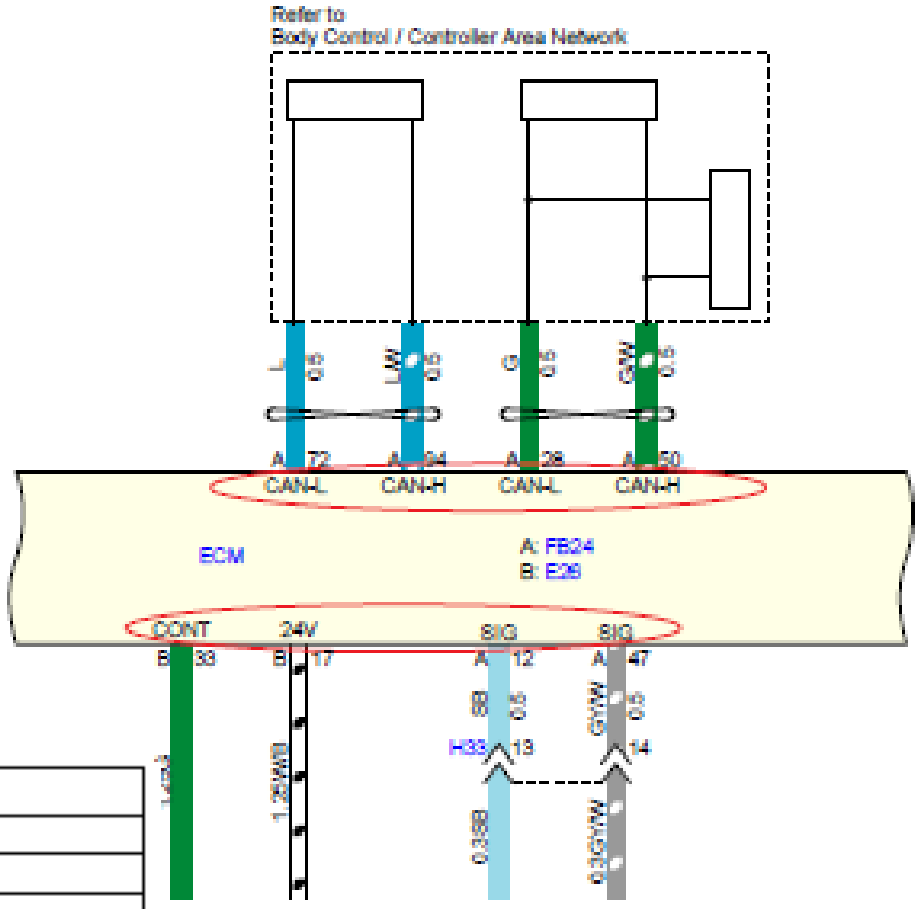


Wiring Diagram

How to Read Wiring Diagrams

Control Unit

Signal names are indicated on the terminals inside the control unit illustrations.
The meaning of the signal names are indicated below.



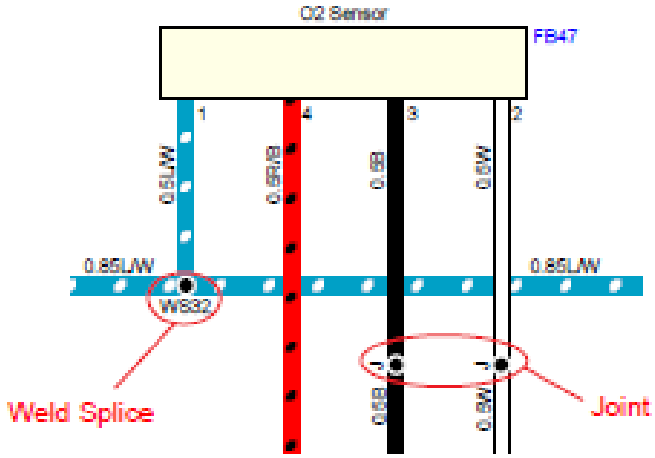
Code	Meaning
24V	Battery voltage
5V	Device voltage
GND	Ground
SIG	Signal input
CONT	Coil, LED drive
DRIVE	Motor drive
U,V,W	Three-phase motor drive
CAN-L	CAN-LOW signal
CAN-H	CAN-HIGH signal

Wiring Diagram

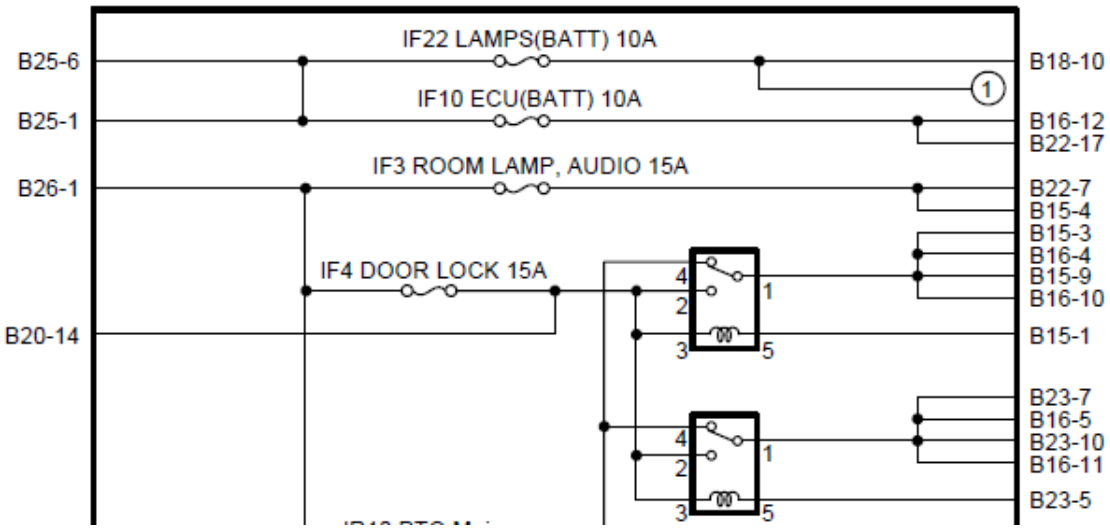
How to Read Wiring Diagrams

Joint, Weld Splice

If the wiring is joined, the weld splice number is indicated on the weld splice and joint terminal, and J is indicated at the joint.



The internal circuit of the J/B (Junction Block) is described.

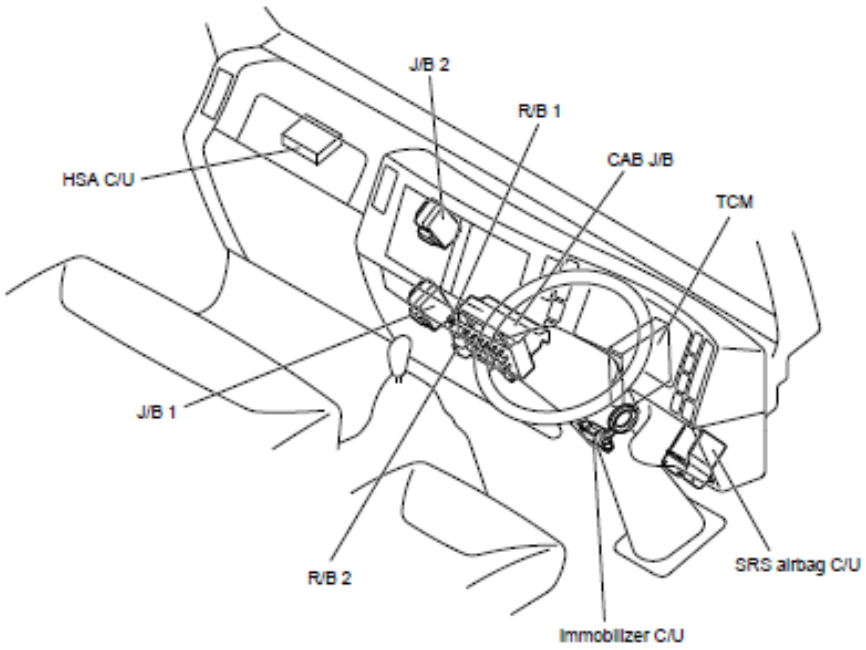


Wiring Diagram

How to Read Wiring Diagrams

Unit Location Diagram

Installation locations of each control unit, J/B (Junction Block), R/B (Relay Block), etc. are described.

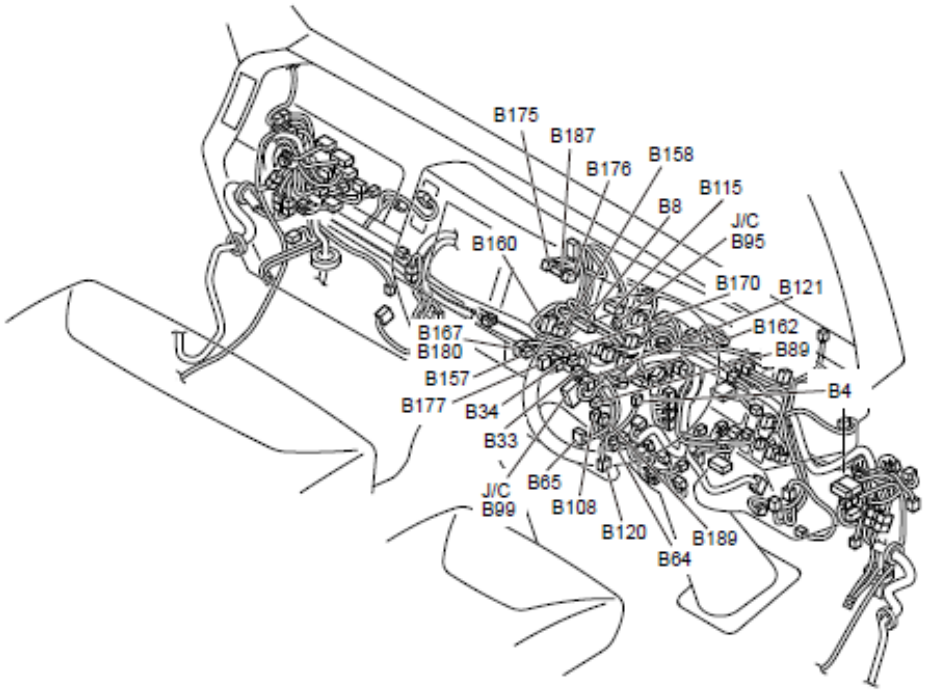


Wiring Diagram

How to Read Wiring Diagrams

Connector Location Diagram

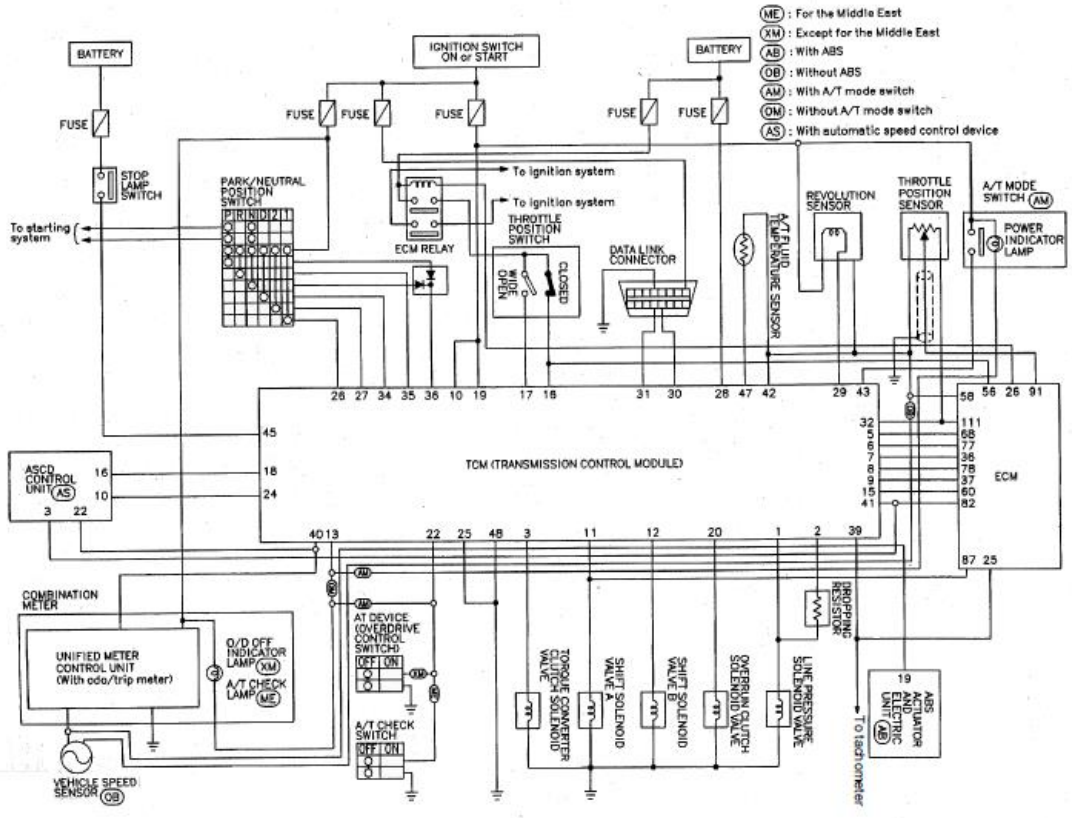
Locations of connectors used in various parts of the vehicle are described.



Wiring Diagram

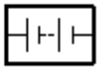
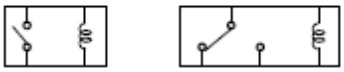
Electrical Symbols

- On an automotive wiring diagram, symbols are used to convey the locations and types of the components used in the vehicle's electrical wiring.
- Most automotive wiring diagrams use the same standard electrical symbols to show the location of basic components such as; switch, fuse and battery.
- Other symbols denote wire size and color, or serve as an abbreviation for a common electrical term.



Wiring Diagram

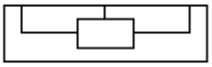
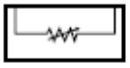
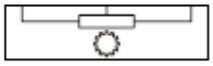
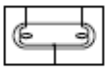
Electrical Symbols

Meaning of symbol	Symbol	Meaning of symbol	Symbol
Battery		Solenoid valve, Magnetic valve, etc.	
Fuse		Resistor	
Slow blow fuse		Horn	
Fusible link (wire)		Buzzer	
Circuit breaker		Speaker	
Relay		Motor	

Meaning of symbol	Symbol
Joint	
Pair	
Twisted pair	
Shield	
Ground	
Connection between pages	

Wiring Diagram

Electrical Symbols

Switch		Magnetic clutch		Connection within a page
Reed switch		Pressure sensor, etc.		Dedicated line
Diode		Temperature sensor		
Light emitting diode		Pulse sensor		
Single filament bulb		Other sensors, etc.		
Double filament bulb		Inline connector		
HID bulb		Joint connector junction block		

Connection within a page	
Dedicated line	

Wiring Diagram

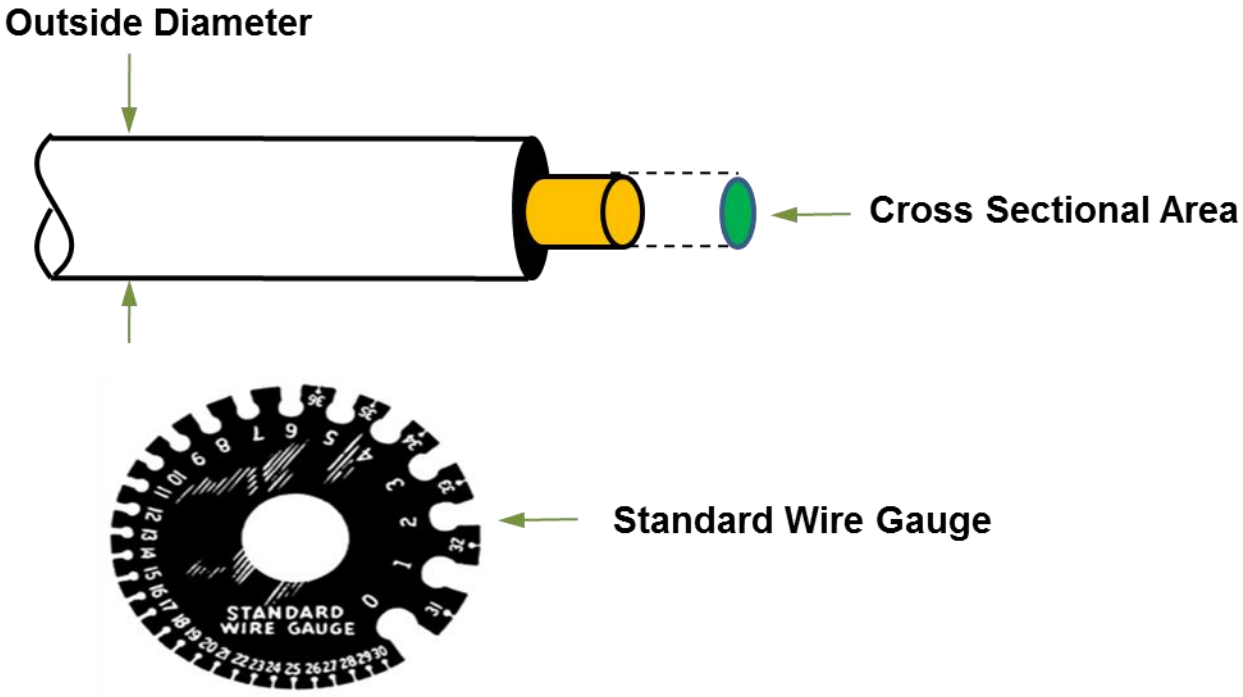
Abbreviations

Abbreviations	Explanation	Abbreviations	Explanation
#	Cylinder or number indication	FFC	Frame Front Center
A/T	Automatic Transmission	FFL	Frame Front Left
BAT	Battery	FFR	Frame Front Right
BCM	Body Control Module	Fr	Front
C/U	Control Unit	FCB	Frame Center Battery
CAB	Cab	FSL	Frame Side Left
CBL	Cab Back Left	FSR	Frame Side Right
CBR	Cab Back Right	IG	Ignition
CFC	Cab Front Center	J/B	Junction Block
CFL	Cab Floor Left	J/C	Joint Connector
CFR	Cab Floor Right	L/H	Left Hand
CHASS	Chassis	M/T	Manual Transmission
DLC	Data Link Connector	M/V	Magnetic Valve
EBL	Engine Block Left	P/W	Power Window
ECB	Engine Compartment Battery	R/B	Relay Block
ECL	Engine Compartment Left	R/H	Right Hand
ECR	Engine Compartment Right	Rr	Rear
ECM	Engine Control Module	S/B	Switch Box
EDU	Engine Driver Unit	ST	Start
EHCU	Electro-hydraulic Control Unit	SW	Switch
EHL	Engine Head Left	TCM	Transmission Control Module

Wiring Diagram

Wire Size

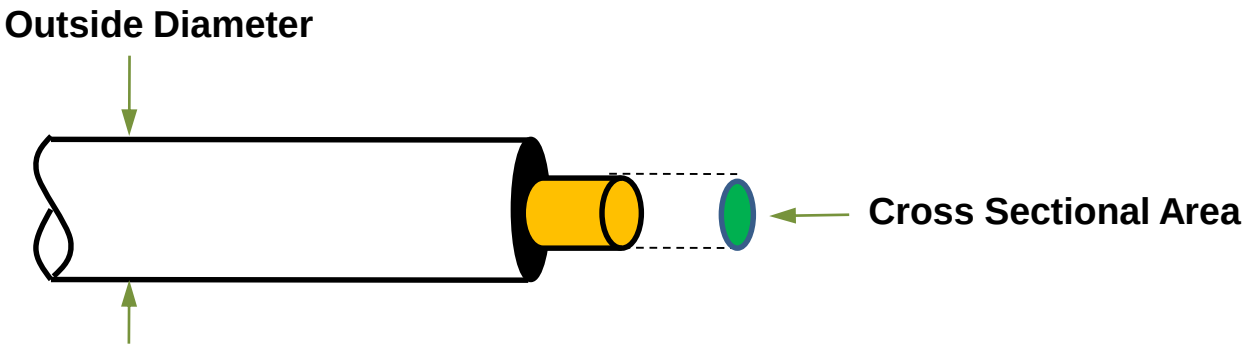
- Wire size is specified with the metric gauge system.
- The metric gauge system gives the wire size in cross sectional area measured in square millimeter (mm^2).



Wiring Diagram

Wire Size Specifications

Normal Size (mm)	Cross-sectional Area (mm^2)	Outside Diameter (mm)	Allowable Current (A)
0.3	0.372	1.8	9
0.5	0.563	2.0	12
0.85	0.885	2.2	16
1.25	1.287	2.5	21
2	2.091	2.9	28
3	3.296	3.6	37.5
5	5.227	4.4	53
8	7.952	5.5	67
15	13.36	7.0	75
20	20.61	8.2	97



Engine Electrical Systems

Engine Electrical Systems

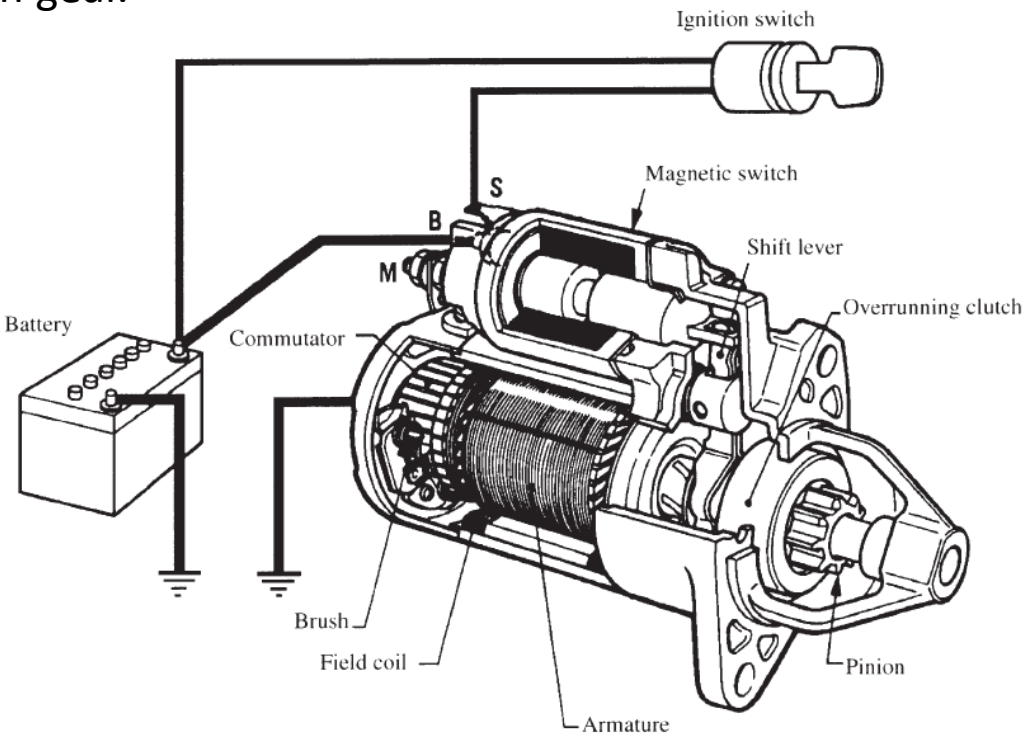
Starting System

The Starting System cranks the engine and it uses a DC motor that operates on electric energy from a battery. The motor rotates when the ignition switch is turned on (ST position and thus rotate the flywheel via ring gear using its pinion gear.

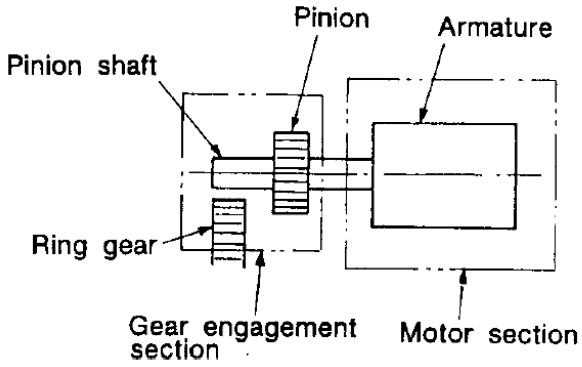
Engine Electrical Systems

Basic Components of a Starter

The Starting System cranks the engine and it uses a DC motor that operates on electric energy from a battery. The motor rotates when the ignition switch is turned on (ST position and thus rotate the flywheel via ring gear using its pinion gear.



Starter Schematic Layout



Engine Electrical Systems

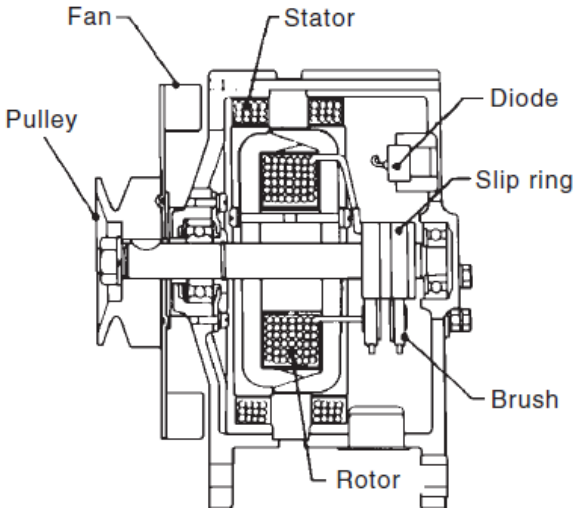
Charging System

The electrical charging system is part of the automobile electrical power system, and its output varies according to each operating condition.

The electrical power output from an alternator is low at relative low rpm and if demand exceeds its capacity, the battery supplements the needed power. At high engine speeds, output power from the alternator is increased to a sufficient level that excess electricity is stored back to the battery.

Alternator

The alternator is driven by the engine using a belt attached to the crank pulley. It is a generator that converts engine rotation (mechanical energy) into electrical energy.



Engine Electrical Systems

Battery

A battery is an electrochemical device for storing energy in chemical form so that it can be released as electricity.

Purpose of Battery

A. When Engine is OFF

Electricity from the battery is used to operate lighting, accessories or other electrical systems when the engine is not running.

B. When Starting the Engine

Electricity from the battery is used to operate the starter motor and to provide current for the ignition system during engine cranking. Starting the car is the battery's important function.

C. When the Engine is Running

Electricity from the battery is needed to supplement the charging system when the vehicle's electrical load requirement exceed the charging system's ability to produce electricity. Both the battery & the alternator supply electricity when demand is high.

Engine Electrical Systems

Common Battery Terms

Specific Gravity

Density of a liquid compared to the density of water. Specific Gravity of electrolyte is the weight of the electrolyte compared to the weight of water of an equal volume.

Open Circuit Voltage

Voltage of a battery when it is not delivering or receiving power. It is 2.11 volts for a fully charged battery cell or 12.66 for a fully charged battery 12 volt battery.

Reserve Capacity

Expressed as the number of minutes a new fully charged at 80°F (26.7°C) can be continuously discharged at 25 amperes and maintain a terminal voltage equal to or higher than 1.75 volts per cell.

Engine Electrical Systems

Common Battery Terms

Cold Cranking Amperes

The Cold Cranking Performance (0°F) rating is the discharge load in amperes which a new fully charged battery at 0°F (-17.8°C) can continuously deliver for 30 seconds and maintain a terminal voltage equal to or higher than 1.20 volts per cell.

Ampere Hour

The amount of energy a battery can give considering discharge rate and time.

Ex. For a 50 AH Battery

- It can give you 1 A for 50 hours or,
- It can give you 50 A for 1 hour.

Short Circuit

An unintended current by-pass, generally very low resistance and thus causing discharge of the battery cell.

Engine Electrical Systems

Troubleshooting

- **No Charging**

Possible problem	Countermeasure
Dead battery	Replace
Open or shorted ammeter	Replace
Loose wiring connection	Replace
One or more generator coil open or shorted	Replace
Bad diode	Replace
Open or shorted wirings	Repair
Bad regulator	Replace
Loosed regulator connections	Repair

Possible problem	Countermeasure
Dead battery	Replace
Open or shorted wirings	Repair
Loosed wiring connection	Repair
Loosed generator drive belt	Adjust belt tension
Stator coil intermittent short	Replace
Open or shorted wirings	Repair
Loosed battery connection	Repair
Loosed regulator connections	Repair

Engine Electrical Systems

Troubleshooting

- **Excessive Charging**

Possible problem	Countermeasure
Bad AC regulator	Replace

- **Unstable Charging**

Open wiring connection or open wire	Repair
Loose alternator drive belt	Adjust belt tension
Open or shorted stator coil	Replace
Loose terminal connection	Repair
Bad AC regulator	Replace
Loose regulator terminal connections	Repair

- **Abnormal Operating Noise**

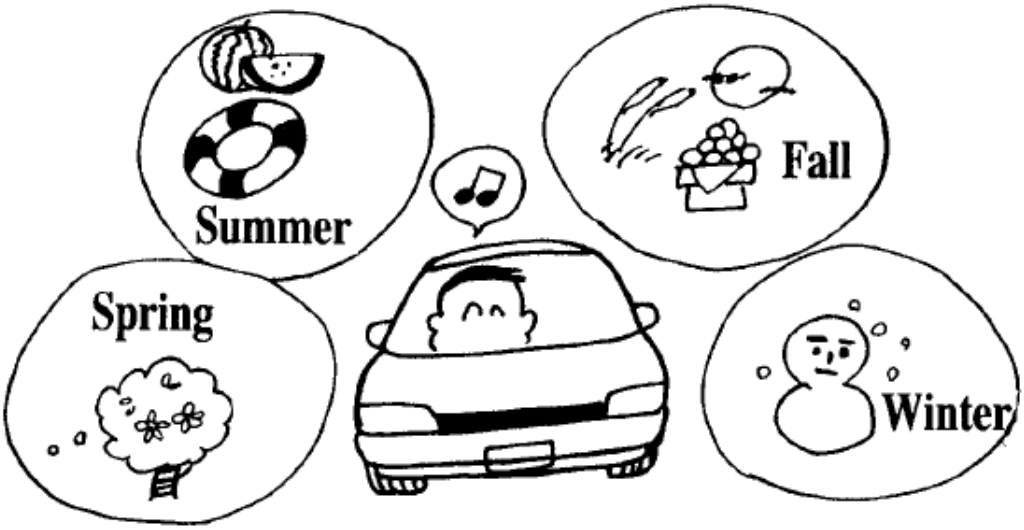
Loose Generator Drive Belt	Adjust Belt Tension
Bad bearing	Replace
Loose rotor core or stator core	Repair
Bad diode	Replace
Open or shorted stator coil	Replace

Air Conditioning System

Air Conditioning System

Introduction

An Air Conditioning System is a system where the functions of a heater and a cooler are integrated into one system, and can create pleasant conditions within a vehicle in all seasons.



Air Conditioning System

Types of Air Conditioning Systems

Currently there are two types of air conditioning systems being used today. Although they are different in terms of operation, both systems share the same components in order to control the in-vehicle temperature.

Manually Controlled Air Conditioners

The driver selects the desired mode by moving a mode or selector lever which shuts off or allows air delivery thru vents and controls heater and air conditioner operation.

Air Conditioning System

Types of Air Conditioning Systems

Automatically Controlled Air Conditioners (Auto Climate)

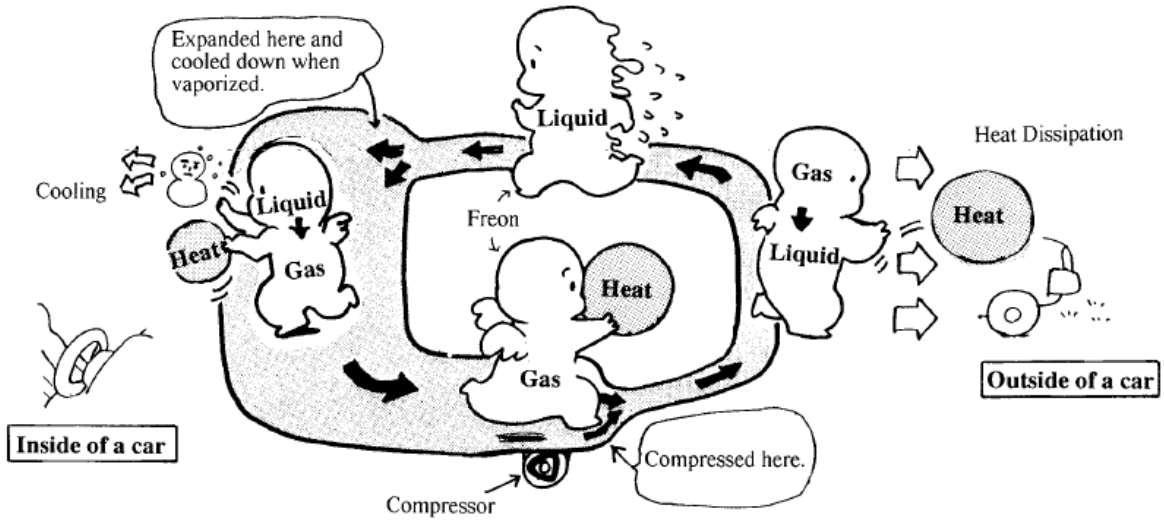
This system allows the driver to select automatic control and the desired temperature. It will maintain the set temperature by providing heat or cooling as required including blower speed and mode selection. There is also an override system in which the driver has the option to manually control the system similar to the manual air conditioning system.

Air Conditioning System

Theory of Air Conditioning

A liquid has the nature of cooling the surrounding area when it becomes a vapor like when an alcohol evaporates from your skin, it feels cool.

In an air cooling system, we use the refrigeration cycle in order to create this effect repeatedly by continuously changing the state of the liquid in to vapor.

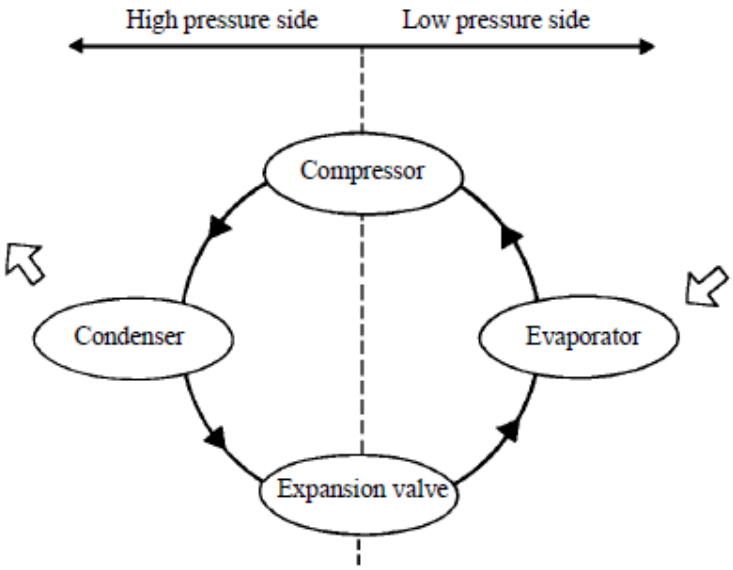


Air Conditioning System

Refrigeration Cycle

The temperature of a gas rises when compressed and becomes liquid when cooled. When it is decompressed, it turns into vapor.

In a refrigeration cycle, the refrigerant is repeatedly compressed and decompressed in order to change its state from liquid to vapor in order to effect cooling.



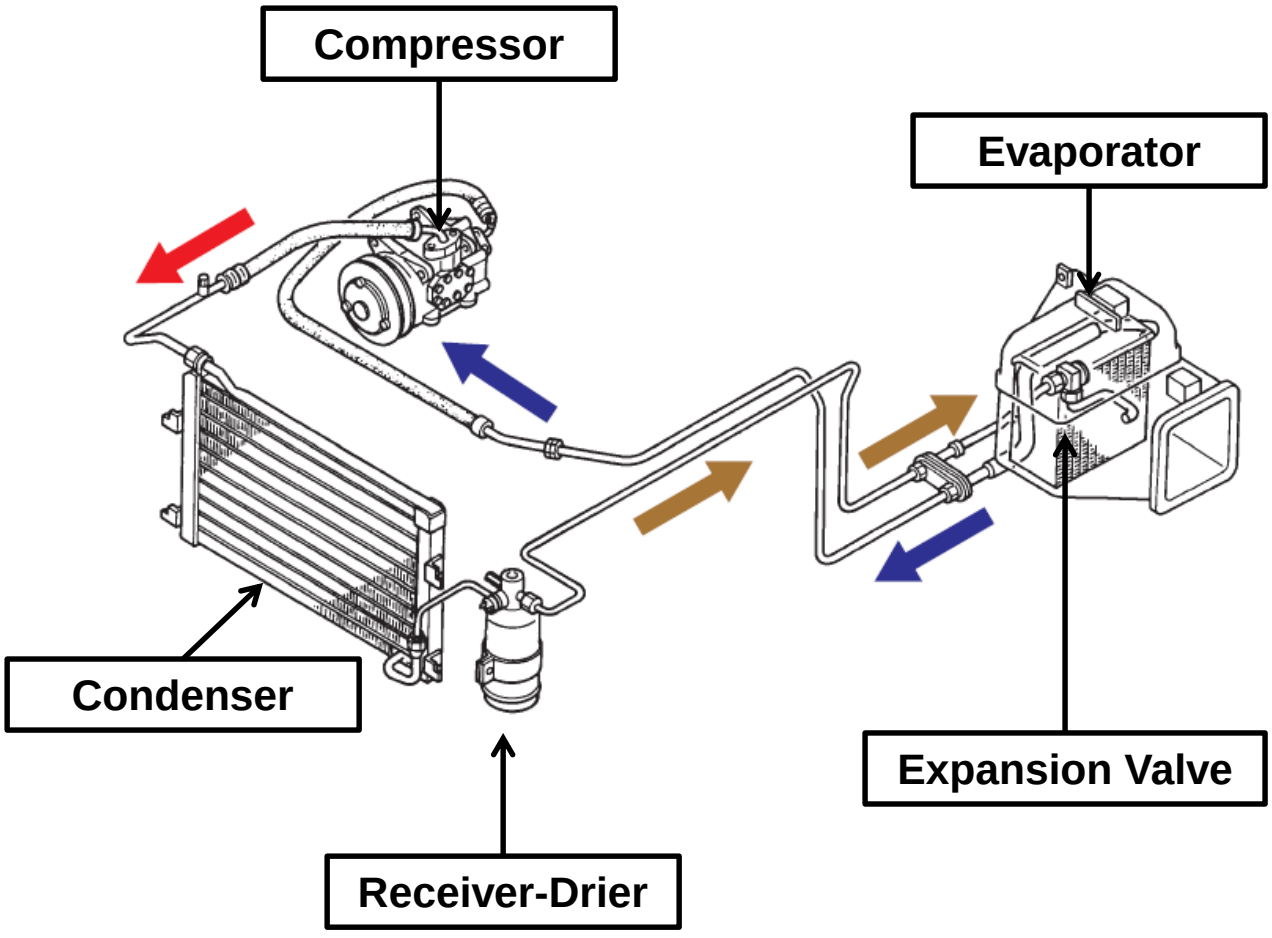
The refrigerant (Freon gas) is compressed by the compressor turning it into high pressure, high temperature vapor. It is then cooled in the condenser and becomes liquid. The liquid refrigerant is then evaporated by reducing its pressure using expansion valve. During evaporation, it absorbs heat from the surrounding air using evaporator.

Air Conditioning System

Components of Air Conditioning System

The air conditioning systems used in vehicles today consists of the following:

- Compressor
- Condenser
- Receiver-Drier
- Expansion Valve
- Evaporator



Air Conditioning System

Components of Air Conditioning System

Compressor

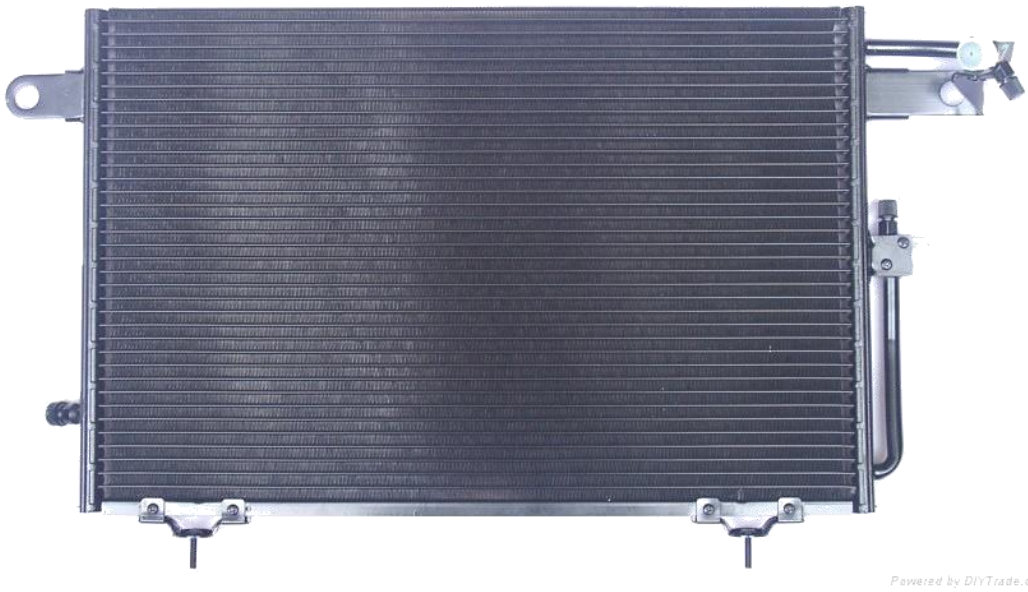
The compressor draws the vaporized refrigerant at a low pressure and temperature and compresses it to become a vapor at high pressure and temperature. The compressed vapor is then delivered to the condenser.

Air Conditioning System

Components of Air Conditioning System

Condenser

High temperature vapor entering the condenser is cooled by the air passing around its fins. When the vapor is cooled down, it begins to condense to liquid form. It is in liquid form (which contains vapor) near the condenser outlet.



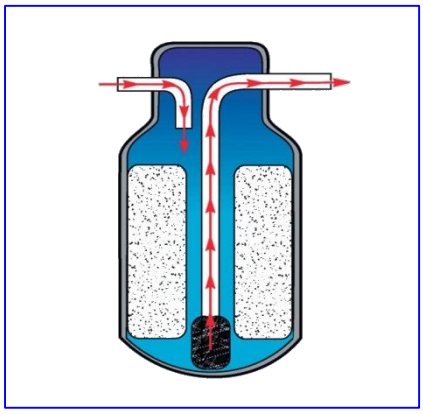
Air Conditioning System

Components of Air Conditioning System

Receiver-Drier

The liquid refrigerant moves into the receiver-drier, where vapor is separated from the liquid refrigerant. Then the liquid refrigerant is delivered to the expansion valve.

The receiver-drier stores the refrigerant until the necessary amount of refrigerant, which dirt and moisture are removed from, is take out going into the expansion valve.



Air Conditioning System

Components of Air Conditioning System

Expansion Valve

When passing through the expansion valve, the liquid refrigerant becomes a mist at a low pressure and temperature as it decompresses. It controls the flow of the refrigerant by throttling.

Air Conditioning System

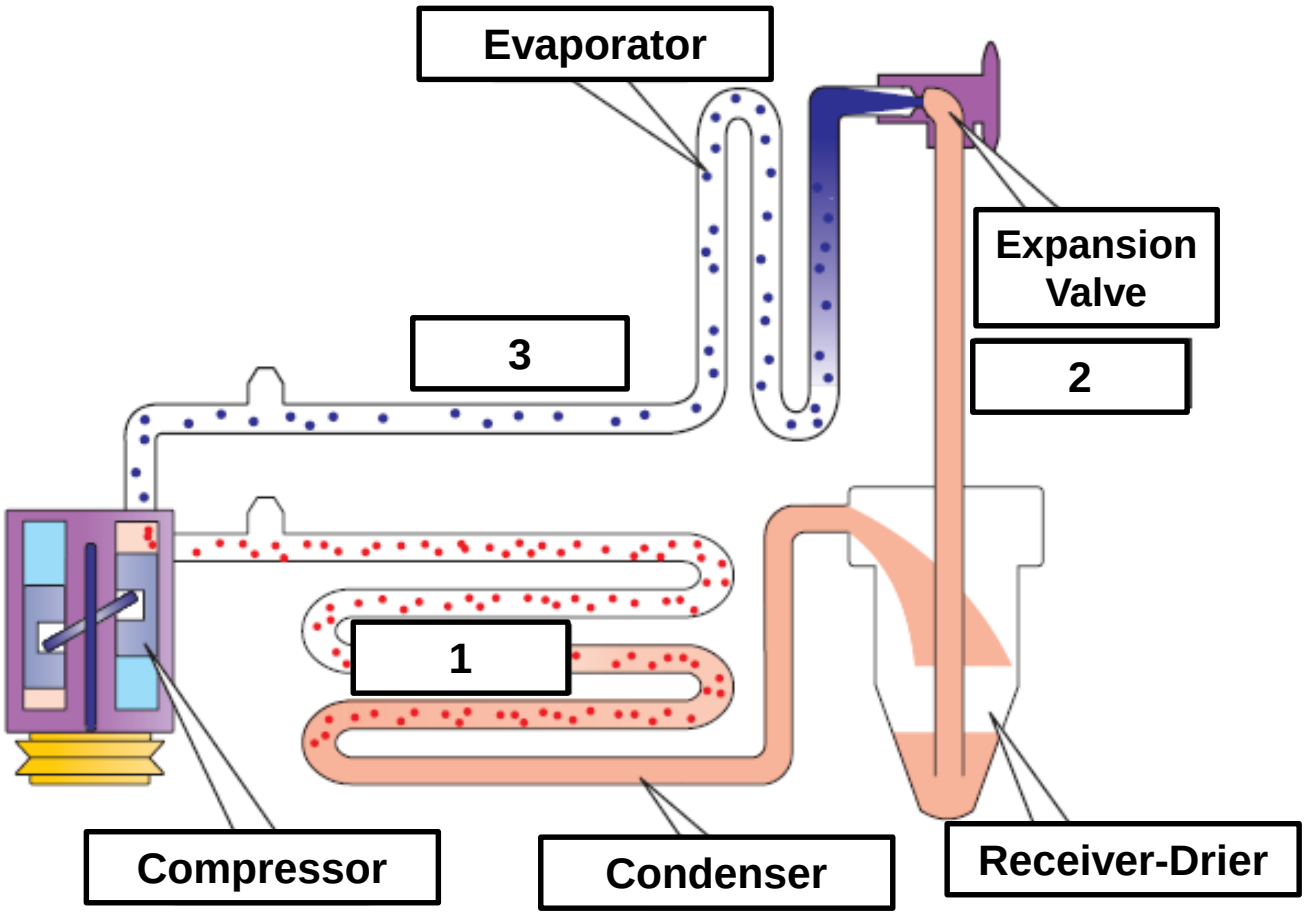
Components of Air Conditioning System

Evaporator

It is a heat exchanger in which it permits the flow of refrigerant inside its tube while air flows around the tube. This allows the heat from the air to be absorbed by the refrigerant which then evaporates as its temperature increases which then cools the air as it exits the evaporator.

Air Conditioning System

Refrigerant Flow



No.	Refrigerant State	Pressure	Temperature
1	Vapor	High	High
2	Liquid	High	High
3	Vapor	Low	Low

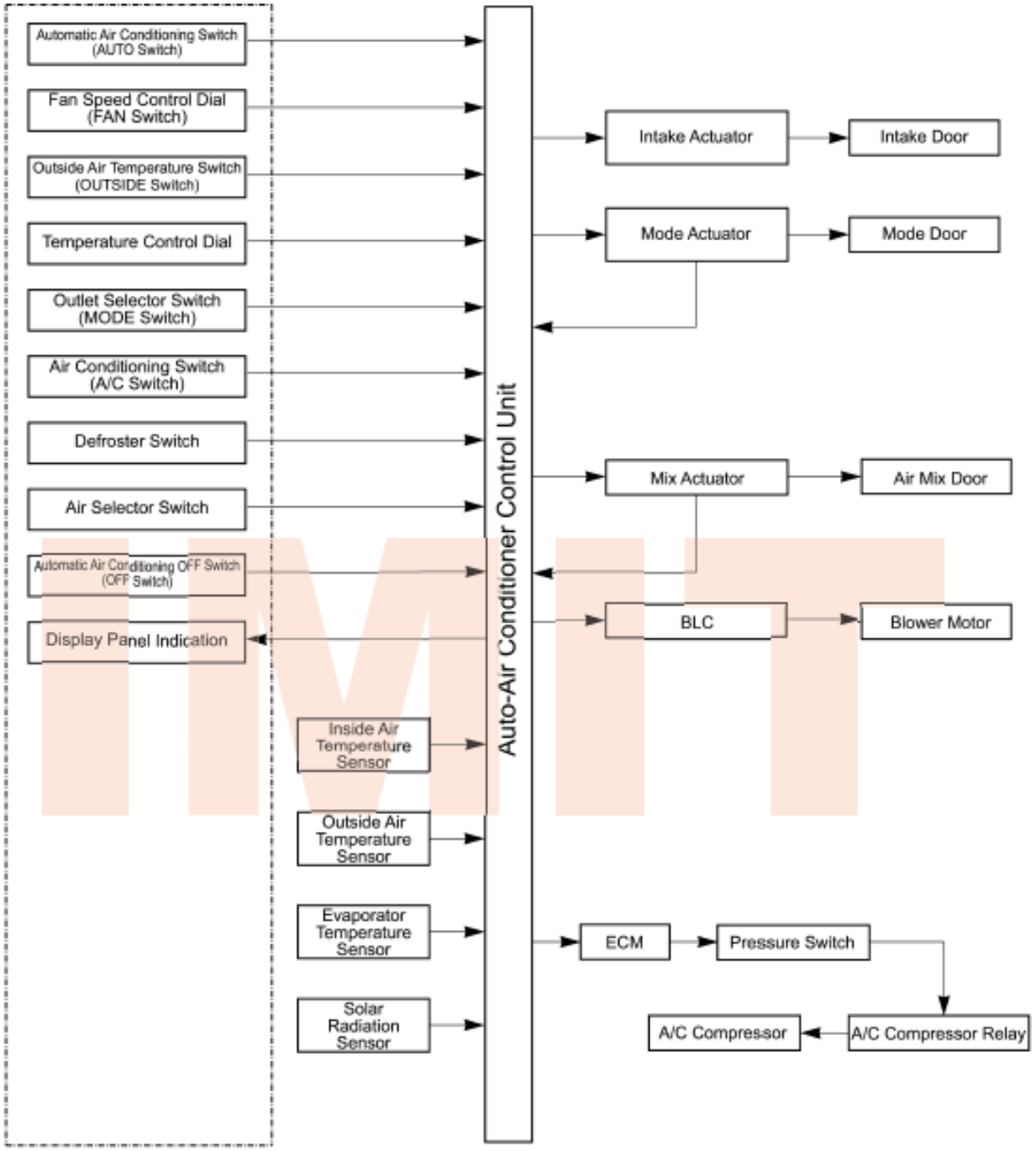
Air Conditioning System

Automatic Air Conditioning System

An automatic air conditioning system (Auto Climate) automatically regulates the temperature of the interior to a set temperature. It uses various sensors to accurately detect the outside temperature, the amount of solar insolation received, the blowing temperature of the evaporator, heater core temperature as well as in-vehicle temperature.

Air Conditioning System

System Layout

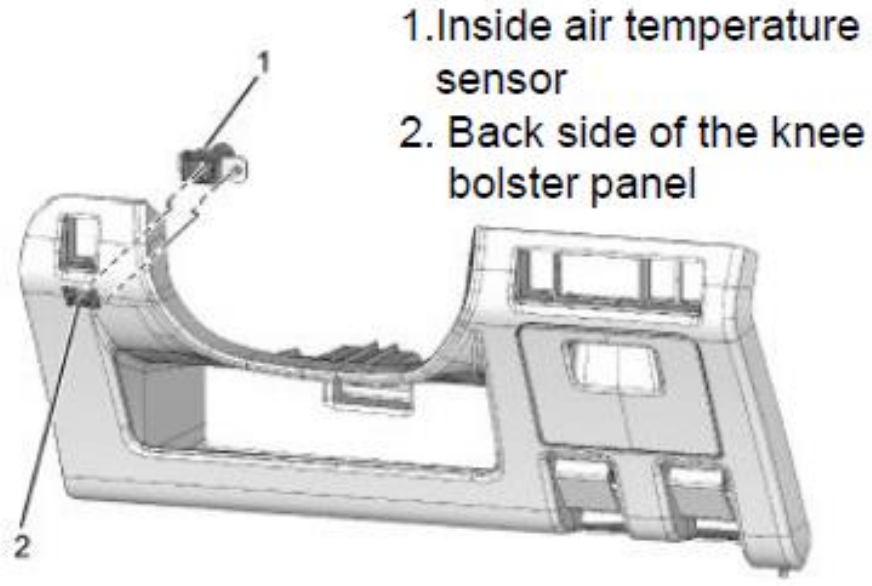


Air Conditioning System

Components (Sensors)

Inside Air Temperature Sensor

It detects the in-vehicle temperature. It converts the temperature into a resistance value which it sends to the Auto-Air Conditioner Control Unit.

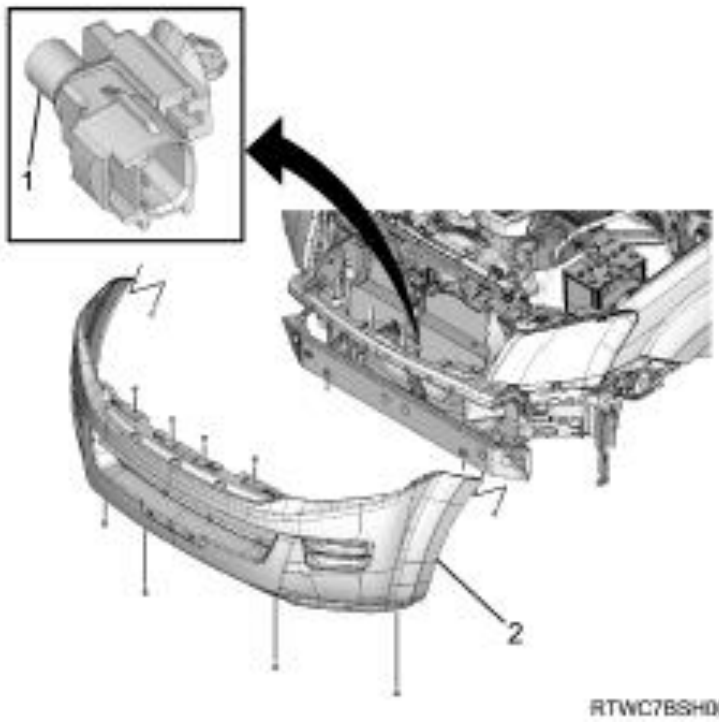


Air Conditioning System

Components (Sensors)

Outside Air Temperature Sensor

It detects the temperature outside the vehicle and converts it into a resistance value to input to the automatic A/C control unit. In order to isolate heat coming from the radiator and condenser, it has an auto amp which makes necessary corrections.

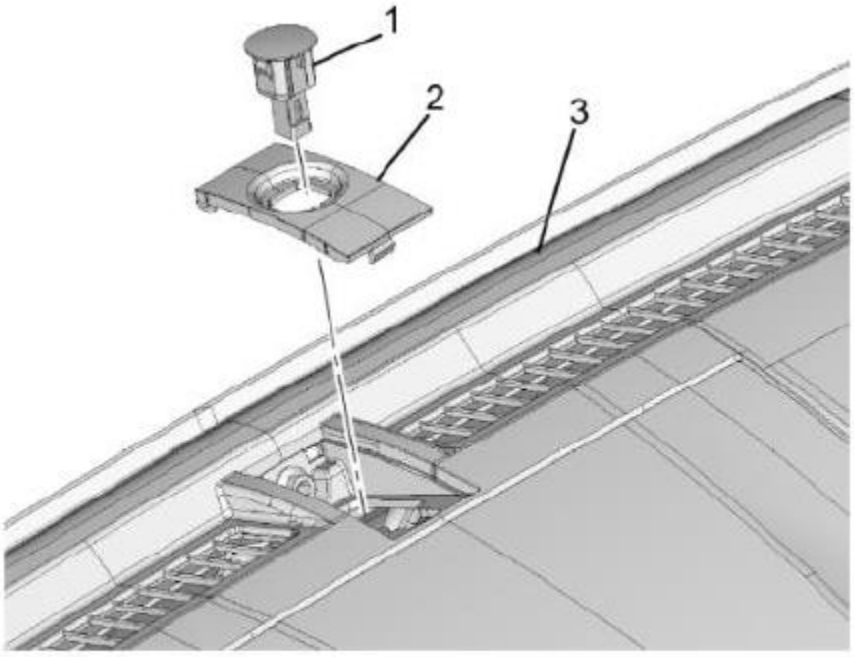


Air Conditioning System

Components (Sensors)

Sun Sensor (Insulation Sensor)

This sensor uses a photodiode to detect the amount of sunlight. It converts the correction signal from changes in the in-vehicle temperature caused by sunlight into a photo-electric current to input to the auto A/C control unit.



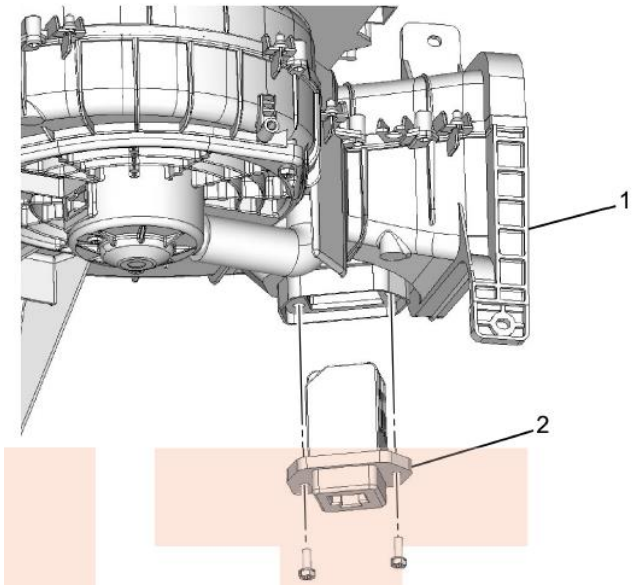
1. Sun sensor
2. Instrument panel upper cover
3. Instrument panel

Air Conditioning System

Components (Actuators)

Blower Assembly

It receives a base current from the auto A/C control unit for variable changing of the speed of the blower motor. The blower module assembly is installed in the blower assembly.



1.) Blower Assembly

2.) Blower Module Assembly

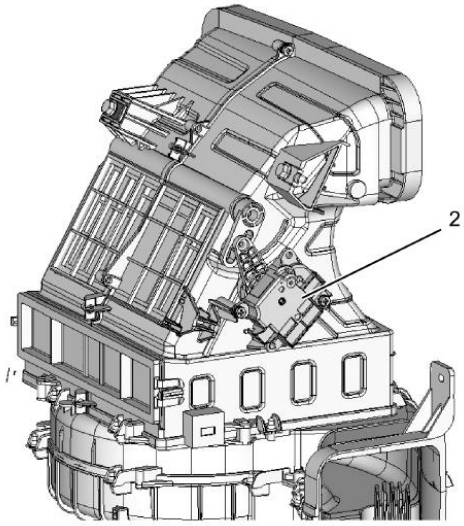
Air Conditioning System

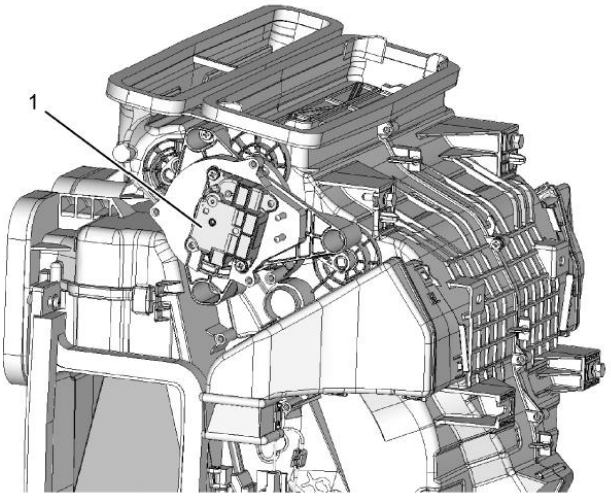
Components (Actuators)

Actuator

It has a built0in compact motor and drives the mode doors of the heater and blower unit using output current from the auto A/C control unit.

The actuator has a mode actuator that switches the mode of the heater unit and an intake actuator that switches the intake of the blower unit.





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1.) Mode Actuator

2.) Intake Actuator

Air Conditioning System

Troubleshooting

Problem	Root Cause	Countermeasure
Outlet selector switch moves but the mode door does not operate	The cable attachment lock clamp is defective or detached.	Correct the lock clamp
	The link unit of the heater unit or the blower assembly is defective.	Repair the link unit
Mode door cannot be set to a specific mode	The link unit of the heater unit or the blower assembly is defective.	Repair the link unit
	The control cable requires proper adjustment.	Adjust the control cable

Air Conditioning System

Troubleshooting

Problem	Root Cause	Countermeasure
Intake actuator does not work	No voltage between Intake Actuator Terminal 1 and GND. Reference Voltage: 12V	Repair harness between intake actuator terminal 1 and Electrical IG1 Fuse.
	Intake Actuator has abnormality or defective.	Replace Intake Actuator
	No continuity between intake actuator terminal 1 and control unit terminal 6.	Repair
	No continuity between actuator terminal 3 and the control unit terminal 7.	Repair
	Faulty control panel assembly.	Replace

Air Conditioning System

Troubleshooting

Problem	Root Cause	Countermeasure
Magnetic clutch not functioning	Low Battery Voltage	Recharge/replace battery
	Blown Fuse	Inspect and repair the cause of the melting first, then replace fuse.
	Ground connection	Repair and Clean connection
	Faulty Air Conditioner Compressor Relay.	Replace Relay
	No continuity in pressure switch.	Replace fan switch
	No continuity in a/c switch.	Replace a/c switch
	Faulty Electronic Thermostat	Replace Electronic Thermostat
	Defective Magnetic Clutch	Replace Magnetic Clutch

Air Conditioning System

Troubleshooting

Problem	Root Cause	Countermeasure
Blower motor does not run (Auto Climate)	Low Battery Voltage	Recharge/replace battery
	Blown Fuse	Inspect and repair the cause of the melting first, then replace fuse.
	Ground connection	Repair and Clean
	Faulty Blower Motor Relay	Replace Relay
	Faulty Blower Motor	Replace Blower Motor
	DTC on ECM related to A/C operation	Check DTC , replace ECM if necessary
	Faulty Electrical Circuit	Follow diagnostic procedures from shop manual.

Air Conditioning System

Troubleshooting

Problem	Root Cause	Countermeasure
Cooling system is not functioning or weak	Magnetic Clutch not functioning	Inspect Magnetic clutch system and repair/replace if necessary.
	Compressor does not rotate properly	Perform repair/ replacement of parts related to compressor operation (i.e. drive belt, pulley etc.)
	Insufficient or excessive refrigerant	Inspect and adjust refrigerant
	Refrigerant Leak	Check leaks in a/c system then repair/retighten/ replace related parts.
	Poor heat dissipation from the condenser.	Clean condenser, inspect operation of radiator fan.

Air Conditioning System

Troubleshooting

Problem	Root Cause	Countermeasure
Cooling system is not functioning or weak (cont)	Defective temperature control link unit of heater unit.	Repair link unit
	Defective expansion valve	Replace expansion valve
	Electronic thermostat not functioning properly	Inspect electronic thermostat and replace if necessary.

Air Conditioning System

Troubleshooting

Problem	Root Cause	Countermeasure
Insufficient air flow from cooling system	Clogged or damaged evaporator	Inspect evaporator core, clean or replace as necessary.
	Air leakage from cooling unit or ducting	Inspect connection of evaporator and duct, perform repair as necessary
	Blower motor does not rotate properly	Inspect fan switch system

Air Conditioning System

Troubleshooting

Problem	Root Cause	Countermeasure
Blower motor does not operate regardless of the switch position	Low Battery Voltage	Recharge/replace battery
	Blown Fuse	Inspect and repair the cause of the melting first, then replace fuse.
	Ground connection	Repair and Clean connection
	Faulty Blower Fuse	Inspect or repair cause of melting first then replace fuse.
	Faulty Blower Motor Relay	Check relay for continuity, replace if necessary
	Faulty Blower Resistor	Check resistor for continuity, replace if necessary
	Faulty Fan Switch	Check continuity of switch, replace if necessary

Air Conditioning System

Troubleshooting

Problem	Root Cause	Countermeasure
Blower motor does not operate regardless of the switch position (cont)	Blower motor not functioning properly	Replace blower motor
	DTC on ECM related to a/c operation	Check DTC, replace ECM if necessary
	Faulty Electrical Circuit	Follow diagnostic procedures from shop manual.

Air Conditioning System

Troubleshooting

Problem	Root Cause	Countermeasure
Blower motor does not function at "LOW, MEDIM LOW, MEDIUM HI and HI" position	Low Battery Voltage	Recharge/replace battery
	Blown Fuse	Inspect and repair the cause of the melting first, then replace fuse.
	Ground connection	Repair and Clean connection
	Faulty Blower Resistor	Check resistor for continuity, replace if necessary
	Faulty Fan Switch	Check continuity of switch, replace if necessary
	Faulty Electrical Circuit	Follow diagnostic procedures from shop manual.

The End