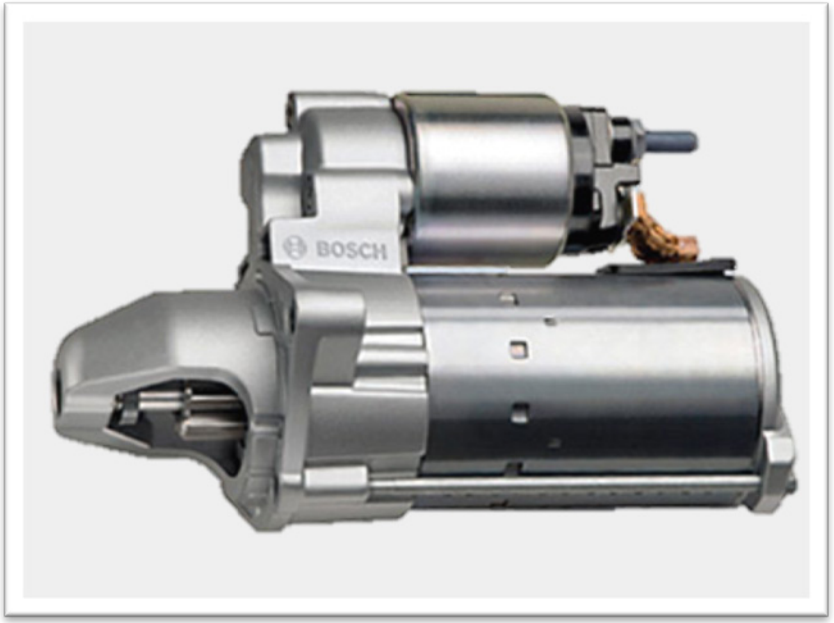
SUZUKI

Way of Life!

Starting system



SUZUKI TECHNICIAN

SUZUKI
TRAINING ACADEMY

Engine Auxiliary Systems

Course code: EN05

Student training manual
Suzuki Online Training

Foreword

This training manual contains basic operating principles of the starting system in a motor vehicle. The main starting system in a motor vehicle includes the starter motor, the wiring harness, the battery.

In this manual, we will look at the basic operating principles of the starter motor and starting system basic diagnosis. After you have carefully studied this lesson, you must complete the on-line lesson exam on Suzuki Online Training, before continuing to the next course.

Smart manuals 

Some sections of this training manual contain videos with detailed information on the topics you are studying. If you are studying this training manual on a PC, look out for the "green play video" symbol on any photo or picture in this manual, click on the green button to watch a video providing you with detailed information on that topic. Note: Internet connection required.

This document is intended solely for training purposes only. All vehicle repairs and adjustments must be carried out according to the procedures stipulated in current service manuals and technical bulletins.

Suzuki Technician curriculum

This training manual is part of the Non Suzuki Technician to Suzuki Technician curriculum. The curriculum consists of the following modules:

1. GE01 Suzuki Introduction
2. GE02 Electrical and Electronics
3. Diagnostics
4. EN02 Engine Mechanical part I
5. En03 Engine Mechanical part II
6. EN04 Engine Mechanical part III
7. EN05 Engine Auxiliary systems
8. DS01 Driveshaft/Axle
9. DS02 Driveshaft/Axle transfer case
10. BR02 Brake control systems
11. Manual transmission / transaxle
12. CS02 Control system / body electrical
13. CS03 Communication / bus systems

You are currently studying EN05 Engine Auxiliary Systems. This module consists of the following courses:

- Charging systems
- Starting systems
- Exhaust system

Click on the other training modules to view their training contents.

Table of contents

Starter motor

In this lesson, we will study the basic construction and operation of a starter motor.

Objectives

At the end of this lesson, you will be able to:

- Describe the function of a starter motor
- Identify and name the different parts of a starter motor
- Describe the functions of the different parts of a starter motor

Operating principle of the DC motor

The starter motor converts electrical energy to mechanical energy. In the motor vehicle, a starter motor is used to start the internal combustion engine.

The starter motor is a DC motor that is series wound. It produces greater torques at low speed. The electrical energy required for starting is generally drawn from the battery.

An armature is positioned inside a powerful magnetic field crated by either permanent magnets or field coils. When current is supplied to the commutator, it flows through the armature windings. The coil in the N side receives a force in the left direction and the coil in the S side receive a force in the right direction. This creates a turning force.

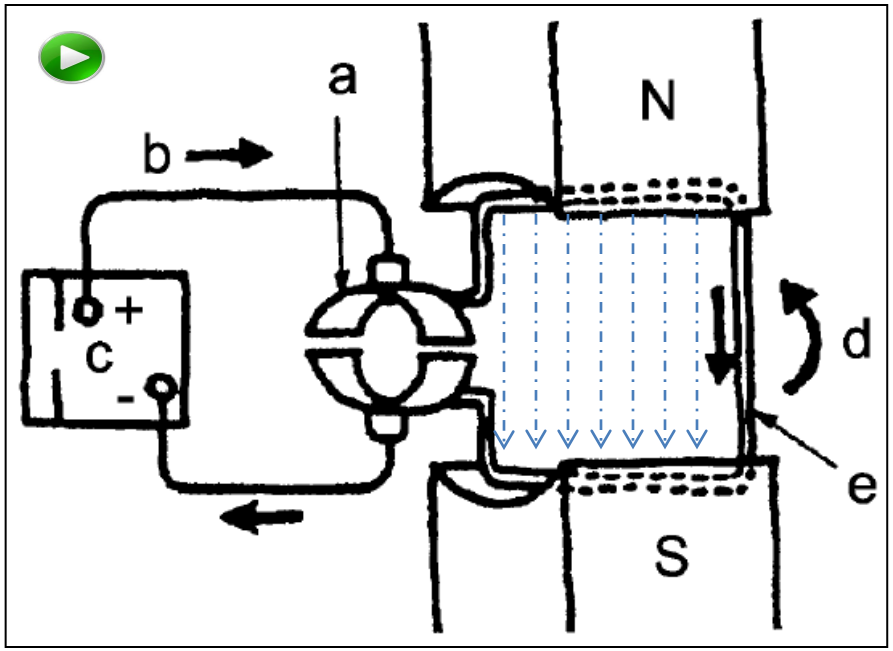


Figure 1- Starter motor operating principle

[a] Commutator
[b] Current flow
[c] Battery
[d] Direction of rotation of armature
[e] Armature coil inside magnetic lines
[N] North pole of magnet (field coil)
[S] South pole of magnet (field coil)
Magnetic lines of force

Starter motor components

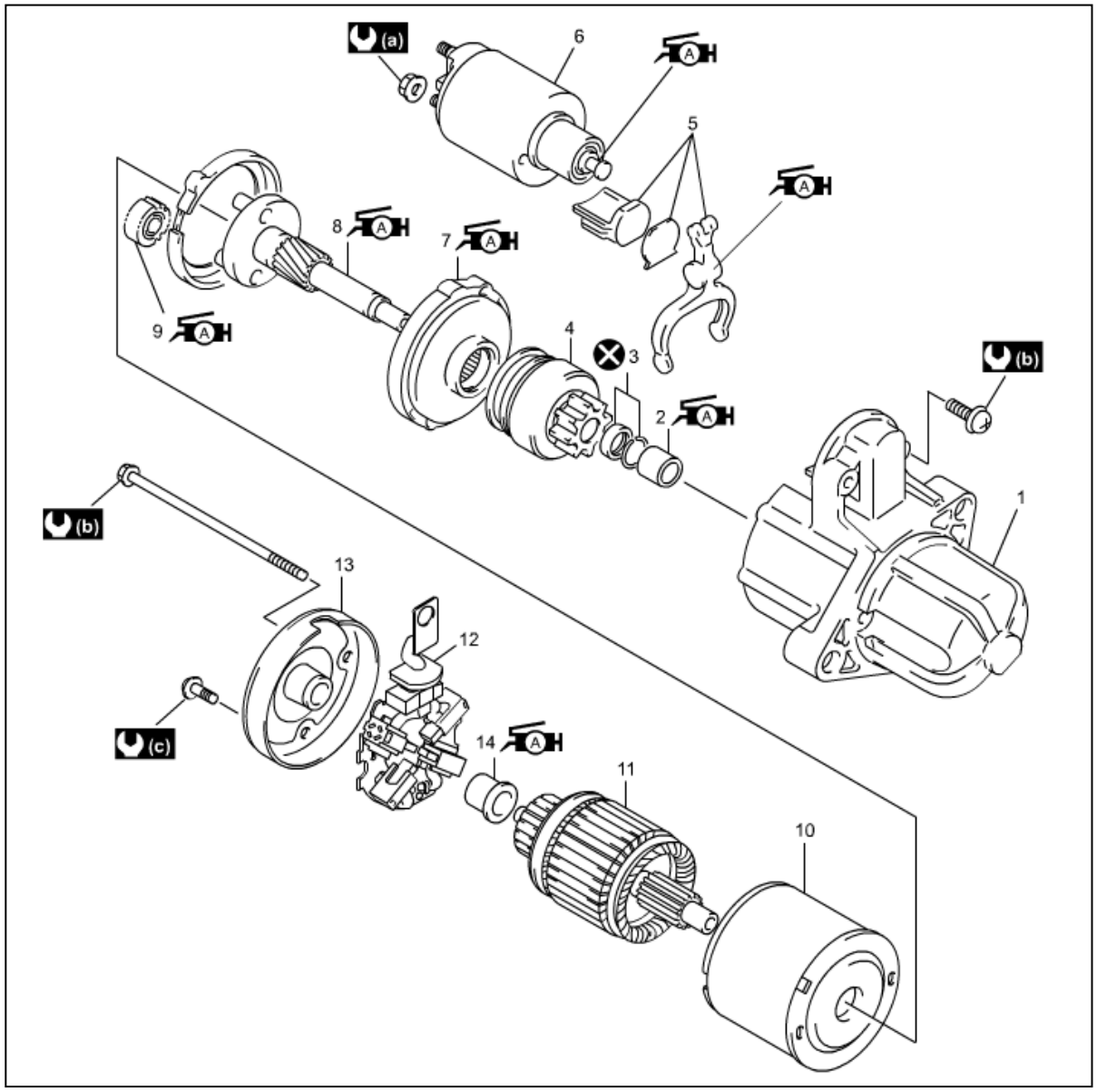


Figure 3 – Starter motor components (Suzuki Kizashi)

[1] Armature housing
[2] Bushing
[3] Pinion stop ring
[4] Overrunning clutch
[5] Drive lever assembly
[6] Magnetic switch
[7] Internal gear
[8] Planetary carrier shaft
[9] Planetary gear
[10] Yoke
[11] Armature
[12] Brush assembly
[13] End housing
[14] bushing

Armature

The armature is the central rotating part of a starter motor. To provide constant rotation and steady torque many wire loops (windings / coils) are required.

The coils are wound in slots, formed in a laminated soft metal core. The end of each coil is soldered to the commutator

Each segment of the commutator is insulated by mica.

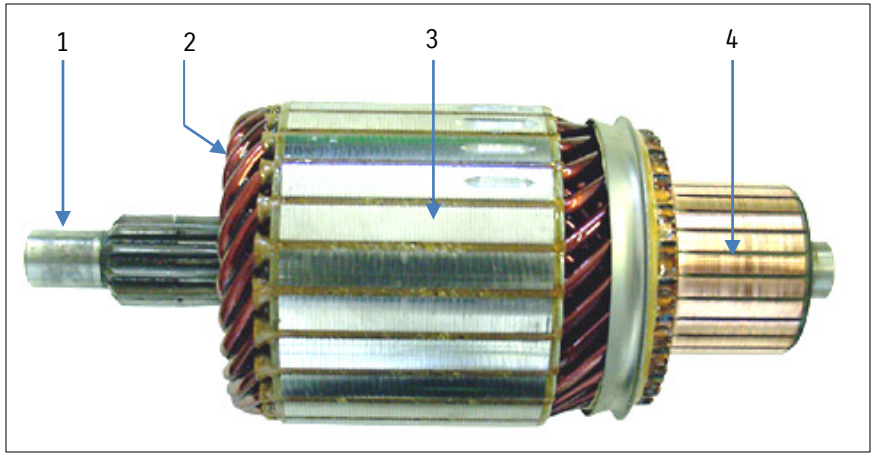


Figure 4 – Armature

[1] Armature shaft
[2] Armature coils
[3] Armature core
[4] Commutator

Brushes and brush holder

Current is delivered to the commutator using carbon brushes. The brushes are housed in a brush holder. The positive brushes are connected to the vehicle battery via the field coil and terminal “M” and they are insulated from the housing. The negative complete the electrical circuit as they are mounted on the brush holder which is grounded via the housing.

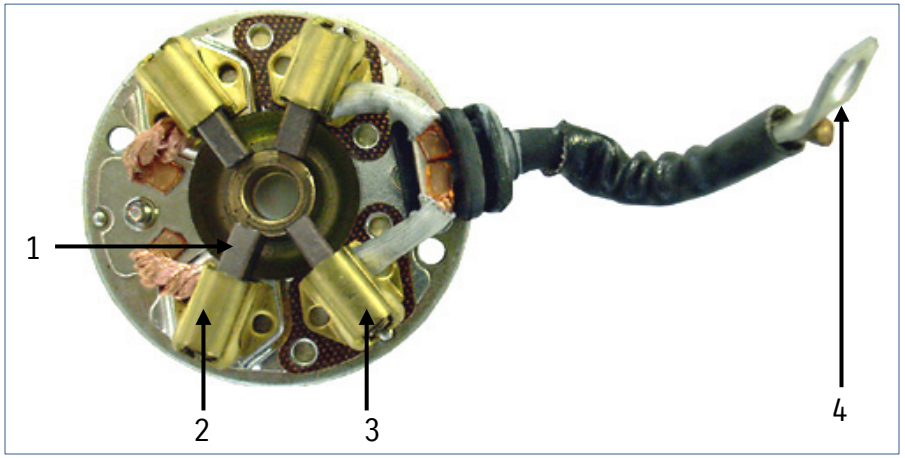


Figure 10 – Brushes

[1] Brushes
[2] Negative brushes
[3] Positive brushes
[4] Terminal M connection

Magnetic switch

The magnetic switch (also known as a solenoid) acts as a relay and connects the battery to the starter motor field coils and armature.

A small current is used to energize the pull-in and hold-in windings of the solenoid enabling large current to be passed from the battery to the starter motor.

A shift lever is also connected to the solenoid. As the plunger is pulled towards the contacts, the shift lever is moved forward to engage the pinion the flywheel ring gear

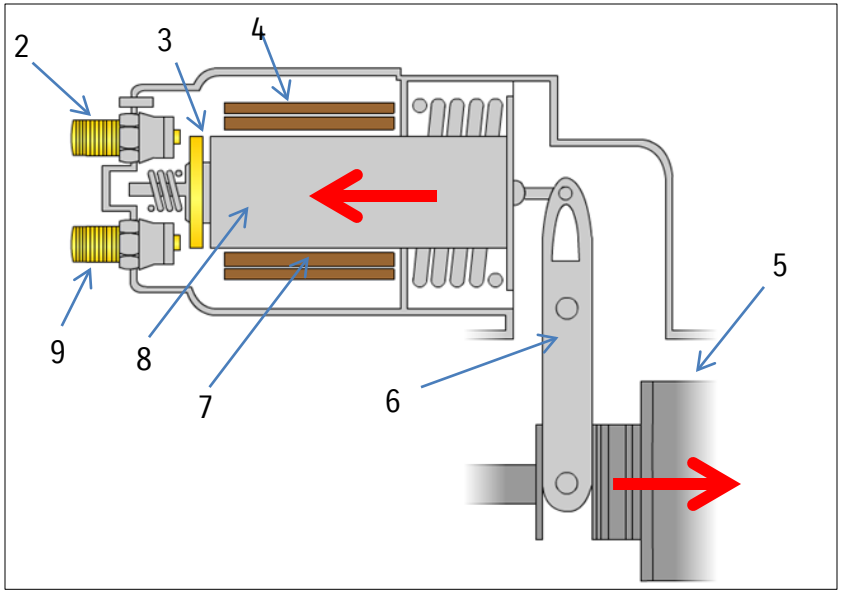


Figure 7 – Magnetic switch

[1] Terminal “M”
[2] Terminal “B”
[3] Contact switch
[4] Hold-in coil
[5] Overrunning clutch & pinion
[6] Shift lever
[7] Pull-in coil
[8] Plunger

Pull-in winding

The pull-in winding: this winding is energized when the ignition is turned to the start position. The magnetic field generated attracts the plunger towards the contact switches.

Hold-in winding

This winding keeps the contacts closed until the ignition switched is switched back to ON position

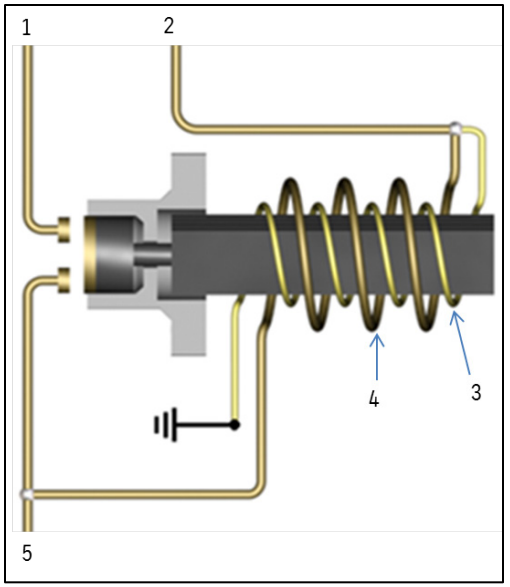


Figure 8 – Pull-in & hold-in coils

[1] Terminal “B”
[2] Terminal “S”
[3] Pull-in coil
[4] Hold-in coil
[5] Terminal “M”

Pinion and overrunning clutch

The pinion is splined to the armature and rotates together with the armature during the starting process. The pinion meshes with the ring gear on the flywheel and transfers the starter torque to the flywheel.

The overrunning clutch is designed to rotate in one direction only. When the pinion is engaged to the flywheel ring gear and the engine has started, the starter motor armature will rotate together with the flywheel. The overrunning clutch prevents over speeding of the armature.

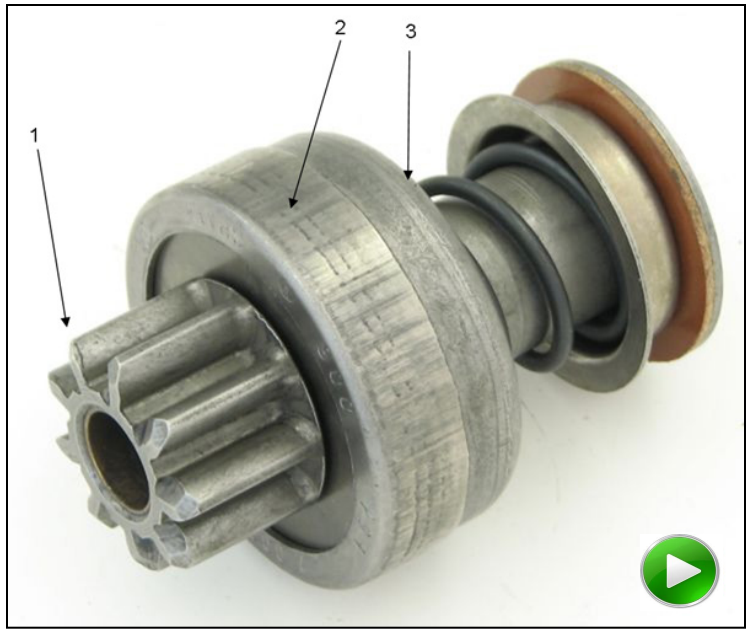


Figure 9 – Pull-in & hold-in coils

[1] Pinion
[2] Overrunning clutch
[3] Spring

Field coils & Permanent magnets

Depending on the type of starter motor, the yoke houses the field coils (figure 6) or sets of permanent magnets (figure 5). These are used produce the magnetic lines in which the armature is positioned.

Field coils are insulated copper wires, wrapped around iron cores. They are connected in opposite pairs, to provide North and South poles. Current flowing through the field coils produces a powerful magnetic field.

In figure 5, permanent magnets are used to create the magnetic field. The permanent magnets are positioned to create North and South poles. The armature rotates inside the yoke.

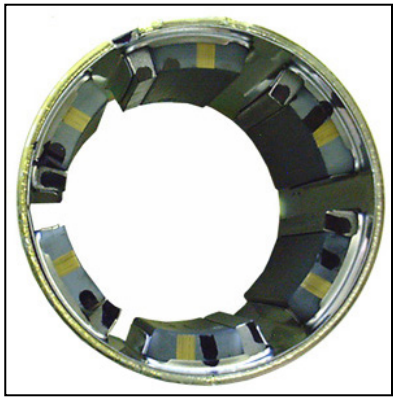


Figure 5 – Yoke with permanent magnets

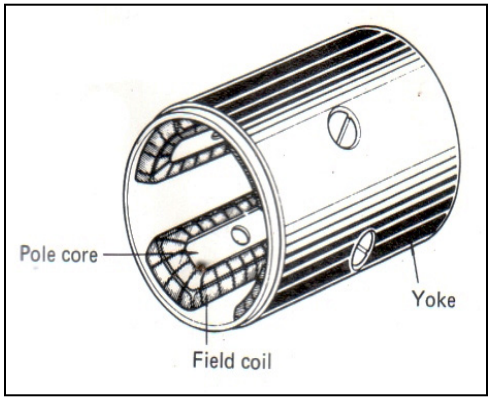


Figure 6 – Yoke with field coils

Reduction gear type starters

Conventional direct-drive starter motor have a pinion that rotates at the same speed as the armature. The pinion and the overrunning clutch are mounted directly on the armature shaft. In order to deliver high torque at low temperatures, a large starter motor would be required.

In a reduction gear type starter motor, a planetary gear set is used to transfer the drive to the pinion and overrunning clutch. A smaller and faster electric motor is used and it achieves the same torque developed by the conventional direct drive starter motor.

The internal gear (2) is fixed and the drive is supplied by the armature and it drives the planetary gears (1). The overrunning clutch and pinion is driven by the planetary gears.

The transmission ratio between the armature and the pinion is variable across a wide range from approximately 3:1 to 6:1.

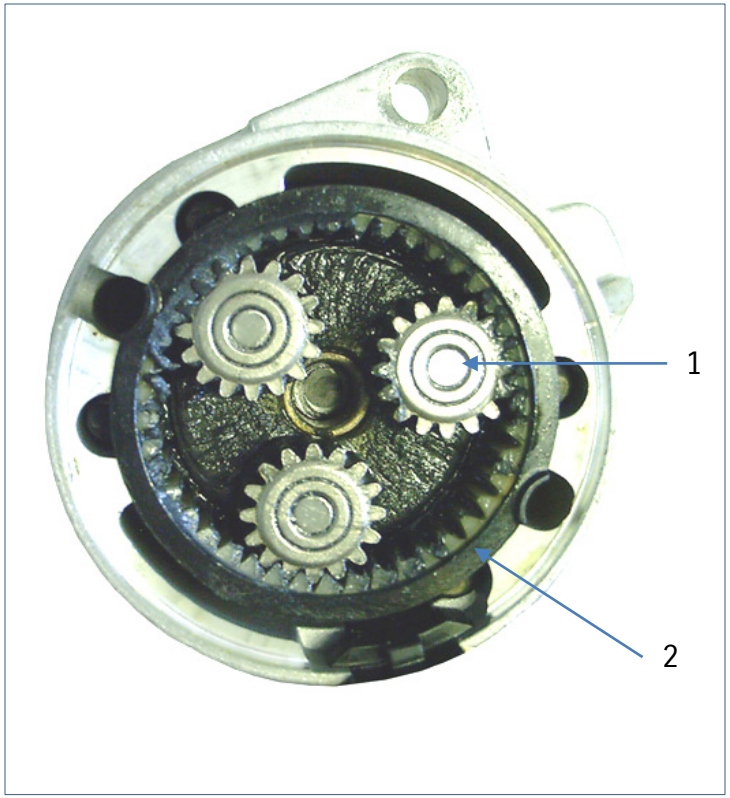


Figure 11 – Planetary gear set

[1] Planetary gears
[2] Fixed internal gear (ring gear)

Starting circuit

In this lesson, we will study the starting system circuit components and the starting process.

Objectives

At the end of this lesson, you will be able to:

- Name and describe the tasks and functions of the components of the starting systems.
- Describe the starting process

Starting system components

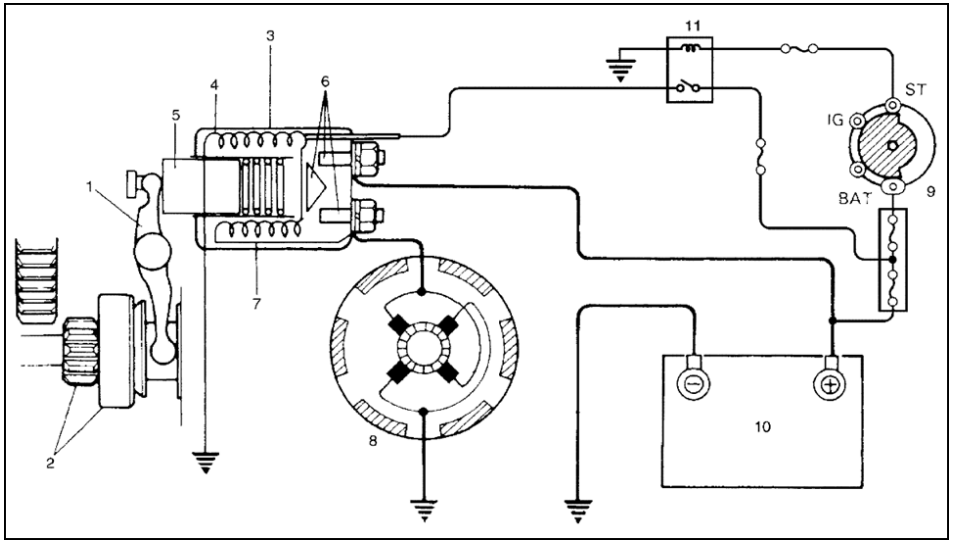


Figure 1 – Starting system circuit/components

A basic starting system circuit consists of the following components:

- Battery (10) – Supplies the electrical energy to the starter
- Starter switch (9) – closes the starter circuit to energise the starter relay
- Starter relay (11) – controls the opening and closing of the circuit from the battery to the magnetic switch
- Magnetic switch (3) – Actuates the shift fork and closes the contacts supplying current to the armature and field coils

- Starter motor (8) – Generates the turning force
- Pinion (2) – Transfers turning force of the armature to the ring gear
- Overrunning clutch (2) – Protects the armature from excessive speeds if the starter switch is not released.

Starting circuit and starting process

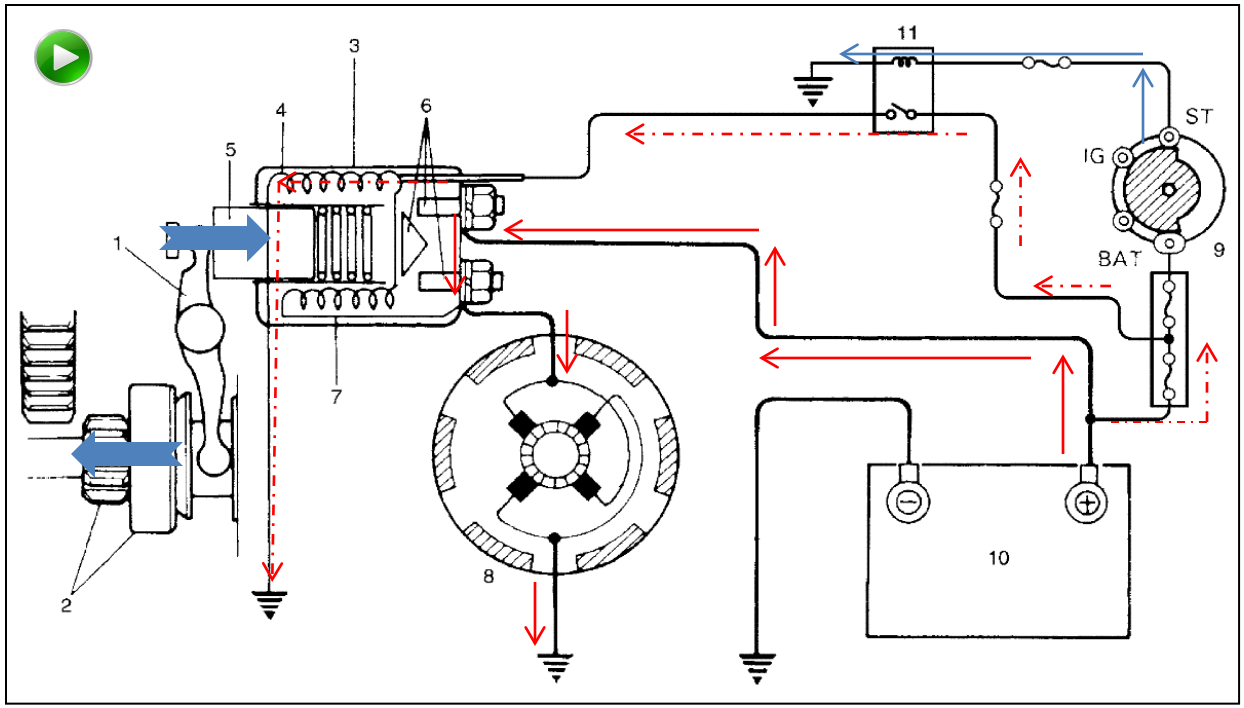


Figure 2 – Starting circuit (Suzuki Jimny)

Current flow to terminal "S"

Current flow to terminal "B" (thick starter cables)

Current flow to starter relay solenoid

Mechanical movements

When the ignition switch (9) is turned to start position, the starter relay (11) is energised and the relay switch is closed allowing current to flow from the battery (10) to terminal S of the magnetic switch (3). The current flows through the pull-in coil (7) creating a magnetic field around the coil. The plunger (5) is then pulled backwards forcing the pinion (2) forwards to mesh with the ring gear on the flywheel.

When the contacts (6) are closed, current flows from the battery to terminal B of the magnetic switch, because the contacts are closed, current flows out via terminal M of the magnetic switch to the field coil (if equipped) and then to the armature commutator.

This causes the armature to rotate. When the armature rotate, it rotates with the pinion which is already engaged to the flywheel ring gear. In this way, the engine is cranked. Once the engine has started, the ignition switch must be returned to ON position to cut the power to the magnetic switch.

The overrunning is a one way clutch that disengages the pinion from the armature once the pinion is rotating more quickly to protect the starter motor from excessive speeds which can cause damage.

Suzuki starting system circuit

The following components are also part of the starting system depending on the model. Refer to the service manuals for model specific starting circuits:

- Engine Control Module
- Keyless start control module
- CPP switch (M/T model) or TR sensor (A/T model)

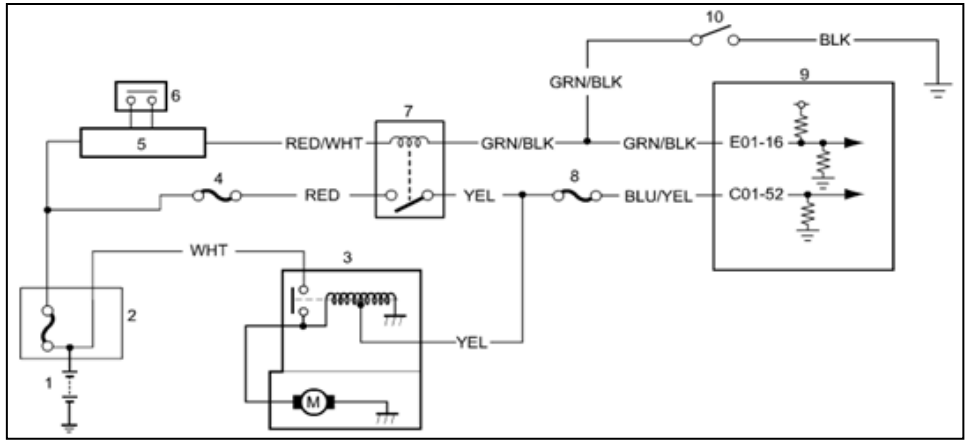


Figure 3 - Suzuki Swift, keyless push start model

[1] Battery
[2] Main fuse box
[3] Starter motor
[4] ST fuse
[5] Keyless start control module
[6] Engine Start switch
[7] Starting motor control relay
[8] "ST SIG2" fuse
[9] Engine control module
[10] TR sensor or CPP No.1 switch

Operation of the keyless push start model

In the keyless push start models, the push start button is connected to the keyless start control module. When the keyless push start button (6) is pressed, a start signal is sent to the keyless start control module which then actuates the starter relay (7). The solenoid circuit of the starter relay is grounded via the TR sensor or CPP switch (10) which ensures the transmission is in the P position or the clutch pedal is depressed.

The starter relay is then energised closing the circuit to the magnetic switch allowing current to flow from the battery to the pull-in and hold-in coils.

Engine control module (9)

The ECM monitors the starter circuit operation and stores DTC's in the event a signal is not received from the starter relay.

Possible ECM DTC's

DTC detecting condition
P0616: Starter Relay Circuit Low Starter switch signal is undetectable even if engine has been started. (2 D/C detection logic)
P0617: Starter Relay Circuit High Starter switch ON signal is high level (ON) for 180 sec. after engine has been started. (2 D/C detection logic)

Starting circuit diagnosis

In this lesson, we will study possible starting system troubles and their possible causes. We will also look at how to perform starter motor testing.

Objectives

At the end of this lesson, you will be able to:

- Describe starting system volt drop and current draw test
- Perform voltage drop on the positive cable, negative cable and battery posts

Starter motor specifications

Vehicle starting systems are generally equipped with pre-engaged starters up to a rated output of approximately 2.5 kW. The nominal voltage is 12V. The starter performance range depends on the combustion system and the size of the internal combustion engine.

The tables below indicate the starting system specifications. The service manual must always be used to obtain starting system specifications.

Voltage			12 volts
Output			0.8 kW
Rating			30 seconds
Direction of rotation			Clockwise as viewed from pinion side
Number of pinion teeth			8
Performance		Condition	Guarantee
Around at 20 °C (68 °F)	No load characteristic	11.5 V	50 A maximum 6000 r/min. minimum
	Load characteristic	9.0 V 150 A	2.84 N·m (0.29 kgf-m, 2.0 lbf-ft) minimum 1950 r/min. minimum
	Locked characteristic	5.5 V	430 A maximum 6.17 N·m (0.63 kgf-m, 5.0 lbf-ft) minimum
	Magnetic switch operating voltage		8 volts maximum

Figure 1 – Starter specification (Suzuki Alto AMF310)

Voltage		12 V			
Output		1.4 kW			
Rating		30 seconds			
Direction of rotation		Clockwise as viewed from pinion side			
Number of pinion teeth		N32A: 12 teeth, J24B: 8 teeth			
Performance		Voltage	Current	Torque	Revolution speed
Around at 20 °C (68 °F)	No-load characteristic	11.0 V	90 A MAX	—	2000 rpm MIN
	Loaded characteristic	7.5 V	300 A	11.0 N·m (1.1 kgf-m, 8.5 lbf-ft) minimum	840 rpm MIN
	Locked characteristic	3.0 V	860 A MAX	20.0 N·m (2.0 kgf-m, 15.0 lbf-ft) minimum	—
	Magnetic switch operating voltage	8 V or less			

Figure 2 – Starter specifications (Suzuki Grand Vitara JB632)

Starter circuit symptom diagnosis

Possible symptoms of starting system trouble would be as follows:

- Starting motor does not run (or runs slowly)
- Starting motor runs but fails to crank engine
- Abnormal noise is heard.

Proper diagnosis must be made to determine exactly where the cause of each trouble lies in battery, wiring harness, starting motor (including magnetic switch) or engine.

Before removing the starting motor to perform inspection, check the following items to narrow down the possible causes of trouble.

- Before removing the starting motor to perform inspection, check the following items to narrow down the possible causes of trouble.
- Discharge of battery
- Mounting of starting motor

On-vehicle starter system test

This test checks the starter system for voltage drop and current draw. It is a good indication of the condition of the starter motor and cables.

To perform an on-vehicle test of the starter circuit,

- Connect a voltmeter and inductive type ammeter to the vehicle battery as shown if figure 3.
- Note the voltage reading of the battery
- Disconnect the ignition system so the vehicle will not start when the engine is being cranked.
- Crank the engine and record the lowest reading measured by the voltmeter and the highest reading recorded by the ammeter (Caution: Do not crank the engine for more than 20 second, otherwise the starter motor could overheat)

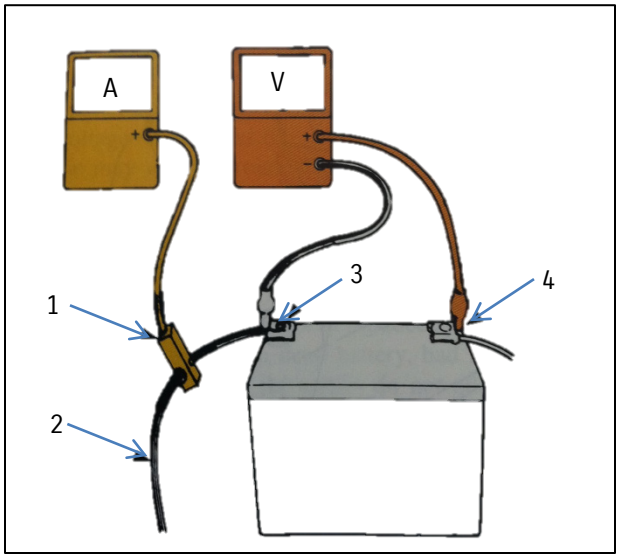


Figure 3

[1] Amp clamp
[2] Negative cable
[3] Negative terminal
[4] Positive terminal

Starting circuit troubleshooting chart

Use the table below to determine the condition of the stating system.

Cranking voltage	Cranking current	Possible cause
Voltage OK	Current OK	System Ok
Voltage OK	Current Low, engine cranks slowly	Starter circuit connections faulty
Voltage low	Current Low, engine cranks slowly	Battery discharged
Voltage low	Current High	Starter Motor faulty

Figure 4 – Starter system troubleshooting chart

Cable voltage drop tests

These tests will quickly locate a cable with high resistance and it provides an easy way of checking the condition of the cables and their connections.

Positive cable volt drop test

Connect the positive probe of the voltmeter to the positive terminal and the negative probe to the starter solenoid terminal B. Crank the engine (starting system disabled) and record voltage reading. If the voltage measured rises above 0.5V, there is excess resistance in the circuit. Check the circuit for loose connections, corroded terminals, etc.

Negative cable volt drop test

Connect the negative probe of a voltmeter to the negative terminal and the positive probe to the starter mounting frame. Crank the engine (starting system disabled) and record the voltage reading.

If the voltage rises above 0.5V, there is excessive resistance in the circuit. Check the cable for loose connections, corrosion, etc.

Battery terminals volt drop test

Poor contacts and corrosion on the battery terminals and cable can cause excessive resistance in the cables. The battery terminals can be checked for high resistance by following this procedure:

Connect the voltmeter as shown in figure 5. Crank the engine (Starting system disabled) and record the voltage reading. If the voltage rises above 0.5 volts, disconnect the battery cable and clean the contact points.

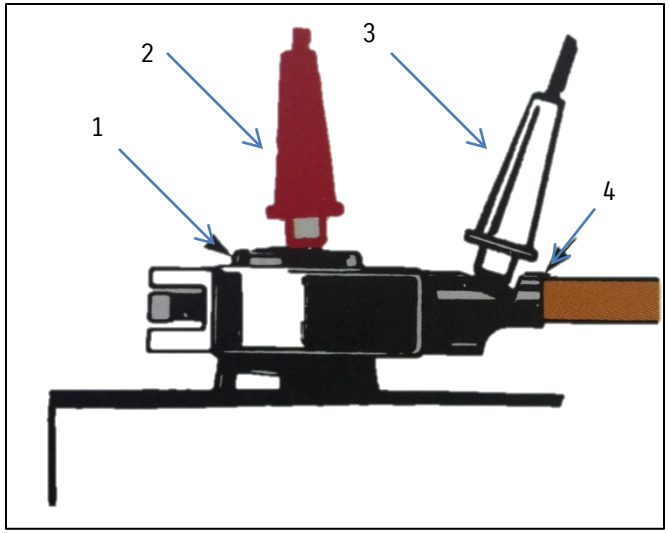
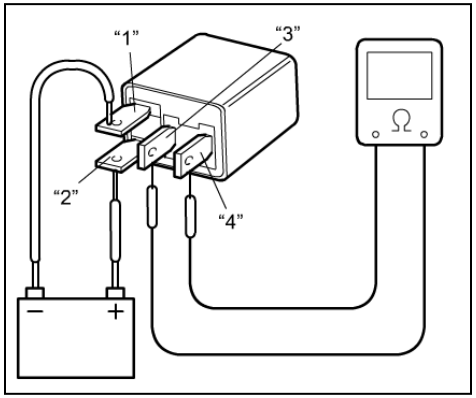


Figure 5 – Battery post resistance

[1] Battery post
[2] Voltmeter positive probe
[3] Voltmeter negative probe
[4] Cable end

Testing the starter motor relay



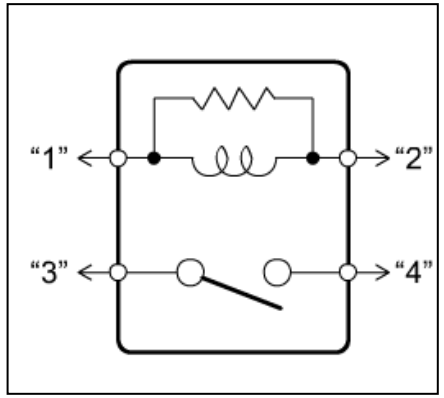


Figure 6 – Relay testing

Connect a battery to the solenoid terminals of the relay (85 & 86 or 1 & 2)then measure the continuity between the switch terminals of the relay (30 & 87 or 3 & 4). If there in no continuity, replace relay.

Starting system faults, possible causes and action

Condition	Possible Cause	Action
Starting motor not running (No operating sound of magnetic switch)	Malfunction of P position switch (CVT model)	*Check P position switch.*
	Malfunction of clutch pedal position switch (M/T model)	*Check clutch pedal position switch.*
	Battery voltage is too low	*Check battery.*
	Charging faulty due to deteriorated battery	*Replace battery.*
	Poor battery terminal connection	*Check terminal connection or replace battery.*
	Poor ground cable connection	*Tighten ground cable.*
	Blown fuse	*Replace fuse.*
	Faulty magnetic switch	*Check magnetic switch.*
	Poor magnetic switch lead wire connector connection	*Check connector connection.*
	Open-circuit between battery and magnetic switch	*Repair circuit.*
	Open-circuit in pull-in coil	*Check pull-in coil circuit.*
	Faulty brushes and/or brush springs	*Check brushes and brush springs*
	Poor sliding of plunger and/or pinion	*Check plunger and pinion.*
	Faulty starting motor control relay	*Check starting motor control relay.*
	Faulty ECM and its circuit	*Check ECM and its circuit.*
	Faulty keyless start system	*Check keyless start system.*

Starting motor not running (Operating sound of magnetic switch heard)	Battery voltage is too low	*Check battery.*
	Charging faulty due to deteriorated battery	*Replace battery.*
	Poor battery terminal connection	*Check terminal connection or replace battery.*
	Poor ground terminal connection	*Tighten ground cable.*
	Faulty magnetic switch	*Check magnetic switch.*
	Faulty brushes and/or brush springs	*Check brushes and brush springs.*
	Faulty brush holder	*Check brush holder.*
	Burnt commutator	*Check commutator.*
	Short-circuit between commutator and armature	*Check commutator.*
	Poor starting motor cable connection	*Check starting motor cable connection.*
	Open circuit between battery and magnetic switch	*Repair circuit.*
	Obstructed crankshaft rotation	*Repair engine assembly.*
Starting motor running but too slowly (small torque) (If battery and wiring are satisfactory, inspect starting motor)	Faulty magnetic switch	*Check magnetic switch.*
	Low battery voltage	*Check battery.*
	Charging faulty due to deteriorated battery	*Replace battery.*
	Poor battery terminal connection	*Check terminal connection or replace battery.*
	Short-circuit between commutator and armature	*Check commutator.*
	Burnt commutator	*Check commutator.*
	Faulty brushes and/or brush springs	*Check brushes and brush springs.*
	Faulty brush holder	*Check brush holder.*

Starting motor running, but not cranking engine	Worn pinion tip	*Replace overrunning clutch.*
	Poor sliding of overrunning clutch	*Check overrunning clutch.*
	Slipping overrunning clutch	*Replace overrunning clutch.*
	Worn teeth of ring gear	*Replace flywheel (M/T model) or drive plate (CVT model)*
Noise	Abnormally worn bushing	*Replace bushing*
	Worn teeth of pinion	*Replace overrunning clutch.*
	Worn teeth of ring gear	*Replace flywheel (M/T model) or drive plate (CVT model)*

Summary

- The starting system consists of the starter motor, relay, wiring , ignition switch, battery and the starter motor.
- In some Suzuki models, the ECM monitors the condition of the starting system and outputs a DTC in the event of faults
- Modern starter motors are of the reduction gear type, which is small and lightweight. The torque required to turn the engine is achieved via use of a planetary gear mechanism
- The magnetic switch is like a relay. A small current is used to connect the battery to the starter motor which have much large current.
- The starter motor is a series wound type, which enables it to produce great torque at low speeds.
- Permanent magnets or field coil magnets can be used to create the magnetic field.
- Simple on-vehicle starter circuit tests can be used to determine the condition of the starting system. These tests include, voltage drop tests, current draw tests and even, relay test and even DTC read out using the SDT.

Well done, you have now completed the “Starting system” training course!

Please complete the online exam