### **GROUP 16**

# **ENGINE ELECTRICAL**

#### **CONTENTS**

CHARGING SYSTEM	16-2	IGNITION SYSTEM	16-29
GENERAL DESCRIPTION	16-2	GENERAL DESCRIPTION	16-29
SPECIAL TOOL	16-3	SPECIAL TOOLS	16-30
CHARGING SYSTEM DIAGNOSIS	16-3	ON-VEHICLE SERVICE	16-30
ON-VEHICLE SERVICE	16-5	IGNITION COIL CHECKSPARK PLUG CABLE RESISTANCE	16-30
GENERATOR OUTPUT LINE VOLTAGE DROP TEST	16-5	CHECK	16-31
OUTPUT CURRENT TEST	16-5 16-7	SPARK PLUG CHECK AND CLEANING	16-31
REGULATED VOLTAGE TEST	16-8	CAMSHAFT POSITION SENSOR	10-31
WAVE PATTERN CHECK USING AN	10 0	CHECK	16-31
OSCILLOSCOPE	16-10	CRANK ANGLE SENSOR CHECK	16-31
		IGNITION SECONDARY VOLTAGE WAVE	
GENERATOR ASSEMBLY	16-12	PATTERN CHECK USING AN	
REMOVAL AND INSTALLATION	16-12	OSCILLOSCOPE	16-31
DISASSEMBLY AND ASSEMBLY	16-13		
INSPECTION	16-15	IGNITION COIL	16-35
STARTING SYSTEM	16-18	REMOVAL AND INSTALLATION	16-35
STARTING STSTEWI	10-10	CAMSHAFT POSITION SENSOR.	16-36
GENERAL DESCRIPTION	16-18	REMOVAL AND INSTALLATION	16-36
DIAGNOSIS	16-19	CRANKSHAFT POSITION SENSOR	16-36
ON VEHIOLE OF BY 10 F		REMOVAL AND INSTALLATION	16-36
ON-VEHICLE SERVICE STARTER RELAY CHECK <m t=""></m>	16-20	KNOOK OENOOD	40.0
STARTER RELAT CHECK (W/T)	16-20	KNOCK SENSOR  REMOVAL AND INSTALLATION	16-37 16-37
STARTER MOTOR ASSEMBLY	16-21	REMOVAL AND INSTALLATION	10-37
REMOVAL AND INSTALLATION	16-21	SPECIFICATIONS	16-38
INSPECTION	16-21	or Lonio Ariono	10-30
DISASSEMBLY AND ASSEMBLY	16-24	FASTENER TIGHTENING	
INSPECTION	16-26	SPECIFICATIONS	16-38
		GENERAL SPECIFICATIONS	16-38
		SERVICE SPECIFICATIONS	16-39

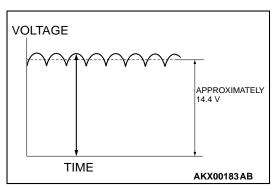
#### **CHARGING SYSTEM**

#### **GENERAL DESCRIPTION**

M1161000100102

The charging system charges the battery with output from the generator to keep the battery charged at a constant level during varying electrical loads.

#### Operation



Rotation of the excited field coil generates AC voltage in the stator.

This alternating current is rectified through diodes to DC voltage having a waveform shown in the illustration above.

The average output voltage fluctuates slightly with the generator load condition. When the ignition switch is turned to the "ON" position, current flows in the field coil and initial excitation of the field coil occurs.

When the stator coil begins to generate power after the engine is started, the field coil is excited by the output current of the stator coil.

Generator output voltage rises as the field current increases and falls as the field current decreases. When the battery positive voltage (generator S terminal voltage) reaches a regulated voltage of approximately 14.4 V, the field current is cut off. When the battery positive voltage drops below the regulated voltage, the voltage regulator regulates the output voltage to a constant level by controlling the field current.

In addition, when the field current is constant, the generator output voltage rises as the engine speed increases.

#### **GENERATOR** В **STATOR** $\pi$ COIL ECM <M/T> PCM <A/T> G FIELD COIL S mm **IGNITION BATTERY** SWITCH VOLTAGE REGULATOR が CHARGING WARNING LIGHT

AK100054 AB

#### **SPECIAL TOOL**

M1161000600129

TOOL	TOOL NUMBER AND NAME	SUPERSESSION	APPLICATION
B991502	MB991502 Scan tool (MUT-II)	MB991496-OD	Checking of engine idle speed
	MB991519 Generator harness connector	Tool not available	Checking of generator (S terminal voltage)

### CHARGING SYSTEM DIAGNOSIS TROUBLESHOOTING HINTS

M1161000700096

- 1. Charging warning light does not come on when the ignition switch is turned to "ON" position, before the engine starts.
  - · Check the bulb.
- Charging warning light does not switch off after the engine starts.
- Check the IC voltage regulator inside the generator.
- 3. Discharged or overcharged battery.
  - Check the IC voltage regulator inside the generator.
- 4. The charging warning light illuminates dimly.
- Check the diode (inside the combination meter or generator) for a short-circuit.

#### TROUBLESHOOTING GUIDE

The charging system troubleshooting guide is shown in the following chart.

#### STEP 1.

Q: Is the battery in good condition? (Refer to GROUP 54A, Battery – On-vehicle Service – Battery Check P.54A-4.)

YES: Go to Step 2.

**NO**: Charge or replace the battery.

#### STEP 2.

Q: Is the generator drive belt in good condition? (Refer to GROUP 00, Maintenance Service – Drive Belts P.00-37.)

YES: Go to Step 3.

**NO**: Adjust the belt tension or replace the belt.

#### STEP 3.

Q: Does the charging system warning light turn on brightly when the ignition switch is turned to the "ON" position?

YES: Go to Step 4.

NO

- Check the ignition switch. (Refer to GROUP 54A, Ignition switch – Inspection P.54A-9.)
- Check for burnt-out charging system warning light bulb.
- Check the generator. (Refer to Generator Disassembly and assembly – Inspection P.16-15.)
- Check the charging system warning light-related circuits.

#### STEP 4.

Q: Does the charging warning light go out after starting the engine?

YES: Go to Step 5.

**NO**: Check the generator (Refer to Generator – Disassembly and assembly – Inspection P.16-15.)

#### STEP 5.

Q: Is an oscilloscope available?

YES: Go to Step 6.
NO: Go to Step 7.

#### STEP 6.

Q: Does the oscilloscope show a normal wave pattern? (Refer to Charging system – Wave pattern check using a oscilloscope P.16-10.)

YES: Go to Step 7.

**NO**: Check the generator. (Refer to Generator – Disassembly and assembly – Inspection P.16-15.)

#### STEP 7.

- Engine: 2,500 r/min
- Headlight: ON (high beam)
- Voltage between generator terminal B and the positive battery terminal

OK: 0.5 V or less

Voltage between the negative battery terminal and generator body

OK: 0.5 V or less

Q: Are the generator output line and ground line in good condition?

YES: Go to Step 8.

**NO:** • Check the generator output line.

Check the generator ground line.

#### STEP 8.

Q: Is the output current normal? (Refer to Charging system – On vehicle service – Output current test P.16-7.)

YES: Go to Step 9.

**NO**: Check the generator (Refer to Generator – Disassembly and assembly – Inspection P.16-15.)

#### STEP 9.

Q: Is the regulated voltage normal? (Refer to Charging system – On vehicle service – Regulated voltage test P.16-8.)

YES: Go to Step 10.

**NO**: Check the generator (Refer to Generator – Disassembly and assembly – Inspection P.16-15.)

#### **STEP 10.**

Q: Is the voltage drops in the generator output line normal? (Refer to Charging system – On vehicle servise

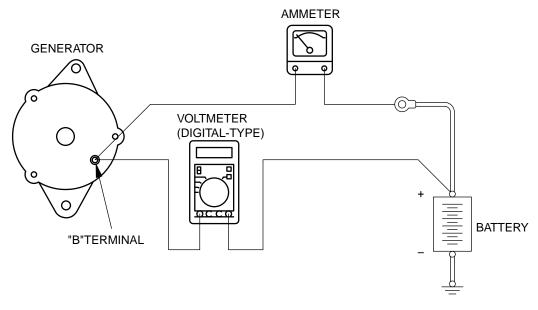
Generator output line voltage drop test P.16-5.)

**YES:** Generator is normal. Check other systems.

**NO:** Check the output line.

### ON-VEHICLE SERVICE GENERATOR OUTPUT LINE VOLTAGE DROP TEST

M1161000900119



AKX00185AB

Required Special Tool: MB991502: Scan Tool (MUT-II) This test determines whether the wiring from the generator "B" terminal to the positive battery terminal (including the fusible link) is in good condition or not:

#### **⚠ WARNING**

# Battery posts, terminals and related accessories contain lead and lead compounds. WASH HANDS AFTER HANDLING.

- 1. Always be sure to check the following before the test.
- Generator installation
- Generator drive belt tension (Refer to GROUP 00, Maintenance Service – Drive Belts P.00-37.)
- Fusible link
- Abnormal noise from the generator while the engine is running.
- 2. Turn the ignition switch to the "LOCK" (OFF) position.
- 3. Disconnect the negative battery cable.
- 4. Disconnect the generator output wire from the generator "B" terminal and connect a DC test ammeter with a range of 0 – 100 A in series between the "B" terminal and the disconnected output wire. (Connect the positive lead of the ammeter to the "B" terminal, and then connect the negative lead of the ammeter to the disconnected output wire.)

NOTE: A clamp-type ammeter which enables measurements to be taken without disconnecting the generator output wire is recommended. If the voltage is dropped due to a bad connection at generator "B" terminal and the generator "B" terminal is loosened when the test ammeter is connected, the connection will be completed at this time and the possibility of finding the problems will be reduced.

- 5. Connect a digital-type voltmeter between the generator "B" terminal and the positive battery terminal. (Connect the positive lead of the voltmeter to the "B" terminal, and then connect the negative lead of the voltmeter to the positive battery cable.)
- 6. Reconnect the negative battery cable.
- 7. Connect a tachometer or scan tool MB991502.
- 8. Leave the hood open.

- 9. Start the engine.
- 10. With the engine running at 2,500 r/min, turn the headlights and other lights on and off to adjust the generator load so that the value displayed on the ammeter is slightly above 30 A.

Read the voltmeter. Voltage reading at or below limit value means voltage drop between generator and battery is OK.

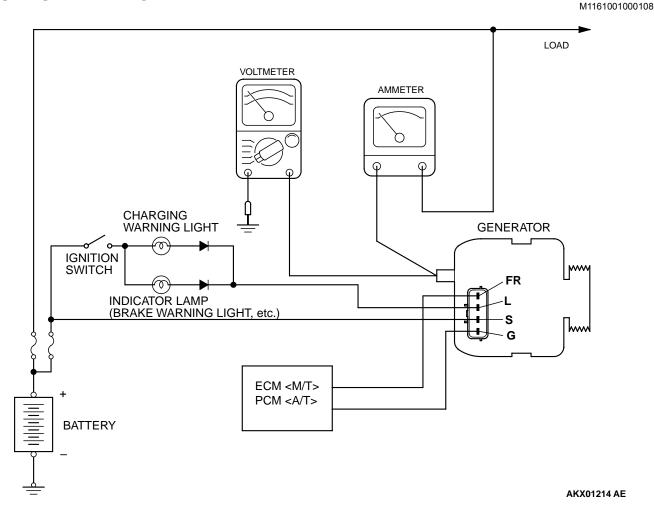
#### Limit value: maximum 0.3 V

NOTE: When the generator output is high and the value displayed on the ammeter does not decrease to 30 A, set the value to 40 A. Read the value displayed on the voltmeter at this time. In this case the limit value becomes maximum 0.4 V.

Adjust the engine speed by gradually decreasing it until the value displayed on the ammeter is 30 A. Take a reading of the value displayed on the voltmeter at this time.

- 11.If the value displayed on the voltmeter is above the limit value, there is probably a malfunction in the generator output wire. Check the wiring between the generator "B" terminal and the positive battery terminal (including fusible link).
  - If a terminal is not sufficiently tight or if the harness has become discolored due to overheating, repair and then test again.
- 12. After the test, run the engine at idle.
- 13. Turn off all lights and turn the ignition switch to the "LOCK" (OFF) position.
- 14.Disconnect the tachometer or scan tool MB991502.
- 15. Disconnect the negative battery cable.
- 16.Disconnect the ammeter and voltmeter and tachometer.
- 17.Connect the generator output wire to the generator "B" terminal.
- 18. Connect the negative battery cable. Run the engine for 10 minutes at an idle after reconnecting negative battery cable.

#### **OUTPUT CURRENT TEST**



#### **Required Special Tool:**

MB991502: Scan Tool (MUT-II)

This test determines whether the generator outputs normal current. For best results, use a charging system tester. If not available, follow the steps below.

#### **⚠** WARNING

# Battery posts, terminals and related accessories contain lead and lead compounds. WASH HANDS AFTER HANDLING.

- 1. Before the test, always be sure to check the following.
- · Generator installation
- Battery (Refer to GROUP 54A, Battery Onvehicle Service – Battery Check P.54A-4.)
  - NOTE: The battery to be used should be slightly discharged. The load in a fully-charged battery will be insufficient and the test may not be able to be carried out correctly.
- Generator drive belt tension (Refer to GROUP 00, Maintenance Service – Drive Belts P.00-37.)
- Fusible link

- Abnormal noise from the generator while the engine is running.
- 2. Turn the ignition switch to the "LOCK" (OFF) position.
- 3. Disconnect the negative battery cable.

#### **MARNING**

# Never use clips to connect the line. Loose connections (e.g. using clips) will lead to a serious accident because of high current.

4. Disconnect the generator output wire from the generator "B" terminal and connect a DC test ammeter with a range of 0 – 100 A in series between the "B" terminal and the disconnected output wire. (Connect the positive lead of the ammeter to the "B" terminal, and then connect the negative lead of the ammeter to the disconnected output wire.)

NOTE: A clamp-type ammeter which enables measurements to be taken without disconnecting the generator output wire is recommended.

- 5. Connect a voltmeter with a range of 0 20 V between the generator "B" terminal and ground. (Connect the positive lead of the voltmeter to the "B" terminal, and then connect the negative lead of the voltmeter to ground.)
- 6. Connect the negative battery cable.
- 7. Connect a tachometer or scan tool MB991502.
- 8. Leave the hood open.
- 9. Check to be sure that the reading on the voltmeter is equal to the battery positive voltage.
  - NOTE: If the voltage is 0 V, the cause is probably an open circuit in the wire or fusible link between the generator "B" terminal and the battery positive terminal or malfunctioning voltmeter.
- 10.After turning on the headlights, start the engine.

  NOTE: Because the current from the battery will
  soon drop after the engine is started, step 11
  should be carried out as quickly as possible in
  order to obtain the maximum current output value.
- 11.Immediately after setting the headlights to high beam and turning the heater blower switch to the high revolution position, increase the engine speed to 2,500 r/min and read the maximum current output value displayed on the ammeter.

#### Limit value: 70 % of nominal current output

NOTE: For the nominal current output, refer to the Generator Specifications.

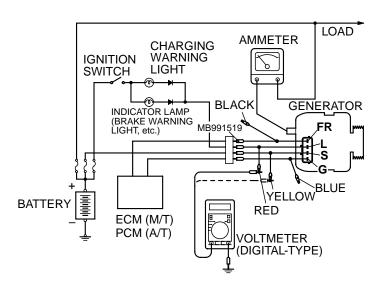
NOTE: The current output value will depend on the electrical load and the temperature of the generator body. NOTE: If the electrical load is small while testing, the specified level of current may not be output even though the generator is normal. In such cases, increase the electrical load by leaving the headlights turned on for some time to discharge the battery or by using the lighting system in another vehicle, and then test again.

NOTE: The specified level of current also may not be output if the temperature of the generator body or the ambient temperature is too high. In such cases, cool the generator and then test again.

- 12. The reading on the ammeter should be above the limit value. If the reading is below the limit value and the generator output wire is normal, remove the generator from the engine and check the generator.
- 13. Run the engine at idle speed after the test.
- 14. Turn the ignition switch to the "LOCK" (OFF) position.
- 15.Disconnect the tachometer or scan tool MB991502.
- 16.Disconnect the negative battery cable.
- 17. Disconnect the ammeter and voltmeter and tachometer.
- 18.Connect the generator output wire to the generator "B" terminal.
- 19. Connect the negative battery cable. Run the engine for 10 minutes at an idle after reconnecting negative battery cable.

#### REGULATED VOLTAGE TEST

M1161001100138



AKX01215 AG

#### **Required Special Tools:**

• MB991502: Scan Tool (MUT-II)

MB991519: Generator Harness Connector

This test determines whether the voltage regulator is correctly controlling the generator output voltage.

#### *↑* WARNING

# Battery posts, terminals and related accessories contain lead and lead compounds. WASH HANDS AFTER HANDLING.

- 1. Always be sure to check the following before the test:
- Generator installation
- Check to be sure that the battery installed in the vehicle is fully charged. (Refer to GROUP 54A, Battery – On-vehicle Service – Battery Check P.54A-4.)
- Generator drive belt tension (Refer to GROUP 00, Maintenance Service – Drive Belts P.00-37.)
- Fusible link
- Abnormal noise from the generator while the engine is running.
- 2. Turn the ignition switch to the "LOCK" (OFF) position.
- 3. Disconnect the negative battery cable.
- 4. Use the special tool (Generator harness connector: MB991519) to connect a digital-type voltmeter between the generator "S" terminal and ground. (Connect the positive lead of the voltmeter to the "S" terminal, and then connect the negative lead of the voltmeter to a secure ground or to the negative battery terminal.)
- 5. Disconnect the generator output wire from the generator "B" terminal.
- 6. Connect a DC test ammeter with a range of 0 100 A in series between the "B" terminal and the disconnected output wire. (Connect the positive load of the ammeter to the "B" terminal, and then connect the negative lead of the ammeter to the disconnected output wire.)

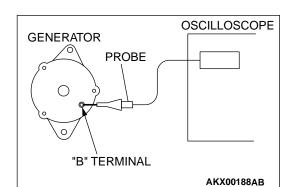
- 7. Reconnect the negative battery cable.
- 8. Connect a tachometer or the scan tool MB991502
- 9. Turn the ignition switch to the "ON" position and check that the reading on the voltmeter is equal to the battery positive voltage.
  - NOTE: If the voltage is 0 V, the cause is probably an open circuit in the wire or fusible link between the generator "S" terminal and the battery positive terminal or malfunctioning voltmeter.
- 10. Check to be sure that all lights and accessories are off.
- 11. Start the engine.
- 12. Increase the engine speed to 2,500 r/min.
- 13.Read the value displayed on the voltmeter when the current output by the generator becomes 10 A or less.
- 14.If the voltage reading conforms to the value in the voltage regulation table, then the voltage regulator is operating normally.
  - If the voltage is outside the standard value, there is a malfunction of the voltage regulator or the generator (Refer to the following table).
- 15. After the test, lower the engine speed to idle.
- 16. Turn the ignition switch to the "LOCK" (OFF) position.
- 17. Disconnect the negative battery cable.
- 18.Disconnect the ammeter, voltmeter and tachometer.
- 19. Connect the generator output wire to the generator "B" terminal.
- 20. Connect the negative battery cable. Run the engine for 10 minutes at an idle after reconnecting negative battery cable.

#### **VOLTAGE REGULATION TABLE**

INSPECTION TERMINAL	VOLTAGE REGULATOR AMBIENT TEMPERATURE [°C (°F)]	STANDARD VALUE (V)
Terminal "S"	-20 (-4)	14.2 – 15.4
	20 (68)	13.9 – 14.9
	60 (140)	13.4 – 14.5
	80 (176)	13.1 – 14.2

### WAVE PATTERN CHECK USING AN OSCILLOSCOPE

M1161001200094

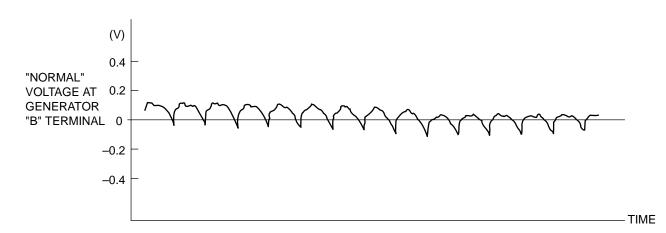


#### **Measurement Method**

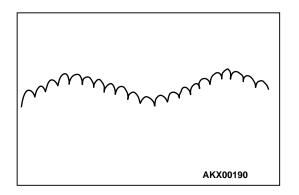
Connect the oscilloscope probe to the generator "B" terminal.

#### Standard Waveform

Observation Conditions	
FUNCTION	SPECIAL PATTERNS
Pattern height	Variable
Variable knob	Adjust while viewing the wave pattern
Pattern selector	Raster
Engine revolutions	Curb idle speed



AKX00189AD



NOTE: The voltage waveform of the generator "B" terminal can undulate as shown at left. This waveform is produced when the regulator operates according to fluctuations in the generator load (current), and is normal for the generator. If the ripple height is abnormally high (approximately 2 V or more during idling), the wires between the generator B terminal and the battery have broken due to fuse blowing, etc. The generator is usually operating properly.

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#### **Abnormal Waveforms Examples**

NOTE: The size of the waveform patterns can differ greatly, depending on the adjustment of the variable knob on the oscilloscope.

NOTE: Identification of abnormal waveforms is easier when there is a large output current (regulator is not operating). (Waveforms can be observed when the headlights are illuminated.)

NOTE: Check the conditions of the charging system warning light (illuminated/not illuminated) also, and carry out a total check.

ABNORMAL WAVEFORMS	PROBABLE CAUSE
Example 1	Open circuit in diode
AKX00191	
Example 2	Short-circuit in diode
AKX00192	
Example 3	Open circuit in stator coil
AKX00193	
Example 4	Short-circuit in stator coil
AKX00194	
Example 5	Open circuit in supplementary
ammamm MMM	diode
AKX00195	

### GENERATOR ASSEMBLY REMOVAL AND INSTALLATION

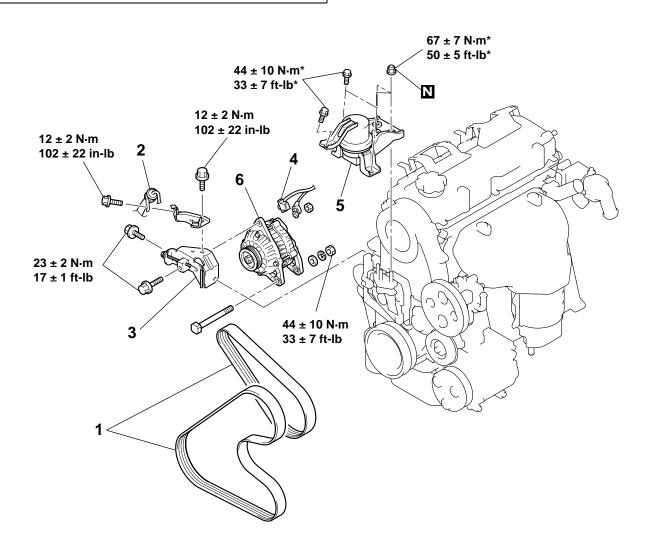
M1161001400333

#### **⚠** CAUTION

\*: Indicates parts which should be initially tightened, and then fully tightened after placing the vehicle horizontally and loading the full weight of the engine on the vehicle body.

#### **Post-installation Operation**

Drive Belt Tension Adjustment (Refer to GROUP 11A,Onvehicle Service P.11A-5.)



AC100803 AB

#### **REMOVAL STEPS**

- DRIVE BELT
- 2. POWER STEERING HOSE CLAMP
- 3. GENERATOR BRACE

#### <<A>>>

#### **REMOVAL STEPS (Continued)**

- 4. GENERATOR CONNECTOR
- 5. ENGINE MOUNT<VEHICLES WITH ABS>
- 6. GENERATOR

#### REMOVAL SERVICE POINT

#### <<A>> ENGINE MOUNT < VEHICLES WITH ABS> REMOVAL

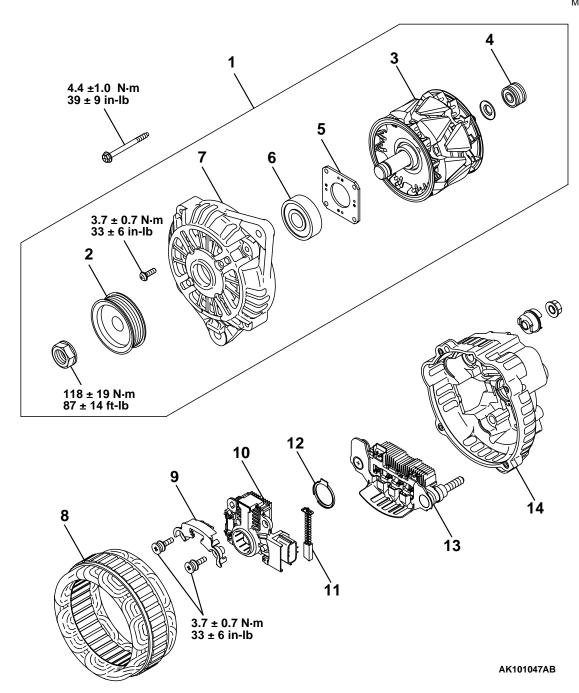
1. Remove all the power steering hose clamp mounting bolts.

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- 2. Jack up and support the engine assembly, and remove the engine mount.
- 3. Tilt the engine to remove the generator.

#### **DISASSEMBLY AND ASSEMBLY**

M1161001600069



<<C>>

#### DISASSEMBLY STEPS

<<A>>> <<B>>> 1. FRONT BRACKET ASSEMBLY

2. GENERATOR PULLEY

>>B<<

- 3. ROTOR ASSEMBLY
- 4. REAR BEARING
- 5. BEARING RETAINER
- 6. FRONT BEARING
- 7. FRONT BRACKET

#### **DISASSEMBLY STEPS**

- 8. STATOR
- 9. PLATE

>>A<< 10. REGULATOR ASSEMBLY

- 11. BRUSH
- 12. SLINGER
- 13. RECTIFIER
- 14. REAR BRACKET

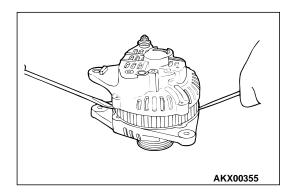
#### **DISASSEMBLY SERVICE POINTS**

#### <<A>> FRONT BRACKET ASSEMBLY REMOVAL

#### **⚠** CAUTION

Do not insert a screwdriver too deep. The stator coil will be damaged.

Insert a flat-tipped screwdriver between the front bracket assembly and the stator core, and pry it downward to separate the stator and front bracket assembly.

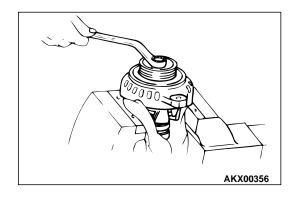


#### <<B>> GENERATOR PULLEY REMOVAL

#### **⚠** CAUTION

Make sure not to damage the rotor.

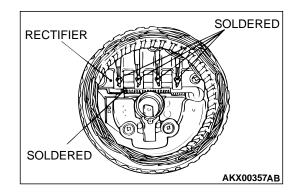
Set the pulley upward, clamp the rotor in a vise, and remove the pulley.



#### <<C>> STATOR REMOVAL

#### **↑** CAUTION

- Check that the heat from the soldering iron is not transmitted to the diode for a long time.
- Use care that no undue force is exerted to leads of diodes.
- 1. Use a soldering iron (180 to 250 W) to unsolder the stator. This work should complete within approximately four seconds to prevent heat from transferring to the diode.
- 2. When removing the rectifier from the regulator assembly, unsolder the points soldered on the rectifier.

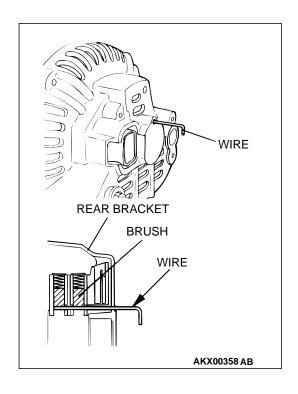


#### **ASSEMBLY SERVICE POINTS**

#### >>A<< REGULATOR ASSEMBLY INSTALLATION

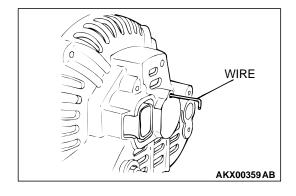
After installing the regulator assembly, insert a wire through the hole provided on the rear bracket while pressing down on the brush, and secure the brush.

NOTE: By inserting a wire, the brush will be secured in place, and the installation of the rotor will be easier.



#### >>B<< ROTOR ASSEMBLY INSTALLATION

After installing the rotor, remove the wire used to secure the brush.



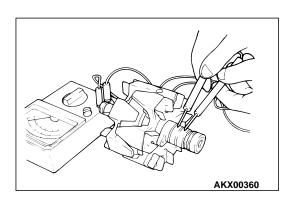
#### **INSPECTION**

M1161001700022

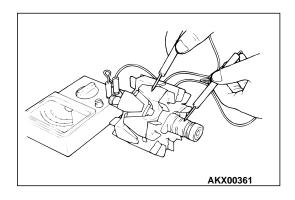
#### **ROTOR CHECK**

1. Check the continuity between the slip rings of the field coil. If the resistance value is not within the standard value, replace the rotor.

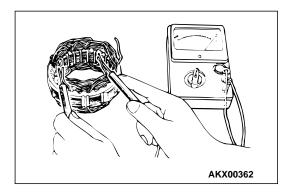
Standard value: approximately 2 – 5  $\Omega$ 



### ENGINE ELECTRICAL CHARGING SYSTEM

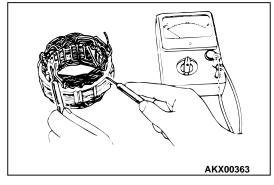


2. Check the continuity between the slip ring and the core. If there is continuity, replace the rotor.

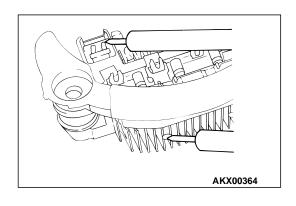


#### **STATOR CHECK**

1. Check the continuity between the coil lead. If there is no continuity, replace the stator.

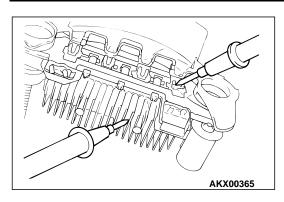


2. Check the continuity between the coil and the core. If there is continuity, replace the stator.

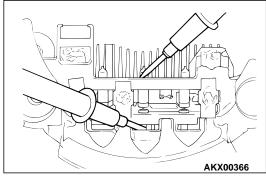


#### **RECTIFIER CHECK**

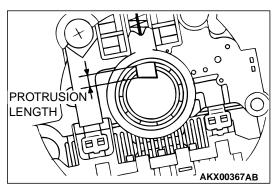
 Check the continuity between the positive rectifier and the stator coil lead connection terminal with a tester. If there is continuity between the terminals, the diode is shorted, so replace the rectifier.



2. Check the continuity between the negative rectifier and the stator coil lead connection terminal with a tester. If there is continuity between the terminals, the diode is grounded, so replace the rectifier.



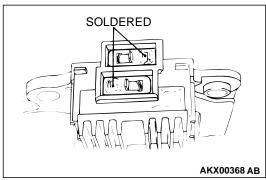
3. Check the continuity of the three diodes by connecting an ohmmeter to both ends of each diode. If there is continuity between the directions, or if there is no continuity, the diode is damaged, so replace the rectifier.



#### **BRUSH CHECK**

1. Replace the brush if the brush protrusion length shown in the illustration is below the minimum limit value.

Minimum limit: 2 mm (0.08 inch)



- 2. The brush can be removed by unsoldering the brush lead wire.
- 3. When installing a new brush, push the brush in to the brush holder, and solder the lead wire.

#### STARTING SYSTEM

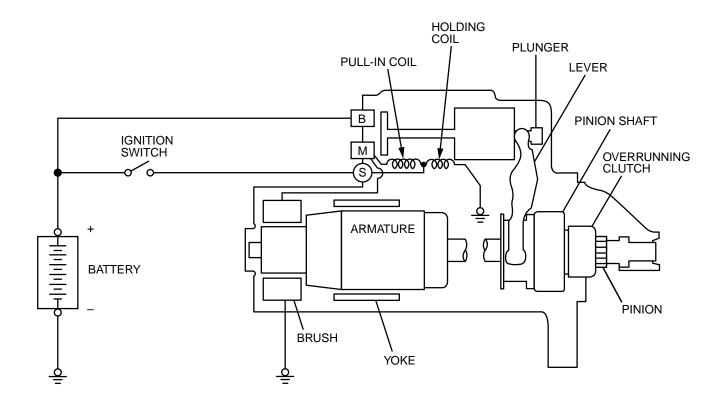
#### **GENERAL DESCRIPTION**

M1162000100086

If the ignition switch is turned to the "START" position, current flows in the coil provided inside magnetic switch, attracting the plunger. When the plunger is attracted, the lever connected to the plunger is actuated to engage the overrunning clutch with the ring gear.

At the same time, attracting the plunger will turn on the magnetic switch, allowing the B terminal and M terminal to conduct. Thus, current flows to engage the starter motor. When the ignition switch is returned to the "ON" position after starting the engine, the overrunning clutch is disengaged from the ring gear.

An overrunning clutch is provided between the pinion and the armature shaft, to prevent damage to the starter.



AK101428 AC

#### **OPERATION**

 For models equipped with M/T, the clutch pedal position switch contact is switched OFF when the clutch pedal is depressed. When the ignition switch is then switched to the "ST" position, electricity flows to the starter relay and the starter motor, the contact (magnetic switch) of the starter is switched ON and the starter motor is activated.

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NOTE: If the ignition switch is switched to the "ST" position without the clutch pedal being depressed, electricity flows to the starter relay (coil), the clutch pedal position switch (contacts) and to ground, with the result that the contacts of the starter relay are switched OFF, and because the power to the starter motor is thereby interrupted, the starter motor in not activated.

 For models equipped with A/T, when the ignition switch is switched to the "ST" position while the selector lever is at the "P" or "N" position, the contact (magnetic switch) of the starter is switched ON and the starter motor is activated.

#### **DIAGNOSIS**

M1162000700088

#### TROUBLESHOOTING HINTS

The starter motor does not operate at all.

- Check the starter (coil).
- Check for poor connection at the battery terminals and starter.
- Check the park/neutral position switch. <A/T>
- Check starter relay. <M/T>
- Check the clutch pedal position switch. <M/T>
- Check the theft-alarm starter relay.

The starter motor doesn't stop

• Check the starter (magnetic switch).

#### TROUBLESHOOTING GUIDE

The starting system troubleshooting guide is shown in the following chart.

#### STEP 1.

Q: Is the battery in good condition? (Refer to GROUP 54A, Battery – On-vehicle Service – Battery Check P.54A-4.)

YES: Go to Step 2.

**NO**: Charge or replace the battery.

#### STEP 2.

- Disconnect the starter motor S (solenoid) terminal connector
- Using a jumper wire, apply battery positive voltage to the starter motor S (solenoid) terminal.
- Check the engine condition.

OK: Turns normally

#### Q: Does the starter motor operate normally?

**YES:** • Check the ignition switch (Refer to GROUP 54A, Ignition Switch – Inspection P.54A-9.)

- Check the starter relay and clutch pedal position switch. <M/T>
- Check the park/neutral position switch. (Refer to GROUP 23A, Automatic Transaxle – On-vehicle Service – Essential Service P.23Aa-18.) <A/T>
- Check the line between the battery and starter motor S (solenoid) terminal.

**NO:** Go to Step 3.

#### STEP 3.

• Check the cable between starter B (battery) terminal and battery positive terminal for connection and continuity.

#### Q: Is the starter cable in good condition?

YES: Go to Step 4.

NO: Repair or replace the cable.

#### STEP 4.

 Check the connection and the continuity of the cable between the starter motor body and the negative battery terminal.

#### Q: Is the ground cable in good condition?

YES: Go to Step 5.

**NO**: Repair or replace the cable.

#### STEP 5.

Q: Is the starter motor in good condition? (Refer to Starting system – Starter motor – Inspection P.16-21.)

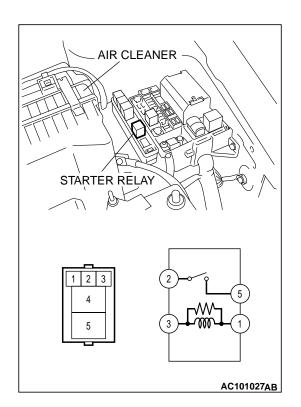
**YES:** Excessive rotational resistance of the engine.

**NO**: Replace the starter motor.

#### ON-VEHICLE SERVICE

#### STARTER RELAY CHECK<M/T>

M1162001400154



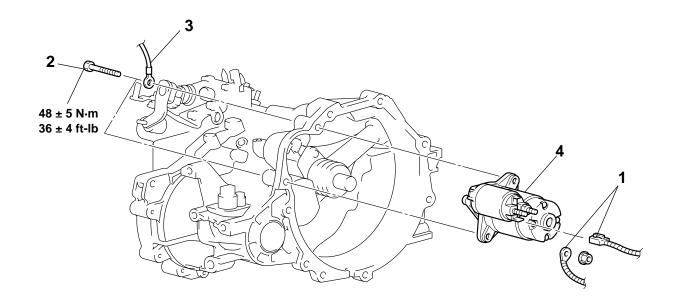
BATTERY VOLTAGE	TERMINAL NO. TO BE CONNECTED TO TESTER	CONTINUITY TEST RESULTS
Not applied	2 – 5	Open circuit
<ul> <li>Connect terminal 1 to the positive battery terminal</li> <li>Connect terminal 3 to the negative battery terminal</li> </ul>	2 – 5	Less than 2 ohms

### STARTER MOTOR ASSEMBLY REMOVAL AND INSTALLATION

M1162001000394

#### Pre-removal and Post-installation Operation

 Air Cleaner Removal and Installation (Refer to GROUP 15, Air Cleaner P.15-4.)



AC100950 AC

#### **REMOVAL STEPS**

- 1. STARTER CONNECTOR, TERMINAL
- 2. STARTER BOLT

#### **REMOVAL STEPS (Continued)**

- 3. GROUND CABLE
- 4. STARTER ASSEMBLY

#### **INSPECTION**

M1162001100090

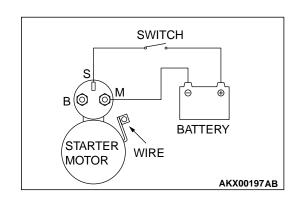


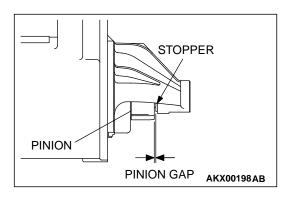
- 1. Disconnect the field coil wire from the M-terminal of the magnetic switch.
- 2. Connect a 12-volt battery between the S-terminal and M-terminal.

#### **⚠** CAUTION

This test must be performed quickly (in less than 10 seconds) to prevent the coil from burning.

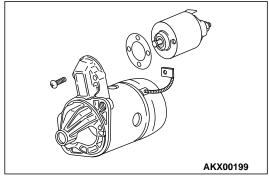
3. Set the switch to "ON," and the pinion will move out.



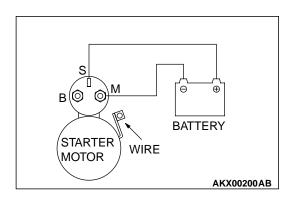


4. Check the pinion-to-stopper clearance (pinion gap) with a feeler gauge.

Standard value: 0.5 - 2.0 mm (0.02 - 0.07 inch)



5. If the pinion gap is out of specification, adjust by adding or removing gasket(s) between the magnetic switch and front bracket.



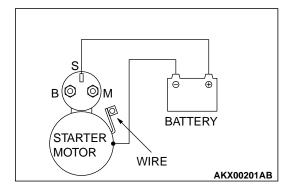
#### **MAGNETIC SWITCH PULL-IN TEST**

1. Disconnect the field coil wire from the M-terminal of the magnetic switch.

#### **↑** CAUTION

This test must be performed quickly (in less than 10 seconds) to prevent the coil from burning.

- 2. Connect a 12-volt battery between the S-terminal and M-terminal.
- 3. If the pinion moves out, the pull-in coil is good. If it doesn't, replace the magnetic switch.



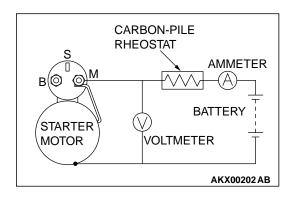
#### **MAGNETIC SWITCH HOLD-IN TEST**

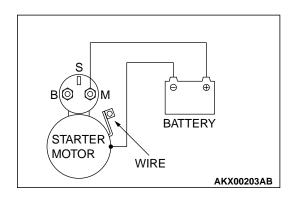
1. Disconnect the field coil wire from the M-terminal of the magnetic switch.

#### **⚠** CAUTION

This test must be performed quickly (in less than 10 seconds) to prevent the coil from burning.

- 2. Connect a 12-volt battery between the S-terminal and body.
- 3. Manually slide out the overrunning clutch as far as the pinion stopper position.
- 4. If the pinion remains out, everything is operating properly. If the pinion returns, the hold-in circuit is open. Replace the magnetic switch.





#### **FREE RUNNING TEST**

- 1. Place the starter motor in a bench-vise equipped with soft jaws and connect a fully-charged 12-volt battery to the starter motor as follows:
- 2. Connect a test ammeter (100-ampere scale) and carbon pile rheostat in series between the positive battery terminal and starter motor terminal.
- 3. Connect a voltmeter (15-volt scale) across the starter motor.
- 4. Rotate carbon pile to full-resistance position.
- 5. Connect the battery cable from the negative battery terminal to the starter motor body.
- 6. Adjust the rheostat until the battery positive voltage shown by the voltmeter is 11 V.
- Confirm that the maximum amperage is within the specifications and that the starter motor turns smoothly and freely.

**Current: maximum 90 Amps** 

#### **MAGNETIC SWITCH RETURN TEST**

1. Disconnect the field coil wire from the M-terminal of the magnetic switch.

#### **⚠** CAUTION

This test must be performed quickly (in less than 10 seconds) to prevent the coil from burning.

2. Connect a 12-volt battery between the M-terminal and body.

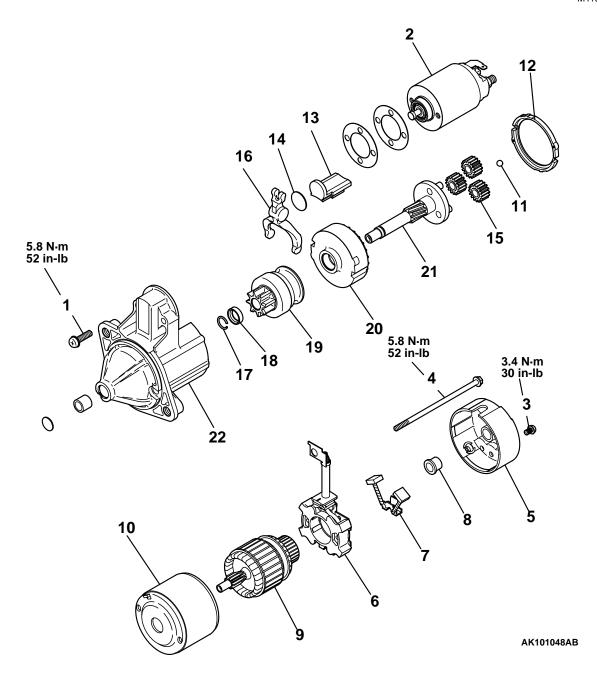
#### **MARNING**

Be careful not to get your fingers caught when pulling out the pinion.

3. Pull the pinion out and release. If the pinion quickly returns to its original position, everything is operating properly. If it doesn't, replace the magnetic switch.

#### **DISASSEMBLY AND ASSEMBLY**

M1162001200064



#### **DISASSEMBLY STEPS**

- 1. SCREW
- 2. MAGNETIC SWITCH
- 3. SCREW
- 4. SCREW
- 5. REAR BRACKET
- 6. BRUSH HOLDER
- 7. BRUSH
- 8. REAR BEARING
- 9. ARMATURE
- 10.YOKE ASSEMBLY
- **<<A>>>** 11.BALL
  - 12.PACKING A

#### **DISASSEMBLY STEPS**

- 13.PACKING B
- 14.PLATE
- 15.PLANETARY GEAR
- 16.LEVER
- <<B>> >>A<< 17.SNAP RING
- <<B>> >>A<< 18.STOP RING
  - 19.OVERRUNNING CLUTCH
  - 20.IINTERNAL GEAR
  - 21.PLANETARY GEAR HOLDER AND
    - PINION SHAFT
  - 22.FRONT BRACKET

<<A>>>

**TSB Revision** 

#### **DISASSEMBLY SERVICE POINTS**

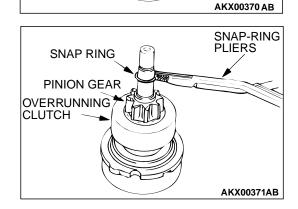
#### <<A>> ARMATURE AND BALL REMOVAL

#### **⚠** CAUTION

When removing the armature, take care not to lose the ball (which is used as a bearing) in the armature end.

#### <<B>> SNAP RING AND STOP RING REMOVAL

1. Press a long socket wrench of appropriate size to the stop ring. Then tap the socket wrench to move the stop ring to ward the pinion gear.



STOP RING

SOCKET

PINION GEAR

OVERRUNNING CLUTCH

2. After removing the snap ring (by using snap-ring pliers), slide the stop ring and the overrunning clutch off the pinion shaft.

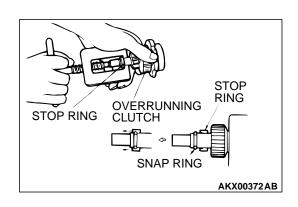
#### STARTER MOTOR PARTS CLEANING

- 1. Do not immerse parts in cleaning solvent. Immersing the yoke and field coil assembly and/or armature will damage insulation. Wipe these parts with a shop towel only.
- Do not immerse the drive unit in cleaning solvent.Overrunning clutch is pre-lubricated at the factory and solvent will wash lubrication from the clutch.
- 3. The drive unit may be cleaned with a brush moistened with cleaning solvent and wiped dry with a shop towel.

#### ASSEMBLY SERVICE POINT

#### >>A<< STOP RING AND SNAP RING INSTALLATION

Using a suitable pulling tool, pull the overrunning clutch stop ring over the snap ring.



#### **INSPECTION**

M1162001300027



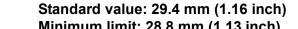
1. Place the armature on a pair of V-blocks, and check the deflection by using a dial gauge.

Standard value: 0.05 mm (0.002 inch)

Limit: 0.1 mm (0.004 inch)

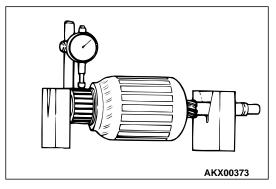


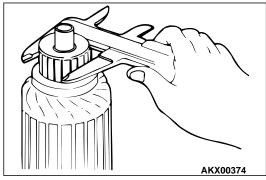
Minimum limit: 28.8 mm (1.13 inch)

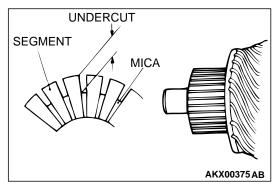


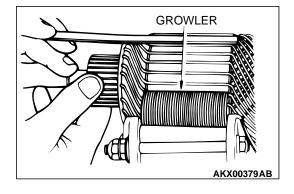
3. Check the depth of the undercut between segments.

Standard value: 0.5 mm (0.02 inch) Minimum limit: 0.2 mm (0.008 inch)



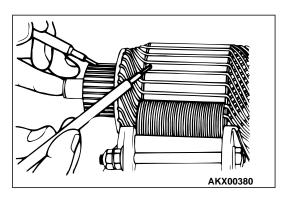




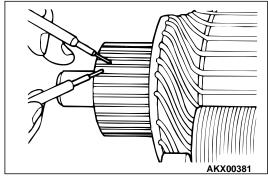


#### ARMATURE CHECK

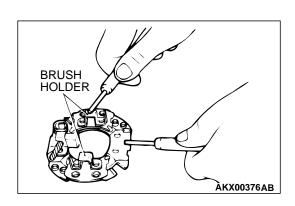
- 1. Check that the armature coil is not grounded.
- 2. Place the armature in a growler.
- 3. Hold a thin steel blade parallel and just above the armature while slowly rotating in the growler. A shorted armature will cause a blade to vibrate and be attracted to the core. Replace the shorted armature.



4. Check the insulation between the armature coil cores and the commutator segments. They are normal if there is no continuity.



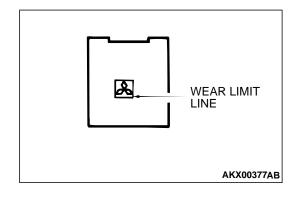
5. Check for continuity between the segments. The condition is normal if there is continuity.



#### **BRUSH HOLDER CHECK**

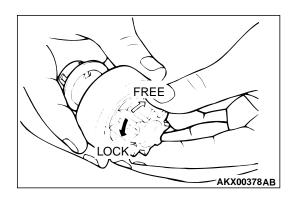
Check for the continuity between the brush holder plate and the brush holder.

There should be no continuity.



#### **BRUSH CHECK**

- 1. Brushes that are worn beyond wear limit line, or oil-soaked, should be replaced.
- 2. When replacing the ground brush, slide the brush from the brush holder by prying the retaining spring back.



#### **OVERRUNNING CLUTCH CHECK**

- 1. While holding the clutch housing, rotate the pinion. The drive pinion should rotate smoothly in one direction, but should not rotate in opposite direction. If the clutch does not function properly, replace the overrunning clutch assembly.
- Inspect the pinion for wear or burrs. If the pinion is worn or burred, replace the overrunning clutch assembly. If the pinion is damaged, also inspect the ring gear for wear or burrs.

#### FRONT AND REAR BRACKET BUSHING CHECK

Inspect the bushing for wear or burrs. If the bushing is worn or burred, replace the front bracket assembly or rear bracket assembly.

#### **IGNITION SYSTEM**

#### **GENERAL DESCRIPTION**

M1163000100108

This system is provided with two ignition coils (A and B) with built-in ignition power transistors for the number 1 and number 4 cylinders, and number 2 and number 3 cylinders respectively.

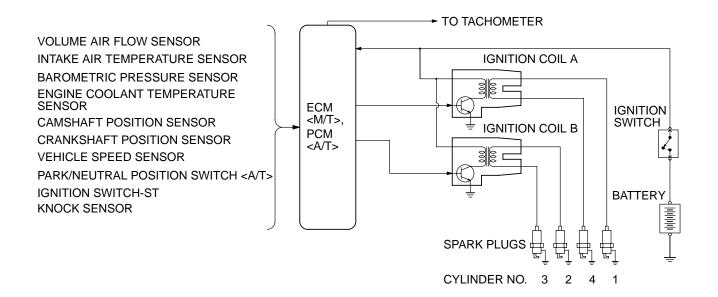
Interruption of the current flowing in the primary side of ignition coil A generates a high voltage in the secondary side of ignition coil A.

The high voltage generated is applied to the spark plugs of number 1 and number 4 cylinders to generate sparks. At the time that the sparks are generated at both spark plugs, if one cylinder is at the compression stroke, the other cylinder is at the exhaust stroke, so that ignition of the compressed air/fuel mixture occurs only for the cylinder which is on the compression stroke.

In the same way, when the primary current flowing in ignition coil B is interrupted, the high voltage thus generated is applied to the spark plugs of number 2 and number 3 cylinders.

The engine control module controls the two ignition power transistors to turn them alternately ON and OFF. This causes the primary currents in the ignition coils to be alternately interrupted and allowed to flow to fire the cylinders in the order 1-3-4-2. The engine control module determines which ignition coil should be controlled by means of the signals from the camshaft position sensor and from the crankshaft position sensor.

It also detects the crankshaft position in order to provide ignition at the most appropriate timing in response to the engine operation conditions. When the engine is cold or operated at high altitudes, the ignition timing is slightly advanced to provide optimum performance.



AK100055 AB

#### **SPECIAL TOOLS**

M1163000600103

TOOL	TOOL NUMBER AND NAME	SUPERSESSION	APPLICATION
	MD998773 Knock sensor wrench	MD998773-01	Knock sensor removal and installation

#### **ON-VEHICLE SERVICE**

#### **IGNITION COIL CHECK**

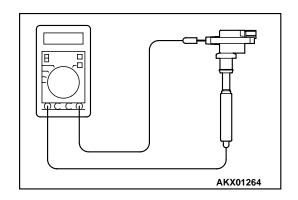
M1163001200153

Check by the following procedure, and replace the coil if there is a malfunction.

#### SECONDARY COIL RESISTANCE CHECK

Measure the resistance between the high-voltage terminals of the ignition coil.

Standard value: 8.5 – 11.5  $k\Omega$ 



### PRIMARY COIL AND IGNITION POWER TRANSISTOR CONTINUITY CHECK

NOTE: An analog-type ohmmeter should be used.

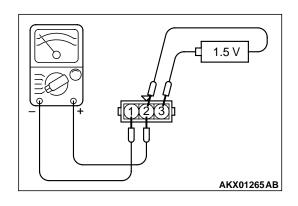
NOTE: Connect the negative probe of the ohmmeter to terminal 1.

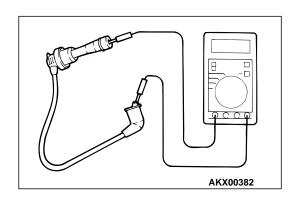
#### **⚠** CAUTION

This test must be performed quickly (in less than 10 seconds) to prevent coil from burning and ignition power transistor from breaking.

- 1. Connect and disconnect 1.5 V battery between terminals 2 and 3, and observe the ohmmeter whether there is continuity or not.
- 2. If results do not agree with the table below, replace the primary coil and ignition power transistor assembly.

1.5 V POWER SUPPLY BETWEEN 2 – 3	CONTINUITY BETWEEN 1 – 2
Current flowing	Yes
Current not flowing	No





#### SPARK PLUG CABLE RESISTANCE CHECK

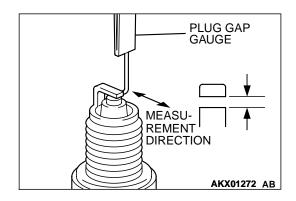
M1163001400072

Measure the resistance of the all spark plug leads.

- 1. Check the cap and coating for cracks.
- 2. Measure the resistance.

Limit: 19  $k\Omega$ 

3. If resistance is greater than 19  $k\Omega$ , replace the cable.



#### SPARK PLUG CHECK AND CLEANING

M1163004300096

- 1. Check that the plug is not burned, that the insulator plug is not damaged, and that the seizure state is good.
- 2. If cleaning is required due to carbon deposits, etc., clean using a plug cleaner or wire brush, etc.
- 3. Check the plug gap using a plug gap gauge, and adjust if not within the standard value.

Standard value: 1.0 – 1.1 mm (0.039 – 0.043 inch)

#### **CAMSHAFT POSITION SENSOR CHECK**

M1163004400101

Refer to GROUP 13A, Diagnostic Trouble Code Procedures – DTC 0340: Camshaft Position Sensor Circuit P.13Ac-295.

#### CRANK ANGLE SENSOR CHECK

M1163004500120

Refer to GROUP 13A, Diagnostic Trouble Code Procedures – DTC P335: Crankshaft Position Sensor Circuit P.13Ac-280.

### IGNITION SECONDARY VOLTAGE WAVE PATTERN CHECK USING AN OSCILLOSCOPE

M1163001700125

#### **MEASUREMENT METHOD**

1. Clamp the spark plug cable (Number 1 or 3) with the secondary pickup.

NOTE: Because of the two-cylinder simultaneous ignition system, the waves for two cylinders in each group appear during wave observation. However, wave observation is carried out for the cylinder (Number 1 or 3) with the spark plug cable which has been clamped by the secondary pickup.

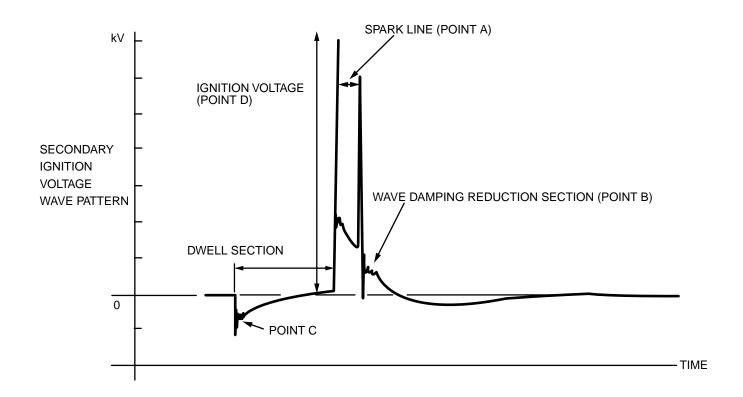
NOTE: Identification of which cylinder wave pattern is displayed can be difficult, but the wave pattern of the cylinder which is clamped by the secondary pickup will be stable, so this can be used as a reference.

2. Clamp the spark plug cable (Number 1 or 3) with the trigger pickup.

NOTE: Clamp the same spark plug cable as the one which has been clamped by the secondary pickup.

#### STANDARD WAVE PATTERN

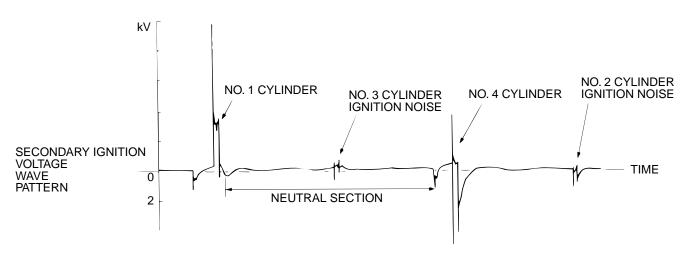
Settings	
FUNCTION	SECONDARY
Pattern height	High (or low)
Pattern selector	Raster
Engine speed	Curb idle speed



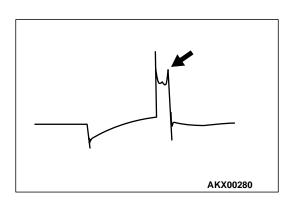
#### AKX00278AB

Settings	
Pattern selector	Display
Pattern height	High (or low)
Engine speed	Curb idle speed

#### **TSB Revision**

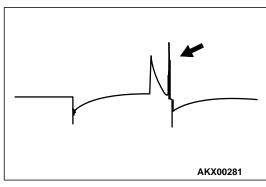


AKX01275AB



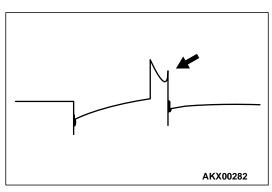
### ABNORMAL WAVEFORMS EXAMPLES Example 1

- Wave characteristics
   Spark line is high and short.
- Cause of problem
   Spark plug gap is too large.



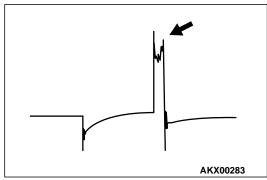
#### Example 2

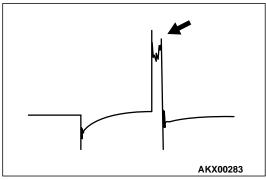
- Wave characteristics
   Spark line is low and long, and is sloping. Also, the second half of the spark line is distorted. This could be a result of misfiring.
- Cause of problem
   Spark plug gap is too small.

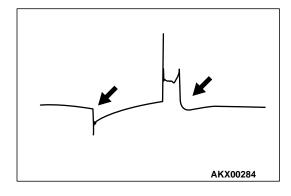


#### Example 3

- Wave characteristics
   Spark line is low and long, and is sloping. However, there is almost no spark line distortion.
- Cause of problem
   Spark plug gap is fouled.







#### Example 4

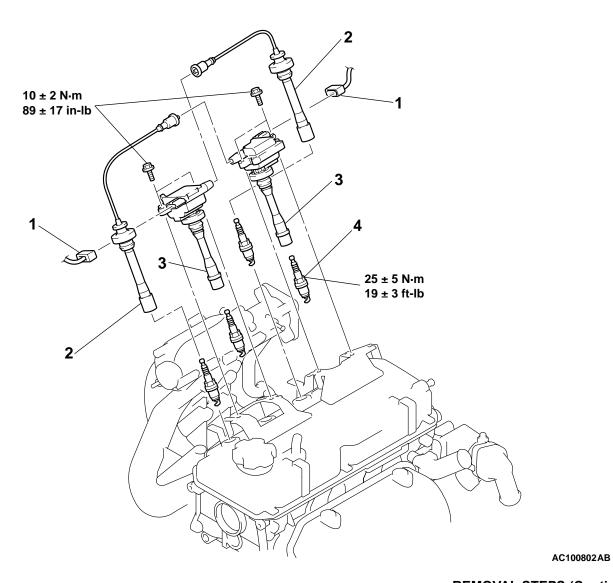
- Wave characteristics Spark line is high and short. Difficult to distinguish between this and abnormal wave pattern example 1.
- Cause of problem Spark plug cable is not properly connected. (Causing a dual ignition)

#### Example 5

- Wave characteristics No waves in wave damping section
- Cause of problem Short in ignition coil.

# IGNITION COIL REMOVAL AND INSTALLATION

M1163004000288



#### **REMOVAL STEPS**

- 1. IGNITION COIL CONNECTOR
- 2. SPARK PLUG CABLE

#### **REMOVAL STEPS (Continued)**

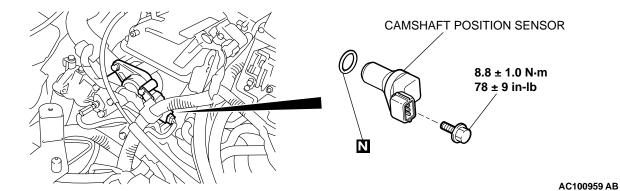
- 3. IGNITION COIL
- 4. SPARK PLUG

# CAMSHAFT POSITION SENSOR REMOVAL AND INSTALLATION

M1163003400313

#### **Pre-removal and Post-installation Operation**

 Air Cleaner Removal and Installation (Refer to GROUP 15,Air Cleaner P.15-4.)

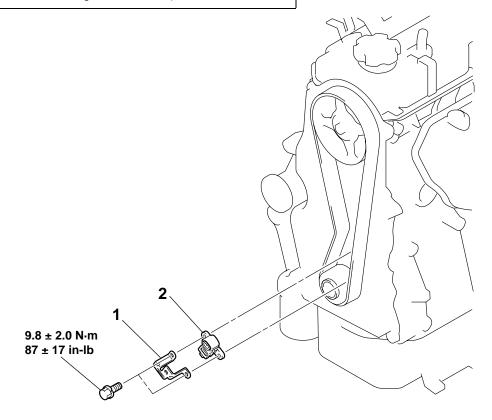


# CRANKSHAFT POSITION SENSOR REMOVAL AND INSTALLATION

M1163003500310

#### **Pre-removal and Post-installation Operation**

• Timing Belt Cover Removal and Installation (Refer to GROUP 11A, Timing Belt P.11A-35.)



AC100804 AB

#### REMOVAL STEPS

- 1. BRACKET
- CRANKSHAFT POSITION SENSOR

**TSB Revision** 

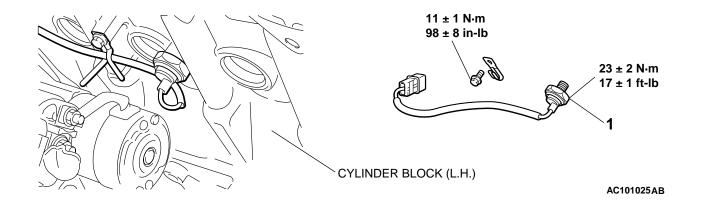
#### **KNOCK SENSOR**

#### **REMOVAL AND INSTALLATION**

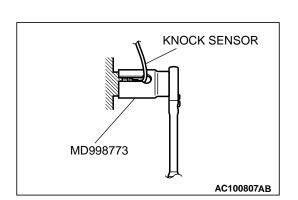
M1163002800318

#### Pre-removal and Post-installation Operation

 Intake Manifold Stay Removal and Installation (Refer to GROUP 15,Intake Manifold P.15-5.)



REMOVAL
<<A>>> >A<< 1. KNOCK SENSOR



#### **REMOVAL SERVICE POINT**

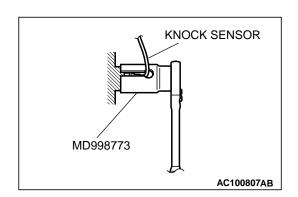
#### <<A>> KNOCK SENSOR REMOVAL

Use special tool MD998773 to remove the knock sensor.

#### INSTALLATION SERVICE POINT

#### >>A<< KNOCK SENSOR INSTALLATION

Use special tool MD998773 to install the knock sensor.



### **SPECIFICATIONS**

#### **FASTENER TIGHTENING SPECIFICATIONS**

M1161002100443

ITEM	SPECIFICATION	
Charging system	,	
Bearing retainer bolt	3.7 ± 0.7 N·m (33 ± 6 in-lb)	
Engine mount bracket to engine nut	67 ± 7 N·m (50 ± 5 ft-lb)	
Engine mount insulator to frame bolt	44 ± 10 N·m (33 ± 7 ft-lb)	
Front bracket assembly bolt	4.4 ± 1.0 N·m (39 ± 9 in-lb)	
Generator bolt	23 ± 2 N·m (17 ± 1 ft-lb)	
Generator brace bolt	23 ± 2 N·m (17 ± 1 ft-lb)	
Generator nut	44 ± 10 N·m (33 ± 7 ft-lb)	
Generator pulley nut	118 ± 19 N·m (87 ± 14 ft-lb)	
Power steering hose clamp bolt	12 ± 2 N⋅m (102 ± 22 in-lb)	
Regulator assembly bolt	$3.7 \pm 0.7 \text{ N} \cdot \text{m} \ (33 \pm 6 \text{ in-lb})$	
Starting system		
Magnetic switch screw	5.8 ± 1.6 N·m (52 ± 14 in-lb)	
Rear bracket screw	3.4 ± 1.0 N·m (30 ± 9 in-lb)	
Stator bolt	48 ± 5 N⋅m (36 ± 4 ft-lb)	
Stator screw	5.8 ± 1.6 N·m (52 ± 14 in-lb)	
Ignition system	,	
Camshaft position sensor bolt	8.8 ± 1.0 N·m (78 ± 9 in-lb)	
Crankshaft position sensor bolt	9.8 ± 2.0 N·m (87 ± 17 in-lb)	
Ignition coil bolt	10 ± 2 N⋅m (89 ± 17 in-lb)	
Knock sensor	23 ± 2 N·m (17 ± 1 ft-lb)	
Knock sensor clamp bolt	11 ± 1 N⋅m (98 ± 8 in-lb)	
Spark plug	25 ± 5 N·m (19 ± 3 ft-lb)	

#### **GENERAL SPECIFICATIONS**

M1161000200110

ITEMS	SPECIFICATIONS
Generator	
Туре	Positive battery positive voltage sensing
Identification number	A2TB0892
Part No.	MD343562
Rated output V/A	12/85
Voltage regulator	Electronic built-in type
Starter motor	
Туре	Reduction drive with planetary gear
Identification number	M0T87581
Part No.	MD377649
Rated output kW/V	1.3/12
Voltage regulator	8

**TSB Revision** 

ITEMS	SPECIFICATIONS	
Ignition coil		
Туре	Molded 2-coil	
Spark plugs		
NGK	BKR5E-11	
DENSO	K16PR-U11	
CHAMPION	RC10YC4	

#### **SERVICE SPECIFICATIONS**

M1161000300140

ITEMS		STANDARD VALUE	LIMIT	
Generator				
Regulated voltage (Ambient temperature at voltage regulator)	–20°C (–4°F)	14.2 – 15.4	_	
	20°C (68°F)	13.9 – 14.9	_	
	60°C (140°F)	13.4 – 14.5	_	
	80°C (176°F)	13.1 – 14.5	_	
Generator output line voltage drop (at 30A) V		-	Maximum 0.3	
Output current		-	70% of normal output current	
Field coil resistance $\Omega$		Approximately 2 – 5	_	
Brush protrusion length mm (in)		_	Minimum 2 (0.08)	
Starter motor				
Free running characteristics	Terminal voltage V	11	_	
	Current A	90	_	
	Speed r/min	2,500 or more	_	
Pinion gap mm (in)		0.5 – 2.0 (0.02 – 0.07)	_	
Commutator run-out mm (in)		0.05 (0.002)	Minimum 0.1 (0.004)	
Commutator diameter mm (in)		29.4 (1.16)	Minimum 28.8 (1.13)	
Undercut depth mm (in)		0.5 (0.02)	Minimum 0.2 (0.008)	
Ignition parts				
Ignition secondary coil resistance at 20°C (68°F) kΩ		8.5 – 11.5	_	
Spark plug gap mm (in)		1.0 – 1.1 (0.039 – 0.043)	_	
Resistor wire resistance $k\Omega$		_	Maximum 19	

**NOTES**