

# Diagnosis and repair of charging system problems

## Liquid-cooled R-series, model-year 2013 onward

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With Andrew Hamer



### Introduction and rationale

BMW R-series motorcycles dating from 2013 onward possess an integral, internally-mounted alternator assembly. This system differs from previous R-series practice by rendering the alternator inaccessible for quick and easy repair or replacement in case of failure.

In all cases where one or more of the major charging system components have failed, symptoms of the resulting failure will manifest as an abnormally low or high charging voltage. In all cases, the diagnosis and repair procedures given in this manual will, if followed correctly, allow accurate, economical isolation and elimination of the root cause of the abnormal charging condition.

Due to the very high cost of BMW-approved repair procedures and genuine parts, a misconception exists that alternator repair or replacement is expensive enough to render an affected motorcycle beyond economic repair. As will be demonstrated in this article, this notion is false. Any enthusiast possessing a reasonable level of technical competence and experience in electrical fault diagnosis should not find these tasks unusually difficult.

The procedures contained in this document were written with extensive reference to a 2013 R1200GS. However, they are also applicable to all other 2013-onward BMW R-series models, as charging-system fault diagnosis and repair procedures are identical for all such models.

**Important:** The test procedures and results described in this document are applicable only to the motorcycles mentioned.

A document outlining the diagnosis and repair of charging system problems on 2008-onward F-series models will also be available from the UKGSer website from June 2016.

The information contained in this document is used and adapted at the reader's personal discretion, and the reader undertaking the procedures described herein accepts responsibility for any deviation from technical standards which may be stipulated by BMW.

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The procedures described herein have been engineered and documented by independent enthusiasts, and are not sanctioned or supported in any way by Bayerische Motorenwerke (BMW), BMW Motorrad or any other BMW subsidiary or affiliate. You are hereby warned that undertaking the procedures described herein may void the motorcycle's warranty (if present). Therefore, it is recommended that these procedures be carried out only on motorcycles on which the factory warranty period has expired.

By undertaking any procedures described herein, the party maintaining and/or repairing the relevant motorcycle(s) accepts unconditional responsibility for their actions, and undertakes to hold the author of this document blameless in the event of any consequences which may arise as a result of said procedures.

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# 1 Equipment List

The following equipment will be needed to complete the tasks in the document:

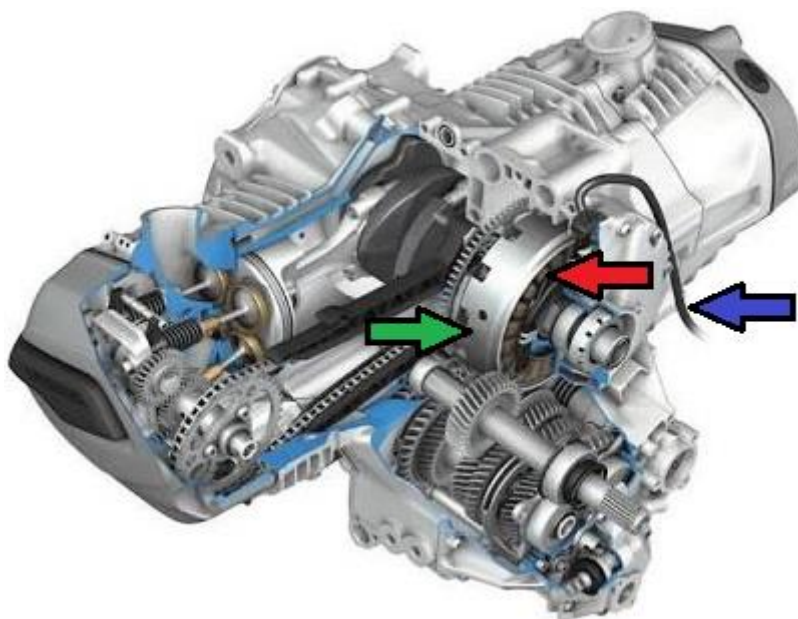
- Digital multimeter capable of reading:
  - Continuity.
  - DC voltages between 10 and 15 volts.
  - AC voltages between 50 and 80 volts.
  - Resistance between 5 and 500 Ohms.
- T25 Torx wrench.
- 10mm hexagonal wrench.
- Intelligent trickle charger for 12 V lead-acid batteries.
- 1.5 mm flat screwdriver (for repair of AC and DC bus plug terminals).
- 12 V, 55 W H3 or H7 incandescent headlight bulb.

## 2 Component location

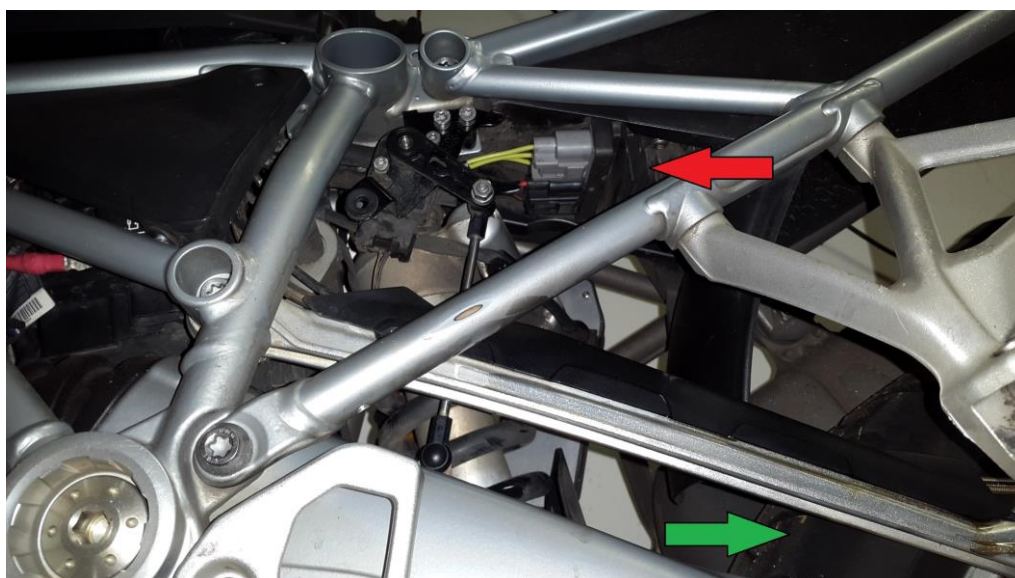
On liquid-cooled R-series engines manufactured from model-year 2013 onward, the alternator installation differs radically from all earlier R-series engines. Where the alternator was previously a separate bolt-on unit driven from the crankshaft by a Poly-V belt, it is now an integrated part of the engine/gearbox assembly.

As shown in the figure below, the alternator is located at the upper rear of the engine/gearbox assembly. The alternator stator (red arrow, below), consists of a soft iron core wound with copper wire windings. The stator is secured to the rear of the crankcase by a cast aluminium frame, and is energized via a gear-driven permanent-magnet rotor (green arrow, below). The resulting three-phase AC current is routed to the physically separate voltage regulator/rectifier via the AC output bus (blue arrow, below).

Removal of the engine/gearbox from the motorcycle's frame, and extensive disassembly of the engine/gearbox, is required to gain access to the alternator assembly.



The voltage regulator/rectifier (red arrow, below) is located above the rear wheel (green arrow, below) and underneath the rider's seat. It is secured to the underside of a plastic tray by two T25 Torx screws, and is easily accessible.



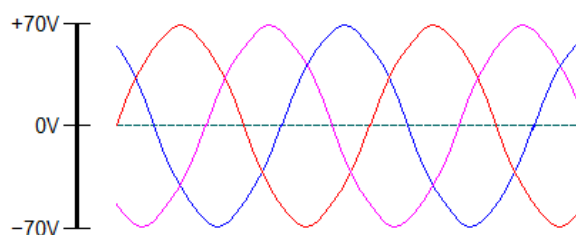
### 3 Working principle (Conversion of high-voltage AC to low-voltage DC)

On liquid-cooled R-series engines, the battery is supplied current by the alternator via the voltage regulator/rectifier. Whenever the engine is running, the alternator generates three-phase alternating current (AC) of approximately 60 to 70 volts.

A single electrical *phase* (voltage wave) is generated each time the alternator *rotor* (a permanent magnet) rotates past the *stator* (a coil of copper wire wound around a soft iron core). Whenever one pole of the magnet passes the coil, a positive voltage wave is generated. Whenever the opposite pole of the magnet passes the coil, a negative voltage wave is generated. This harmonized generation produces electric current in a parabolic sine wave pattern.

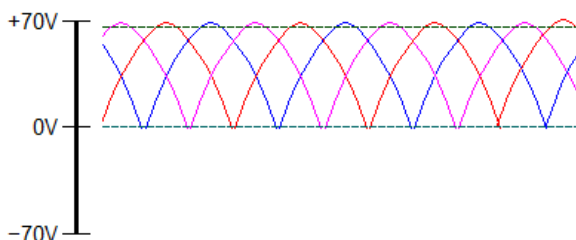
The alternator stator is equipped with three coils, spaced  $120^\circ$  out of phase with one other, and joined at a common point.

For every revolution completed by the rotor, the alternator generates three harmonized voltage waves, likewise  $120^\circ$  out of phase. Each voltage wave oscillates between positive and negative voltage over time. The frequency of current generation (i.e. the number of wave oscillations per second) is directly proportional to engine speed. If plotted on an oscilloscope, the raw output of a three-phase alternator would look approximately like this:

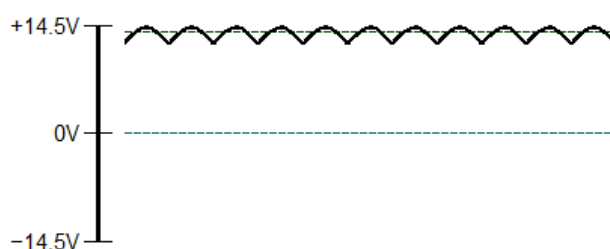


Since negative-earth vehicle electrical systems can only use current of positive voltage, the alternator's raw output is *rectified* to a form that consists of positive voltage only.

Since the rectified electric current no longer alternates between positive and negative voltage, it is said to have been *converted* from *alternating current* (AC) to *direct current* (DC). If plotted on an oscilloscope, the rectified and converted output would look approximately like this:



Finally, the rectified output is passed through a series of transistors, being *regulated* to a standard voltage that can be used by the vehicle's electrical system, and tolerated by standard, commonly-available 12V batteries. In a well-functioning 12-volt electrical system, the rectified output is regulated to a maximum of approximately 14.3 volts before being routed to the battery. This slightly higher voltage is needed to accommodate the vehicle's normal electrical demands, while efficiently charging the battery at the same time. If plotted on an oscilloscope, the rectified, converted and regulated output would look approximately like this:



On liquid-cooled R-series engines, the engine is equipped with an alternator able to supply a claimed output of 510 Watts (0.51 Kilowatt).

Unlike previous R-series engines, the alternator is not a separate, bolt-on assembly that takes drive from the crankshaft via a Poly-V belt. Instead, the alternator is built into the engine's crankcase as an integrated part of the

engine assembly. This arrangement has the advantage of making the engine/gearbox assembly more compact. However, it has the serious disadvantage that if the alternator fails, the engine has to be removed from the motorcycle and dismantled in order to remove the alternator assembly for inspection and repair.

## 4 Diagnosis and repair procedures

**Important:** The test procedures and results described in this document are specifically applicable to liquid-cooled BMW R-series boxer engines manufactured from 2013 onward.

Unless explicitly stated, the described test procedures and results are not applicable to any other motorcycle, regardless of whether or not the motorcycle is manufactured by BMW Motorrad.

A document outlining the diagnosis and repair of charging system problems on 2008-onward F-series models will also be available from the UKGSer website from June 2016.

BMW Motorrad R-series motorcycles manufactured from 2013 onward are equipped with computerized self-monitoring systems, including a charging voltage monitoring function. In addition, motorcycles equipped with the Trip Computer Pro also possess a built-in Voltmeter function.

Many possible reasons exist for an abnormally low or high charge rate. However, in most cases, failure of charging system components will manifest as abnormally low charging voltage.

Under normal conditions, charging voltage should be between 14.2 V and 14.4 V. In rarer cases, abnormally high charging voltages (greater than 14.6 V) may be seen.

In all cases, the diagnosis and repair procedures given in this manual must be followed sequentially. To isolate and repair the actual cause of the abnormal charging condition, proceed as described in the following sub-sections, testing the battery first. After testing the battery, perform the output voltage test. After performing the output voltage test, test the alternator. After testing the alternator, test the voltage regulator/rectifier.

### 4.1 Testing the battery

Before declaring the alternator and/or voltage regulator/rectifier suspect, the battery's ability to hold a specified charge must be tested.

Modern BMW motorcycles use high-quality absorbent glass mat (AGM) lead-acid batteries. If the motorcycle is used regularly and/or the battery is regularly charged, failures of these batteries are rare.

**Cautions:** Under no circumstances must the battery terminals be disconnected while the engine is running. Doing so may cause severe damage throughout the motorcycle's electrical and electronic systems.

If the battery fails to pass the tests described in this section, do not attempt to run the engine without first replacing the suspect battery with a good one.

Test the battery as follows:

1. Remove the battery access cover on the right-hand side of the motorcycle, under the rider's seat. The battery's negative terminal and positive jumper terminal will be exposed.



2. Using a T25 Torx wrench, disconnect the positive jumper terminal from its normal position. Ensure that the jumper terminal cannot contact its normal seat as the following steps are performed.
3. Connect an intelligent trickle charger for lead-acid batteries to the battery's negative terminal and positive jumper lead.
4. If possible, set the intelligent trickle charger for minimum charge intensity. Charge the battery for the time specified by the battery manufacturer for the relevant charge intensity.
5. When charging is completed, disconnect the trickle charger.
6. Re-connect the battery to the motorcycle's electrical harness.
7. Using a T25 Torx wrench, remove the black plastic covers from both fuel injectors.
8. Disconnect the two-pin harness plug from each fuel injector.
9. Perform the tests below only with the engine dead cold (i.e. not run for at least twelve hours). This will increase the load on the starter motor, helping to simulate a realistic test condition.
10. Set the multimeter to the *20V DC voltage* scale.
11. Touch the negative probe to the battery negative terminal, and the positive probe to the battery positive jumper terminal. The battery voltage should read at least 12.5 V with the engine not running.
12. Turn on the ignition switch.
13. Get a helper to crank the engine for at least ten seconds. The indicated voltage should not drop below 9.6 V during the whole of the ten-second cranking period. If the indicated voltage drops below 9.6 V, the battery is suspect and must be examined by a competent battery service centre.

## 4.2 Output voltage test

Before testing the alternator's AC voltage output and the integrity of the voltage regulator/rectifier, perform an output DC voltage test as follows:

1. On all RT models, and on all models equipped with Dynamic ESA, remove the black plastic panel covering the rear suspension load sensor (blue arrow, below) as follows:



On all GS, GS Adventure, R and RS models with Dynamic ESA:

- i. Gently pull the lower edge of the cover outward to slide the locating pin out of the rubber bobbin.
  - ii. Lift the cover upward and outward.
  - iii. There will now be enough clearance to access the voltage regulator/rectifier.
2. Remove the two T25 Torx screws holding the voltage regulator/rectifier in place under the rider's seat.
  3. Lower the regulator/rectifier down and out of its stowed location.
  4. Disconnect the grey three-pin plug and the black two-pin plug from the voltage regulator/rectifier.
  5. Verify that all female terminals in the two plugs are making adequate contact with their equivalent male terminals in the regulator/rectifier unit. If necessary, crimp the female terminals to ensure proper contact.

6. Re-connect the grey three-pin plug and black two-pin plug to the voltage regulator/rectifier.
7. Set the multimeter to the *20V DC voltage* scale.
8. Turn on the ignition switch and kill switch. Start the engine.
9. Create an electrical load by switching on the high beam, and switching the heated grips (if fitted) to position II.
10. Touch the negative probe to the battery negative terminal, and the positive probe to the battery positive jumper terminal.
11. The indicated voltage between battery terminals should be between 14.2 V and 14.4 V with the engine at idle speed and the electrical load present. If the indicated voltage is lower than 13.8 V, test the no-load DC output at the terminals of the voltage regulator/rectifier as follows:
  - i. Turn off the motorcycle's ignition switch.
  - ii. Disconnect the black two-pin plug from the voltage regulator/rectifier. Ensure that the grey three-pin plug is securely connected.
  - iii. Start the engine.
  - iv. Touch the negative probe to the regulator/rectifier's negative output terminal, and the positive probe to the regulator/rectifier's positive output terminal:
    - If the indicated voltage now rises to between 14.2 V and 14.4 V with the engine at idle speed, there is a possibility that the regulator/rectifier unit may be faulty. Test the unit as described in section [4.4 \(Testing the voltage regulator/rectifier\)](#).
    - If the indicated voltage remains lower than 13.8 V, there is a likelihood that the alternator stator is faulty. Test the stator as described in section [4.3 \(Testing the alternator\)](#).
12. Re-installation of the regulator/rectifier unit is a reverse of removal.

### 4.3 Testing the alternator

Numerous alternator failures have been documented among R-series motorcycles equipped with the liquid-cooled engine. Failure is mostly confined to the alternator stator windings, and mostly affects engines manufactured before April 2014. After this date, the original alternator was superseded by an improved alternator as a running change.

**Important:** If the alternator fails any of the tests described in this sub-section, the voltage regulator/rectifier must also be regarded as suspect. Test the regulator/rectifier unit as described in section [4.4 \(Testing the voltage regulator/rectifier\)](#).

Test the alternator as follows:

1. Turn off the motorcycle's ignition switch.
2. On all RT models, and on all models equipped with Dynamic ESA, remove the plastic panel covering the rear suspension load sensor, and displace the voltage regulator/rectifier unit from its regular position as described in section [4.2 \(Output voltage test\)](#).
3. Disconnect the grey three-pin plug from the voltage regulator/rectifier. This plug is the AC bus plug.
4. Set the multimeter to the *Continuity* setting.
5. Before commencing the tests below, test the integrity of the multimeter by touching the two test probes together. The multimeter should indicate continuity.
6. Test for continuity between all terminals of the alternator's AC output plug (the three yellow wires) by touching the probes to terminals:
  - 1 and 2.
  - 1 and 3.
  - 2 and 3.

Continuity should be present in all three cases above.



- If continuity is present in all cases above, proceed to step 7 below.
  - If continuity is *not* present in any or all cases, an open circuit exists on one or more of the alternator's stator windings. Refer to section 5.2 (Replacing or repairing the alternator) for alternator repair or replacement.
7. Set the multimeter to the 20 Ohm *Resistance* setting.
  8. Test the relative resistance between the three stator windings (three yellow wires) by touching the probes to terminals:
    - 1 and 2.
    - 1 and 3.
    - 2 and 3.

Electrical resistance of between approximately 8 Ohms, and *of approximately the same resistance value between windings*, should be present in all three cases above.

- If the same resistance value is present in all cases, proceed to step 9 below.
  - If resistance values vary significantly between windings, and/or if any resistance values are substantially higher than 8 Ohms, a short circuit exists somewhere between the stator windings and earth (ground), or between an alternator AC output lead and earth (ground). Isolate the actual cause of the short circuit by referring to step 9 below.
9. Test for current leakage from the stator windings to earth (ground) as follows:
    - i. Turn off the motorcycle's ignition switch.
    - ii. Set the multimeter to the *Continuity* setting.
    - iii. Touch one probe to a known good earth (ground) point on the engine or frame, such as a sub-frame mounting screw head.
    - iv. Touch the second probe to terminals 1, 2 and 3 of the AC bus plug in turn.
    - v. In all three cases, continuity should *not* be present.

If continuity is *not* present in all cases, proceed to step 10 below.

If continuity exists between any of the AC bus plug terminals and earth (ground), a short circuit exists somewhere between the stator windings and earth (ground). Pinpoint the location of the short circuit as follows:

- i. Expose the entire length of the AC output bus by removing the seats, side panels and fuel tank.
  - ii. The AC output bus consists of three yellow wires running from the top rear of the engine/gearbox assembly to the grey input terminal of the voltage regulator/rectifier. Inspect and repair as follows:
    - a. Carefully inspect all three wires for breakage or cracking/chafing of the wiring insulation, and consequent contact with any metal parts.
    - b. If such damage is found, re-solder, re-insulate and physically shield the affected wiring in such a way that it cannot be re-damaged.
    - c. Re-test the alternator using all tests in this section.
  - iii. If no damage to the AC output bus wiring is found in the step above, the short circuit probably exists between the alternator stator windings and the stator chassis, most likely as a result of breakdown of the stator winding insulation. Refer to section 5.2 (Replacing or repairing the alternator) for alternator repair or replacement.
10. If the alternator passes all tests described above, test the alternator's raw AC output as follows:
    - i. Ensure that the battery has sufficient charge to start the engine. If it does not, charge or replace the battery.
    - ii. Improvise a suitable test load by connecting a length of electrical flex to each terminal of a 12 Volt, 55 Watt, two-pin tungsten-filament headlight bulb, such as an H3 or H7.
    - iii. Set the multimeter to the *200 VAC voltage* setting.

- iv. With the AC output bus plug disconnected from the voltage regulator/rectifier, start the engine.

**WARNING:** During the test step below, do not allow any of the bare ends of electrical flex to touch one another while the engine is running. Doing so may cause a high-voltage electrical arc, and may also damage the stator.

- v. With the engine running, insert the free end of each length of electrical flex into the terminals of the AC output bus plug terminals as follows:
- 1 and 2.
  - 1 and 3.
  - 2 and 3.
- vi. With the test bulb connected between each pair of AC output terminals as in step v. above, measure the AC voltage between each pair of stator windings by touching the multimeter probes to the terminals occupied by the lengths of electrical flex. (In other words, if the test load is connected between terminals 1 and 2, AC voltage should likewise be measured between terminals 1 and 2).
- In all three cases, a voltage readout of between 60 VAC and 70 VAC should be seen.
- vii. With the test bulb connected between each pair of terminals as described in step v. above, slowly increase the engine speed from idle to approximately 1 800 RPM. The bulb brightness should steadily increase in proportion to engine speed.

**Caution:** Do not exceed 2 000 RPM with the bulb connected. Doing so may destroy the bulb.

- viii. Stop the engine and turn off the ignition switch.

A test result of between 60 VAC and 70 VAC in all cases above indicates that the alternator is in optimal condition. Proceed to step 4.4 ([Testing the voltage regulator/rectifier](#)).

If the AC voltage is substantially lower than 60 VAC to 70 VAC in any individual case or in all cases, it is probable that a short circuit exists between portions of the stator windings, or between the stator windings and the stator chassis. Refer to section 5.2 ([Replacing or repairing the alternator](#)) for alternator repair or replacement.

**Important:** Alternator stator failure frequently results in oxidized insulation separating from the copper wiring of the stator windings. This leads to contamination of the engine oil.

If a failed stator is being replaced, the engine oil and oil filter must be replaced at the same time.

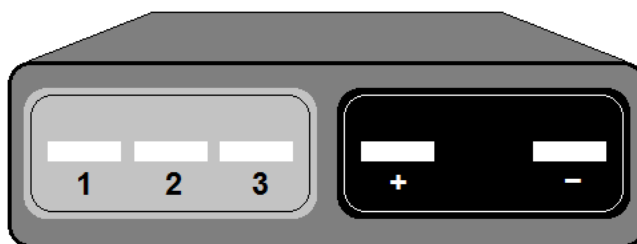
## 4.4 Testing the voltage regulator/rectifier

The voltage regulator/rectifier is a metal-oxide silicon field-effect transistor (MOSFET) type manufactured by Shindengen. Two part numbers are in circulation: FH012AA and FH020AA.

Test the voltage regulator/rectifier for correct functioning as follows:

1. On all RT models, and on all models equipped with Dynamic ESA, remove the plastic panel covering the rear suspension load sensor, and displace the voltage regulator/rectifier unit from its regular position as described in section 4.2 ([Output voltage test](#)).
2. Disconnect the grey three-pin plug and the black two-pin plug from the voltage regulator/rectifier.
3. Place the voltage regulator/rectifier on a flat surface in such a way that the smooth aluminium side faces downward, and all input and output terminals are clearly visible.

4. For purposes of testing the regulator/rectifier unit, all terminals are designated as follows when facing the terminal blocks:



- 1, 2 and 3 are the AC bus input terminals.
  - + and – are the DC bus output terminals.
5. Check all male terminals on the voltage regulator/rectifier, and all female terminals on the black and grey wiring harness plugs, for good contact and signs of contamination with foreign matter, corrosion, and oxidation. If any abnormal conditions are present, correct them before proceeding.
6. Set the multimeter to the *diode test* (continuity) setting.

It is important that, in the following tests, the probes be applied to the terminals only as described.

**Note:** The readings noted in the following tests may change according to variations in ambient temperature.

#### **Test 1:**

1. Touch the positive (red) test probe to the '-' terminal.
2. Touch the negative (black) test probe to AC bus terminals 1, 2 and 3 in turn. Write down the readings.
3. All resistance readings should be within an approximate range of 460 to 480 Ohms. All resistance readings should be identical or nearly identical. Any other conditions indicate test failure.

#### **Test 2:**

1. Touch the positive (red) test probe to the '+' terminal.
2. Touch the negative (black) test probe to AC bus terminals 1, 2 and 3 in turn. Continuity must *not* be present. Any other condition indicates test failure.

#### **Test 3:**

1. Touch the negative (black) test probe to the '-' terminal.
2. Touch the positive (red) test probe to AC bus terminals 1, 2 and 3 in turn. Continuity must *not* be present. Any other condition indicates test failure.

#### **Test 4:**

1. Touch the negative (black) test probe to the '+' terminal.
2. Touch the positive (red) test probe to AC bus terminals 1, 2 and 3 in turn. Write down the readings.
3. All resistance readings should be within an approximate range of 103 to 105 Ohms. All resistance readings should be identical or nearly identical. Any other conditions indicate test failure.

Any failure condition registered in the tests above indicates failure of a diode bridge within the regulator/rectifier unit. In case of any failure condition, the failed regulator/rectifier unit must be replaced.

## **5 Procedures for component replacement**

### **5.1 Replacing the voltage regulator/rectifier**

The same voltage regulator/rectifier (BMW part number 12 31 8 523 367, Shindengen part numbers FH012AA or FH020AA) is common to all liquid-cooled R1200GS, R1200GS Adventure, R1200R, R1200RS and R1200RT models. A good used voltage regulator/rectifier previously fitted to any 2013-onward R-series motorcycle may be removed and

fitted to any other. Alternatively, a generic five-pin voltage regulator/rectifier, intended for any motorcycle of the same alternator wattage output or higher, may be fitted.

The voltage regulator/rectifier is located on the underside of the plastic tray below the engine ECU, under the rider's seat, and is secured by two screws. On all R-series models, the voltage regulator/rectifier can be removed and replaced as follows:

1. Turn off the motorcycle's ignition switch.
2. On all RT models, and on all other models equipped with Dynamic ESA, remove the plastic panel covering the rear suspension load sensor as described in section 4.2 ([Output voltage test](#)).
3. Remove the two T25 Torx screws, and lower the regulator/rectifier down and out of its stowed location.
4. Disconnect the grey three-pin plug and the black two-pin plug from the voltage regulator/rectifier.
5. Installation is a reverse of removal.

Alternatively, the faulty Shindengen regulator/rectifier can be replaced with a generic five-pin regulator/rectifier. Source the generic five-pin voltage regulator/rectifier from any good aftermarket motorcycle spares supplier. Specifications for the generic regulator/rectifier must be as follows:

- The unit must be capable of nominal current output of approximately 14.4 VDC.
- The unit must be capable of accepting a minimum of 70 VAC, for minimum total power handling of 510 Watts @ 12 volts DC.
- The unit must possess three AC input terminals and two 12 VDC output terminals.

## 5.2 Replacing or repairing the alternator stator

**IMPORTANT:** If a failed stator is to be re-wound, the contractor performing the rewinding must be informed that the stator should only be re-wound using the original winding pattern. Any deviation from the factory winding pattern will result in sub-standard alternator output.

Replacing the alternator stator on liquid-cooled R-series motorcycles is a time-consuming and complicated task. Therefore, owners may want to consider having this task done by a BMW Motorrad dealer, or by an independent workshop familiar with these motorcycles.

The same alternator assembly is common to all liquid-cooled R1200GS, R1200GS Adventure, R1200R, R1200RS and R1200RT models. Therefore, a good used alternator previously fitted to any of these motorcycles may be removed and fitted to any other.

Early model LC R-series motorcycles used BMW part number 12 31 8 526 908. Later, the alternator was supplanted by an improved alternator (BMW part number 12 31 7 724 032) as a running change. If possible, the improved alternator should be used.

Alternatively, a faulty alternator stator can be rebuilt by any armature rewinding company capable of rebuilding alternators and starter motors. This route is typically much less expensive, with a shorter turn-around time, than buying a new genuine part.

**Tip:** If ordering a new alternator stator from a BMW Motorrad dealer, order the part well in advance of the planned repair date. BMW Motorrad dealers typically do not keep stock of high-value, low-turnover parts, and waiting periods for special orders can be lengthy.

If replacing or repairing the alternator on a do-it-yourself basis, refer to the appropriate BMW REPROM (BMW part number 01 59 8 555 666) for the alternator replacement procedure.

## 6 How to prevent future alternator and voltage regulator/rectifier problems

The risk of alternator stator failure on liquid-cooled R-series engines can be minimized as follows:

1. If the fuel tank is removed from the motorcycle, shield the AC output bus wiring from damage, and route the AC output bus wiring to the voltage regulator/rectifier only as per the original wiring-harness routing pattern specified by BMW Motorrad.
2. Liquid-cooled R-series boxer engines are vulnerable to excessive heat loads. If possible, do not run the motorcycle under conditions of excessive heat. For example:
  - Do not let the engine idle at zero vehicle speed for more than ten minutes.
  - Do not run the engine under high-throttle, high-load, low vehicle-speed conditions.
  - Do not ride the motorcycle at higher than legal freeway speeds for long periods under ambient temperatures of more than approximately 35 degrees C. (During such conditions, average engine temperatures can easily exceed 95 degrees C.)
3. If possible, do not fit the motorcycle with electrical accessories which may cause excessive current draw. This may place an excessive load on the alternator.
4. Do not exceed the specified engine-oil replacement intervals. Doing so causes acids and petroleum residues to build up in the engine oil. This creates a corrosive condition in which the insulation of the stator windings can deteriorate.
  - Change the engine oil and engine oil filter at the intervals specified by BMW Motorrad.
  - Use only premium-quality, fully-synthetic, motorcycle-specific engine oils, such as Castrol Power 1 Racing.