

Repair of compact throttle-position sensor

All BMW models not equipped with fly-by-wire throttle, model-year 2004 onward

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Introduction and rationale

Most BMW motorcycles dating from 2004 are equipped with a fuel-injection system utilizing a compact Throttle-Position Sensor (hereafter TPS), BMW part number 7 696 412. This sensor is mounted in a position where it can receive actuation from the throttle-butterfly spindle. The sensor's function is to relay a corresponding throttle-position signal to the engine ECU, enabling accurate fuel metering via the fuel injectors.

The TPS is a potentiometer (a type of rheostat, also known as a variable resistor) which sends an electrical signal of varying current to the engine ECU, depending on the prevailing position of the throttle butterfly valve. To send the throttle-position signal, the TPS uses very fine steel-wire brushes moving on carbon 'tracks'. The greater the effective length of the track the brush is on, the greater the resistance.

The TPS is arguably the most critical sensor upon which electronic engine-management functionality relies. If a TPS signal is not received by the engine ECU, the engine will not run. The TPS is an extremely sensitive component, and should its internals be contaminated with dirt or water, it is likely that the resistance value being read by the ECU will be outside the parameters the engine ECU is programmed to accept. Under these conditions, the indications listed below will start to manifest.

Malfunction or failure of the compact throttle-position sensor is a known product issue on BMW motorcycles. It is a much more frequent occurrence on motorcycles where the TPS is mounted in a position where it is exposed to water and physical damage (i.e. on R-series). TPS malfunction and failure is much rarer on in-line-engined BMWs where the TPS is protected by frame spars and/or body panels (i.e. K-series and F-series).

Indications

1. Where the TPS malfunctions (particularly due to water ingress), symptoms may include:
 - Erratic throttle response (the engine may 'snatch' or 'jerk' at low revs).
 - Misfires at low engine speeds and under acceleration.
 - The engine dies at idle, and can only be kept idling by keeping the throttle above idle position.
 - Grey exhaust smoke when starting from cold.
 - Higher-than-normal fuel consumption which seems to start quite suddenly.
 - The Master Caution light (yellow triangle) on the motorcycle's instrument cluster will more than likely *not* illuminate, and it is unlikely that a TPS-related fault code will be logged by the ECU.
2. If the TPS suffers catastrophic failure while the engine is not running, the engine will fail to start.
3. If the TPS suffers catastrophic failure while the engine is running, the engine will cut out, and subsequent re-starting will be impossible.

This document illustrates a procedure whereby a malfunctioning or failed TPS (ostensibly an 'un-repairable' component) can be dismantled, inspected for correct operation using commonly-available instruments, and repaired to original standard where necessary, thus eliminating the need to purchase an expensive factory replacement.

This procedure was written with reference to a 2009-model R1200GS. However, the procedure is applicable to all F-series, R-series and K-series motorcycles which utilize the compact TPS.

Note: Certain BMW motorcycles manufactured from approximately model-year 2011 onward are equipped with fly-by-wire throttle. These motorcycles do not possess a separate TPS. To check whether or not the motorcycle possesses a separate TPS, inspect the throttle twist grip. Motorcycles possessing fly-by-wire throttle do not have a conventional throttle cable. There will be an electrical-harness terminal connected to the twist grip pulley.

On motorcycles other than R-series, additional components will have to be temporarily displaced or removed from the motorcycle in order to access the TPS. Should this be the case, refer to the appropriate Haynes manual or BMW workshop manual for your BMW model in order to accomplish component removal, as the appropriate procedure(s) are not described here.

Note that unimpeded access to the relevant throttle body or throttle-body group will be required no matter what motorcycle this repair is performed on.

The information in this technical article is used and adapted at the readers' 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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Equipment List

- Your motorcycle's ignition key.
- Suitable tool(s) to remove and replace the battery terminals (typically either a screwdriver or hex wrench).
- T20 Torx wrench.
- Clean, lint-free cloth.
- Rubber car floor-mat.
- 5.5mm round dowel (in an emergency, an old 5mm metric bolt or screw can be used).
- Magnifying glass.
- Digital multimeter.

Consumables List

- 1x appropriate-sized rubber O-ring, if required (see text for details).
- Unopened bottle of methylated spirits.
- Cotton-wool buds.
- High-quality metal polish (if required).

Procedure

Initial Disassembly

1. Place the motorcycle on its centre stand on a hard, flat, level surface. If the motorcycle is not equipped with a centre stand, engage 1st gear and place it on its sidestand.
2. **R-series:** Remove the rear seat and front seat. Disconnect the battery negative terminal. Ensure that the terminal connector cannot contact the battery terminal.
All other models: Follow the necessary procedures to gain access to the battery. Disconnect the battery negative terminal. Ensure that the terminal connector cannot contact the battery terminal.
3. The TPS is located as follows:
 - **798 cm³ F-series:** The TPS is located on the throttle-body group underneath the engine airbox, behind the right-hand section of the main frame.
 - **2004-early 2013 R-series:** The TPS is located on the left-hand throttle body.
 - **2005-onward K-series fours:** The TPS is located on the throttle-body group underneath the engine airbox, behind the right-hand main frame spar.
4. Disconnect the three-pin electrical connector from the TPS (Red arrow, Figure 1).

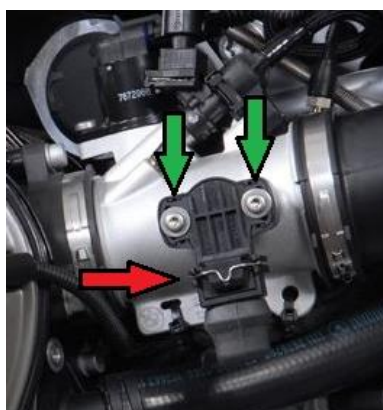


Figure 1

5. Remove the two T20 screws (Green arrows, Figure 1) holding the TPS to the throttle body. Remove the sensor.

Important: Be careful not to misplace or damage the rubber O-ring positioned between the TPS and aluminium throttle body.

6. **CHECK POINT 1:** Examine the rear side of the TPS. There should be a rubber O-ring (Blue arrow, Figure 2) nested in the cavity between the TPS and the aluminium throttle body. Alternatively, the O-ring may be stuck to the throttle body.
 The O-ring is a component whose presence is critical for the TPS to function normally. If the O-ring was absent or is damaged, it is more likely than not that the motorcycle's symptoms are due to internal contamination of the TPS with water.



Figure 2

7. Clean the O-ring well with methylated spirits and a clean, lint-free cloth. Examine the O-ring carefully. If it is perished, cracked or damaged, discard it and replace it with a new one of identical dimensions.
8. Prepare a clean, dry workspace approximately one metre square. Place a pliable but firm buffer (such as a clean rubber car floor mat) on the work surface.
9. Place the TPS on the workspace with its outer side face-up.
10. Holding the TPS down with one hand, use a 5.5mm round dowel (in an emergency, an old 5mm metric bolt or screw can be used) to carefully press out the two steel fastening pins (Yellow arrows, Figure 3) by pushing the pins down and out of the TPS in the direction of its rear side. Figure 3A shows both fastening pins successfully removed.



Figure 3



Figure 3A

11. Holding the TPS face-down over a clean, dry container, carefully separate the two halves of the TPS. The brush spindle - a white plastic part with two small steel brushes - will be exposed (Figure 4).



Figure 4

Caution: The brush spindle is exceptionally delicate and should under no circumstances be damaged or forcibly manipulated.

12. Carefully remove the brush spindle from the TPS body, placing it with the brushes facing upward (Figure 5). Do not touch the brushes at this point.



Figure 5

13. CHECK POINT 2:

- a. Carefully examine the ends of the brush spindle's steel brushes. All brush points should terminate in a uniformly straight line without deviation or kinking, and should be a bright silver-grey, free of discolouration and corrosion (Figures 6A and 6B).

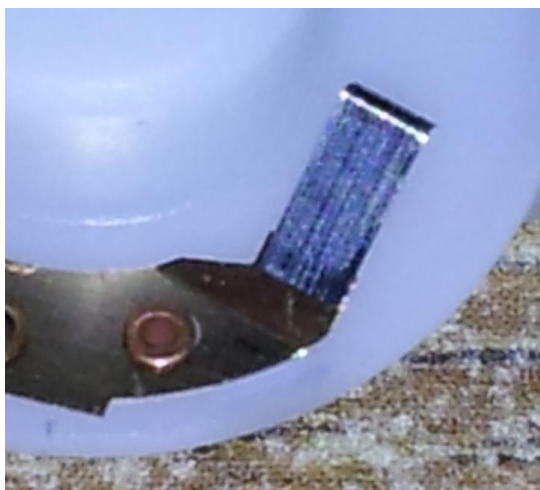


Figure 6A



Figure 6B

- b. If either or both of the brush points are damaged or kinked, the TPS may have suffered impact or have been incompetently repaired at a previous stage.
- c. If either or both of the brush points are discoloured or corroded, it is likely that they have been exposed to water and/or some foreign substance.

14. Place the brush spindle where it cannot be damaged or mislaid.

15. **CHECK POINT 3:** Examine the space between the outer TPS cover and the TPS body. There should be a labyrinthine rubber seal nested in the cavity between the TPS cover and TPS body. Remove the seal, clean it well with methylated spirits and examine it carefully (bottom portion, Figure 7). If any part of the seal is perished, cracked or damaged, it is not available as a separate part from BMW. In this case, two options exist: scavenge a serviceable labyrinthine seal from a non-functional TPS, or replace the entire TPS assembly with a new one.



Figure 7

16. Examine the interior of the TPS (Figure 8), paying special attention to the condition of the carbon tracks for damage and contamination by foreign matter and water. If the motorcycle started exhibiting symptoms after being washed and/or ridden in the rain, water droplets may be seen on or near the carbon tracks.

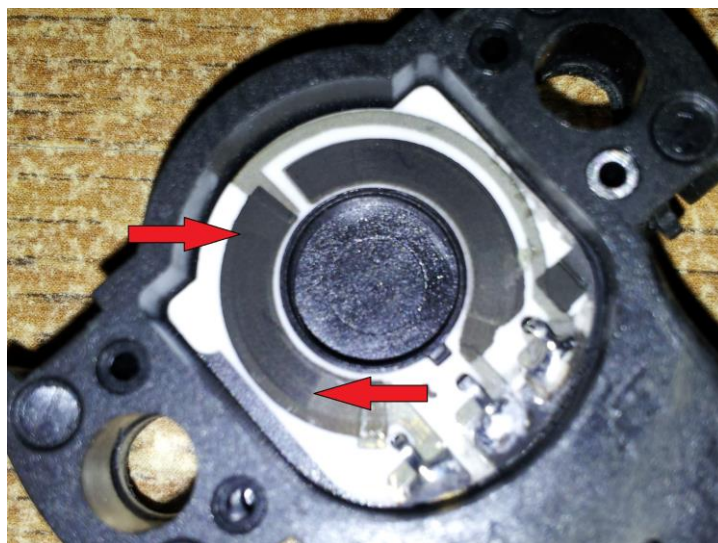


Figure 8

Caution: The following step should be performed only using a freshly-opened bottle of methylated spirits. Methylated spirits contain alcohol which absorbs airborne moisture, possibly resulting in condensation forming on the carbon tracks and/or being trapped by the steel brushes.

17. Open a fresh bottle of methylated spirits. Soak a clean, lint-free cloth in spirits and use this cloth to carefully clean all parts of the TPS interior, paying special attention to the carbon tracks.
18. Allow all alcohol and other fluids to evaporate completely.
19. Using a magnifying glass, carefully examine the carbon tracks. Paths along which steel brushes have travelled should be obvious (the red arrows in Figure 8 above delineate the beginning and end of one of the two brush tracks). If either of the tracks are scored, worn though or have breaks or cracks in them, the TPS body is unserviceable and the TPS will either have to be replaced with a new one or rebuilt using a new main body.
20. Wick any moisture from the steel-brush threads by gently touching a clean, dry cotton-wool bud to the tip of each steel brush, applying minimal pressure.
21. Using a magnifying glass, carefully examine the brushes for any corrosion or discolouration. If there is corrosion and/or discolouration, it may be possible to remove it by dipping the brush ends in a high-quality metal polish, cleaning well with methylated spirits and drying by gently touching a clean, dry cotton-wool bud to the tip of each steel brush.

Cautions: Do not apply water-repellent lubricant, silicone grease or any other substance to the inside of the TPS. Foreign substances change the potentiometer resistance values, causing the TPS to relay 'corrupt' signals to the engine ECU.

Do not apply petroleum jelly or similar substances to the rubber seal and/or O-ring. Such substances will destroy any rubber-containing parts.

Do not apply silicone sealants containing acids to the rubber seal and/or O-ring. The acid is released as the sealant cures, and will corrode the brushes and/or damage the carbon tracks.

22. **CHECK POINT 4 (DIAGNOSTICS, PART 1):** Set the digital multimeter to the *continuity* setting. Test for positive continuity between:

- a. The contact points of the two steel brushes (Yellow arrows, Figure 9A).
If an open circuit is indicated, the brush spindle must be replaced. Repairs will result in unacceptable changes to the brush spindle resistance values.
- b. Terminal 1 and it's associated solder point (Bottom red arrow and left-hand Green arrow, Figure 9B).
- c. Terminal 2 and it's associated solder point (Middle red arrow and middle Green arrow, Figure 9B).
- d. Terminal 3 and it's associated solder point (Top red arrow and right-hand Green arrow, Figure 9B).
If an open circuit is indicated between any terminal and it's solder point, the TPS main body must be replaced.

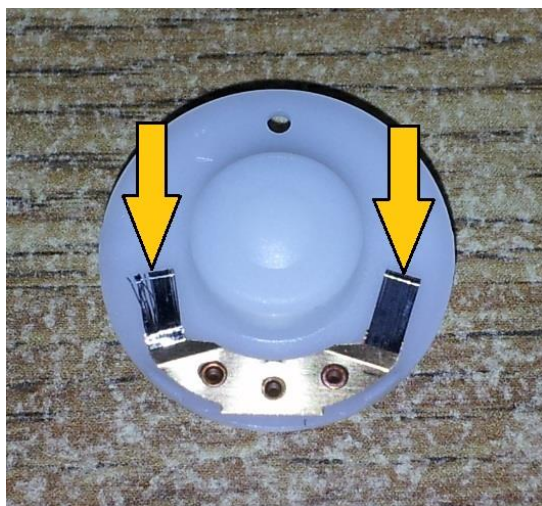


Figure 9A



Figure 9B

23. Replace the labyrinthine rubber seal into the TPS cover in its correct orientation (Figure 10).



Figure 10

24. Holding the TPS face-up over a clean, dry container, carefully replace the brush spindle into the main TPS body. The steel brushes should contact the carbon tracks, and the detent (Green arrow) should face toward the sensor's terminals (Figure 11).



Figure 11

25. Carefully replace the TPS cover over the main body (Figure 12). Ensure that there is no conflict between the cover and the brush spindle interface.



Figure 12

26. Ensure that the brush spindle interface (the white plastic portion) is visible as in Figure 12. Use a suitable tool to gently rotate the brush spindle to full lock in both directions, as in Figures 13A and 13B. The spindle should turn freely and very easily in both directions. If it does not, do not force it - stop and investigate the problem.



Figure 13A



Figure 13B

27. Holding the two halves of the TPS together, press the two steel fastening pins into the body of the TPS from the rear (cover) side. Each pin should 'snap' into place with only moderate pressure from a thumb.

28. **CHECK POINT 5 (DIAGNOSTICS, PART 2):**

Note that for this step, the TPS terminals are numbered 1, 2 and 3 as per Figure 14.

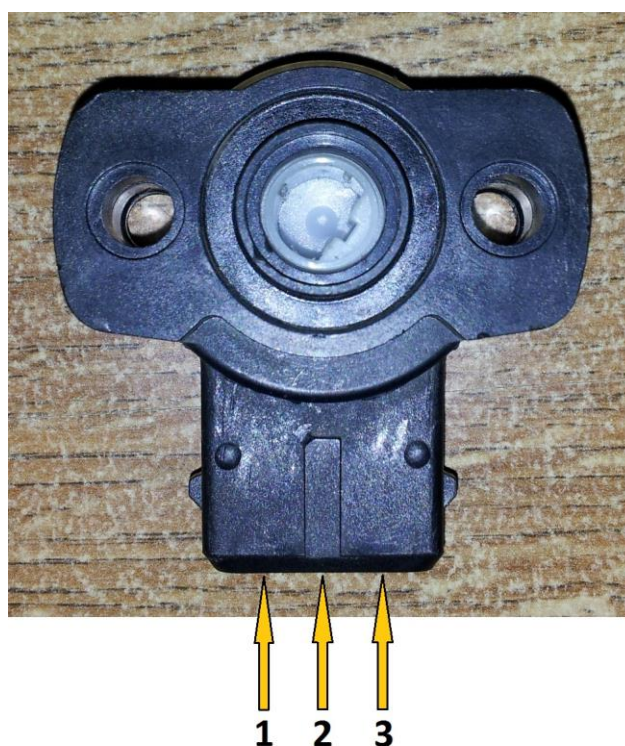


Figure 14

- a. Place the TPS on a firm surface. The brush spindle interface must face upward, and the three electronic terminals must face the person performing the test as in Figure 14. Set the digital multimeter to the 200 k Ω setting.
 1. With the brush spindle turned to it's fully clockwise position:
Indicated resistance between terminals 1 and 2 should read approximately 5.3.
Indicated resistance between terminals 1 and 3 should read approximately 4.4.
Indicated resistance between terminals 2 and 3 should read approximately 0.7.
 2. With the brush spindle turned to it's fully anti-clockwise position:

Indicated resistance between terminals 1 and 2 should read approximately 0.9.
 Indicated resistance between terminals 1 and 3 should read approximately 0.9.
 Indicated resistance between terminals 2 and 3 should read approximately 1.5.

3. Alternately holding the positive and negative multimeter probes between terminals 1 & 2, 1 & 3, and 2 & 3, very slowly rotate the brush spindle from fully anti-clockwise to clockwise and back again.

Watch the multimeter display carefully as this test is performed. Resistance values should progress evenly from their indicated minimum to their indicated maximum. At no stage during spindle rotation should the display indicate an open circuit (on multimeters, this is usually indicated by an 'I' (Infinite resistance), or 'OL' (Open Line) on the display).

29. Place the rubber O-ring into the cavity around the TPS's brush spindle interface (Figure 15). Ensure it does not fall out as the next step is performed.



Figure 15

30. Carefully replace the TPS on the engine's throttle body with the electrical terminals facing downward, ensuring that the TPS spindle protruding from the throttle body mates correctly with the TPS brush spindle interface. When you are certain that the two parts are in perfect alignment, push the TPS gently but firmly to seat it against the throttle body.
31. Ensure that the two T20 screws holding the TPS to the throttle body are equipped with appropriate washers. Insert and fasten the T20 screws to the correct torque value.
32. Re-connect the three-pin electrical connector to the TPS.
33. Re-connect the battery negative terminal.
34. Turn on the motorcycle's ignition switch and kill switch. Do not start the engine at this time. Turn the throttle from rest to fully open, then release it so that it comes back to the rest position. Repeat this step once or twice. Turn off the ignition switch.
35. Remove the ignition key. Leave the motorcycle to stand for one minute.
36. Re-insert the ignition key. Turn on the ignition and start the motorcycle. If all procedures have been performed correctly, the motorcycle should start, idle and run normally, with no symptoms.
37. If all is in order at this point, the motorcycle must be taken to a BMW Motorrad dealer so that the TPS resistance values can be matched to the engine ECU, particularly if a replacement TPS or components have been fitted.
 Alternatively, the TPS matching procedure can be performed using a Hexcode GS911 diagnostic tool if one is available.

Tip: On R-series motorcycles, the TPS can be effectively shielded from physical damage by using an aftermarket TPS cover made from aluminium or stainless steel.

It is recommended that only TPS covers utilizing three mounting points instead of the conventional two be used. A third mounting typically utilizes the hole on the underside of the throttle body which is used to secure the wiring in the immediate area.