| DTC | P2195 | OXYGEN (A/F) SENSOR SIGNAL STUCK LEAN (BANK 1 SENSOR 1) |
|---|---|---|

| DTC | P2196 | OXYGEN (A/F) SENSOR SIGNAL STUCK RICH (BANK 1 SENSOR 1) |
|---|---|---|

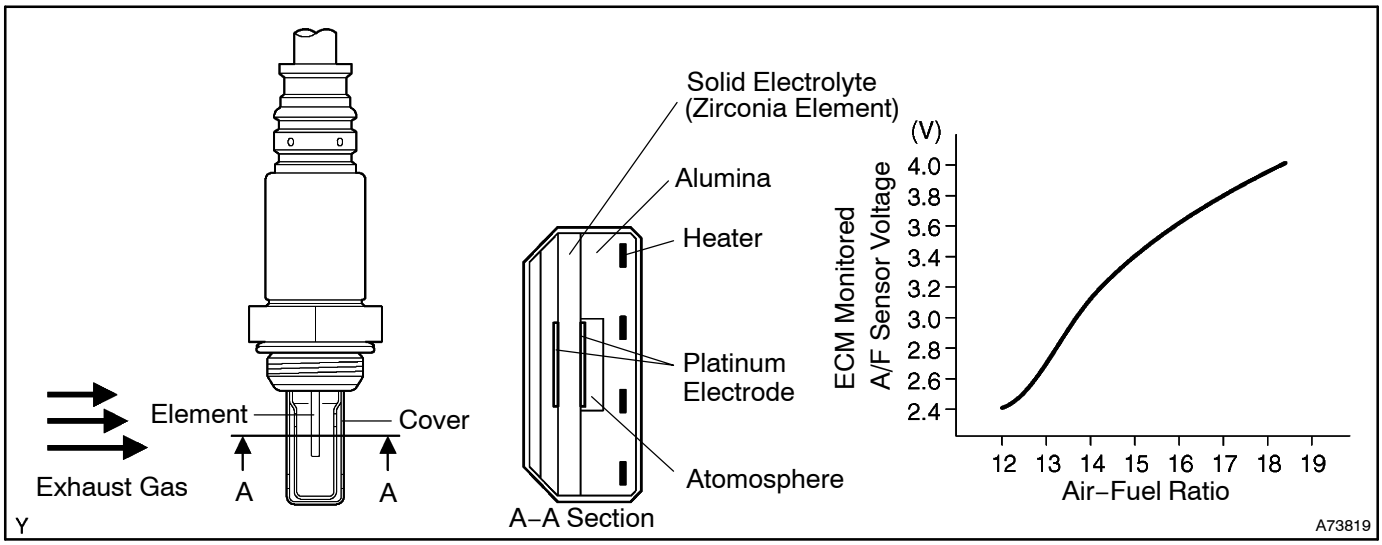
| DTC | P2197 | OXYGEN (A/F) SENSOR SIGNAL STUCK LEAN (BANK 2 SENSOR 1) |
|---|---|---|

| DTC | P2198 | OXYGEN (A/F) SENSOR SIGNAL STUCK RICH (BANK 2 SENSOR 1) |
|---|---|---|

HINT:
These DTCs are recorded when air–fuel ratio (A/F) sensor has a malfunction, although the caption is oxygen sensor.

## CIRCUIT DESCRIPTION

The A/F sensor is the planar type. Compared to the conventional type, the sensor and heater portions of the planar type are narrower overall. Because the heat of the heater is conducted through the alumina to zirconia (of the sensor portion) it accelerates the activation of the sensor.
To obtain a high purification rate of the CO, HC and NOx components of the exhaust gas, a three–way catalytic converter is used. For the most efficient use of the three–way catalytic converter, the air–fuel ratio must be precisely controlled so that it is always close to the stoichiometric air–fuel ratio.
The A/F sensor has the characteristic that it provides output voltage* being approximately proportional to the existing air–fuel ratio. The A/F sensor output voltage* is used to provide feedback for the ECM to control the air–fuel ratio.
By the A/F sensor output, the ECM can determine the deviation amount from the stoichiometric air–fuel ratio and control the proper injection time immediately. If the A/F sensor is out of order, ECM is unable to perform the accurate air–fuel ratio control.
The A/F sensor is equipped with a heater which heats the zirconia element. The heater is controlled by the ECM. When the intake air volume is low (the temperature of the exhaust gas is low), the current flows to the heater to heat the sensor for the accurate oxygen concentration detection.
*: The voltage value changes at the inside of the ECM only.

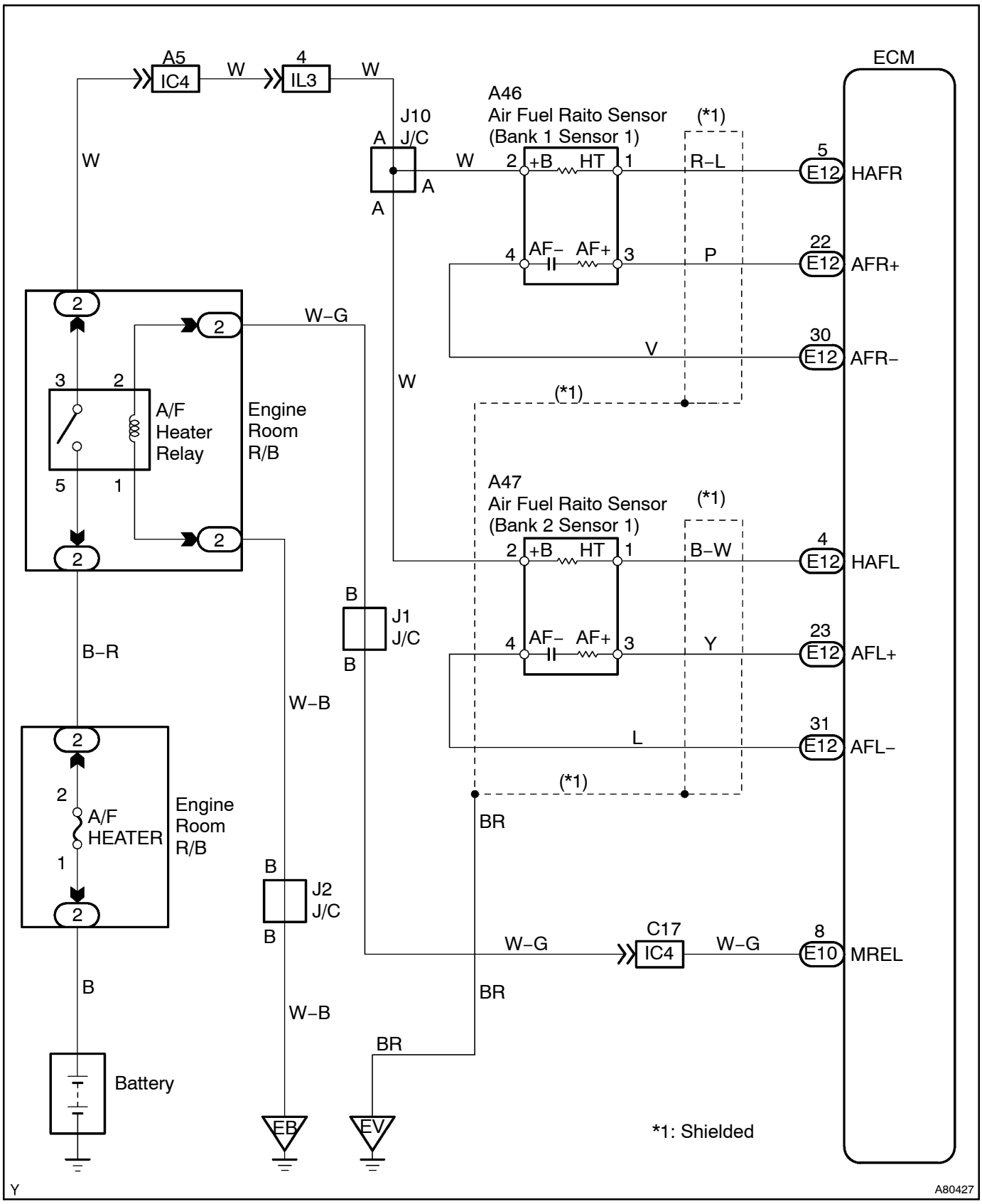


| DTC No. | DTC Detecting Condition | Trouble Area |
|---|---|---|
| P2195<br>P2197 | Condition (a) continues for 10.0 sec. or more :<br>(a) AF sensor voltage > 3.8 V | • Open or short in A/F sensor (bank 1, 2 sensor 1) circuit<br>• A/F sensor (bank 1, 2 sensor 1)<br>• A/F sensor heater<br>• A/F sensor heater relay<br>• A/F sensor heater and relay circuit<br>• Air induction system<br>• Fuel pressure<br>• Injector<br>• ECM |
| P2196<br>P2198 | Condition (a) continues for 10.0 sec. or more :<br>(a) AF sensor voltage < 2.8 V | |

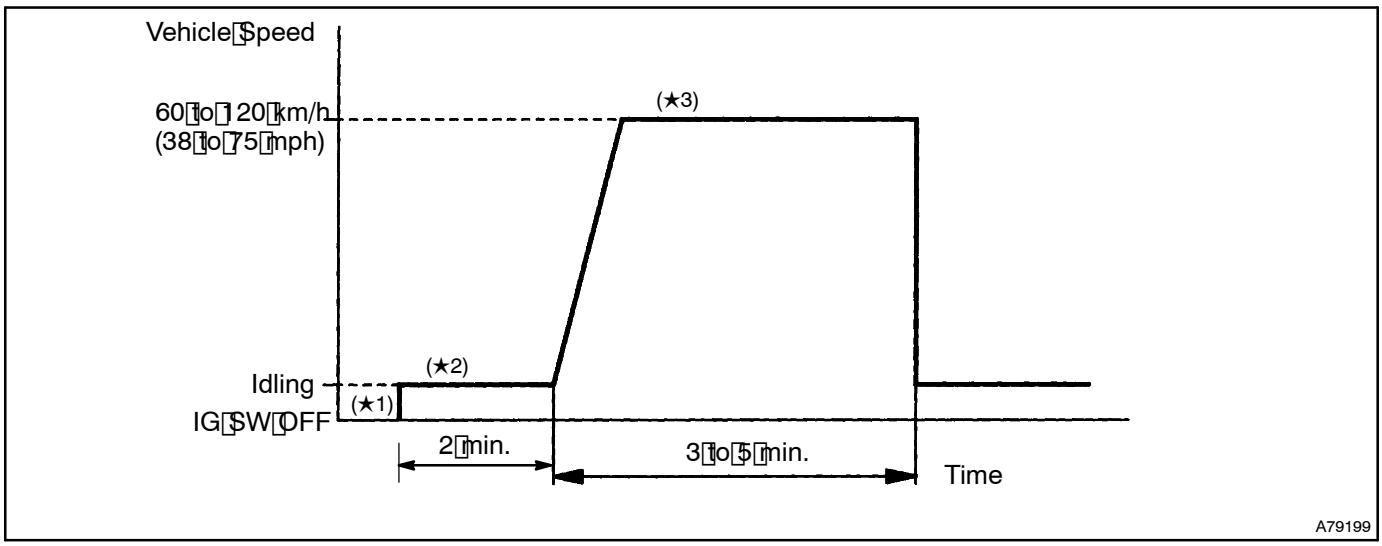
HINT:

- DTCs P2195 and P2196 means malfunction related to the bank 1 A/F sensor circuit.
- DTCs P2197 and P2198 means malfunction related to the bank 2 A/F sensor circuit.
- Bank 1 refers to the bank that includes cylinder No. 1.
- Bank 2 refers to the bank that includes cylinder No. 2.
- Sensor 1 refers to the sensor closest to the engine assembly.
- After confirming DTC P2195, P2196, P2197 and P2198 use the hand−held tester to confirm voltage output of A/F sensor (AFS B1 S1/AFS B2 S1) from the ”DIAGNOSIS / OBD/MOBD / DATA LIST / ALL”.
- The A/F sensor’s output voltage and the short−term fuel trim value can be read using the OBD II scan tool or the hand−held tester.
- The ECM controls the voltage of the AFR+, AFL+, AFR− and AFL− terminals of the ECM to the fixed voltage. Therefore, it is impossible to confirm the A/F sensor output voltage without the hand−held tester.

# WIRING DIAGRAM



## CONFIRMATION DRIVING PATTERN




1. **Connect the hand–held tester to the DLC3.(★1)**
2. **Switch the hand–held tester from the normal mode to the check mode (See page 05–7).(★1)**
3. **Start the engine and warm it up with all the accessory switches OFF.(★2)**
4. **Drive the vehicle at 60 to 120 km/h (38 to 75 mph) and engine speed at 1,400 to 3,200 rpm for 3 to 5 min.(★3)**

HINT:
If a malfunction exists, the CHK ENG will illuminate during step (★3)

**NOTICE:**
**If the conditions in this test are not strictly followed, detection of the malfunction will not be possible.**
**If you do not have a hand–held tester, turn the ignition switch OFF after performing steps (★2) and (★3), then perform steps (★2) and (★3) again.**

## INSPECTION PROCEDURE

HINT:
Hand–held tester only:
Narrowing down the trouble area is possible by performing ACTIVE TEST of the following ”A/F CONTROL” (A/F sensor, heated oxygen sensor or other trouble areas can be distinguished).

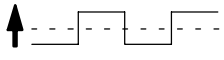
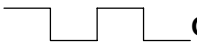
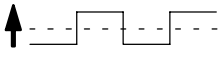
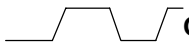
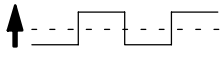
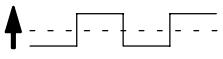
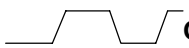
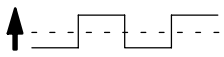
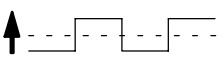
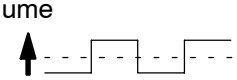
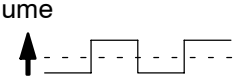
(a) Perform ACTIVE TEST by the hand–held tester (A/F CONTROL).

HINT:
”A/F CONTROL” is an ACTIVE TEST which changes the injection volume to –12.5 % or +25 %.

(1) Connect the hand–held tester to the DLC3 on the vehicle.
(2) Turn the ignition switch ON.
(3) Warm up the engine with the engine speed at 2,500 rpm for approx. 90 sec.
(4) Select the item ”DIAGNOSIS / OBD/MOBD / ACTIVE TEST / A/F CONTROL”.
(5) Perform ”A/F CONTROL” when idle condition (press the right or left button).

**Result:**
**A/F sensor reacts in accordance with increase and decrease of injection volume:**
**+25 % → rich output: Less than 3.0 V**
**–12.5 % → lean output: More than 3.35 V**
**Heated oxygen sensor reacts in accordance with increase and decrease of injection volume:**
**+25 % → rich output: More than 0.55 V**
**–12.5 % → lean output: Less than 0.4 V**

**NOTICE:**
**There is a few second delay in the A/F sensor output and there is about 20 seconds delay in the heated oxygen sensor output.**

| | Output voltage of A/F sensor (sensor 1) | Output voltage of heated oxygen sensor (sensor 2) | Mainly suspect trouble area |
|---|---|---|---|
| Case 1 | Injection volume<br>+25 %<br>–12.5 %<br><br>Output voltage<br>More than 3.35 V<br>Less than 3.0 V<br><br>**OK** | Injection volume<br>+25 %<br>–12.5 %<br><br>Output voltage<br>More than 0.55 V<br>Less than 0.4V<br><br>**OK** | — |
| Case 2 | Injection volume<br>+25 %<br>–12.5 %<br><br>Output voltage<br>No reaction<br>**NG** | Injection volume<br>+25 %<br>–12.5 %<br><br>Output voltage<br>More than 0.55 V<br>Less than 0.4V<br><br>**OK** | A/F sensor<br>(A/F sensor, heater, A/F sensor circuit) |
| Case 3 | Injection volume<br>+25 %<br>–12.5 %<br><br>Output voltage<br>More than 3.35 V<br>Less than 3.0V<br><br>**OK** | Injection volume<br>+25 %<br>–12.5 %<br><br>Output voltage<br>No reaction<br>**NG** | Heated oxygen sensor<br>(heated oxygen sensor, heater, heated oxygen sensor circuit) |
| Case 4 | Injection volume<br>+25 %<br>–12.5 %<br><br>Output voltage<br>No reaction<br>**NG** | Injection volume<br>+25 %<br>–12.5 %<br><br>Output voltage<br>No reaction<br>**NG** | Extremely rich or lean of the actual air–fuel ratio<br>(Injector, fuel pressure, gas leakage in exhaust system, etc.) |

The following procedure of A/F CONTROL enables the user to check its output (show its graph indication) of A/F sensor and heated oxygen sensor.
For displaying the graph indication, enter ”ACTIVE TEST/ A/F CONTROL/USER DATA”, then select ”AFS B1S1 and O2S B1S2” or ”AFS B2S1 and O2S B2S2” by pressing ”YES” button and push ”ENTER” button before pressing ”F4” button.
HINT:

- If DTC P2195 or P2196 is displayed, check the bank 1 sensor 1 circuit.
- If DTC P2197 or P2198 is displayed, check the bank 2 sensor 1 circuit.
- A low A/F sensor voltage could be caused by a rich air fuel mixture. Check for conditions that would cause the engine to run rich.
- A high A/F sensor voltage could be caused by a lean air fuel mixture. Check for conditions that would cause the engine to run lean.
- Read freeze frame data using the hand–held tester, as freeze frame data records the engine conditions when a malfunction is detected. When troubleshooting, it is useful for determining whether the vehicle was running or stopped, the engine was warmed up or not, the air–fuel ratio was lean or rich, etc. at the time of the malfunction.

| 1 | CHECK OTHER DTC OUTPUT (BESIDES A/F SENSOR DTC) |
|---|---|

(a) Read the DTC using the hand–held tester.

**Result:**

| Display | Proceed to |
|---|---|
| A/F sensor circuit DTC are output. | A |
| A/F sensor circuit DTC and other codes are output. | B |

HINT:

If any other codes besides A/F sensor DTC are output, perform the troubleshooting for those DTCs first.

B → **GO TO RELEVANT DTC CHART (See page 05–22)**

A

| 2 | READ VALUE OF HAND–HELD TESTER (OUTPUT VOLTAGE OF A/F SENSOR) |
|---|---|

(a) Connect the hand–held tester to the DLC 3.

(b) Warm up the A/F sensors (bank 1, 2 sensor 1) with the engine at 2,500 rpm for approximately 90 seconds.

(c) Read A/F sensor voltage output on the hand–held tester.

(d) Hand–held tester only:
Select the ”DIAGNOSIS / OBD/MOBD / SNAPSHOT / MANUAL SNAPSHOT / USER DATA” mode on the hand–held tester.

(e) Select ”AFS B1 S1 or AFS B2 S1/ENGINE SPD” and press button ”YES”.

(f) Monitor the A/F sensor voltage carefully.

(g) Check the A/F sensor voltage under the condition as follows.

(1) Allow engine to idle for 30 seconds.

(2) Engine is racing at approx. 2,500 rpm (when engine revolution is not suddenly changed).

(3) Raise the engine speed to 4,000 rpm and release the accelerator pedal fully closed quickly.

**Standard:**

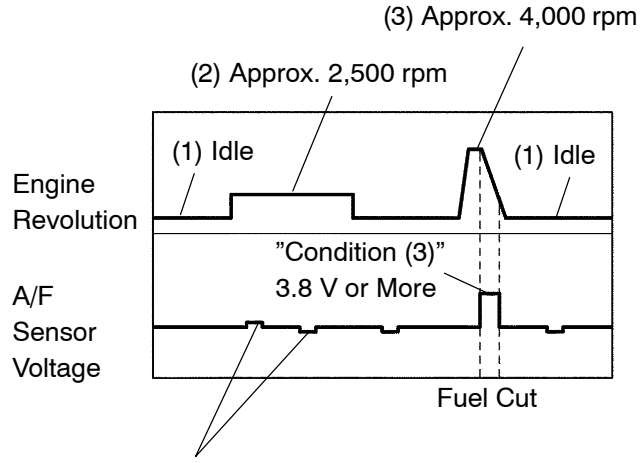
**Condition (1) and (2)**

**Voltage change in the vicinity of 3.3 V (0.66 V)* (between approx. 3.1 to 3.5 V) as shown in the illustration.**

**Condition (3)**

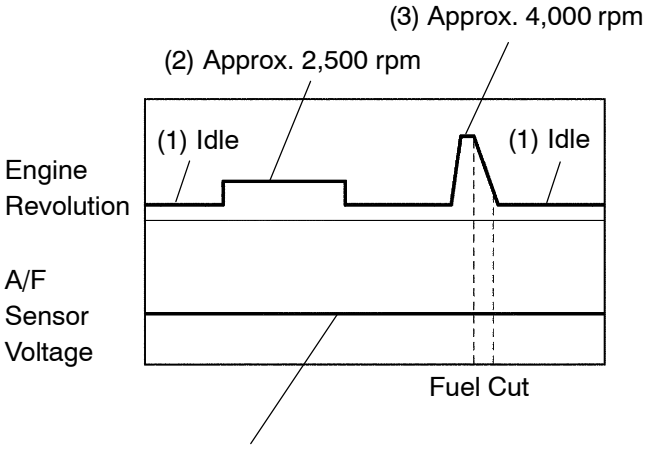
**A/F sensor voltage increase to 3.8 V (0.76 V)* or more during engine deceleration (when fuel cut) as shown in the illustration.**

**Normal Condition**




"Condition (1), (2)"
Change in the vicinity of approx. 3.3 V

**Malfunction Condition**




"Condition (1), (2), (3)"
When A/F sensor circuit is malfunctioning, voltage output does not change

A72304

HINT:

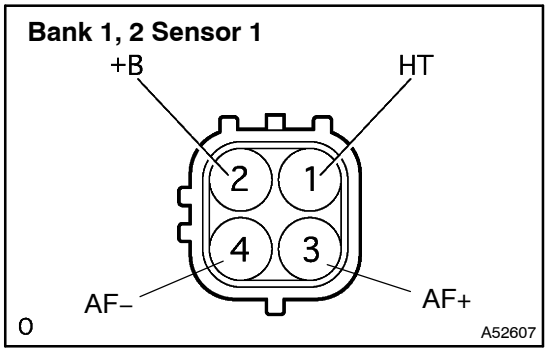
- Whenever the output voltage of the A/F sensor remains at approx. 3.3 V (0.660 V)* (see dwg. 2) under any condition as well as the above conditions, the A/F sensor may have an open–circuit. (This will happen also when the A/F sensor heater has an open–circuit.)
- Whenever the output voltage of the A/F sensor remains at a certain value of approx. 3.8 V (0.76 V)* or more, or 2.8 V (0.56 V)* or less (see dwg. 2) under any condition as well as the above conditions, the A/F sensor may have a short–circuit.
- The ECM will stop fuel injection (fuel cut) during engine deceleration. This will cause a lean condition and should result in a momentary increase in A/F sensor voltage output.
- The ECM must establish a closed throttle position learned value to perform fuel cut. If the battery terminal has been disconnected, the vehicle must be driven over 10 mph to allow the ECM to learn the closed throttle position.
- When the vehicle is driven:
  In the case that the output voltage of the A/F sensor is below 2.8 V (0.76 V)* during fuel enrichment (for example, when the vehicle tries to overtake another vehicle on a highway, the vehicle speed is suddenly increased with the accelerator pedal fully depressed), the A/F sensor is functioning normally.
- The A/F sensor is a current output element, and therefore the current is converted into voltage inside the ECM. If measuring voltage at connectors of A/F sensor or ECM, you will obtain a constant voltage.

*: When not using the hand–held tester.

| | |
|---|---|
| **OK** | **Go to step 13** |

**NG**

## 3 INSPECT AIR FUEL RATIO SENSOR(RESISTANCE OF A/F SENSOR HEATER)

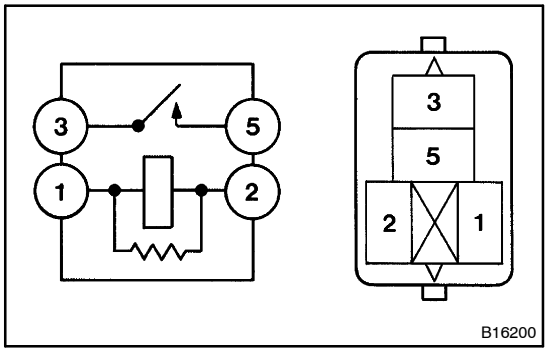



(a) Disconnect the A/F sensor connector.
(b) Measure resistance between terminals HT and +B of the A/F sensor.
**Resistance: 1.8 to 3.4 Ω (20°C)**

**NG** → **REPLACE AIR FUEL RATIO SENSOR**

**OK**

## 4 INSPECT AIR FUEL RATIO SENSOR HEATER RELAY



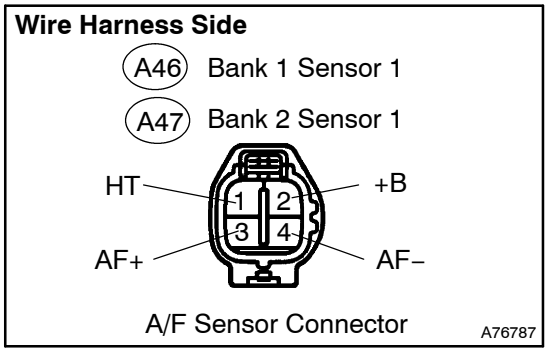

(a) Remove the A/F sensor heater relay from the engine room R/B.
(b) Inspect the A/F senor heater relay.
**Standard:**

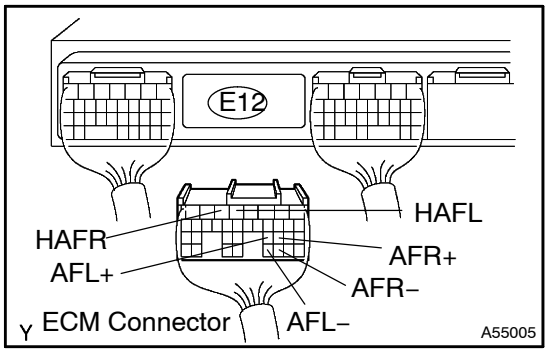
| Terminal No. | Specified condition |
|---|---|
| 1 – 2 | Continuity |
| 3 – 5 | No Continuity |
| | Continuity (Apply battery voltage terminals 1 and 2) |

**NG** → **REPAIR OR REPLACE AIR FUEL RATIO SENSOR HEATER RELAY**

**OK**

## 5 CHECK HARNESS AND CONNECTOR(A/F SENSOR – ECM)




(a) Disconnect the A46 or A47 A/F sensor connector.
(b) Disconnect the E12 ECM connector.
(c) Check for continuity between the wire harness side connectors.

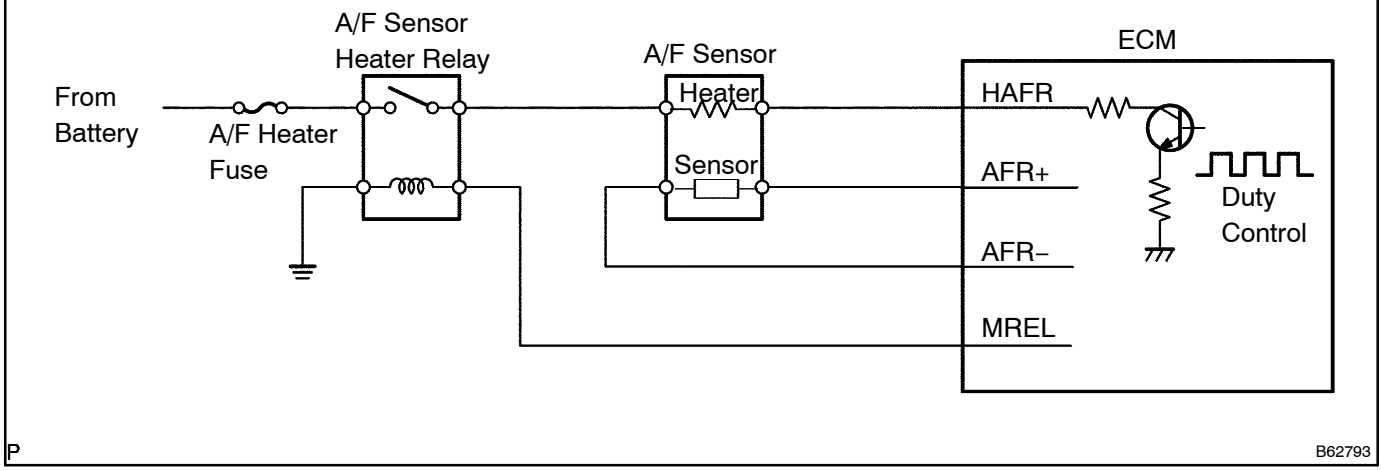
**Standard (Check for open):**

| Symbols (Terminal No.) | Specified condition |
|---|---|
| AF+ (A46–3) – AFR+ (E12–22) | Continuity |
| AF– (A46–4) – AFR– (E12–30) | |
| HT (A46–1) – HAFR (E12–5) | |
| AF+ (A47–3) – AFL+ (E12–23) | |
| AF– (A47–4) – AFL– (E12–31) | |
| HT (A47–1) – HAFL (E12–4) | |

**Standard (Check for short):**

| Symbols (Terminal No.) | Specified condition |
|---|---|
| AF+ (A46–3) or AFR+ (E12–22) – Body ground | No continuity |
| AF– (A46–4) or AFR– (E12–30) – Body ground | |
| HT (A46–1) or HAFR (E12–5) – Body ground | |
| AF+ (A47–3) or AFL+ (E12–23) – Body ground | |
| AF– (A47–4) or AFL– (E12–31) – Body ground | |
| HT (A47–1) or HAFL (E12–4) – Body ground | |

**Reference (Bank 1 Sensor 1 System Drawing)**




NG → REPAIR OR REPLACE HARNESS OR CONNECTOR

OK

| 6 | CHECK AIR INDUCTION SYSTEM |
|---|---|

(a) Check for vacuum leaks in air induction system.

NG → REPAIR OR REPLACE AIR INDUCTION SYSTEM

OK

| 7 | CHECK FUEL PRESSURE (See page 11–5) |
|---|---|

(a) Check fuel pressure (High or low fuel pressure).

NG → REPAIR OR REPLACE FUEL SYSTEM

OK

| 8 | INSPECT FUEL INJECTOR ASSY (See page 11–7) |
|---|---|

(a) Check injector injection (High or low fuel pressure).

NG → REPLACE FUEL INJECTOR ASSY (See page 11–12)

OK

| 9 | REPLACE AIR FUEL RATIO SENSOR |
|---|---|

GO

| 10 | PERFORM CONFIRMATION DRIVING PATTERN |
|---|---|

HINT:
Clear all DTCs prior to perform the confirmation driving pattern.

GO

| 11 | READ OUTPUT DTC (A/F SENSOR DTC OUTPUT AGAIN) |
|---|---|

(a) Read the DTC using the hand–held tester.

**Result:**

| Display | Proceed to |
|---|---|
| A/F sensor circuit DTC are not output. | A |
| A/F sensor circuit DTC are output. | B |

B → CHECK AND REPLACE ECM (See page 01–35) AND PERFORM CONFIRMATION DRIVING PATTERN

A

| 12 | CONFIRM IF VEHICLE HAS RUN OUT OF FUEL IN PAST |
|---|---|

NO → CHECK FOR INTERMITTENT PROBLEMS (See page 05–7)

YES

DTC IS CAUSED BY RUNNING OUT OF FUEL

| 13 | PERFORM CONFIRMATION DRIVING PATTERN |
|---|---|

HINT:
Clear all DTCs prior to perform the confirmation driving pattern.

GO

| 14 | READ OUTPUT DTC (A/F SENSOR DTC OUTPUT AGAIN) |
|---|---|

(a) Read the DTC using the hand–held tester.

**Result:**

| Display | Proceed to |
|---|---|
| A/F sensor circuit DTC are output. | A |
| A/F sensor circuit DTC are not output. | B |

B → Go to step 18

A

| 15 | REPLACE AIR FUEL RATIO SENSOR |
|---|---|

GO

| 16 | PERFORM CONFIRMATION DRIVING PATTERN |
|---|---|

HINT:
Clear all DTCs prior to perform the confirmation driving pattern.

GO

| 17 | READ OUTPUT DTC (A/F SENSOR DTC OUTPUT AGAIN) |
|---|---|

(a) Read the DTC using the hand–held tester.

**Result:**

| Display | Proceed to |
|---|---|
| A/F sensor circuit DTC are not output. | A |
| A/F sensor circuit DTC are output. | B |

B → CHECK AND REPLACE ECM (See page 01–35) AND PERFORM CONFIRMATION DRIVING PATTERN

A

| | |
|---|---|
| 18 | CONFIRM IF VEHICLE HAS RUN OUT OF FUEL IN PAST |

NO → CHECK FOR INTERMITTENT PROBLEMS (See page 05–7)

YES

| |
|---|
| DTC IS CAUSED BY RUNNING OUT OF FUEL |