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)

HINT:
- Although the DTC titles say oxygen sensor, these DTCs relate to the Air-Fuel Ratio (A/F) sensor.
- Sensor 1 refers to the sensor mounted in front of the Three-Way Catalytic Converter (TWC) and located near the engine assembly.

ES

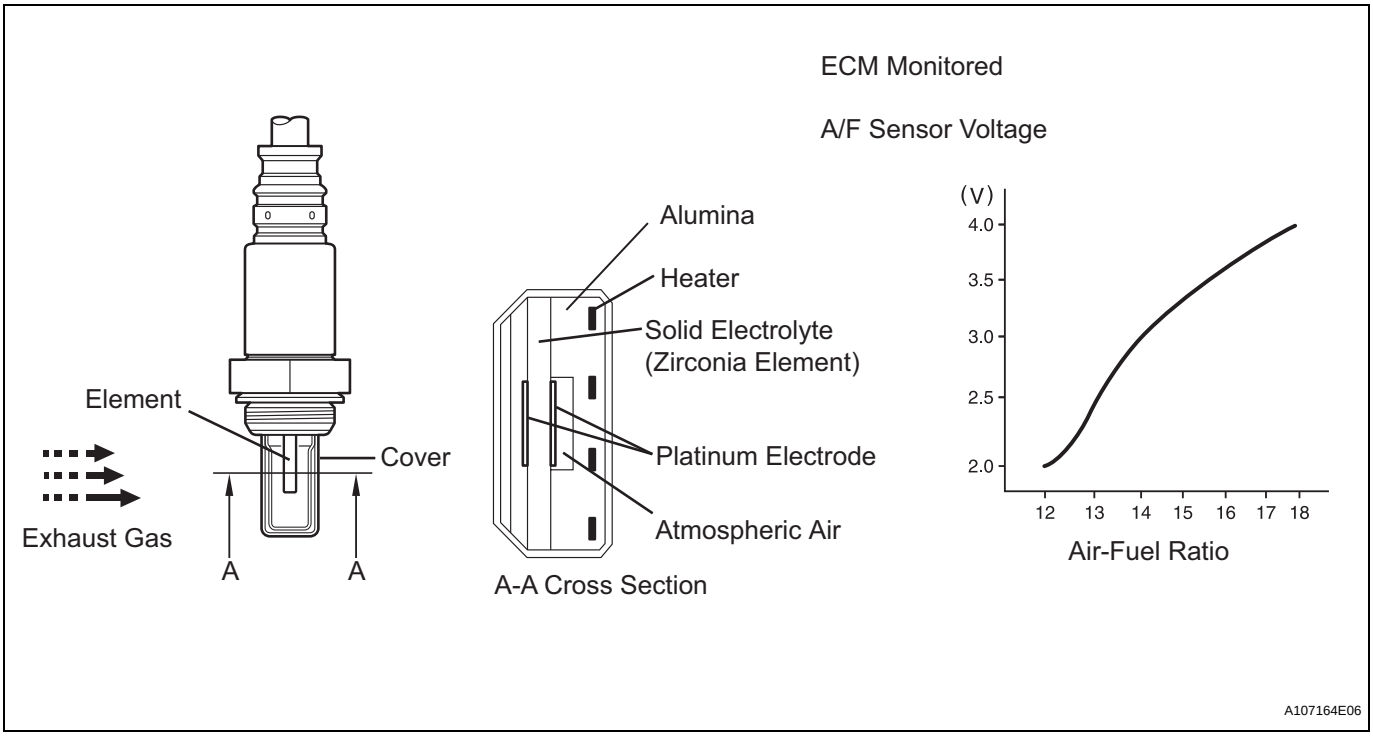
DESCRIPTION

The A/F sensor generates a voltage* that corresponds to the actual air-fuel ratio. This sensor voltage is used to provide the ECM (included in hybrid vehicle control ECU) with feedback so that it can control the air-fuel ratio. The ECM determines the deviation from the stoichiometric air-fuel ratio level, and regulates the fuel injection time. If the A/F sensor malfunctions, the ECM is unable to control the air-fuel ratio accurately.

The A/F sensor is of the planar type and is integrated with the heater, which heats the solid electrolyte (zirconia element). This heater is controlled by the ECM. When the intake air volume is low (the exhaust gas temperature is low), a current flows into the heater to heat the sensor, in order to facilitate accurate air-fuel ratio detection. In addition, the sensor and heater portions are narrower than the conventional type. The heat generated by the heater is conducted to the solid electrolyte through the alumina, therefore the sensor activation is accelerated.

A three-way catalytic converter (TWC) is used in order to convert the carbon monoxide (CO), hydrocarbon (HC), and nitrogen oxide (NOx) into less harmful substances. To allow the TWC to function effectively, it is necessary to keep the air-fuel ratio of the engine near the stoichiometric air-fuel ratio.

*: Value changes inside the ECM. Since the A/F sensor is the current output element, a current is converted into a voltage inside the ECM. Any measurements taken at the A/F sensor or ECM connectors will show a constant voltage.



DTC No.	DTC Detection Conditions	Trouble Areas
P2195	Conditions (a) and (b) continue for 10 seconds or more (2-trip detection logic): (a) A/F sensor voltage more than 3.8 V (b) Heated Oxygen (HO2) sensor voltage 0.15 V or more	• Open or short in A/F sensor (sensor 1) circuit • A/F sensor (sensor 1) • A/F sensor heater (sensor 1) • Integration relay (EFI MAIN relay) • A/F sensor heater and EFI MAIN relay circuits • Hybrid vehicle control ECU
	While fuel-cut operation performed (during vehicle deceleration), A/F sensor current 3.6 mA or more for 3 seconds (2-trip detection logic)	• A/F sensor • Hybrid vehicle control ECU
P2196	Conditions (a) and (b) continue for 10 seconds or more (2-trip detection logic): (a) A/F sensor voltage less than 2.8 V for 10 seconds (b) HO2 sensor voltage less than 0.6 V	• Open or short in A/F sensor (sensor 1) circuit • A/F sensor (sensor 1) • A/F sensor heater (sensor 1) • Integration relay (EFI MAIN relay) • A/F sensor heater and EFI MAIN relay circuits • Hybrid vehicle control ECU
	While fuel-cut operation performed (during vehicle deceleration), A/F sensor current less than 1.0 mA for 3 seconds (2-trip detection logic)	• A/F sensor • Hybrid vehicle control ECU

ES

HINT:

- When either of these DTCs is set, check the A/F sensor output voltage by selecting the following menu items on the intelligent tester: DIAGNOSIS / ENHANCED OBD II / DATA LIST / PRIMARY / AFS B1 S1.
- Short-term fuel trim values can also be read using the intelligent tester.
- The ECM regulates the voltages at the A1A+ and A1A- terminals of the ECM to a constant level. Therefore, the A/F sensor output voltage cannot be confirmed without using the intelligent tester.
- If the A/F sensor is malfunctioning, the ECM sets DTC P2195 or P2196.

MONITOR DESCRIPTION

Sensor voltage detection monitor

Under the air-fuel ratio feedback control, if the A/F sensor output voltage indicates rich or lean for a certain period of time, the ECM determines that there is a malfunction in the A/F sensor. The ECM illuminates the MIL and sets a DTC.

Example:

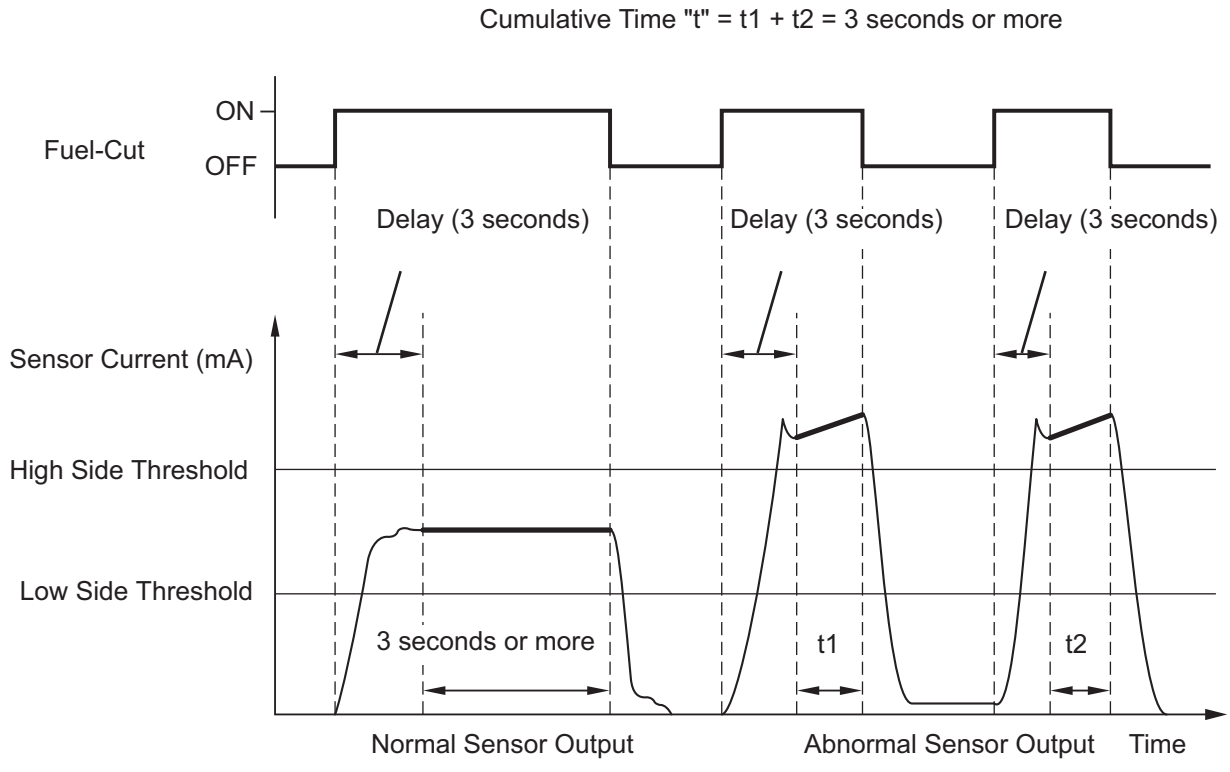
If the A/F sensor output voltage is less than 2.8 V (very rich condition) for 10 seconds, despite the rear HO2 sensor output voltage being less than 0.6 V, the ECM sets DTC P2196. Alternatively, if the A/F sensor output voltage is more than 3.8 V (very lean condition) for 10 seconds, despite the rear HO2 sensor output voltage being 0.15 V or more, DTC P2195 is set.

Sensor current detection monitor

A rich air-fuel mixture causes a low A/F sensor current, and a lean air-fuel mixture causes a high A/F sensor current. Therefore, the sensor output becomes low during acceleration, and it becomes high during deceleration with the throttle valve fully closed. The ECM monitors the A/F sensor current during fuel-cut and detects any abnormal current values.

If the A/F sensor output is 3.6 mA or more for more than 3 seconds of cumulative time, the ECM interprets this as a malfunction in the A/F sensor and sets DTC P2195 (high-side stuck). If the A/F sensor output is less than 1.0 mA for more than 3 seconds of cumulative time, the ECM sets DTC P2196 (low-side stuck).

A/F Sensor Current Monitor:



MONITOR STRATEGY

Related DTCs	P2195: A/F sensor signal stuck lean P2196: A/F sensor signal stuck rich
Required Sensors/Components (Main)	A/F sensor
Required Sensors/Components (Related)	HO2 sensor
Frequency of Operation	Continuous
Duration	10 seconds: Sensor voltage detection monitor 3 seconds: Sensor current detection monitor
MIL Operation	2 driving cycles
Sequence of Operation	None

TYPICAL ENABLING CONDITIONS

All:

Monitor runs whenever following DTCs not present	P0031, P0032 (A/F sensor heater - Sensor 1) P0037, P0038 (O2 sensor heater - Sensor 2) P0100 - P0103 (MAF meter) P0110 - P0113 (IAT sensor) P0115 - P0118 (ECT sensor) P0120 - P0223, P2135 (TP sensor) P0125 (Insufficient ECT for Closed Loop) P0136 (O2 Sensor - Sensor 2) P0171, P0172 (Fuel system) P0300 - P0304 (Misfire) P0335 (CKP sensor) P0340 (CMP sensor) P0455, P0456 (EVAP system) P0500 (VSS)

Sensor voltage detection monitor (Lean side malfunction P2195):

Duration while all of following conditions met	2 seconds or more
Rear HO2 sensor voltage	0.15 V or more
Time after engine start	30 seconds or more
A/F sensor status	Activated
Fuel system status	Closed-loop
Engine	Running

Sensor voltage detection monitor (Rich side malfunction P2196):

Duration while all of following conditions met	2 seconds or more
Rear HO2 sensor voltage	Below 0.6 V
Time after engine start	30 seconds or more
A/F sensor status	Activated
Fuel system status	Closed-loop
Engine	Running

Sensor current detection monitor P2195 and P2196:

Battery voltage	11 V or more
Atmospheric pressure	76 kPa (570 mmHg) or more
A/F sensor status	Activated
Continuous time of fuel cut	3 to 10 seconds
ECT	75°C (167°F) or more

TYPICAL MALFUNCTION THRESHOLDS

Sensor voltage detection monitor (Lean side malfunction P2195):

A/F sensor voltage	More than 3.8 V for 10 seconds

Sensor voltage detection monitor (Rich side malfunction P2196):

A/F sensor voltage	Less than 2.8 V for 10 seconds

Sensor current detection monitor (High side malfunction P2195):

A/F sensor current during fuel cut	3.6 mA or more

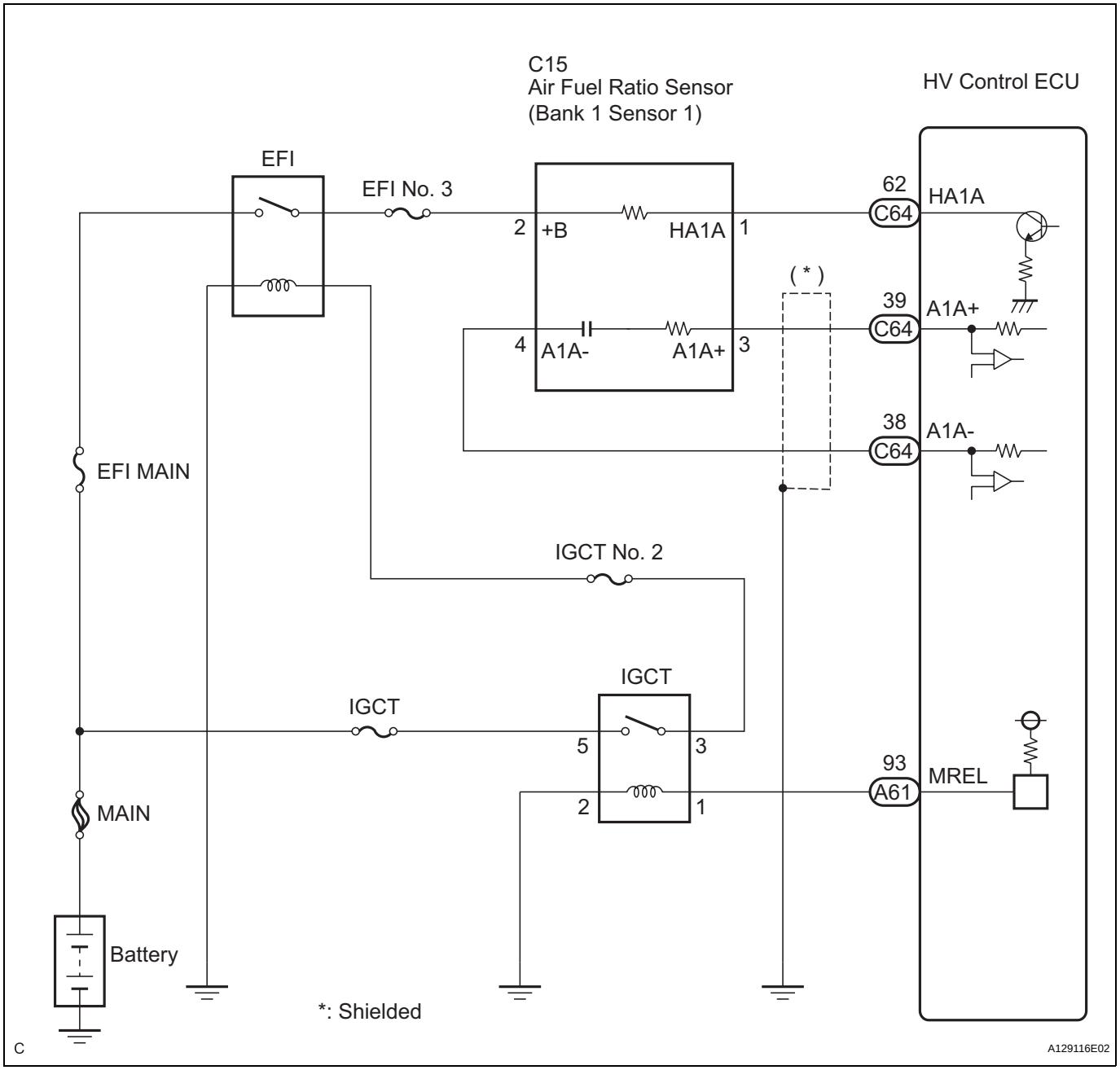
Sensor current detection monitor (Rich side malfunction P2196):

A/F sensor current during fuel cut	Less than 1 mA

MONITOR RESULT

Refer to CHECKING MONITOR STATUS (See page ES-14).

WIRING DIAGRAM

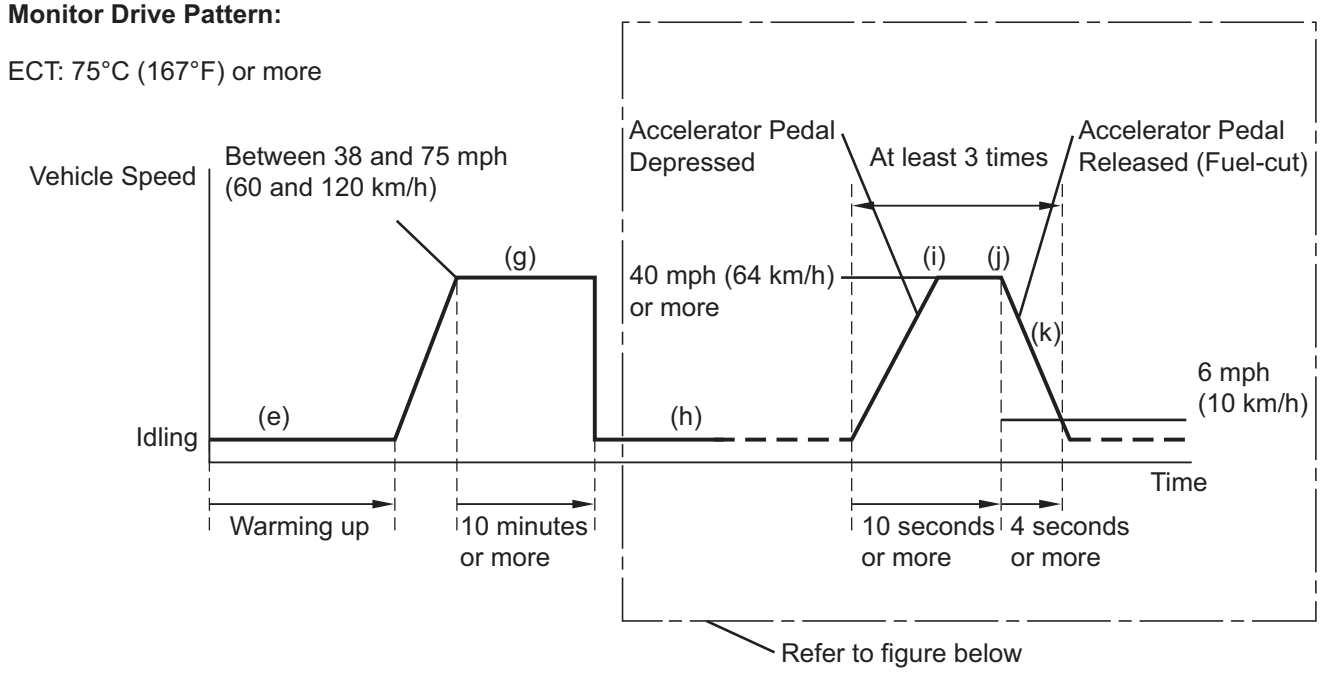


ES

CONFIRMATION DRIVING PATTERN

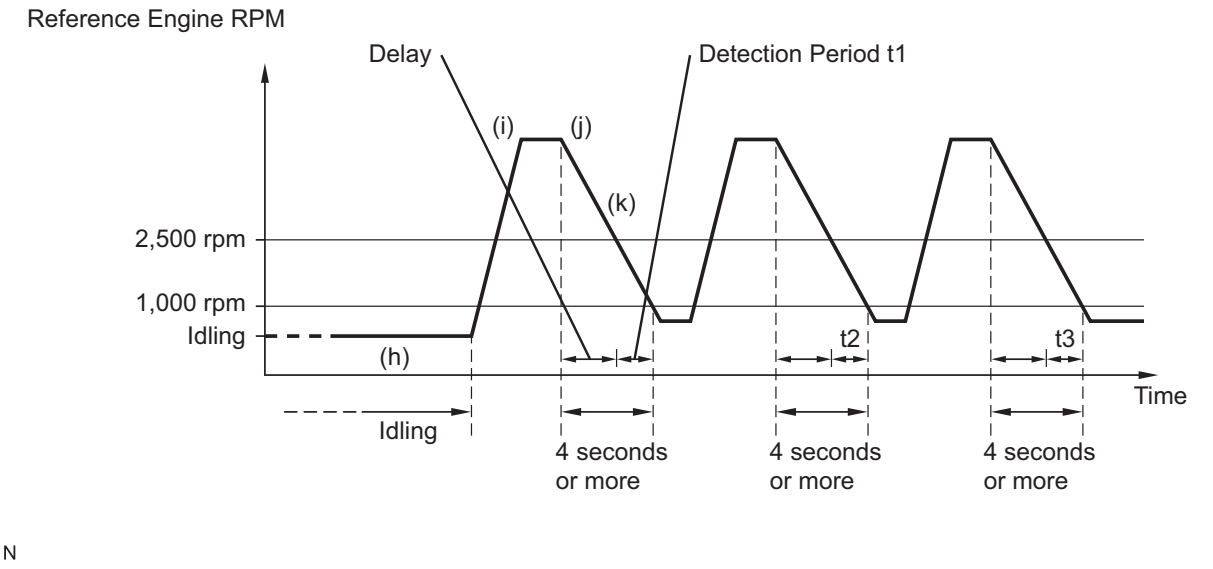
This confirmation driving pattern is used in the "PERFORM CONFIRMATION DRIVING PATTERN" procedure of the following diagnostic troubleshooting procedure.

Monitor Drive Pattern:



Driving Pattern Detail for (h) through (k):

Cumulative Detection Period "t" = t1 + t2 + t3 = 3 seconds or more



(a) Connect the intelligent tester to the DLC3.
(b) Turn the power switch on (IG).
(c) Turn the tester on.
(d) Clear the DTCs (See page ES-31).
(e) Put the engine in inspection mode (See page ES-35), warm it up until the ECT reaches 75°C (167°F) or higher.
(f) On the intelligent tester, select the following menu items to check the fuel-cut status: DIAGNOSIS / ENHANCED OBD II / DATA LIST / USER DATA / FC IDL.
(g) Drive the vehicle at between 38 mph (60 km/h) and 75 mph (120 km/h) for at least 10 minutes.
(h) Change the transmission to the 2nd gear.

(i) Drive the vehicle at a proper vehicle speed to perform fuel-cut operation.
HINT:
Fuel-cut is performed when the following conditions are met:
- Accelerator pedal is fully released.
- Engine speed is 2,500 rpm or more (fuel injection resumes at 1,000 rpm).

(j) Accelerate the vehicle to 40 mph (64 km/h) or more by depressing the accelerator pedal for at least 10 seconds.
(k) Soon after performing step (j) above, release the accelerator pedal for at least 4 seconds without depressing the brake pedal, in order to execute fuel-cut control.
(l) Allow the vehicle to decelerate until the vehicle speed declines to less than 6 mph (10 km/h).
(m) Repeat steps from (h) through (k) above at least 3 times in one driving cycle.
HINT:
Completion of all A/F sensor monitors is required to change the value in TEST RESULT.
CAUTION:
Strictly observe posted speed limits, traffic laws, and road conditions when performing these drive patterns.

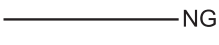
INSPECTION PROCEDURE

HINT:
Intelligent tester only:
Malfunctioning areas can be identified by performing the A/F CONTROL function provided in the ACTIVE TEST. The A/F CONTROL function can help to determine whether the Air-fuel Ratio (A/F) sensor, Heated Oxygen (HO2) sensor and other potential trouble areas are malfunctioning.
The following instructions describe how to conduct the A/F CONTROL operation using the intelligent tester.
(a) Connect the intelligent tester to the DLC3.
(b) Put the engine in inspection mode (See page ES-35).
(c) Turn the tester on.
(d) Warm up the engine at an engine speed of 2,500 rpm for approximately 90 seconds.
(e) On the tester, select the following menu items: DIAGNOSIS / ENHANCED OBD II / ACTIVE TEST / A/F CONTROL.
(f) Perform the A/F CONTROL operation with the engine idling (press the RIGHT or LEFT button to change the fuel injection volume).
(g) Monitor the output voltages of the A/F and HO2 sensors (AFS B1 S1 and O2S B1 S2) displayed on the tester.
HINT:
- The A/F CONTROL operation lowers the fuel injection volume by 12.5% or increases the injection volume by 25%.
- The sensors react in accordance with increases and decreases in the fuel injection volume.

Standard

Tester Display (Sensor)	Injection Volume	Status	Voltages
AFS B1 S1 (A/F)	+25%	Rich	Less than 3.0
	-12.5%	Lean	More than 3.35
O2S B1 S2 (HO2)	+25%	Rich	More than 0.5
	-12.5%	Lean	Less than 0.4

NOTICE:
The A/F sensor has an output delay of a few seconds and the HO2 sensor (sensor 2) output has a maximum output delay of approximately of 20 seconds.

Case	A/F Sensor (Sensor 1) Output Voltage		HO2 Sensor (Sensor 2) Output Voltage		Main Suspected Trouble Areas
1	Injection Volume +25% -12.5%		Injection Volume +25% -12.5%		-
	Output Voltage More than 3.35 V Less than 3.0 V		Output Voltage More than 0.5 V Less than 0.4 V		
2	Injection Volume +25% -12.5%		Injection Volume +25% -12.5%		• A/F sensor • A/F sensor heater • A/F sensor circuit
	Output Voltage Almost no reaction		Output Voltage More than 0.5 V Less than 0.4 V		
3	Injection Volume +25% -12.5%		Injection Volume +25% -12.5%		• HO2 sensor • HO2 sensor heater • HO2 sensor circuit
	Output Voltage More than 3.35 V Less than 3.0 V		Output Voltage Almost no reaction		
4	Injection Volume +25% -12.5%		Injection Volume +25% -12.5%		• Injector • Fuel pressure • Gas leakage from exhaust system (Air-fuel ratio extremely lean or rich)
	Output Voltage Almost no reaction		Output Voltage Almost no reaction		

Following the A/F CONTROL procedure enables technicians to check and graph the voltage outputs of both the A/F and HO2 sensors.
To display the graph, select the following menu items on the tester: DIAGNOSIS / ENHANCED OBD II / ACTIVE TEST / A/F CONTROL / USER DATA / AFS B1 S1 and O2S B1 S2, and press the YES button and then the ENTER button followed by the F4 button.
HINT:

- DTC P2A00 may be set when the air-fuel ratio is stuck rich or lean.
- Read freeze frame data using the intelligent tester. The ECM records vehicle and driving condition information as freeze frame data the moment a DTC is stored. When troubleshooting, freeze frame data can help determine if the vehicle was moving or stationary, if the engine was warmed up or not, if the air-fuel ratio was lean or rich, and other data from the time the malfunction occurred.
- 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.

1	CHECK ANY OTHER DTCS OUTPUT (IN ADDITION TO P2195 OR P2196)

(a) Connect an intelligent tester to the DLC3.
(b) Turn the power switch on (IG).
(c) Turn the tester on.
(d) Select the following menu items: DIAGNOSIS / ENHANCED OBD II / DTC INFO / CURRENT CODES.
(e) Read the DTCs.

Result

Display (DTC Output)	Proceed to
P2195 or P2196	A
P2195 or P2196 and other DTCs	B

HINT:
If any DTCs relating to the A/F sensor (DTCs for the A/F sensor heater or A/F sensor admittance) are output, troubleshoot those DTCs first.

B → GO TO DTC CHART

A

ES

2 READ VALUE USING INTELLIGENT TESTER (TEST VALUE OF A/F SENSOR)

(a) Connect the intelligent tester to the DLC3.
(b) Turn the power switch on (IG) and turn the tester on.
(c) Clear the DTCs (See page ES-31).
(d) Drive the vehicle in accordance with the drive pattern described in CONFIRMATION DRIVING PATTERN.
(e) Select the following menu items: DIAGNOSIS / ENHANCED OBD II / MONITOR INFO / MONITOR STATUS.
(f) Check that the status of O2S MON is COMPL.
If the status is still INCMPL, drive the vehicle according to the driving pattern again.
HINT:
- AVAIL indicates that the component has not been monitored yet.
- COMPL indicates that the component is functioning normally.
- INCMPL indicates that the component is malfunctioning.

(g) Select the following menu items: DIAGNOSIS / ENHANCED OBD II / MONITOR INFO / TEST RESULT / RANGE B1 S1; then press the ENTER button.
(h) Check the test value of the A/F sensor output current during fuel-cut.

Result

Test Value	Proceed to
Within normal range (1.0 mA or more, and less than 3.6 mA)	A
Outside normal range (Less than 1.0 mA, or 3.6 mA or more)	B

B → Go to step 12

A

3 READ VALUE USING INTELLIGENT TESTER (OUTPUT VOLTAGE OF A/F SENSOR)

(a) Connect the intelligent tester to the DLC3.
(b) Put the engine in inspection mode (See page ES-35).
(c) Turn the tester on.

(d) Warm up the A/F sensor at an engine speed of 2,500 rpm for 90 seconds.
(e) On the tester, select the following menu items: DIAGNOSIS / ENHANCED OBD II / SNAPSHOT / MANUAL SNAPSHOT / USER DATA / AFS B1 S1 and ENGINE SPD.
(f) Check the A/F sensor voltage 3 times, when the engine is in each of the following conditions:
(1) While idling (check for at least 30 seconds)
(2) At an engine speed of approximately 2,500 rpm (without any sudden changes in engine speed)
(3) Drive the vehicle at a constant speed of between 40 mph and 70 mph (65 km/h and 113 km/h) and then quickly release the accelerator pedal so that the throttle valve is fully closed.

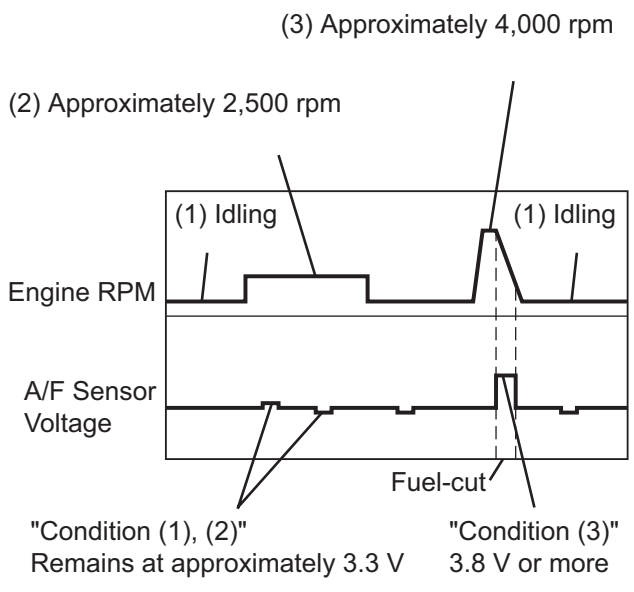
ES

Standard voltage

Conditions	A/F Sensor Voltage Variations	Reference
(1) and (2)	Remains at approximately 3.3 V	Between 3.1 V and 3.5 V
(3)	Increases to 3.8 V or more	This occurs during engine deceleration (when fuel-cut performed)

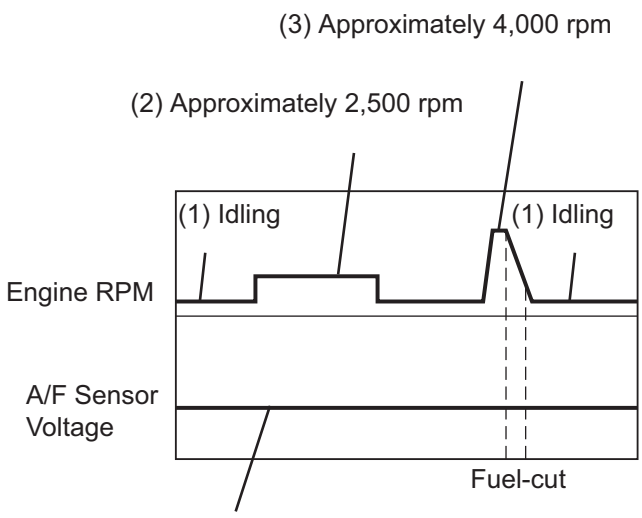
HINT:
- For more information, see the diagrams below.

Normal Condition:



N

Malfunction Condition:



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- If the output voltage of the A/F sensor remains at approximately 3.3 V (see Malfunction Condition diagram) under any conditions, including those above, the A/F sensor may have an open circuit. (This will also happen if the A/F sensor heater has an open circuit.)

- If the output voltage of the A/F sensor remains at either approximately 3.8 V or more, or 2.8 V or less (see Malfunction Condition diagram) under any conditions, including those above, the A/F sensor may have a short circuit.
- The ECM stops fuel injection (fuel cut) during engine deceleration. This causes a lean condition and results in a momentary increase in the A/F sensor output voltage.
- The ECM must establish a closed throttle valve position learning value to perform fuel cut. If the battery terminal has been reconnected, the vehicle must be driven over 10 mph (16 km/h) to allow the ECM to learn the closed throttle valve position.
- When the vehicle is driven:
  The output voltage of the A/F sensor may be below 2.8 V during fuel enrichment. For the vehicle, this is translated to a sudden increase in speed with the accelerator pedal fully depressed when trying to overtake another vehicle. The A/F sensor is functioning normally.
- The A/F sensor is a current output element; therefore, the current is converted into a voltage inside the ECM. Measuring the voltage at the connectors of the A/F sensor or ECM will show a constant voltage result.

ES

NG → **Go to step 9**

OK

4	PERFORM CONFIRMATION DRIVING PATTERN

NEXT

5	CHECK WHETHER DTC OUTPUT RECURS (DTC P2195 OR P2196)

(a) Read the DTCs using the intelligent tester.
(b) Select the following menu items: DIAGNOSIS / ENHANCED OBD II / DTC INFO / PENDING CODES.

Result

Display (DTC Output)	Proceed to
P2195 or P2196	A
No output	B

B → **END**

A

6	REPLACE AIR-FUEL RATIO SENSOR

NEXT

7	PERFORM CONFIRMATION DRIVING PATTERN

NEXT

ES

8	CHECK WHETHER DTC OUTPUT RECURS (DTC P2195 OR P2196)

(a) Read the DTCs using the intelligent tester.
(b) Select the following menu items: DIAGNOSIS / ENHANCED OBD II / DTC INFO / PENDING CODES.

Result

Display (DTC Output)	Proceed to
No output	A
P2195 or P2196	B

B → REPLACE HYBRID VEHICLE CONTROL ECU

A

END

9	INSPECT AIR-FUEL RATIO SENSOR (HEATER RESISTANCE) (See page ES-75)

NG → REPLACE AIR-FUEL RATIO SENSOR

OK

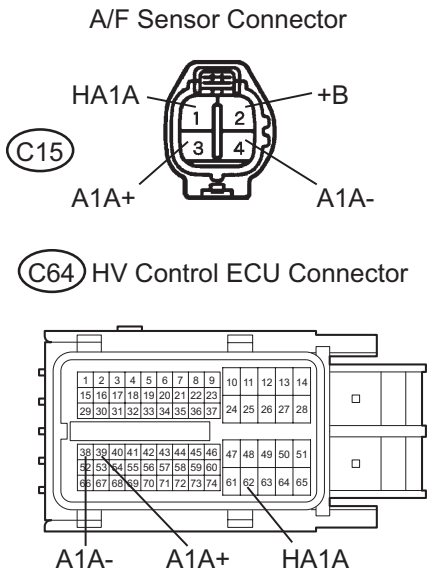
10	INSPECT INTEGRATION RELAY (EFI RELAY) (See page ES-76)

NG → REPLACE INTEGRATION RELAY (EFI MAIN RELAY)

OK

11 CHECK HARNESS AND CONNECTOR (A/F SENSOR - HV CONTROL ECU)

Wire Harness Side:



(a) Disconnect the C15 A/F sensor connector.
(b) Turn the power switch on (IG).
(c) Measure the voltage between the +B terminal of the A/F sensor connector and body ground.

Standard voltage

Tester Connections	Specified Conditions
C15-2 (+B) - Body ground	9 to 14 V

(d) Turn the power switch off.
(e) Disconnect the C64 hybrid vehicle control ECU connector.
(f) Measure the resistance.

Standard resistance (Check for open)

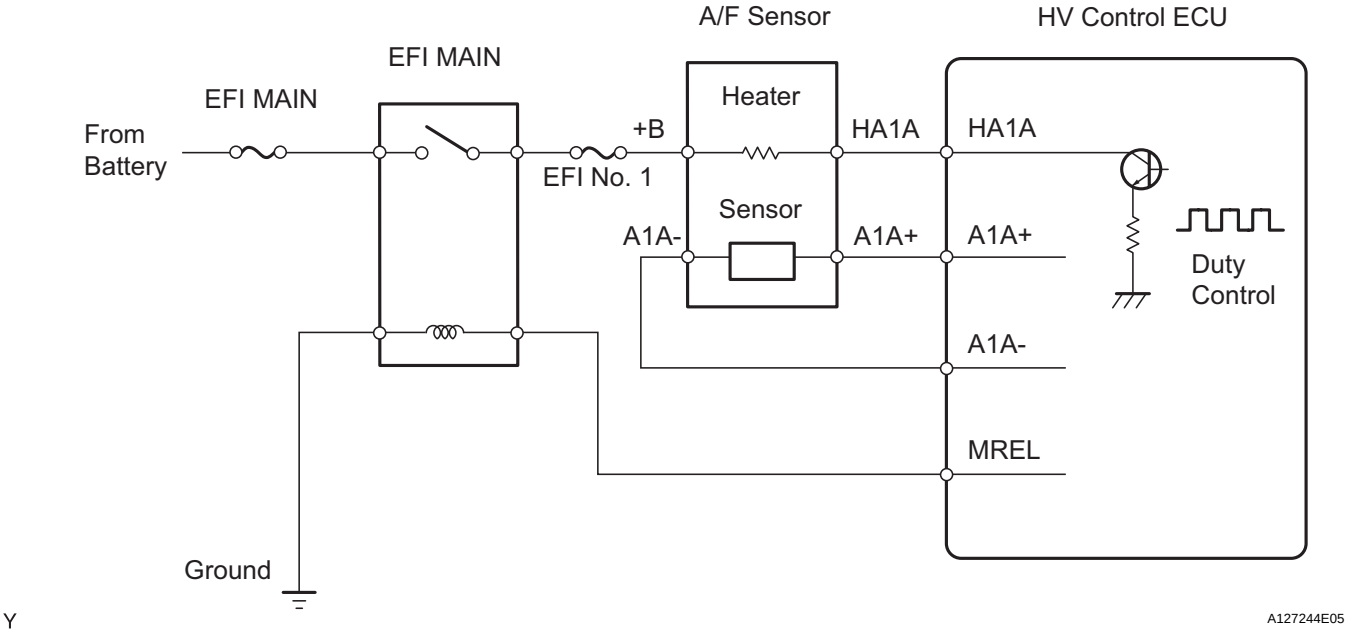
Tester Connections	Specified Conditions
C15-1 (HA1A) - C64-62 (HA1A)	Below 1 Ω
C15-3 (A1A+) - C64-39 (A1A+)	Below 1 Ω
C15-4 (A1A-) - C64-38 (A1A-)	Below 1 Ω

Standard resistance (Check for short)

Tester Connections	Specified Conditions
C15-1 (HA1A) or C64-62 (HA1A) - Body ground	10 kΩ or higher
C15-3 (A1A+) or C64-39 (A1A+) - Body ground	10 kΩ or higher
C15-4 (A1A-) or C64-38 (A1A-) - Body ground	10 kΩ or higher

(g) Reconnect the hybrid vehicle control ECU connector.
(h) Reconnect the A/F sensor connector.

Reference (System Diagram of Sensor 1):



NG → **REPAIR OR REPLACE HARNESS OR CONNECTOR**

OK

12	REPLACE AIR-FUEL RATIO SENSOR

NEXT

13	PERFORM CONFIRMATION DRIVING PATTERN

NEXT

ES

14	CHECK WHETHER DTC OUTPUT RECURS (DTC P2195 OR P2196)

(a) Read the DTCs using the intelligent tester.
(b) Select the following menu items: DIAGNOSIS / ENHANCED OBD II / DTC INFO / PENDING CODES.

Result

Display (DTC Output)	Proceed to
No output	A
P2195 or P2196	B

B → REPLACE HYBRID VEHICLE CONTROL ECU

A

END