WORKSHEET 2–1
Position/Mode Switches and Circuits

Vehicle	Year/Prod. Date	Engine	Transmission

Technician Objectives

With this worksheet, you will learn to test position/mode circuits using the required tools and equipment, retrieve and apply the needed service information, retrieve and interpret service data information.

Tools and Equipment

- Vehicle Repair Manual
- Vehicle EWD
- Diagnostic Tester
- Hand Tool Set

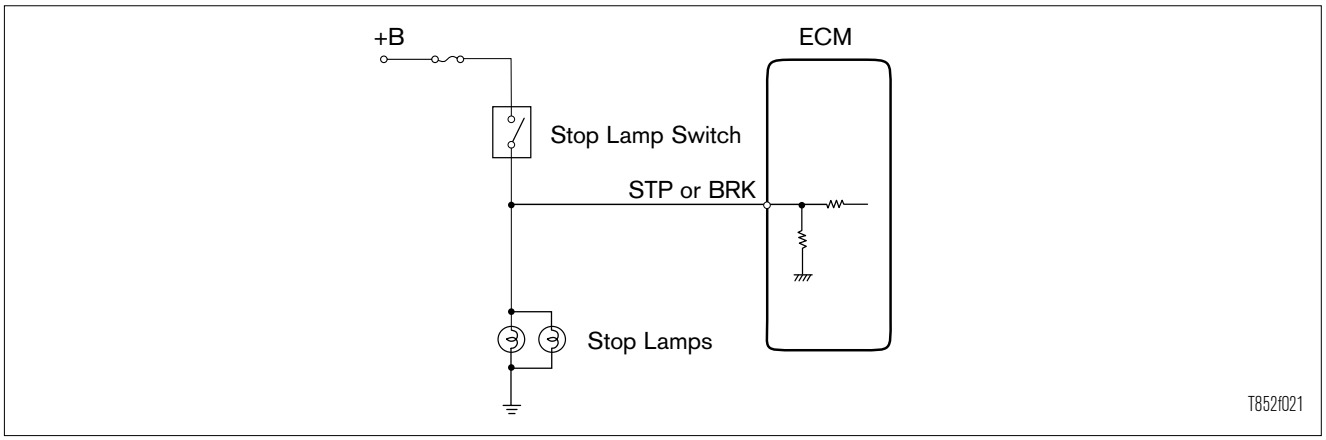
Section 1

The ECM needs to know the position of a component or when a circuit is being activated. A switch connected to the ECM is often used. The switch can be electrically connected to the ECM in two fundamental ways:

- The switch is between the Battery and ECM.
- The switch is between the ECM and Ground.

Section 2

Switch Between Battery and ECM



When the switch is located between the battery and ECM, the switch controls the voltage to the ECM. A very common example is the Stop Lamp Switch. When the driver steps on the brake, the switch closes completing the circuit. The ECM detects battery voltage and "knows" the vehicle is braking.

1. Connect the Diagnostic Tester to the ECM, scroll to Stop Light Switch and observe the reading.
2. Step on the brake and note the change.
3. Using the appropriate EWD and/or RM, locate the STP terminal.

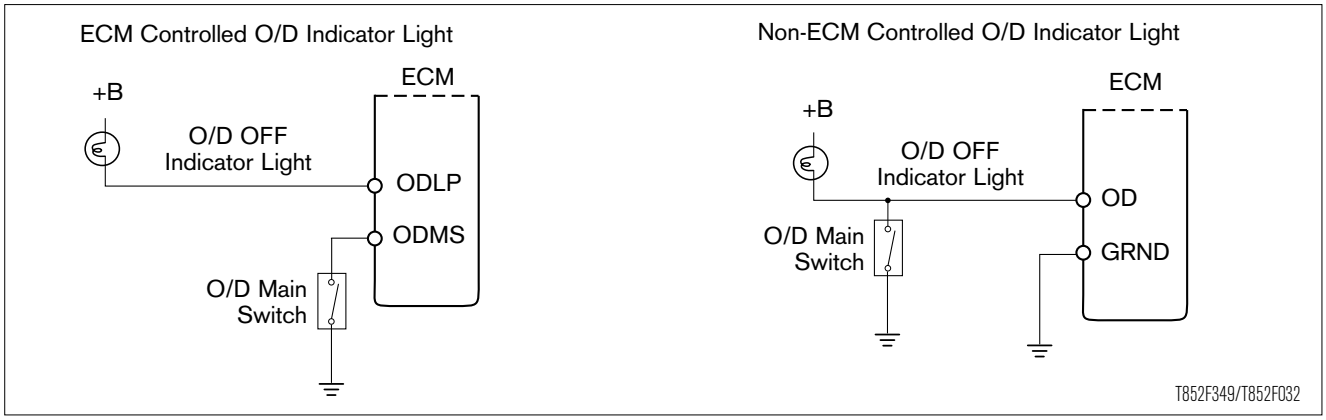
   STP Connector No: _____ Pin No: _____ Wire Color: _____

4. Connect the positive (+) lead of the DVOM to the STP terminal, the Negative (-) lead to ground. Switch the DVOM to DC Volts.
   note the voltage reading: _____

5. Step on the brake, and note the voltage reading: _____
   Compare the Diagnostic Tester reading to the DVOM reading with brake ON/OFF. What is the difference?

   _____

Switch Between Battery And Ground



6. When the switch is located between the ECM and Ground, the switch controls the voltage to ground. An example is the Overdrive (O/D) main switch. (If O/D is unavailable, select another vehicle).

7. Connect the Diagnostic Tester to the ECM, scroll to O/D Switch, and observe the reading.

8. Locate the Overdrive(O/D) main switch terminal.

   Connector No: _____ Pin No: _____ Wire Color: _____

9. Predict the voltage at the Overdrive (O/D) main switch terminal with the Light Off _____ and with the light On _____.

10. Connect the positive (+) lead of the DVOM to the O/D main switch terminal, the negative (-) lead to ground. Switch the DVOM to DC Volts.

O/D Switch Position	Voltage @ ECM	Diagnostic Tester Shows
O/D Switch OFF		
O/D Switch ON		

Switch Position

As a rule, the EWD shows the switch in it's natural, at rest position. Most switches connected to the ECM are normally open switches, regardless if they are on the power or ground side.

The stop light switch is a normally open switch. The switch closes when the brake pedal; is stepped on.
From the EWD, locate the switches connected to the ECM. Identify if they are:

- Power side/ground side switched.
- Normally open/closed.

Fill in the Chart Blanks:

Section 3

Switch	Power/Ground Side	Normally Open/Closed	Voltage Signal at Rest	Voltage When Activated
Stop Light				
OD				
Power Steering				

Mode Circuits

There are times when the ECM needs to know what systems are being activated. For example, when the engine is being started, the ECM receives a signal at the STA terminal.

At the designated vehicle, locate the starter (STA) and electric load circuit (ELS) connected to the ECM and terminals. Connect the Diagnostic Tester and DVOM to the appropriate terminals. Try to predict the voltages in each state and compare to the readings.

Circuit	PREDICT The Voltage Signal with Circuit ON	PREDICT The Voltage Signal with Circuit OFF	ACTUAL DVOM Reading ON	ACTUAL DVOM Reading OFF	ACTUAL Diagnostic Tester ON	ACTUAL Diagnostic Tester OFF
STA						
ELS						
4WD						

Notes

Position/Mode Switches and Circuits

Name _____ Date _____

Review this sheet as you are doing the worksheet. Check each category after completing the worksheet and instructor presentation. Ask the instructor if you have questions. The comments section is for you to write where to find the information, questions, etc.

Topic	*I have questions*	*I know I can*	Comment
Locate components in the switch sensing circuits using the EWD and RM.			
Find wire colors, pin numbers in the switch sensing circuit using the EWD and RM.			
Identify a normally closed and normally open switch.			
Identify the switch sensors and position from the Data List.			
Measure the voltage signal of the switch sensor at the ECM.			
Test a supply side switch and compare to specifications to determine condition.			
Test a ground side switch and compare to specifications to determine condition.			
Check and retrieve relevant DTCs.			
Describe the difference between a supply side and ground side switched circuit.			
Describe the difference between a normally closed and normally open switch.			

Notes

WORKSHEET 2–2
Temperature Sensors

Vehicle	Year/Prod. Date	Engine	Transmission

Technician Objectives

With this worksheet, you will learn to test temperature sensors and circuits using the required tools and equipment, retrieve and apply the needed service information, retrieve and interpret service data information.

Tools and Equipment

- Vehicle Repair Manual
- Vehicle EWD
- Diagnostic Tester & DVOM
- Hand Tool Set
- Vehicle at room temperature

Section 1

Engine Coolant Temperature (ECT) and Intake Air Temperature (IAT) Operation

1. Connect the Diagnostic Tester and go to the Data List. Observe and record the IAT and ECT temperature. Do they match?

   _____

   Why is this important?

   _____

2. Using the Repair Manual/EWD, locate the THW and E2 terminals.

   THW Connector No. _____ Pin No. _____ Wire Color _____

   E2 Connector No. _____ Pin No. _____ Wire Color _____

3. Connect the positive (+) lead of the DVOM to the THW terminal and the negative (-) lead to terminal E2. With the ignition key in the run position, record the voltage: _____

4. Using the Repair Manual/EWD locate the THA terminal.

   THA Connector no. _____ Pin No. _____ Wire Color _____

5. Move only the positive (+) lead of the DVOM to the THA terminal and record the voltage.

   _____

   HOLD the IAT sensor in your hand. What happened to the voltage and temperature?

   _____

6. Turn the Ignition key off.

7. Disconnect the IAT at the sensor. Using the test lead connector and DVOM, measure the resistance of the IAT. Does it match the Repair Manual chart?

_____

8. HOLD the IAT sensor in your hand? What happened to the resistance and temperature?

_____

9. Reconnect the IAT.

Section 2

Make sure the Parking Brake is securely set and exhaust hose is connected.

Connect the positive (+) lead of the DVOM to the THW terminal and the negative (-) lead to terminal E2.

Start the engine and observe the ECT reading on the Diagnostic Tester and the DVOM voltage reading. Plot the temperature and voltage on the chart below.

Temp (°F)	80	90	100	110	120	130	140	150	160	170	180
Volts											

Complete the following:

1. As the engine gets warmer, the ECT voltage signal is: _____

2. As the engine gets warmer, ECT resistance is: _____

3. Note the difference in voltage every 10°F. What happened to the change in voltage signal the last 40°F?

_____

4. Shut the engine off, then turn the ignition key on. What should happen to ECT voltage signal?

_____

5. Does the DVOM and Diagnostic Tester confirm your prediction?

_____

Section 3

The following exercises will help you understand the Repair Manual diagnostic procedures.

Create an Open Circuit Fault

1. Disconnect the IAT (or ECT) at the sensor, and record the temperature and circuit voltage at the ECM:

   _____

Create a Short Circuit Fault

1. At the sensor connector, use a wire to connect the two terminals together and record the sensor temperature reading and voltage.

2. At the sensor connector, ground the TH_ wire. Is the reading approximately the same?

   _____

3. What DTC was created?

   _____

Repair Manual Logic

1. A customer vehicle comes in with DTC P0115, the Diagnostic Tester reads -40°(F). You would look for what type of circuit fault?

   _____

2. What step would you take next?

   _____

Section 4

Solving Open Circuit Faults

1. An open in the ECT or IAT will read on the DT: _____; DVOM _____

This step determines if the fault is with ECT or the circuit.

A jumper wire is inserted at the sensor connector. This creates a shorted circuit and the temperature should go high (hot). If it does:

What must be good?

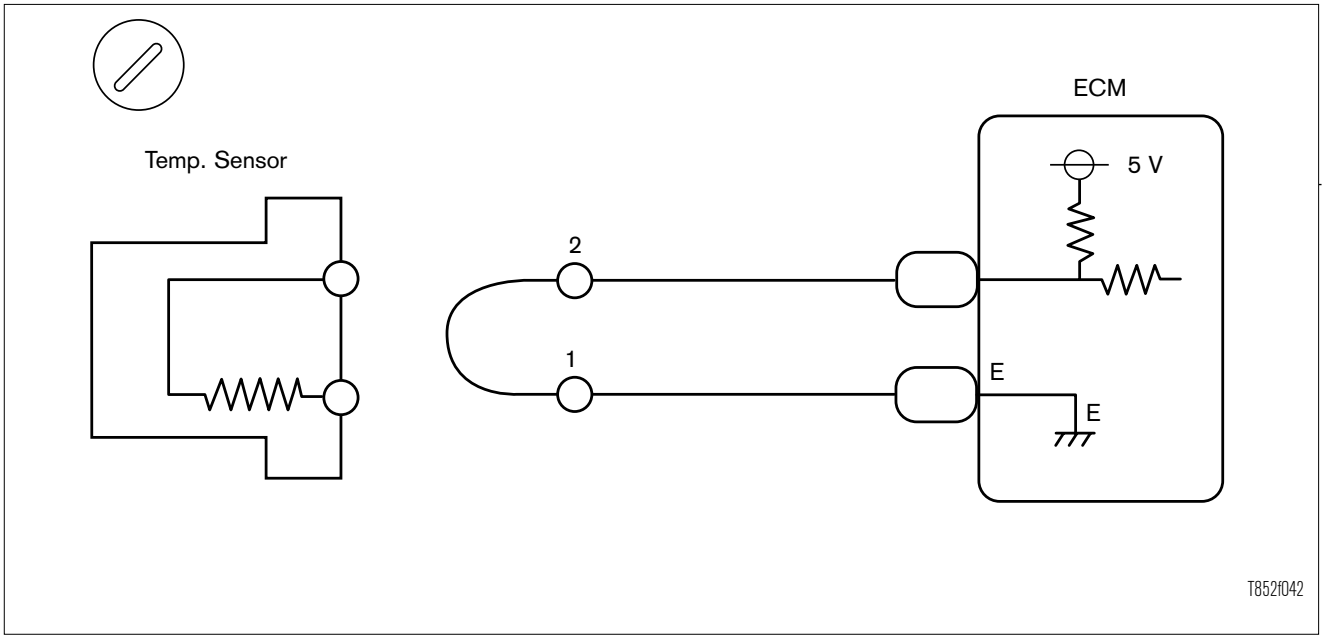
_____

What must be at fault?

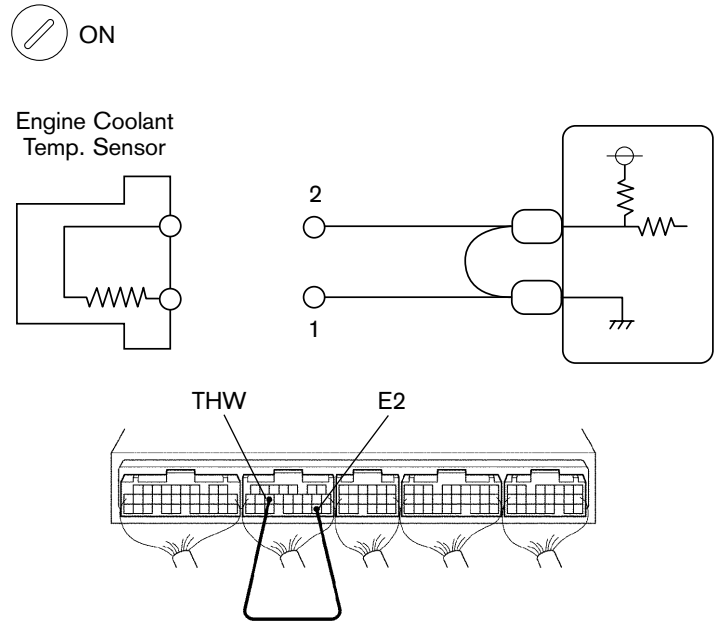
_____

If the temperature did not go high (hot), then the problem is with:

_____



Next, determine if the problem is with the circuit or the ECM.



With a jumper wire between the THW terminal and E2 at the ECM, temperature should go high.

If it does, the problem is in:

_____

If it does not go high it is either the:

_____

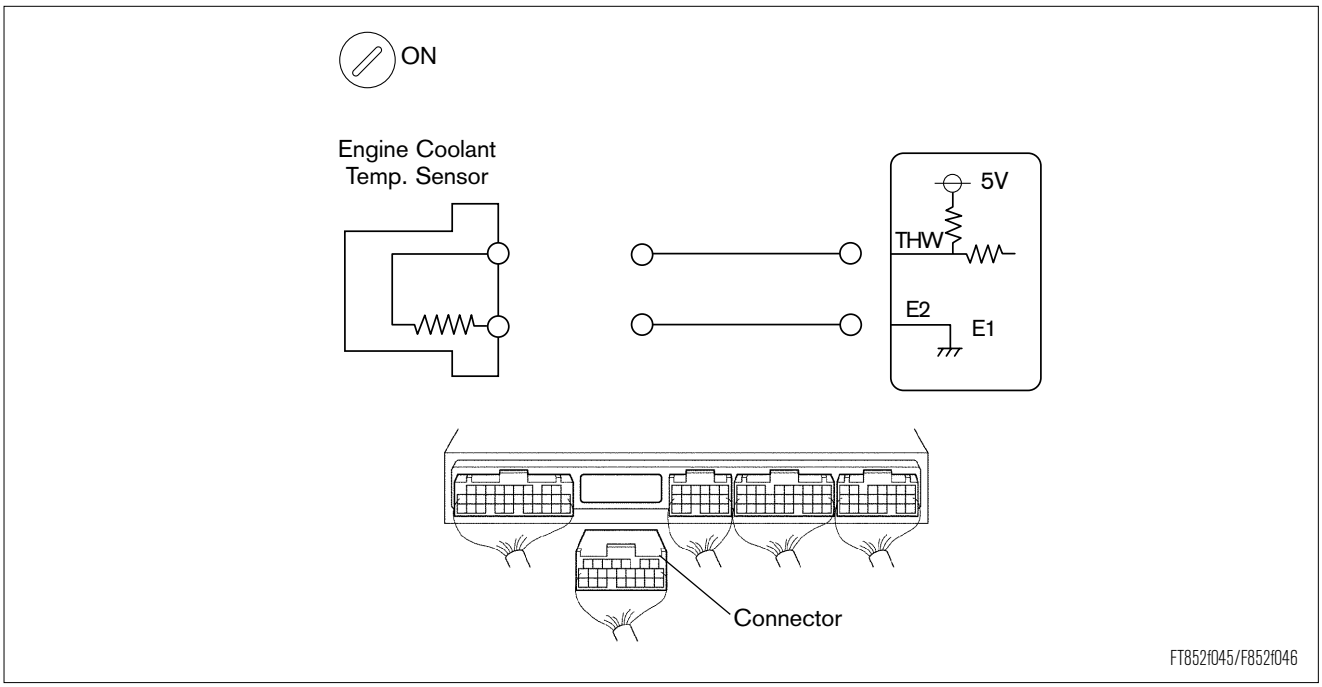
Solving Shorted Circuit Faults

1. A shorted ECT or IAT will read on the DT: _____; DVOM _____

Disconnecting the temperature sensor creates an open circuit and the temperature should go extremely low (cold). If it does, _____ must have been shorted to ground.

If not, the problem must be with the

_____ or _____ .



With the connector at the ECM disconnected, temperature should go low (cold). If it does, the fault is:

_____

If not, the problem is with:

_____

Temperature Sensors

Name _____ Date _____

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Topic	*I have questions*	*I know I can*	Comment
Locate components in the temperature sensing circuits using the EWD and RM.			
Find wire colors, pin numbers in the temp. sensing circuit using the EWD and RM.			
Locate the temperature reading from the Data List.			
Measure the voltage drop of the sensor.			
Test VC (supply voltage) and compare to specifications to determine condition.			
Test E (ground line) and compare to specifications to determine condition.			
Test sensor resistance and compare to specifications to determine condition.			
Check and retrieve relevant DTCs.			
Describe purpose of ECT and IAT.			
Describe ECM strategy if the ECT and IAT circuit fails.			

Notes

WORKSHEET 2–3
Position Sensors

Vehicle	Year/Prod. Date	Engine	Transmission

Technician Objectives

With this worksheet, you will learn to test position sensors and circuits using the required tools and equipment, retrieve and apply the needed service information, retrieve and interpret service data information.

Tools and Equipment

- Vehicle Repair Manual
- Vehicle EWD
- Diagnostic Tester
- Hand Tool Set with DVOM
- Vehicle at room temperature
- Pencil

Section 1

The ECM needs to know the position of some components such as throttle valve position, EGR valve height, etc.

1. At the bottom of this page, draw a dark line approximately 1/4" wide. Connect the supply leads to VC and E2. Attach the DVOM ground lead to vehicle ground. Turn the ignition key on. With positive (+) lead of the DVOM touching VC, the DVOM should read 5v. Now slowly move the positive (+) lead on the drawn line towards E2 and note the DVOM reading. What happened to the voltage as the lead moved closer to E2?

   _____

   The strength of the voltage signal is how the ECM determines the position of the component.

Section 2

2. With the Diagnostic Tester connected to the vehicle, turn the ignition switch to ON and note the throttle position. Slowly depress the throttle and note the change on the Diagnostic Tester.

3. Connect a DVOM between the VTA and E2 terminals. Slowly depress the throttle and note the voltage on the DVOM. Did the voltage increase with throttle opening?

Just like the beginning exercise you did, the ECM measures position by the strength of the voltage signal.

The ECM sends 5 volts to the TPS on the VC wire. Voltage is then divided between the signal wire (VTA) and ground (E2). The closer the signal arm moves to the supply voltage, the higher the voltage signal.

Repair Manual Checks

The following explanations describe common diagnostic procedures found in the Repair Manual on throttle position sensors. You may find discrepancies with the order in the RM.

Diagnostic Tester

1. Compare throttle position to the Diagnostic Tester data at idle and WOT.
2. Do the readings match specifications?

_____

Check voltage between terminal VC of the TPS and body ground.

1. Disconnect the TPS connector and measure the voltage at the VC terminal. It should be about 5 volts. If you get this reading it confirms that the wire is good and ECM is providing the correct voltage. If not, the problem may be with the circuit or ECM.

2. With the TPS disconnected, what did the DT read? _____

Check voltage between terminals VC and E2 of ECM connector.

This test confirms that the ECM is putting out the necessary supply voltage. You would do this test if you did not measure 5 volts at the VC terminal at the TPS connector.
If you get 5 volts at the ECM connector, the problem is in the

_____.

If you did not get 5 volts, the ECM is at fault.

Inspect Throttle Position Sensor

On some models, you will find TPS checks in the Throttle Body On Vehicle Inspection in the SF Section.

1. With DVOM measure the resistance of the TPS at the specified terminal locations. What terminals are used?

_____

2. Does the TPS meet specifications?

_____

Check voltage between terminals VTA and E2 of ECM connector.

This test is the same as in the exercise you did above. This test is to determine if the circuit or the ECM is at fault. If voltage readings are in specifications, the ECM may be at fault. (Intermittent problems in the circuit or TPS may also be the problem.) If voltage readings are not in spec., there may be an open or short in harness and connector between ECM and TPS on the VTA or E2 line.

1. If the VTA line were shorted to ground, what would the voltage reading be?

_____

2. If the VTA line were open, what would the voltage reading be?

_____

3. What test(s) can be made to determine the difference?

_____

4. If the E2 line were open, VTA voltage will be approximately?

_____

Position Sensors

Name _____ Date _____

Review this sheet as you are doing the worksheet. Check each category after completing the worksheet and instructor presentation. Ask the instructor if you have questions. The comments section is for you to write where to find the information, questions, etc.

Topic	*I have questions*	*I know I can*	Comment
Locate components in the position sensing circuits using the EWD and RM.			
Find wire colors and pin numbers in the position sensing circuit using the EWD and RM.			
Locate the TPS/EGR VPS reading from the Data List.			
Measure the voltage signal of the sensor.			
Test VC (supply voltage) and compare to specifications to determine condition.			
Test E (ground line) and compare to specifications to determine condition.			
Test sensor resistance and compare to specifications to determine condition.			
Check and retrieve relevant DTCs.			
Describe purpose of TPS/EGR VPS.			
Describe ECM strategy if the TPS circuit fails.			

Notes

WORKSHEET 2–4
Mass Airflow (MAF) Sensors

Vehicle	Year/Prod. Date	Engine	Transmission

Technician Objectives

With this worksheet, you will learn to test MAF sensor and circuits using the required tools and equipment, retrieve and apply the needed service information, retrieve and interpret service data information.

Tools and Equipment

- Vehicle Repair Manual
- Vehicle EWD
- Diagnostic Tester & DVOM
- Hand Tool Set

Section 1

The MAF sensor is needed by the ECM to measure the volume of air entering the engine. From the air volume measurement, the ECM can inject the correct amount of fuel and adjust the ignition timing.

List each terminal on the MAF connector and explain the purpose.

Terminal	Purpose

Section 2

MAF Operation

1. With the DT, select the MAF reading from the Data List.

   _____

2. Locate MAF signal wire at:

   ECM connector: _____ Terminal: _____ Wire Color: _____

3. Connect the positive (+) lead of the DVOM to MAF signal terminal. Connect negative (-) lead to E2.
4. Slowly accelerate the engine in the increments shown and record voltage and grams/sec.

RPM	Idle	1000	1250	1500	1750	2000	2250	2500	2750	3000
G/S										
Volts										

5. What happened to airflow and voltage as RPMs increased?

_____

6. When finished, shut the engine off.
7. Remove the MAF from the air induction hose, but leave electrically connected. Start the engine. What happened?

_____

8. If the MAF sensor were plugged with debris, what is the most likely engine symptom?

_____

Section 3

MAF Sensor Component Check

According to the Repair Manual, perform the MAF test procedure for operation.

1. What indicates a good MAF sensor?

_____

2. What DTCs are related to the MAF circuit?

_____

3. What MAF DTC is a one trip? Two trip?

_____

4. What are the Detecting Conditions for the one trip? Two trip?

_____

5. Does this have a Fail-Safe condition?

_____

Name _____ Date _____

Review this sheet as you are doing the worksheet. Check each category after completing the worksheet and instructor presentation. Ask the instructor if you have questions. The comments section is for you to write where to find the information, questions, etc.

Topic	*I have questions*	*I know I can*	Comment
Locate components in the MAF circuit using the EWD and RM.			
Find wire colors, pin numbers in the MAF circuit using the EWD and RM.			
Locate the MAF reading from the Data List.			
Measure the voltage signal of the sensor.			
Test supply voltage and compare to specifications to determine condition.			
Test E (ground line) and compare to specifications to determine condition.			
Test sensor performance and compare to specifications to determine condition.			
Check and retrieve relevant DTCs.			
Describe purpose of the MAF sensor.			
Describe ECM strategy if the MAF circuit fails.			

Notes

WORKSHEET 2–5
Manifold Absolute Pressure (MAP) Sensor

Vehicle	Year/Prod. Date	Engine	Transmission

Technician Objectives

With this worksheet, you will learn to test the MAP sensor and circuit using the required tools and equipment, retrieve and apply the needed service information, retrieve and interpret service data information.

Tools and Equipment

- Vehicle Repair Manual & EWD
- Diagnostic Tester & DVOM
- Hand Tool Set Vacuum Pump
- Vehicle

Section 1

MAP Sensor signal

Use the positive (+) DVOM to measure MAP voltage signal and DT to measure pressure. *Fill in the blanks.*

1. Positive (+) lead Connected to: Connector No: _____ Pin No. _____.
2. Negative (-) lead connected to: Connector No: _____ Pin No. _____.
3. MAP voltage signal KOEO _____.
4. MAP voltage signal at idle _____.
5. MAP voltage signal at brief WOT _____.
6. What happened to intake manifold pressure as the throttle opened?

   _____

7. Why does the ECM need the MAP (PIM) voltage signal?

   _____

Use the DVOM to measure the regulated voltage supply to the MAP. *Fill in the blanks.*

1. Positive (+) lead Connected to: Connector No: _____ Pin No. _____.
2. Negative (-) lead connected to: Connector No: _____ Pin No. _____.
3. MAP regulated voltage (VC) supply _____.

Section 2

MAP Component Test

Applied Vacuum					
Key ON PIM					
PIM Voltage					
Calculated Voltage Drop					
Voltage Drop Specification					
DT Pressure*					

Use the RM for MAP sensor component test. Fill in the following:

* The RM does not give pressure readings by using the DT.

1. Is the MAP sensor good?

   _____

2. What DTCs are related to the MAP circuit?

   _____

3. What MAP DTC is a one trip? Two trip?

   _____

4. What are the Detecting Conditions for the one trip? Two trip?

   _____

5. Does this have a Fail-Safe condition?

   _____

Manifold Absolute Pressure (MAP) Sensors

Name _____ Date _____

Review this sheet as you are doing the worksheet. Check each category after completing the worksheet and instructor presentation. Ask the instructor if you have questions. The comments section is for you to write where to find the information, questions, etc.

Topic	*I have questions*	*I know I can*	Comment
Locate components in the MAP circuit using the EWD and RM.			
Locate the MAP reading from the Data List.			
Measure the voltage signal of the sensor.			
Test the VC supply voltage and compare to specifications to determine condition.			
Test E (ground line) and compare to specifications to determine condition.			
Test sensor performance and compare to specifications to determine condition.			
Check and retrieve relevant DTCs			
Describe purpose of the MAP sensor.			
Describe ECM strategy if the MAP circuit fails.			

Notes

WORKSHEET 2–6
Position/Speed Sensors

Vehicle	Year/Prod. Date	Engine	Transmission

Technician Objectives

With this worksheet, you will learn to test camshaft and crankshaft sensors using the required tools and equipment, retrieve and apply the needed service information, retrieve and interpret service data information.

Tools and Equipment

- Vehicle Repair Manual
- Vehicle EWD
- Diagnostic Tester
- DVOM
- Hand Tool Set

Section 1

The ECM needs to know position and speed of many components such as the engine crankshaft, camshaft, vehicle speed, transmission, etc.

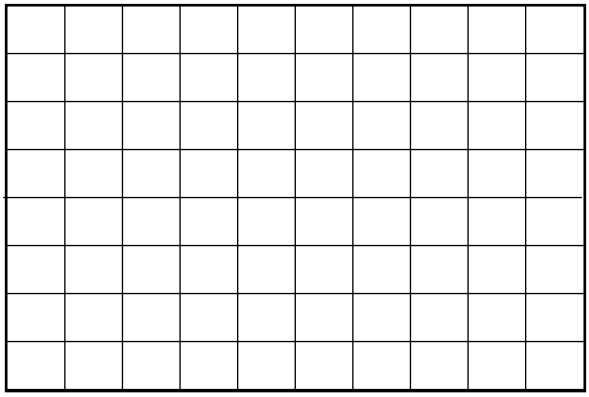
Camshaft Position (Variable Valve Timing) Sensor

1. Connect the Diagnostic Tester Autoprobe and DVOM to the camshaft sensor circuit at the ECM.

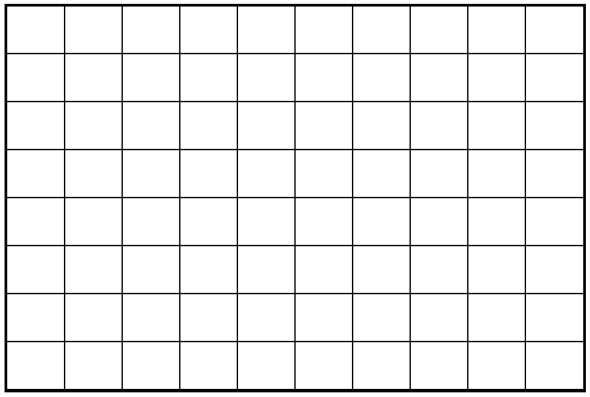
   ECM terminals: _____
2. Set the Diagnostic Tester to the Oscilloscope/autoprobe function, refer to Repair Manual for settings

   Connect DVOM and set to AC volts, Hz.
3. Start the engine and draw or print the waveform at IDLE. What is the frequency? _____

IDLE



2000 RPM



4. Does the waveform match the Repair Manual waveform?

   _____
5. Raise engine RPM to 2000. What happened to the waveform and frequency?

   _____

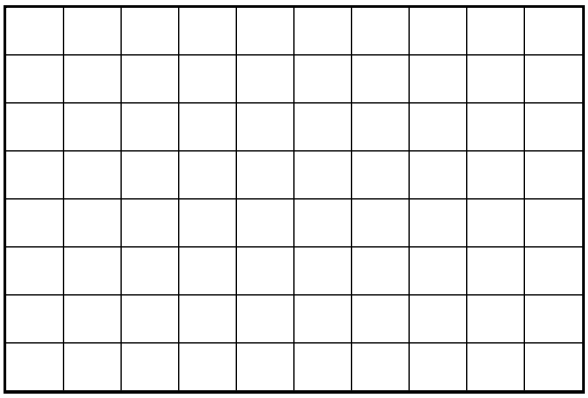
Crankshaft Position Sensor

1. Connect the Diagnostic Tester Autoprobe and DVOM to the crankshaft position sensor signal.
   ECM terminals: _____
2. Start the engine and at idle RPM note the waveform.
3. Does the waveform match the Repair Manual waveform?

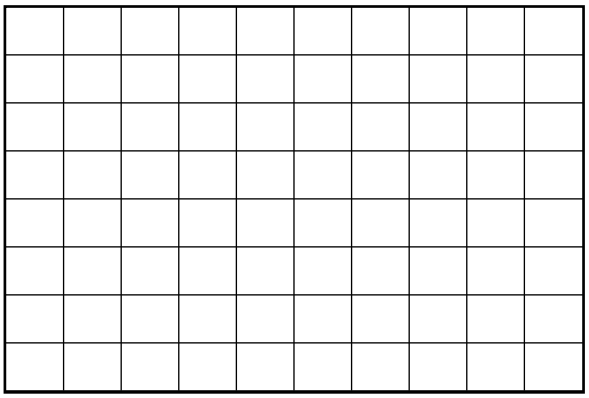
   _____

4. Draw or print the waveform at IDLE. What is the frequency? _____

IDLE



2000 RPM



5. Raise engine RPM to 2000. What happened to the waveform and frequency?

   _____

6. What sections in the RM contain diagnostic information on these sensors?

   _____

7. What are the coil resistance specifications for the crankshaft and camshaft position sensors?

   _____

Position/Speed Sensors

Name _____ Date _____

Review this sheet as you are doing the worksheet. Check each category after completing the worksheet and instructor presentation. Ask the instructor if you have questions. The comments section is for you to write where to find the information, questions, etc.

Topic	*I have questions*	*I know I can*	Comment
Locate components in the crankshaft and camshaft sensing circuits using the EWD and RM			
Find wire colors, pin numbers in the crankshaft and camshaft sensing circuits using the EWD and RM			
Locate the crankshaft and camshaft readings from the Data List			
Measure the voltage signal of the sensors with a DVOM			
Observe the voltage signal pattern of the sensors with an oscilloscope			
Test wires for continuity and compare to specifications to determine condition			
Test sensor resistance and compare to specifications to determine condition			
Check and retrieve relevant DTCs			
Describe purpose of crankshaft and camshaft sensors			
Describe ECM strategy if the crankshaft circuit fails			
Describe ECM strategy if the camshaft circuit fails			

Notes

WORKSHEET 2–7
Oxygen Sensor

Vehicle	Year/Prod. Date	Engine	Transmission

Technician Objectives

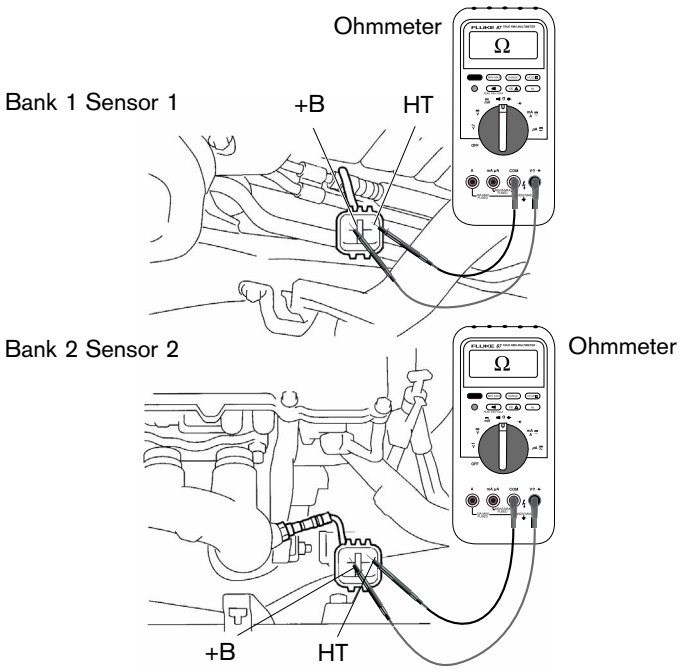
With this worksheet, you will learn to test oxygen sensor and circuits using the required tools and equipment, retrieve and apply the needed service information, retrieve and interpret service data information.

Tools and Equipment

- Vehicle Repair Manual
- Vehicle EWD
- Diagnostic Tester
- DVOM
- Hand Tool Set

Section 1

Disconnect the oxygen sensor connector. Using a DVOM, measure the heater element resistance and compare to specifications.



Heater Resistance Test

T852f350

1. Record resistance readings B1S1 _____ ohm, B2S1 _____ ohms.

   Was the resistance within specification?

   _____

2. Use the EWD to trace the oxygen sensor heater circuit. What component supplies power to the oxygen sensor heater?

_____

3. With the key on and engine off, at the HTL or HTR terminal of the ECM, measure oxygen sensor heater voltage: _____
4. Start the engine. What happened as the engine warmed up?

_____

_____

5. What DTCs could set if the heater did not work?

_____

Section 2

Oxygen Sensor Signal

1. Connect the Diagnostic Tester and scroll to the oxygen sensor.
2. Locate the oxygen sensor terminal on the ECM. Connect the positive (+) lead of the DVOM to the oxygen sensor signal terminal, connect the negative (-) lead to E2. Set the DVOM to the DC scale.
3. With vehicle in park, exhaust hose connected, parking brake set, start the engine. Note that initial readings will change based on engine temperature.
4. After the engine has warmed up, record the oxygen sensor signal at idle. Are the readings normal?

_____

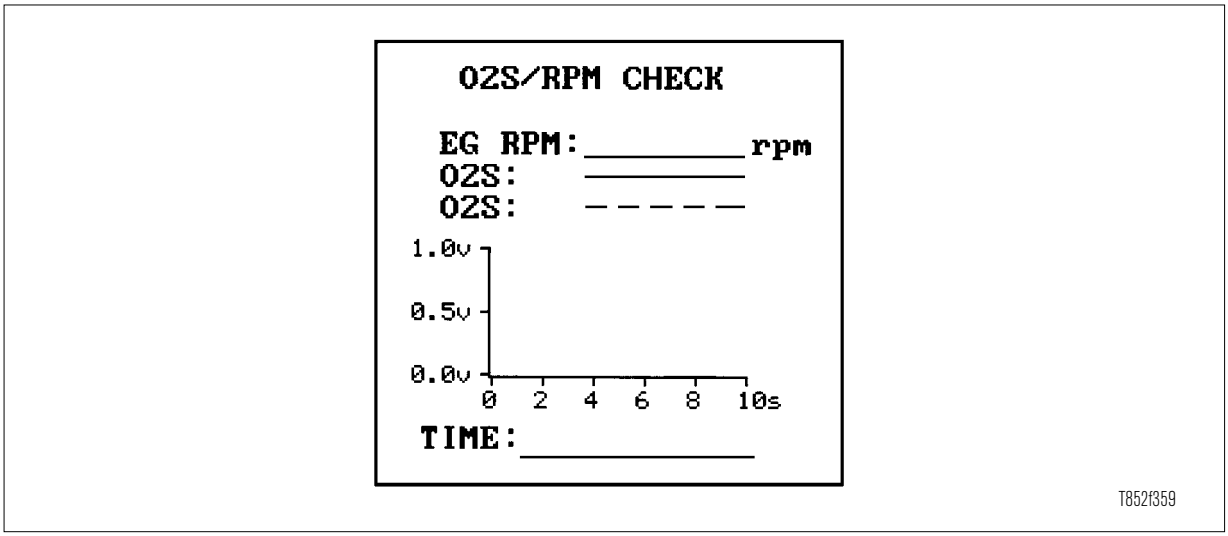
5. Briefly snap the throttle wide open and release. What happened to the oxygen sensor signal?

_____

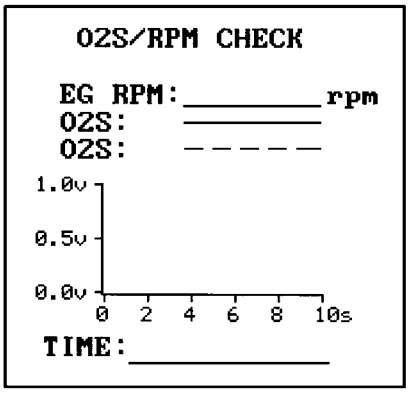
6. Hold the engine at 2,500 RPM. What happened to Oxygen sensor readings?

_____

7. With the Diagnostic Tester, go to the O2S/RPM check. (Instructions found in Diagnostic Toolset manual.) Raise engine to 1000 RPM. Draw the pattern on the following graph.



Raise engine to 2500 RPM. Draw the pattern on the following graph.



T852f359

1. What happened to oxygen sensor frequency?

   _____

2. With the engine at idle, create an intake manifold vacuum leak, by disconnecting a vacuum hose. What happened to the O2 sensor reading?

   _____

3. Reconnect the vacuum hose. What happened?

   _____

Section 3

Oxygen Sensor Response

With the engine at operating temperature, go to Data List and note the oxygen sensor voltage signal and Fuel Trim.

1. Disconnect a vacuum hose. Was there a change to oxygen voltage signal and Short Term Fuel Trim?

   _____

2. Reconnect vacuum hose.
3. **Predict** what **will** happen to oxygen sensor signal voltage if more fuel is added?

   _____

4. Go to Injector Volume Active test. Add fuel using the Active Test to increase injector duration. What happened to oxygen sensor voltage signal?

   _____

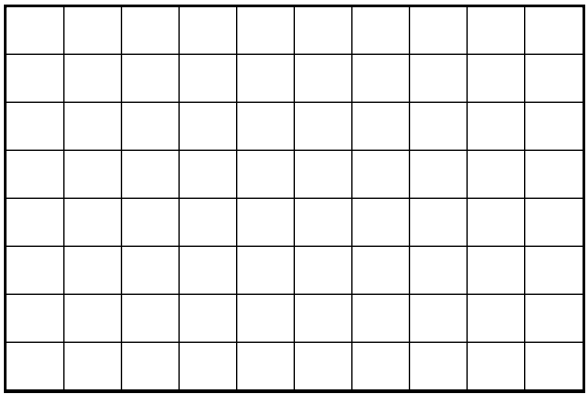
5. Decrease injector duration. What happened to oxygen sensor signal voltage?

   _____

Section 4

Oxygen Sensor Signal Using AutoProbe

1. Connect AutoProbe to the Diagnostic Tester and calibrate according to the Diagnostic Tester manual. Go to oscilloscope screen. Set the time and voltage according to the instructor's directions. (typically 1 second and 0.2 volts)
2. Connect the AutoProbe to the oxygen sensor signal wire at the ECM. Start the engine and observe the pattern.
3. Draw the pattern. TIME setting _____, VOLT setting _____.



4. What is the major difference between using the AutoProbe and the OS2 Check?

_____

_____

Oxygen Sensor

Name _____ Date _____

Review this sheet as you are doing the worksheet. Check each category after completing the worksheet and instructor presentation. Ask the instructor if you have questions. The comments section is for you to write where to find the information, questions, etc.

Topic	*I have questions*	*I know I can*	Comment
Locate components in the oxygen sensing circuits using the EWD and RM			
Find wire colors, pin numbers in the oxygen sensing circuits using the EWD and RM			
Locate the oxygen sensor readings from the Data List			
Measure the voltage signal of the sensor with DVOM and compare to specifications to determine condition			
Test sensor performance with oscilloscope and compare to specifications to determine condition			
Test heater supply voltage and compare to specifications to determine condition			
Test ground lines and compare to specifications to determine condition			
Check and retrieve relevant DTCs			
Describe purpose of the front oxygen sensor(s)			
Describe ECM strategy if the front oxygen sensor circuit(s) fails			

Notes

WORKSHEET 2–8
Air/Fuel Ratio

Vehicle	Year/Prod. Date	Engine	Transmission

Technician Objective

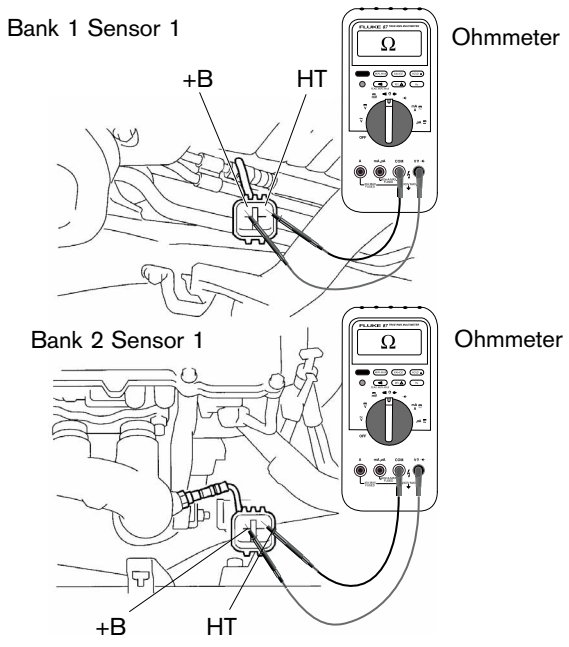
With this worksheet, you will learn to test A/F sensor and circuits using the required tools and equipment, retrieve and apply the needed service information, retrieve and interpret service data information.

Tools and Equipment

- Vehicle Repair Manual & EWD
- Diagnostic Tester & DVOM
- Hand Tool Set Vacuum Pump
- Vehicle

Section 1

A/F Sensor Heater



Heater Resistance Test

T852f350

1. Disconnect the A/F sensor connector. Using a DVOM, measure the heater element resistance.

   Record resistance readings B1S1: _____ ohms, B2S1 _____ ohms.

   Was the resistance within specification?

   _____

2. Reconnect A/F sensor. With the key on and engine off, measure A/F sensor heater voltage and body ground.

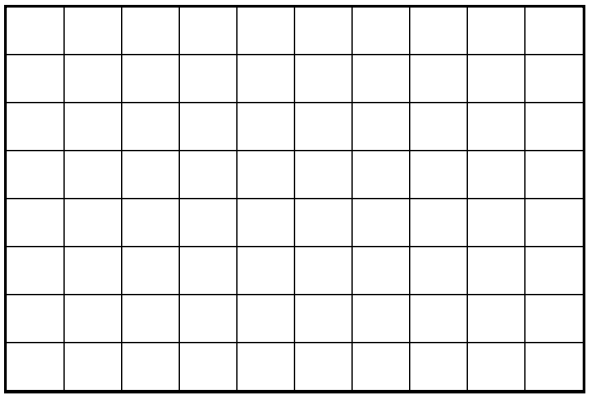
   _____

3. With the engine cold connect a DVOM and AutoProbe to the A/F sensor heater terminal at the ECM. Go to oscilloscope screen. Set the time and voltage according to the instructor's directions.

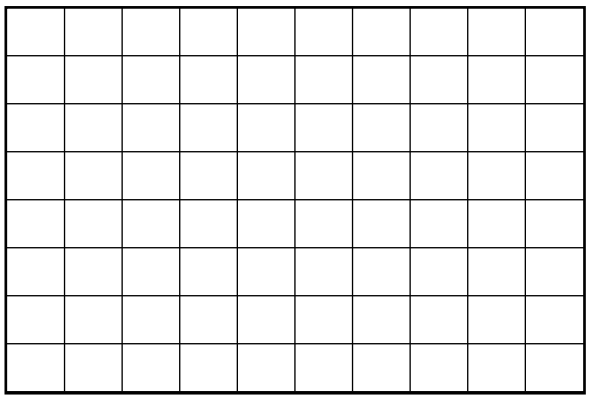
   Start the engine and observe the DVOM voltage and oscilloscope pattern.

   What was the voltage at start? _____ Warm idle? _____

   Draw the pattern. TIME setting: _____ VOLT setting: _____



   Increase engine RPM to 2500. Draw the pattern.



4. What happened to the pattern?

   _____

5. Use the EWD to trace the A/F Sensor Heater circuit. What turns on the A/F sensor heater relay?

   _____

6. These tests confirm the operation of which components and continuity of which circuits?

   _____

7. What DTCs could set if the heater did not work?

   _____

Section 2

A/F Sensor Response

Connect the Diagnostic Tester. With the engine at operating temperature, go to Data List, USER DATA and select one of the A/F sensors, Short Term Fuel Trim, and select ENTER. Select F4.

1. Record A/F sensor engine idling. Briefly, snap the throttle wide open and release. What happened?

   _____

2. Disconnect a vacuum hose. Was there a change to A/F voltage signal and Short Term Fuel Trim?

   _____

3. Reconnect vacuum hose.
4. **Predict** what **will** happen to A/F signal voltage if more fuel is added?

   _____

5. Go to Injector Volume Active Test. Increase injector duration. What happened to A/F sensor voltage signal?

   _____

6 Decrease injector duration. What happened to A/F sensor signal voltage?

   _____

Notes

Name _____ Date _____

Review this sheet as you are doing the worksheet. Check each category after completing the worksheet and instructor presentation. Ask the instructor if you have questions. The comments section is for you to write where to find the information, questions, etc.

Topic	*I have questions*	*I know I can*	Comment
Locate components in the A/F Ratio sensing circuits using the EWD and RM			
Find wire colors, pin numbers in the A/F Ratio sensing circuits using the EWD and RM			
Locate the A/F ratio sensor readings from the Data List and compare to specs. to determine condition			
Test sensor performance and compare to specifications to determine condition			
Test heater resistance and compare to specifications to determine condition			
Test heater supply voltage and compare to specifications. to determine condition			
Test ground lines and compare to specs. to determine condition			
Check and retrieve relevant DTCs			
Describe purpose of the A/F sensor(s)			
Describe ECM strategy if the A/F sensor circuit(s) fails			

Notes

WORKSHEET 2–9
Knock Sensor

Vehicle	Year/Prod. Date	Engine	Transmission

Technician Objectives

With this worksheet, you will learn to test knock sensor and circuit using the required tools and equipment, retrieve and apply the needed service information, retrieve and interpret service data information.

Tools and equipment

- Vehicle Repair Manual
- Vehicle EWD
- Diagnostic Tester
- Hand Tool Set

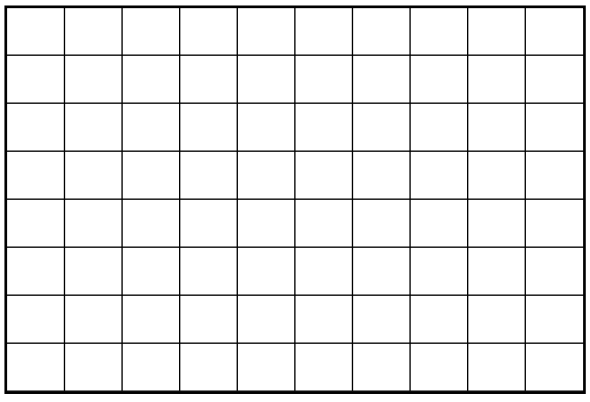
Section 1

The knock sensor is will generate a signal, based on the strength and frequency of the knocking sound caused spontaneous combustion. Engine mechanical noises, such as a worn connecting rod may also be the cause.

Section 2

1. Locate and connect the Autoprobe to the knock sensor terminal on the ECM according to the Repair Manual.
2. Accelerate the engine to the RPM specified in the manual or per instructor's recommendation. Connect DVOM and set to AC volts, Hz. Start the engine and draw or print the waveform.
3. Note the DVOM reading: _____

   Draw the waveform pattern.



4. Does the waveform match the Repair Manual waveform?

   _____

5. What is the frequency? _____

6. List any other test method(s) for the knock sensor.

_____

7. For DTC P0325, what are the Detecting Conditions?

_____

_____

_____

8. Is it 1 or 2 trip logic detection?

_____