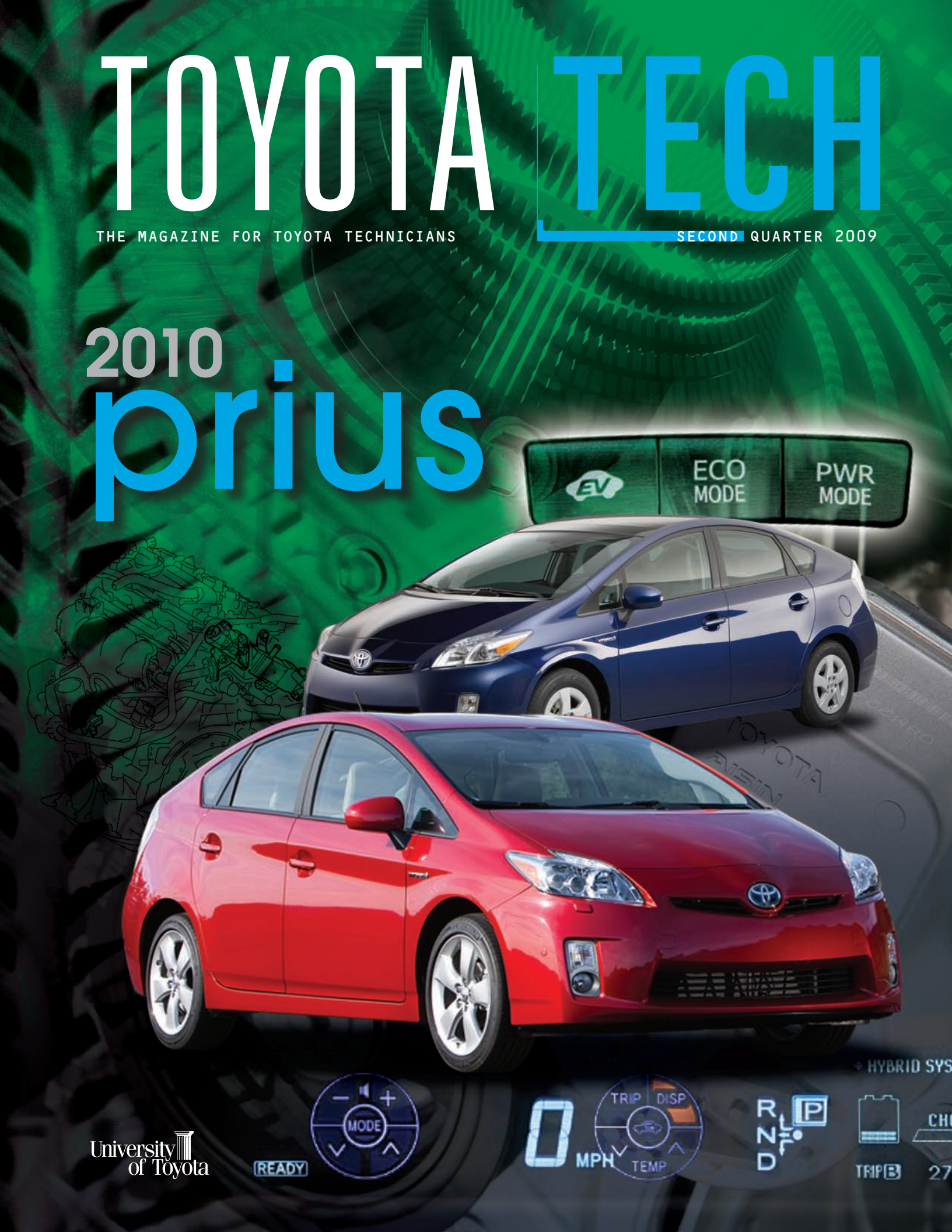
TOYOTA TECH

THE MAGAZINE FOR TOYOTA TECHNICIANS

SECOND QUARTER 2009

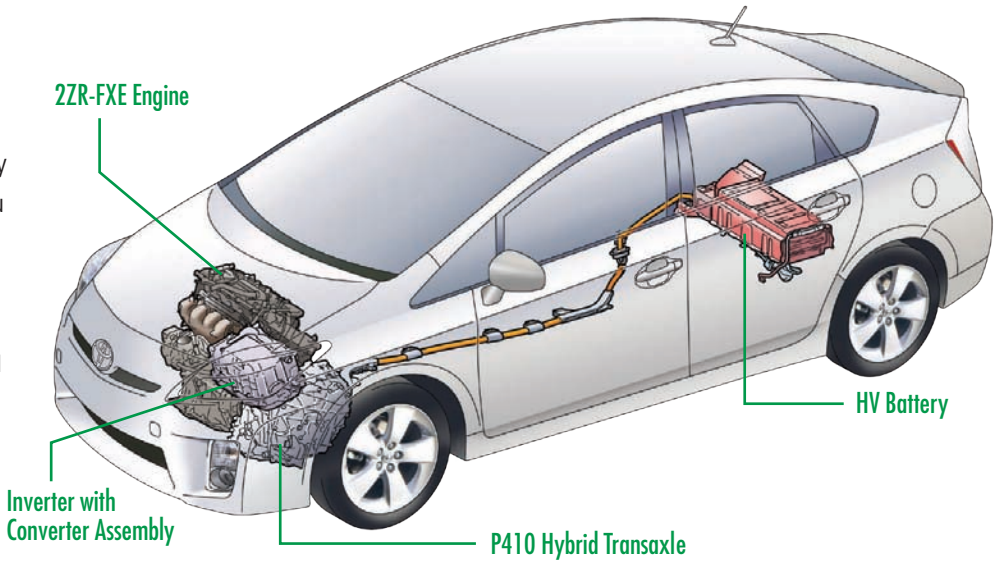
2010 prius



University of Toyota

2010 **PRIUS** New Model Highlights – *PART 1*

The 2010 Toyota Prius represents the third generation of the nameplate. It builds upon the previous generation's proven hybrid technology and adds many new features. As a Toyota technician, you will be called upon to maintain the new Prius for individuals as well as other customers who will use the green vehicle for private or public fleets. This article will help familiarize you with the 2010 Prius so you are better prepared to diagnose and service its complex systems.



Overview

Although the hybrid system is 90 percent new on the 2010 Prius, the basic layout of the hybrid components remain the same. The HV battery is located behind the rear seats under the cargo floor. The service plug is relocated to the right rear of the HV battery. Orange high-voltage cables carry power from the HV battery to the inverter along the passenger side undercarriage. While the inverter is smaller and lighter than before, the maximum boost voltage has increased from 500 volts to 650 volts. Completely redesigned to be smaller and lighter, MG1 and MG2 are housed in the new P410 hybrid transaxle. MG2 moves the vehicle through an all-new compound gear reduction unit that no longer uses a drive chain.

TOYOTA TECH ▸ Contents SECOND QUARTER 2009

Published by the Technical & Body Training Development Department, Toyota Motor Sales, U.S.A., Inc. Contents may be reprinted with permission. Address all correspondence to *Toyota Tech*, c/o Technical & Body Training Development Department S102, Toyota Motor Sales, U.S.A., Inc., 19001 S. Western Avenue, Torrance, CA 90501.

John Saia — *Technical & Body Training Development Manager* | **Miki Todd** — *Editor-in-Chief* | **Think Ink** — *Design*

Toyota Tech is a magazine for the Toyota dealership technician. Subscriptions and outside mailings are not available.

University of Toyota

The 2010 Prius has optonal LED low beam headlamps with halogen high beams. The headlamps are comprised of 3 LEDs each and feature an LED driver module integrated into the headlamp assembly. While the halogen bulbs and LED driver can be replaced separately, LEDs can only be replaced with a new headlamp assembly. All vehicles equipped with LED headlamps also have the automatic headlight beam level control system.

In addition to "Normal" driving in the 2010 Prius, three new drive modes are available. EV mode allows the vehicle to drive up to approximately 25 mph for short distances using only MG2 without help from the gasoline engine. ECO mode controls acceleration and air conditioning performance to maximize fuel economy. PWR mode is also available on the 2010 Prius. PWR mode improves mid-range acceleration by changing the vehicle's response to accelerator pedal input.

Advanced Technology Systems

Prius is equipped with several advanced technology systems that improve the driving experience and improve safety. Dynamic radar cruise control is available on Prius to maintain a pre-set vehicle-to-vehicle following distance while driving. The system uses a millimeter wave radar sensor behind the front Toyota emblem to detect the presence and speed of vehicles ahead. A switch on the steering wheel allows the driver to choose from three different following distances to adjust for driving conditions.

The millimeter wave radar sensor is also used by the new Pre-Collision System. The Pre-Collision System (PCS) operates when:

- a possible collision is detected,
- the brakes are suddenly applied, or
- the vehicle is about to enter a skid.

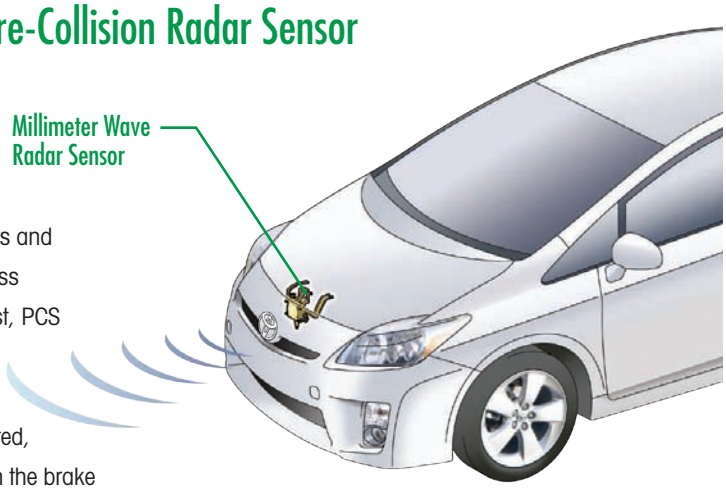
When PCS detects a possible collision, it retracts the front seatbelts and puts Brake Assist into standby mode. Any brake application, regardless of intensity, will cause Brake Assist to activate. If the conditions persist, PCS will signal the Skid Control ECU to apply the brakes automatically, regardless of brake pedal application.

When the brakes are applied suddenly or a potential skid is detected, PCS retracts the front seat belts. The seatbelt tension is released when the brake pedal is released or the vehicle recovers from the skid.

The PCS communicates warning messages to the driver through the Multi-Information Display.

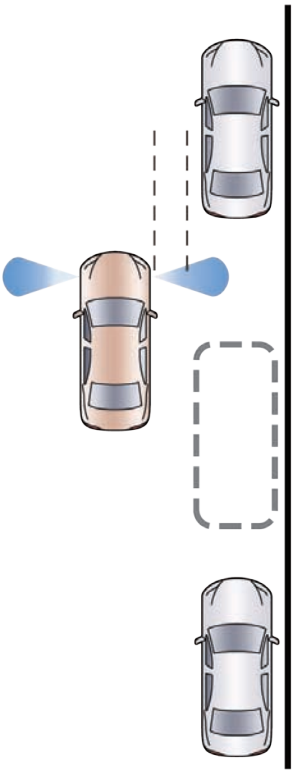
Note: Techstream and Special Service Tools must be used to adjust the millimeter wave radar sensor assembly when it is replaced.

Pre-Collision Radar Sensor



Advanced Parking Guidance System (APGS)

PARALLEL PARKING



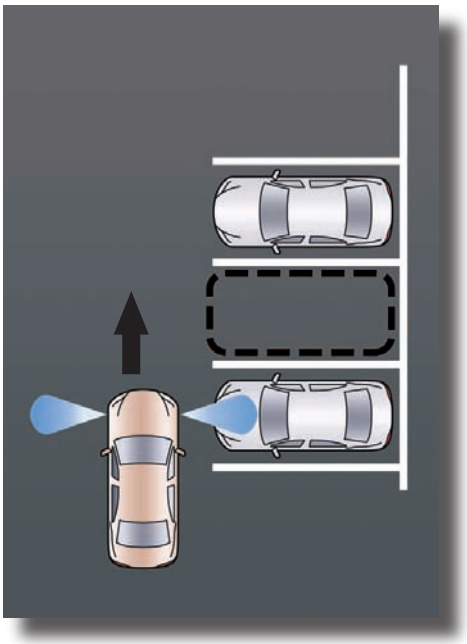
The 2010 Prius also features a system new to Toyota, the Advanced Parking Guidance System (APGS). This system uses ultrasonic sensors in the front bumper and the Backup Monitor system to detect a target parking space. The system also controls the steering to assist the driver with parallel and perpendicular parking.

APGS includes a Pre-Support Function that uses on-screen instructions to help the driver position the vehicle prior to backing up. The target parking space is measured with the ultrasonic sensors as the vehicle moves past the parking space during the Pre-Support Function.

Once the parking space is identified, the driver need only control vehicle speed with the brake pedal while the system controls steering.

Television camera replacement necessitates several initialization and calibration procedures to ensure proper system operation. All APGS calibrations are performed using the NAV screen. Refer to the Repair Manual for detailed instructions on these procedures.

PERPENDICULAR PARKING

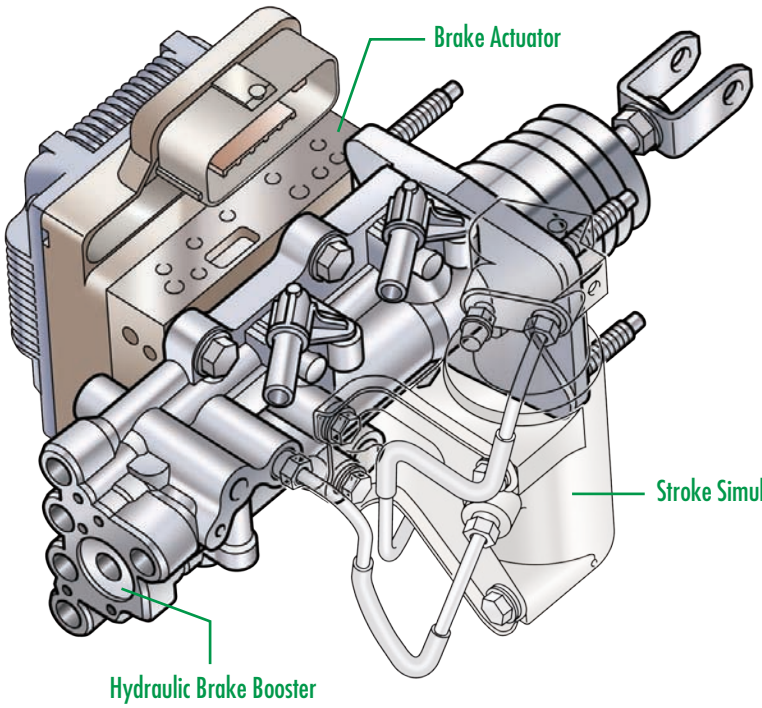


Electronically Controlled Brakes (ECB)

Prius has an all-new Electronically Controlled Brake System. The Brake Actuator incorporates the Skid Control ECU and multiple valves and sensors used to operate the vehicle brakes. MG2 is still used for regenerative braking in combination with the hydraulic brakes to slow the vehicle. New to ECB is a hydraulic brake booster assembly. This booster replaces the capacitors used on the previous generation Prius and allows for fail-safe modes.

Note: When servicing the hydraulic brake system, use Techstream to perform air bleeding procedures and component initialization. These procedures have changed for the 2010 Prius, so refer to the Repair Manual for detailed instructions.

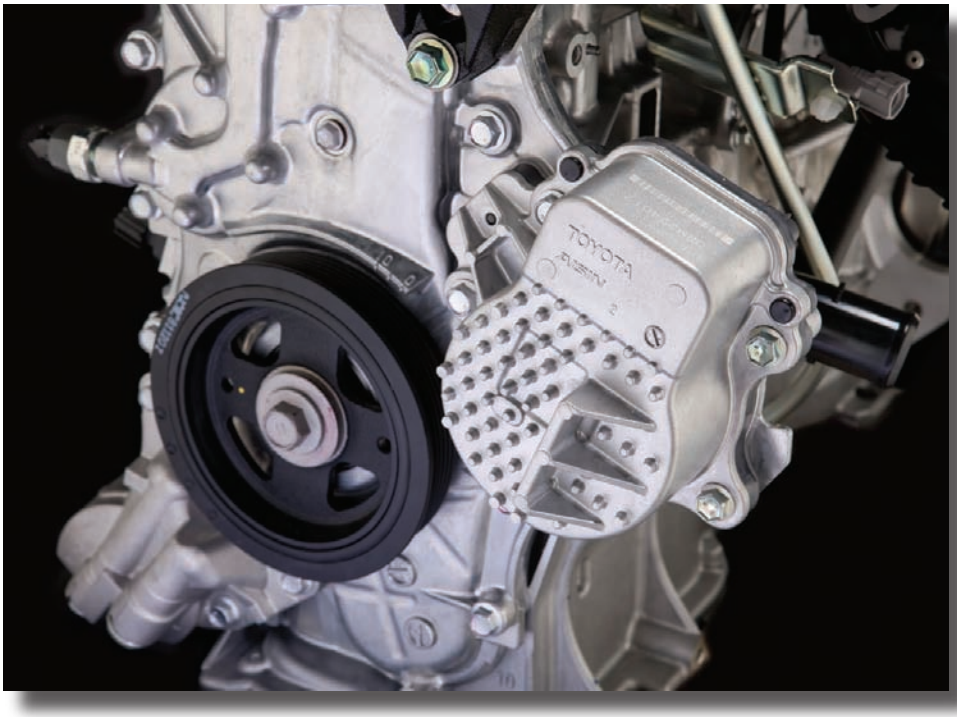
Hydraulic Brake Booster

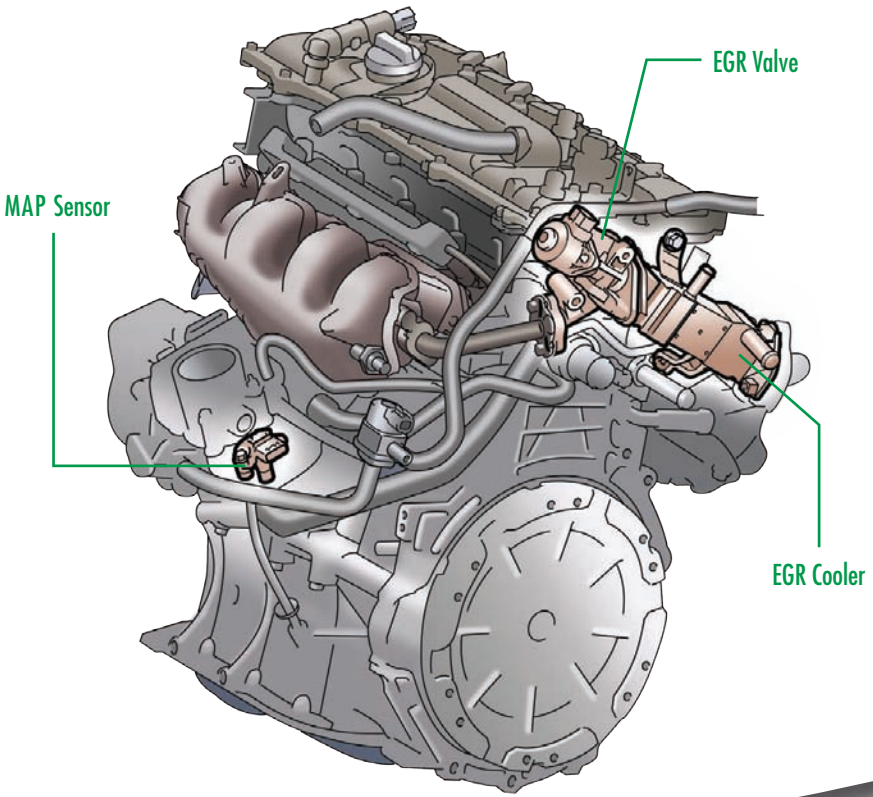


Engine

The 2010 Prius has a new gasoline engine. It is the 4-cylinder 2ZR-FXE 1.8-liter engine, which is similar to the 2ZR-FE used in Corolla and Matrix but the 2ZR-FXE uses the Atkinson cycle for improved efficiency. The bladder-type fuel tank has been discontinued on the 2010 Prius and is replaced with a multilayered plastic tank. The 2010 Prius uses the Key OFF EVAP System.

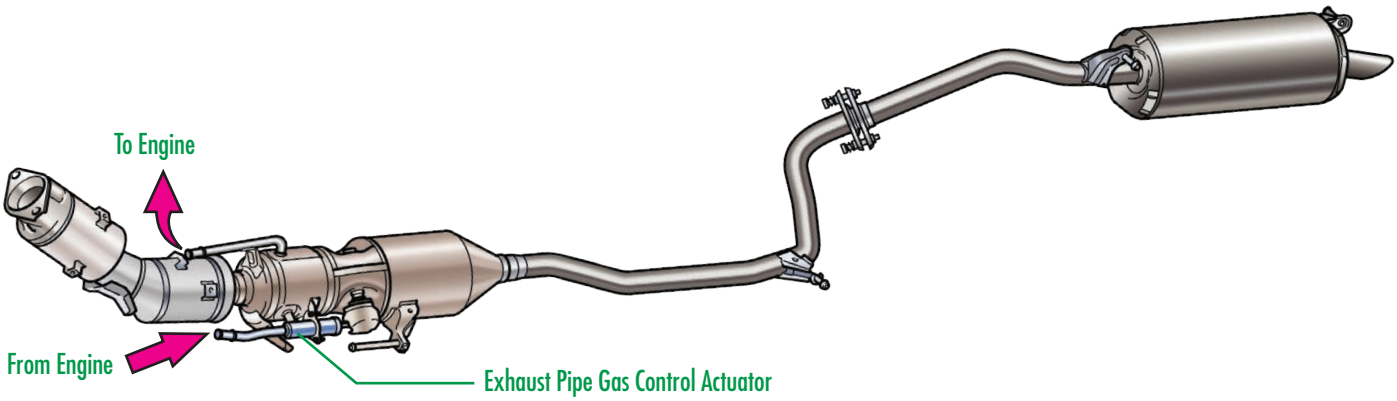
The 2ZR-FXE employs an electric water pump for engine cooling duties. This pump eliminates the need for any belts on the engine and improves fuel economy. The electric water pump includes a new Active Test and new Data List parameters to indicate the target and actual pump speed. The coolant replacement procedure for Prius has changed; the electric water pump is used during the procedure to help remove air from the system. See the Repair Manual for details.





The 2ZR-FXE also features a cooled EGR system to improve fuel economy and reduce emissions. This system routes exhaust gas through the EGR cooler, which uses engine coolant to reduce the temperature of the gas. The gas is then sent to the EGR valve which controls flow into the intake manifold for distribution to the cylinders. A new manifold absolute pressure sensor (vacuum sensor) on the intake manifold provides feedback to the ECM to confirm EGR valve operation. The cooled EGR system includes a new Active Test and new Data List items.

Exhaust Heat Recirculation System



The 2010 Prius introduces an all-new exhaust heat recirculation system to decrease engine warm-up time and improve heater performance. The system replaces the coolant heat storage tank used on the previous generation Prius.

Coolant is routed to the exhaust heat recirculation assembly, which is behind the three-way catalyst. When coolant temperature is low, a valve inside the assembly is closed, forcing hot exhaust through passages next to the engine coolant. The exhaust warms the coolant, which is routed back to the engine.

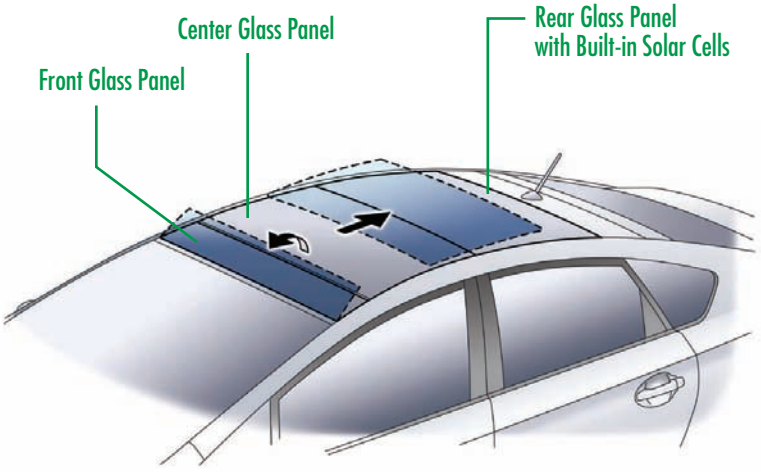
Once the coolant becomes sufficiently warm, the exhaust pipe gas control actuator opens the valve and allows exhaust to flow normally. A new Coolant Temperature Switch is used with this system in addition to the traditional ECT sensor. The new switch is used to illuminate an indicator on the combination meter if the coolant becomes too warm.

HVAC Systems

The HVAC on the 2010 Prius includes two all-new systems to help reduce cabin temperature while the vehicle is parked. These systems, when used together, can significantly cool the interior.

The first new system is the Solar Ventilation System. The panorama moonroof that is available on the Prius includes a solar module built into the rear glass panel. This module is made up of 36 solar cells and generates electricity that is used to power the HVAC blower when the vehicle is parked. The system begins operation approximately 10 minutes after the vehicle is parked when all operating conditions are met. Power created by the solar module is routed directly to the blower motor, drawing in outside air and venting cabin air at the rear of the vehicle. The Solar Ventilation System includes several Data List items and a Test Mode to aid in diagnosis.

Glass Roof



The second new HVAC system on the 2010 Prius is Remote A/C. This system uses the HV battery to power the A/C compressor without starting the gasoline engine. The system is activated with a button on the key fob. When the button is pressed for about a second, the A/C compressor operates via power from the HV battery. The Remote A/C system will operate for approximately 3 minutes.

Body Electrical

Prius features an all-new combination meter with integrated Multi-Information Display (MID) on all models. In addition to several new warning/operation indicators, the combination meter includes a new instant fuel economy indicator next to the vehicle speed indicator. The new MID allows the driver to view several different screens to monitor energy flow, fuel consumption, and system status. Warning messages and service reminders are displayed on the MID as well. Several items can be customized using the MID without Techstream.

Also new to Prius is Touch Tracer, which displays a virtual representation of the steering wheel switches when they are lightly touched. The switch being touched is highlighted on the Touch Tracer display. This allows the driver to operate steering wheel switches without taking his/her eyes off the road. The steering wheel switches used with Touch Tracer are essentially two switches in one. The first switch requires only a small amount of force to activate, causing the system to display Touch Tracer. The second switch requires greater force to activate, and causes the switch function to operate.

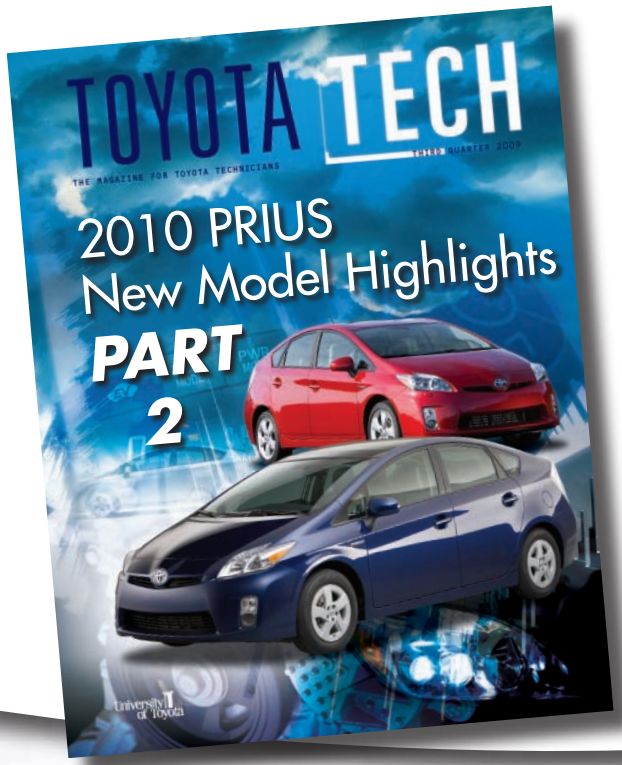
The 2010 Prius is equipped with the smart key system as a standard feature. However, two different smart key systems are available. One system has smart entry on the driver's door only. The other smart key system has smart entry on both front doors and the rear door. The easiest way to determine which system is on a vehicle is to look for the lock sensor on the passenger front door or the lock switch on the rear door. Regardless of smart entry, all Prius vehicles have the smart start function.

Note: The ID Code Box is sometimes referred to as the Immobilizer Code ECU in the 2010 Prius Repair Manual.

For more information on the 2010 Prius, see the *2010 Prius New Model Technical Preview* e-learning module.

Adam Crawford — Technical Training

Coming this fall in *TOYOTA TECH* magazine



Unlock the Door:

Smart Key System Diagnosis

Knowing where to start is one of the biggest challenges when diagnosing the smart key system. This article will show you how to use your eyes, hands and ears to check the system and lead you to a diagnostic starting point.

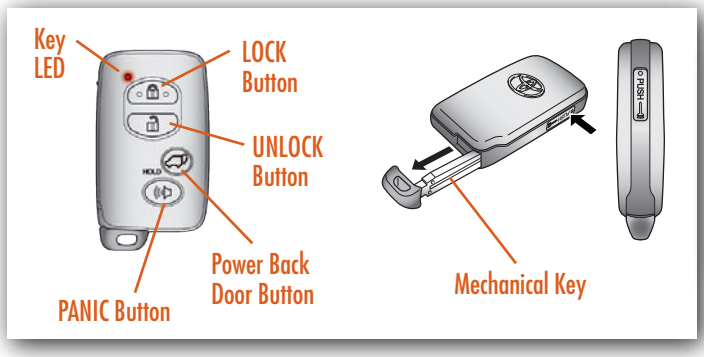
Let's take a step by step look at a normally functioning smart key system using the Smart Key Operation Table.

The system operation is divided into 8 groups (see table rows 1-8). The second column (EVENT), describes a sensory event – something you can see, feel, or hear. When the event occurs, specific system components are working. The third column, (CONCLUSIONS), identifies these working components and the signals needed for each event. For example, opening the door causes the Door Open warning light to illuminate (GROUP 3 EVENT occurs). This confirms that the door courtesy switch (Group 3 CONCLUSIONS) is OK.

Note that the system operates sequentially, and if any event does not occur, the system has stopped at that point. For example, when the key is taken inside the vehicle, the LED does not blink (Group 4 EVENT does not occur). Begin diagnosing room oscillator operation (the component listed under Group 4 CONCLUSIONS).

SMART KEY OPERATION TABLE

GROUP	EVENT	CONCLUSIONS
1	The LED on the key blinks when you approach the vehicle	• Key is partially registered (key has the vehicle's ID code) • Certification ECU is functioning • Door oscillator is functioning • Tuner is functioning • Key battery is above 2.2 V • Vehicle battery is good enough to energize some ECUs
2	Puddle or dome lights illuminate	• Certification ECU verified key ID code • Body ECU (or equivalent) is functioning
3	Opening the door causes the Door Open warning light to illuminate	• Door courtesy switch is OK
4	When the key is taken inside the vehicle, the LED on the key blinks	• Room oscillator is functioning
5	The LED on the Engine/Power Switch is green after depressing the brake pedal	• Stop Light Switch input is OK • Park/Neutral Position Switch input is OK
6	Steering wheel unlocks	• S code verified • ID Code Box is functioning • L code verified • Steering Lock ECU is functioning
7	Security light is OFF	• Lock bar in unlock position signal is sent to the Certification ECU • ECM is functioning • 3-bit code is released in the ECM
8	Engine starts and runs	• G code is verified



Let's look at what happens when you approach a locked vehicle.

Group 1 Event – Key LED Blinks

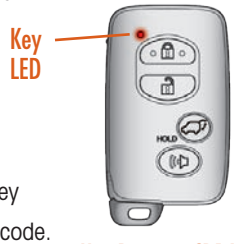
With the engine off and the doors locked, the door oscillators are transmitting Low Frequency (LF) signals from two or four doors, depending on the vehicle. The LF signals are transmitted through the door handle antenna every 0.25 second (four times per second).

When the door oscillator transmissions are received by the key, the key transmits a Radio Frequency (RF) signal. The key's RF signal is received by the tuner (Door Lock Control Receiver). The information in the RF signal is sent from the tuner to the Certification ECU.

When a key is in a door oscillator detection area, four levels of communication must occur between the key and the Certification ECU to verify a registered key:

1. The Certification ECU checks for a key in a door oscillator detection area.
2. The Certification ECU determines the location of the key.
3. The Certification ECU requests the **vehicle ID code**, the key transmits the vehicle ID code, and the Certification ECU verifies the vehicle ID code.
4. The Certification ECU requests the **key ID code**, the key transmits the key ID code **(key LED blinks)**, and the Certification ECU verifies the key ID code.

SMART KEY WITH TRANSPONDER CHIP



After the key is verified, the Certification ECU puts the door handle touch sensor in standby mode, which allows the door to be unlocked when the sensor is touched.

Service Tip: During normal operation, an oscillator's LF signal can be "heard" using an AM radio. The oscillator signal is heard as interference in the AM band and sounds like a tick or pop. Tune the radio so that no other signals are picked up. The tick or pop should be clear. Usually the best tuning frequencies are near the lower end of the frequency range, but under certain conditions the best tuning may be near the upper frequencies. This method will work for both exterior and interior oscillators. You may have to tune the radio differently to hear the exterior and interior oscillators clearly.

DIAGNOSTIC TIP

THE KEY BROADCASTS THE KEY ID CODE WHEN:

- A wireless button is depressed.
- The key ID code is transmitted for smart entry.
- The key ID code is transmitted for smart start.

Notes: If the LED does not blink when the wireless button is depressed, check for a damaged key or a dead key battery. (See page 13 for more details on the smart key batteries.)

Broadcasting the key ID code is the only thing that will cause the key LED to blink.

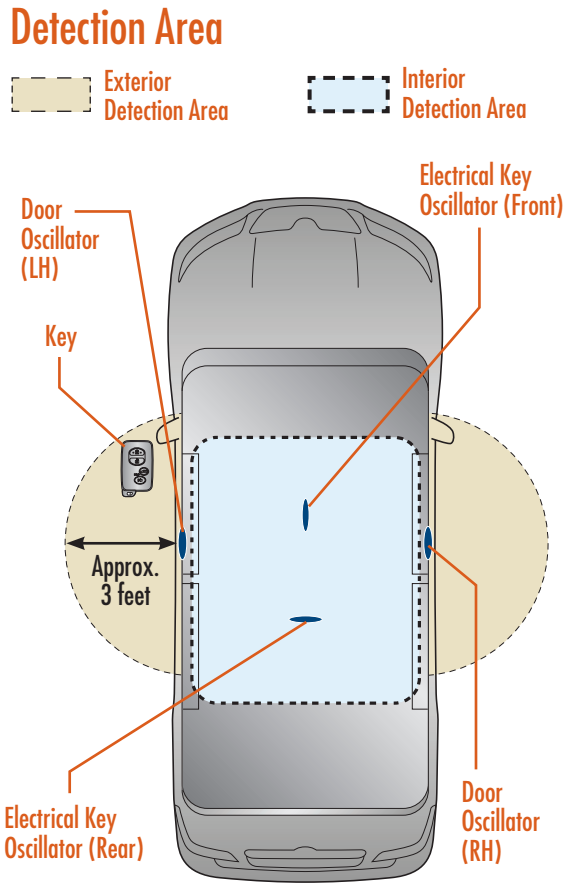
Group 1 Conclusions

For communication to occur between the vehicle and a key, multiple components must operate:

1. **Certification ECU** – Manages the smart key system.
2. **Door Oscillator and Antenna** – Receives the request signal from the Certification ECU and forms the detection area around the door by transmitting an LF signal. The antenna is located in the outside door handle.
3. **Key** – The key receives the signals from the door oscillator and transmits the requested information to the tuner using an RF signal.
4. **Tuner (Door Lock Control Receiver)** – Receives the information from the key and sends it to the Certification ECU using vehicle electrical circuits.
5. **Vehicle Electrical Circuits** – Wire harnesses and connectors must be in good operating condition to allow components, not using LF or RF signals, to communicate.

You know that when the LED on the key blinks as you enter the door oscillator detection area, the components and circuits are working.

Service Tip: Normally, when approaching or entering a vehicle, the LED on the key blinks 1 time. However, the LED may blink 2 or more times. Multiple blinking occurs when the Certification ECU did not receive a recognizable key ID code and requests for the key ID code to be resent. **Note:** Multiple blinking could be caused by electrical noise or interference in your work area. The interference could be caused by a computer wireless router, another smart key system or a battery charger operating near the vehicle.



Group 2 Event – Puddle or Dome Lights Illuminate

Observe the vehicle's exterior and interior lighting to determine the current status of the smart key system. The lighting comes on after the key ID code is verified by the Certification ECU. Keep in mind that vehicle lighting operation will vary between models and can be influenced by switch position (dome light) and customized settings. You can find this information in the New Car Features book or use a known good vehicle as a reference.

When the door is unlocked, additional interior lights may come on, such as door courtesy lights. Unlock answer-back features will also activate, such as a double blink of the hazard lights.

When the door is opened, additional interior lights may come on, such as floor or footwell lights, or additional door courtesy lights.

During normal operation, the Certification ECU verifies that a registered key is in the detection area, and the door handle touch sensor is put in standby mode. Touching the touch sensor, in standby mode, sends a request to the Body Electrical system to unlock the door.

Diagnostic Tip: When Techstream is connected to the vehicle to access the smart key system Data List parameters, Techstream puts all touch sensors in standby mode for testing. The "Door Touch Sensor" Data List will change from ON to OFF when the sensor is touched **(Figure 1)**.

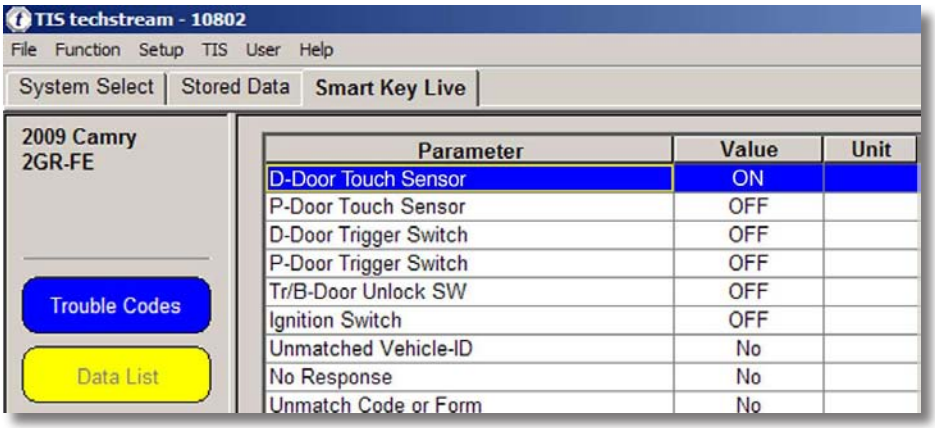


Figure 1 Driver Door Touch Sensor

Group 2 Conclusions

- Certification ECU verified the key ID code.
- Body ECU (or equivalent) is functioning.

Group 3 Event – Door Open Warning Light Illuminates

When the driver's door is opened, the smart key system uses the signal from the door courtesy switch to begin the transition from smart entry to smart start. This signal is used by the Certification ECU to turn on the room (interior) oscillators and turn off the driver's door oscillator to save battery power. The Body Electrical system turns on additional lighting and turns on the Door Ajar warning light in the combination meter.

Group 3 Conclusions

- Door courtesy switch is OK.

Group 4 Event – Key LED Blinks

Observe that, when a registered key is brought into the vehicle, the key LED blinks. The Body Electrical system has informed the Certification ECU that the driver's door is open so that the room (interior) oscillators can be turned on and, at the same time, turn off the driver's door oscillator.

When the system detects a registered key inside the vehicle and the Engine Switch or brake pedal are not depressed, the system will continue to verify the presence of the key every 5 seconds, for 30 seconds. This can be verified by watching the LED on the key blink every 5 seconds.

At the end of the 30-second cycle, the system turns off the room oscillator to save battery power (the LED on the key will stop blinking).

To turn the system back on:

- Cycle the driver's door courtesy switch to begin another 30-second key verification cycle, or
- Press the brake pedal and the key will be verified every 5 seconds for as long as the brake pedal is depressed, or
- Press the Engine Switch and the system will verify the key one time.

Group 4 Conclusions

- Room oscillator is functioning.

Group 5 Event – Engine Switch Green LED is ON

When a registered key is detected inside the vehicle and the brake pedal is depressed, the green LED on the Engine Switch turns on. The Stop Light Switch must function, and the Park/Neutral Position Switch must be in Park or Neutral for the green LED to turn on.

Engine Switch Light

- OFF: OFF or Engine Running
- Amber: Accessory ON or Ignition ON
- Green: Engine or Hybrid System is in standby mode for start. The brake pedal must be depressed and the key must be in the room (interior) detection area for the light to turn green.

Group 5 Conclusions

- Stop light switch input to the Body Electrical system is OK.
- Park/Neutral Position Switch input to the Body Electrical system is OK.

Group 6 Event – Steering Wheel Unlock

STARTING THE ENGINE

Check key location and ID code → Steering lock/immobilizer canceled → Engine starts

Engine Switch

When the Engine Switch is depressed, the steering wheel unlocks. The following steps must occur, in this sequence, for the steering wheel to unlock:

- S code is verified – key, Certification ECU and ID Code Box registration.
- L code is verified – ID Code Box to Steering Lock ECU registration.
- Steering lock bar moves from lock to unlock position.

Service Tip: Use Techstream to see S code verification on the Data List parameter "S Code Check." When the S code is verified between the Certification ECU and ID Code Box, the data list value will be OK **(Figure 2)**. The data list value will only change to NG when S code verification fails.

After the S code registration is verified, the Certification ECU instructs the ID Code Box to verify the L code registration with the Steering Lock ECU.

Parameter	Value	Unit
IG2 Status	OFF	
IG(Lin)	OFF	
ID-BOX Sleep Condition	Yes	
ID-BOX Start Condition	No	
Engine Start Request	NG	
3bit Code Request	NG	
S Code Check	OK	
L Code Check	OK	

Figure 2 S Code Check

Group 6 Event – Steering Wheel Unlock (cont.)

Service Tip: The L code verification can be seen on Techstream Data List parameter "L Code Check." When the L code is verified between the ID Code Box and the Steering Lock ECU, the Data List parameter will be OK **(Figure 3)**. The Data List value will only change to NG when L code verification fails.

Confirmation of L code verification is sent to the Certification ECU. The Certification ECU then sends a signal to the Steering Lock ECU to unlock the steering column. When the steering is unlocked, the Steering Lock ECU will send an unlock confirmation signal to the Certification ECU.

Parameter	Value	Unit
L Code Check	OK	
Unlock Request Receive	NG	
Lock Request Receive	NG	
Engine Start Request(Past)	OK	
S Code Check(Past)	NG(Past)	
L Code Check(Past)	NG(Past)	
Steering Lock	Set	
Steering Unlock	Unset	

Figure 3 L Code Check

Group 6 Conclusions

- ID code box is functioning
- S code was verified.
- Steering lock ECU is functioning
- L code was verified.

Group 7 Event – Security Light Is OFF

The steering unlock confirmation signal prompts the Certification ECU to notify the Body Electrical system to begin the Start Engine/Ready ON process. At the same time the Certification ECU sends a signal to the ID Code Box to "release" the 3-bit code in the ECM. When the 3-bit code is released, the security light stops blinking.

Parameter	Value	Unit
Push Start Error	OK	
IG2 Status	OFF	
IG(Lin)	ON	
ID-BOX Sleep Condition	No	
ID-BOX Start Condition	No	
Engine Start Request	OK	
3bit Code Request	OK	
S Code Check	OK	

Figure 4 3-bit Code Request

Service Tip: The 3-bit code is a temporary immobilizer unset command that reduces crank time. This can be monitored using Techstream Data List parameter "3-bit Code Request" **(Figure 4)**.

Group 7 Conclusions

- Lock bar in the unlock position confirmation signal was sent to the Certification ECU.
- ECM is functioning.
- 3-bit code released in the ECM.

Group 8 Event – Engine Starts and Runs

When the engine speed reaches approximately 500-700 rpm (based on the NE signal), the ECM verifies the G Code with the ID Code Box. When the G code is verified, the engine continues to run and the security light stays off until the Engine Switch is turned OFF. If G code verification fails, the engine will shut off and the security light will turn back on.

Service Tip: The G code can be monitored using Techstream Data List parameter "EFI Code Receive." This parameter will stay NG until the G code verification is complete. The value will change from NG to OK for about 10 seconds (depending on the Techstream refresh rate) and then the value will return to NG **(Figure 5)**.

Parameter	Value	Unit
Unlock Request Receive	NG	
Lock Request Receive	NG	
Engine Start Request(Past)	OK	
S Code Check(Past)	NG(Past)	
L Code Check(Past)	NG(Past)	
Steering Lock	Unset	
Steering Unlock	Set	
EFI Code Receive	OK	

Figure 5 EFI Code Receive

Group 8 Conclusions

- G code is verified.

Tracy Bauer — Technical Training

NEW COMPONENT REGISTRATION

NEW COMPONENT	KEY ID	S CODE	L CODE	G CODE
Key	Techstream (Smart Code Registration)	———	———	———
Certification ECU	Techstream (Smart Code Registration)	———	———	———
ID Code Box	———	Automatic	Techstream (ECU Communication ID Registration)	SST at DLC3 (TC to CG for 30-44 minutes)
Steering Lock ECU	———	———	Techstream (ECU Communication ID Registration)	———
ECM*	———	———	———	Automatic
Certification ECU & ID Code Box	Techstream (Smart Code Registration)	Automatic	Automatic	SST at DLC3 (TC to CG for 30-44 minutes)

*If a used ECM is installed, manual G code registration using the SST at DLC3 (TC to CG for 30-44 minutes) must be completed.

This table is a reference for new component registration.

Note: Additional resources are located on TIS. Select the "Technical Training" tab and use Keyword search "T973B." Currently, the search will result in 3 documents:

- T973B High Tech Update: Smart Key Handout
- T973B High Tech Update: Smart Key Diagram
- T973B High Tech Update: Smart Key

SMART KEY BATTERIES

The small, wafer style batteries in the key fob experience a rapid voltage drop under a load. However, the batteries recover voltage quickly. The following can be observed:

1. Battery voltage above 2.2 V will allow the key to operate normally and cause the LED to blink.
2. Battery voltage between 2.0 V and 2.19 V will allow the key to operate normally, *but the LED will not blink*.
3. Battery voltage that is 1.9 V and below will not allow the key to operate or cause the LED to blink.

A key battery check procedure can be found in Technical Service Bulletin T-SB-0122-08, Smart Key Battery Diagnostics, located on TIS. **Note:** Use the **wireless lock button** during the key battery diagnostic procedure detailed in the TSB.

During smart entry, when a registered key is detected by the vehicle and a door is not unlocked using the touch sensor, the system continues to verify the presence of the key every 3 seconds for 10 minutes (the LED on the key fob will blink every 3 seconds). After 10 minutes, the Certification ECU turns off the door oscillator. This function saves vehicle and key battery power. This condition can be monitored using the Techstream Data List parameter "Power Save Cnt 10 min." **(See Figure 6.)**

To turn the system back on:

- Press a wireless button on the key fob, or
- Press the Lock Switch on a door handle, or
- Use the mechanical key in a door lock cylinder.

Parameter	Value	Unit
Key Low Battery	No	
Power Save Cnt 10 Min.	0	
Power Save Cnt 5 Days	0	
Power Save Cnt 14 Days	0	
# Codes	0	
ACC Switch	OFF	
ID Code Difference (Resp)	No	
C Code Difference	No	

Figure 6 Power Save Cnt 10 Min.

The Certification ECU tells the key to complete a low key battery warning voltage check 20 minutes after engine start. This gives the battery time to recover after the electrical loads of smart entry and smart start communication. When the Engine Switch is cycled OFF, and the driver's door is opened, the Certification ECU via an interior oscillator asks the key for the key battery voltage information. If this voltage is below the programmed threshold, the Certification ECU will request that the Body Electrical system signal a low key battery warning. **Note:** A buzzer is used as a warning on all vehicles. If a vehicle is equipped with a multi-information display, a buzzer will sound and a text message will appear on the display. The type of warning for each model is in the New Car Features book.

Service Tip: Average key fob battery life is 1-2 years.

SMART KEY
QUESTIONNAIRE

SECTION 1 (for use by the service advisor)

12-VOLT BATTERY

○ Yes ○ No	Is the battery dead?
○ Yes ○ No	Was the vehicle jump-started?

DOOR LOCK AND UNLOCK

○ Yes ○ No	Does the wireless remote lock and unlock the doors?

SERVICE HISTORY

○ Yes ○ No	Was the vehicle recently serviced or repaired?

SECTION 2 (for use by the service technician)

12-VOLT BATTERY

Volts	What is the current voltage?

SMART KEY SYSTEM

○ Yes ○ No	Is the smart key system turned off?
○ Yes ○ No	Using immobilizer override, will the vehicle start?

KEY BATTERY

○ Yes ○ No	Is the smart key battery good?
○ Yes ○ No ○ Yes ○ No	Does the red LED on the key blink when you: • approach the locked vehicle or • enter the vehicle?
○ Yes ○ No	Using SST 00002-09001-01, "RF Detector," is the key transmitting an RF signal?

SMART KEY OPERATION

○ Yes ○ No	Does the green LED on the ENGINE/POWER switch illuminate when the brake pedal is depressed?
○ Locked ○ Unlocked	What is the status of the steering lock?
○ Yes ○ No	Does the engine crank?
○ Yes ○ No	Does the engine crank, start, and stall?
○ Yes ○ No	Is the security light blinking?

TECHSTREAM DATA

○ Yes ○ No	Are any smart key DTCs present?
○ Yes ○ No	Can you display a Data List for the Smart Access ECU?

Q & A: MISFIRE MONITOR *Explained*

Misfire monitor requirements and data list parameters have changed. This article will help you interpret the data list parameters and explain misfire monitor detection logic. Having this information on hand can help you shorten diagnostic time and resolve the cause of the misfire.

In general, what is the role of the misfire monitor?

The misfire monitor informs the driver when the vehicle exceeds emissions threshold and/or when the catalytic converter could potentially be damaged.

When does a pending DTC set? When does a current DTC set?

When a cylinder(s) misfires, fuel (hydrocarbons [HC]) are pumped into the exhaust system. Should enough misfires occur to exceed the emissions threshold, a pending Diagnostic Trouble Code (DTC) will set on the first trip. If enough misfires occur on the next trip, simultaneously the Malfunction Indicator Lamp (MIL) will turn on and a current DTC(s) with Freeze Frame Data (FFD) will set.

Why does the MIL blink?

If the amount of HC in the exhaust stream is high enough to potentially damage the catalytic converter, the MIL will blink and a pending DTC will set on the first trip. If the misfires continue on the next trip, the MIL will blink and a current DTC will set.

Misfire Detection

How does the ECM detect misfires?

The misfire monitor uses the crankshaft position sensor for crankshaft position and speed and the camshaft sensor for cylinder identification. Using the crankshaft position sensor signal, the ECM monitors crankshaft speed from the top dead center position of each cylinder on the power stroke. The change in crankshaft speed, detected by the ECM, is used to determine if the cylinder has misfired. A cylinder that is performing normally will accelerate the crankshaft, but a cylinder that misfires will not accelerate the crankshaft.

The ECM will count the number of misfires at every 200 revolutions and at every 1,000 engine revolutions. At the end of the 200-revolution period, the ECM will determine if the number of misfires exceeded the threshold for catalyst damage. At the end of the 1,000-revolution period, the ECM will determine if the number of misfires exceeded the emissions threshold. This monitor operates continuously.

When enough misfires are detected that cross either the catalyst damage and/or the emissions threshold, a DTC will set. Misfire DTCs are defined as follows:

DTC	DETECTION ITEM
P0300	Misfiring of random cylinders
P0301 through P0308*	Misfiring of a particular cylinder

* For example, P0301 means cylinder number 1 was detected as having a misfire.

Diagnostic Tip: Before clearing DTCs or using Check Mode, save the Engine Live Data List and DTC/monitor information!

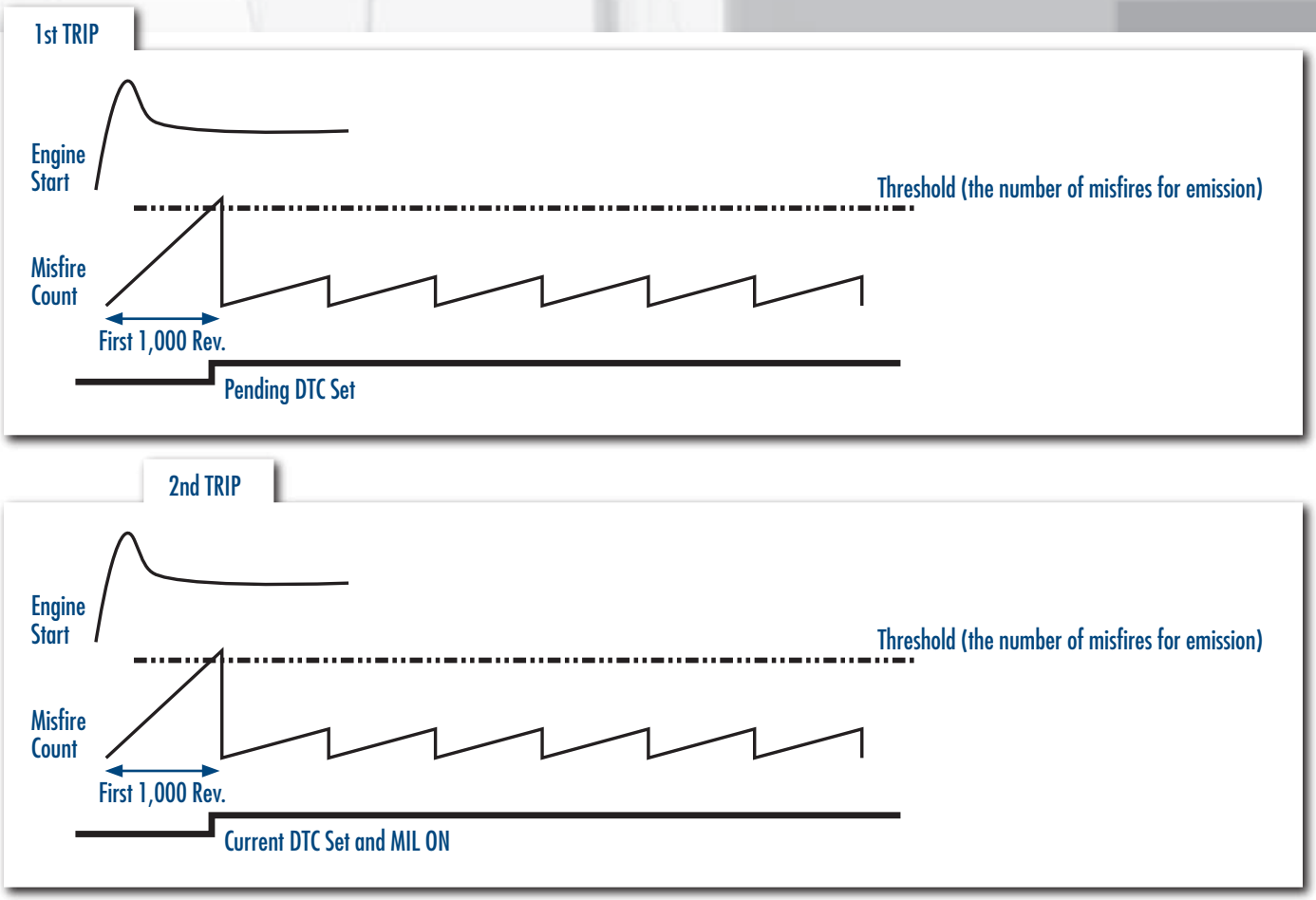


Figure 1 Misfire Detection for Emissions – The First 1,000 Revolutions

Can You Explain Misfire Detection in Greater Detail?

Here is misfire monitor detection in greater detail.

Misfire detection for emissions: What happens during the first 1,000 revolutions?

The ECM monitors the first 1,000 engine revolutions from engine start. If the number of misfires exceeds the emissions threshold within the first 1,000 revolutions, a pending DTC will set. On the second trip, a current DTC will set if the number of cylinder misfires exceeds the threshold within the first 1,000 revolutions. (This is two-trip detection logic.) If this happens, the MIL stays on. **See Figure 1.**

How do I know if the misfire DTC was set during the first 1,000 revolutions?

Look at the Freeze Frame Data for engine coolant temperature and engine run time.

FREEZE FRAME DATA	MISFIRE DETECTED
Engine coolant temperature is below 167° F. (75° C.)	When the engine is cold
Engine run time is below 120 seconds	Soon after engine start

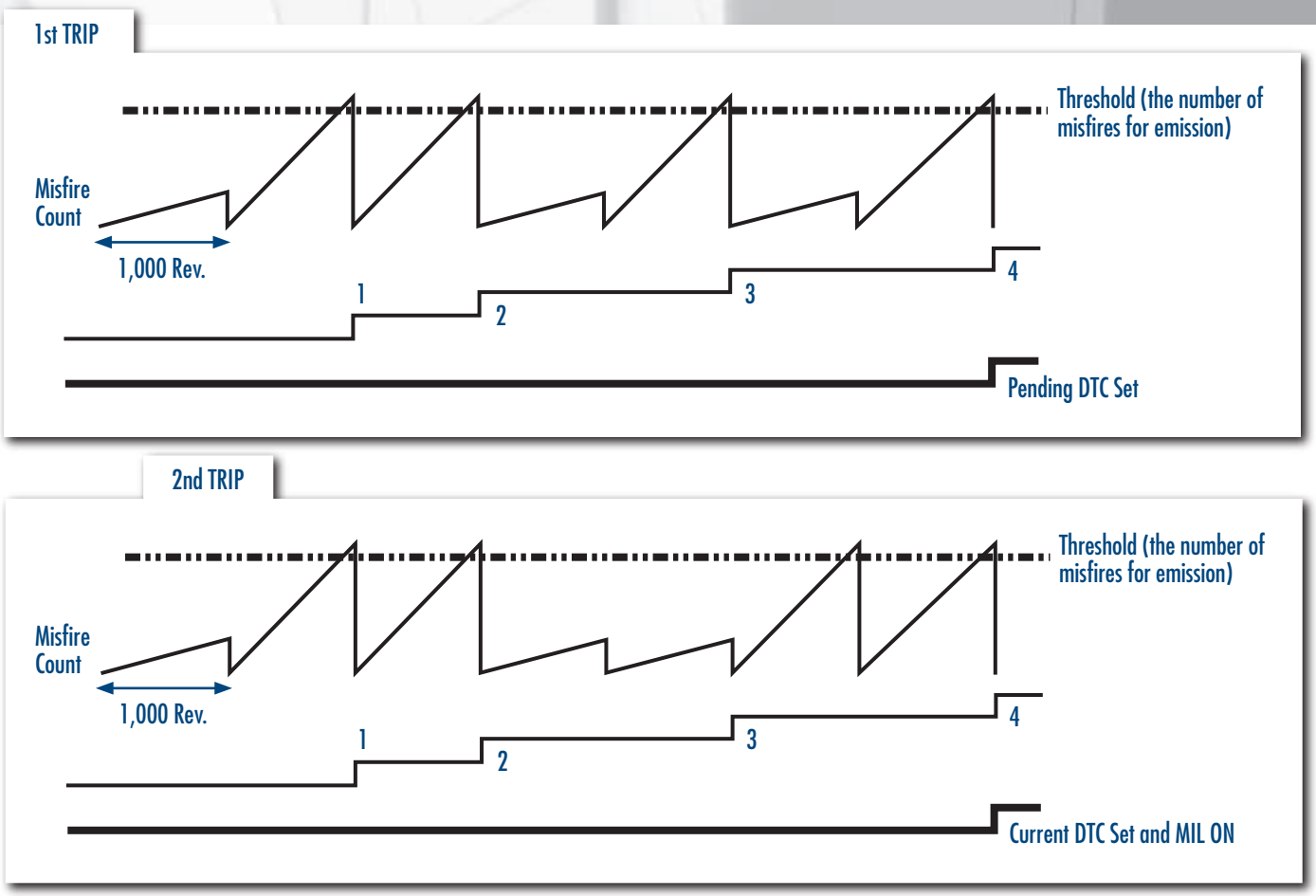


Figure 2 Misfire Detection for Emissions – 1,000 Revolutions

Misfire detection for emissions: What is the logic for misfire detection after the first 1,000 engine revolutions?

When the engine is running, the misfire count is evaluated every 1,000 revolutions, and should the misfire count exceed the emissions threshold four times, a pending DTC will set. On the next trip, if the number of misfires exceeds the emissions threshold four times, a current DTC will set. (This is two-trip detection logic.) The 1,000-revolution periods where the number of misfires exceeds the threshold may or may not be consecutive. If the threshold is exceeded four times, a DTC will set. **See Figure 2.**

Is there a way to shorten the detection period for diagnosis?

Use Check Mode. When Check Mode is engaged, the misfire detection period drops to one 1,000-revolution period. This can reduce the time needed to duplicate a misfire condition.

Diagnostic Tip: Save the Freeze Frame Data and the Engine Live Data List before engaging Check Mode.

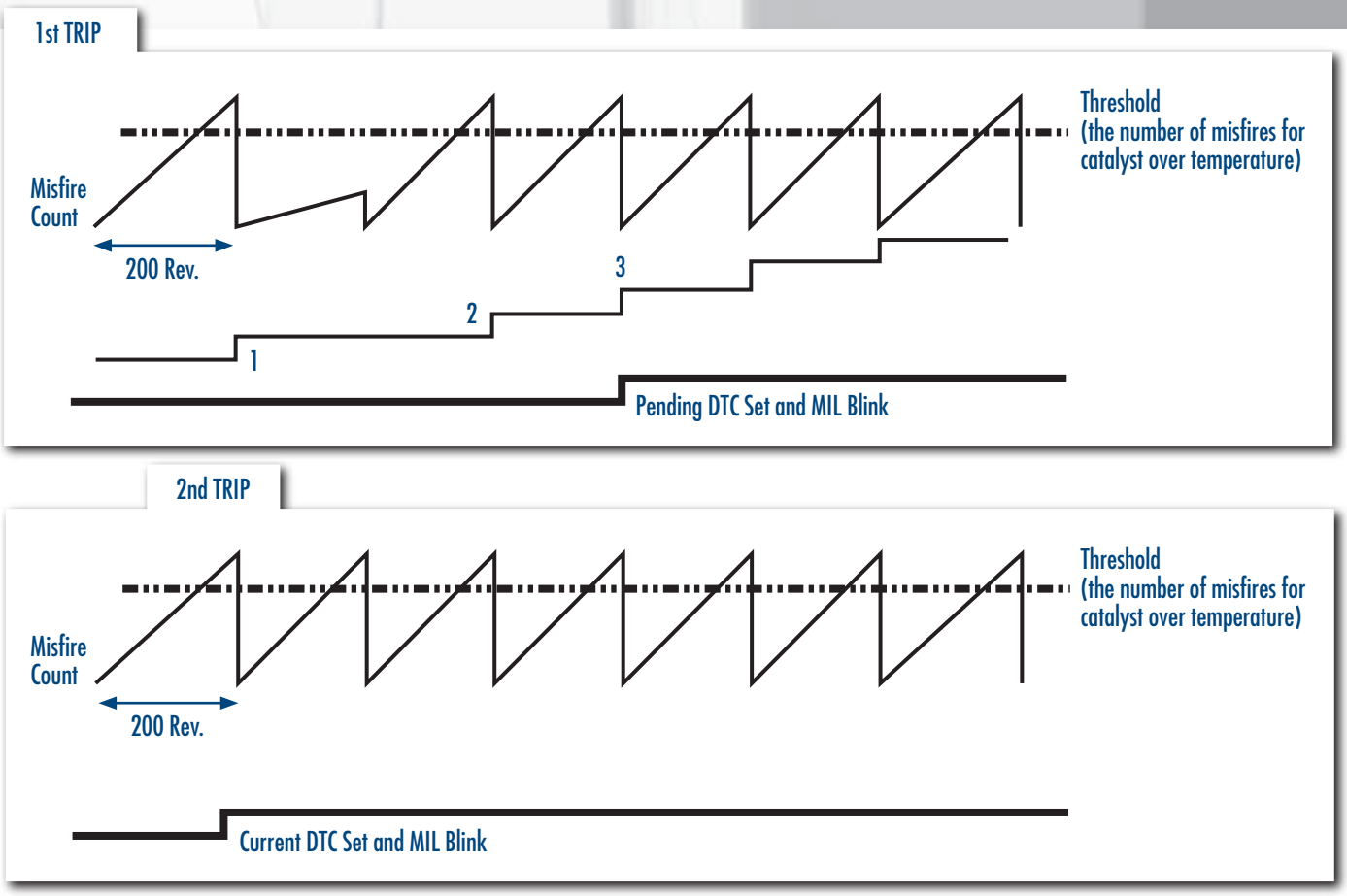


Figure 3 Misfire Detection for Catalyst Over Temperature – 200 Revolutions

How does the misfire detection for catalyst over temperature (potentially damaging the catalytic converter) work?

The misfire count is evaluated every 200 engine revolutions, and should the misfire count exceed the catalyst over temperature threshold three times, a pending DTC will set and the MIL blinks. On the next trip, if the number of misfires exceeds the threshold in 200 revolutions one time, a current DTC will set and the MIL blinks. (This is two-trip detection logic.) **See Figure 3.**

At high load, high engine speeds, if the threshold is exceeded one time in the first trip, a pending DTC will set. And if the threshold is exceeded one time in the second trip, a current DTC will set. **See Figure 4.**

On some engines, once the MIL blinks, it will continue to blink on that trip even if the catalyst is not in an over temperature condition. On the next key cycle, the MIL will not blink until the misfires cross over the catalyst over temperature threshold.

At light engine loads, even a continuous misfire may not reach the catalyst damage threshold.

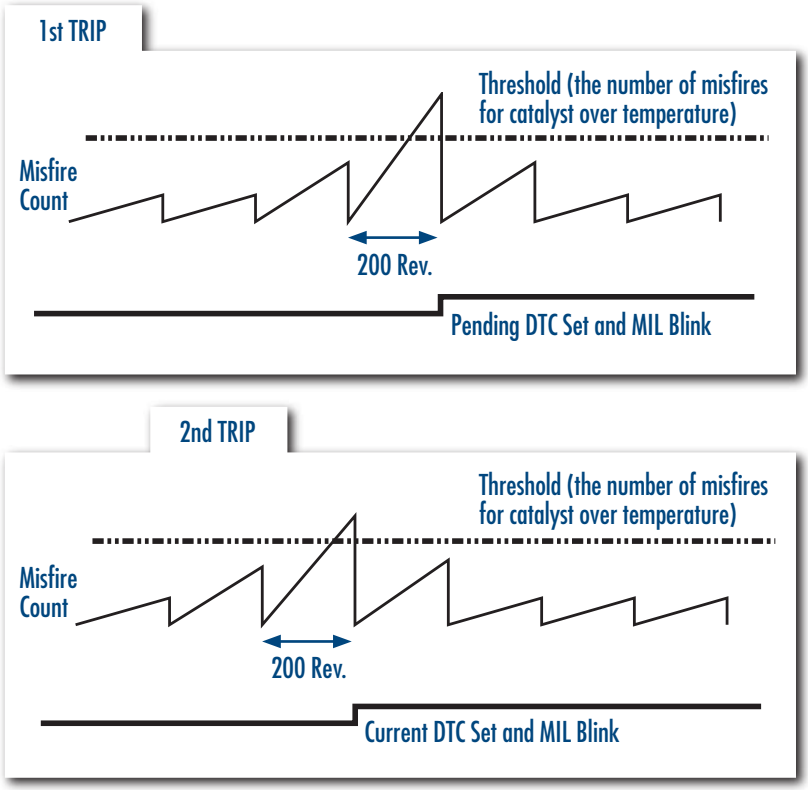


Figure 4 Misfire Detection for Catalyst Over Temperature – High Speed, High Load

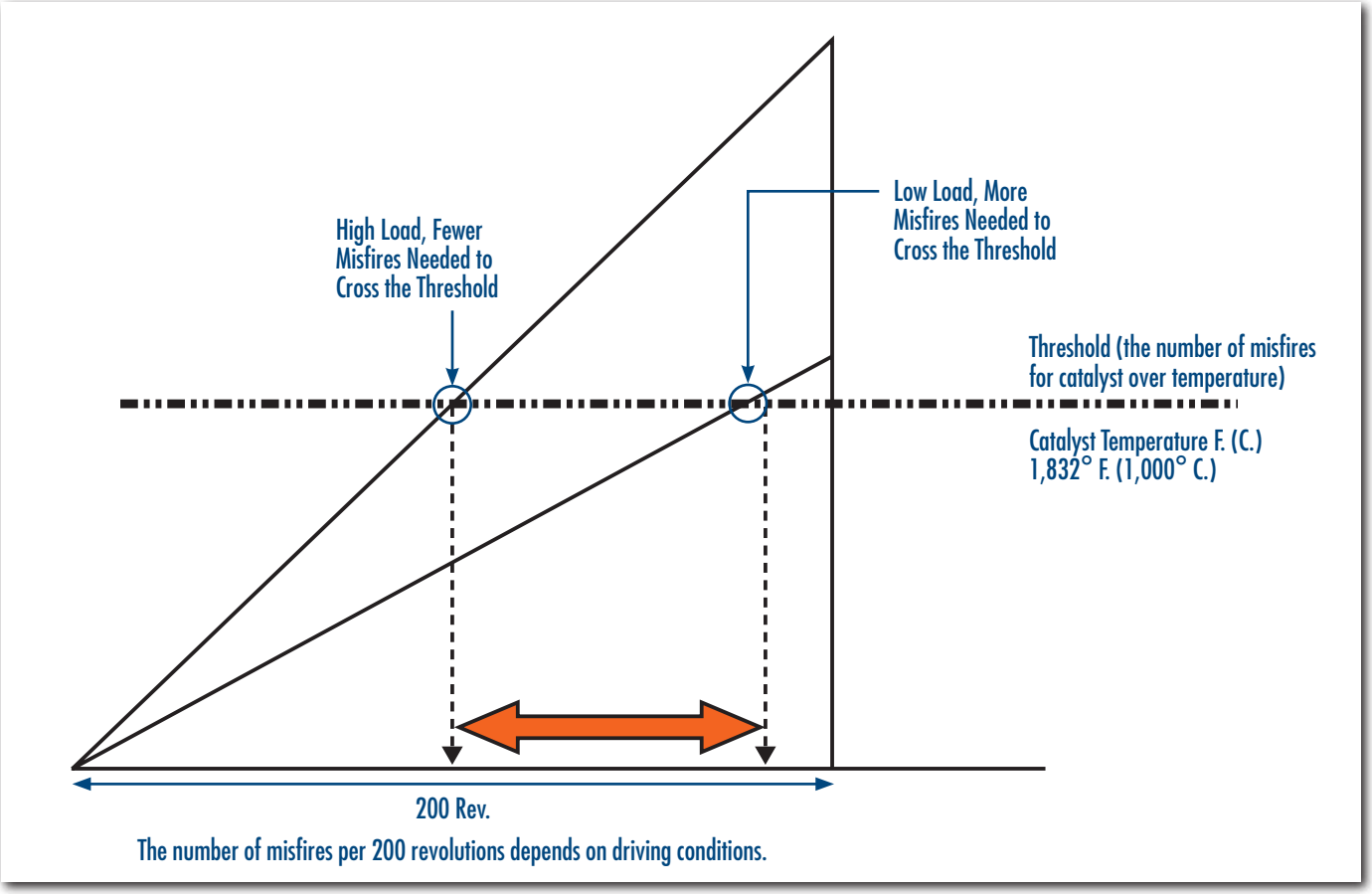


Figure 5 Catalyst Over Temperature Misfire Detection

Catalyst Over Temperature Misfire Detection

Why does the MIL blink earlier under some engine conditions?

The number of misfires needed to cross the threshold will vary according to engine conditions. At high engine loads, more fuel (HC) and air are in the cylinders. When the cylinder misfires under this condition, more HC will be pumped into the exhaust stream, reaching the catalyst over temperature threshold earlier than a cylinder misfiring under a lighter load. **See Figure 5.**

Catalyst Over Temperature Misfire Fuel Cut (Cat OT MF F/C)

I have heard that during severe engine misfire, the fuel injector is turned off. How can I tell if this is happening?

When cylinders misfire, causing a catalyst over temperature condition, the fuel injector for the misfiring cylinder is turned off to prevent the catalyst over temperature condition. When this happens, the CAT OT MF F/C cylinder value changes to ON in the Data List. **See Figure 6.**

Diagnostic Tip: OFF means the fuel injector is operating, ON means the ECM shut off the fuel injector.

The following explains the data list parameters:

- Catalyst OT MF F/C shows Avail when this function is available and shows Not Avl when this function is disabled.
- Catalyst OT MF F/C History changes from OFF to ON when the fuel cut function is turned on.
- Catalyst OT MF F/C Cylinder #1 through #6 changes from OFF to ON when fuel cut is activated for that particular cylinder.

Diagnostic Tip: During diagnosis, you may not want the fuel injector to turn off. Perform the Active Test PROHIBIT CAT OT F/C and the fuel injector will remain on.

Parameter	Value	Unit
Catalyst OT MF F/C	Avail	
Cat OT MF F/C History	ON	
Cat OT MF F/C Cylinder#1	OFF	
Cat OT MF F/C Cylinder#2	ON	
Cat OT MF F/C Cylinder#3	OFF	
Cat OT MF F/C Cylinder#4	OFF	
Cat OT MF F/C Cylinder#5	OFF	
Cat OT MF F/C Cylinder#6	OFF	

Figure 6 Cat OT MF F/C Data List

Parameter	Value	Unit
Ignition Trig. Count	0	
Cylinder #1 Misfire Count	0	
Cylinder #2 Misfire Count	60	
Cylinder #3 Misfire Count	0	
Cylinder #4 Misfire Count	0	
Cylinder #5 Misfire Count	0	
Cylinder #6 Misfire Count	0	
All Cylinders Misfire Count	255	
Misfire RPM	675	rpm
Misfire Load	0.51	g/rev
Misfire Margin	-100.00	%

Figure 7 Misfire Data List

Misfire Data List

How do the other misfire data list parameters operate?

To assist you in misfire diagnosis, the following defines each data list parameter. **See Figure 7.**

Ignition Trig. (Trigger) Count

This data parameter displays the number of ignition counts (all cylinders) occurring every 200 revolutions. **See Figure 8.** When the ignition trigger count is cycling, the misfire monitor is operating and reporting to the data list. When the value changes to 0, the misfire count is not being communicated and misfire count values cannot be seen at that moment. However, the misfire monitor may still be operating even when the ignition trigger count is 0.

NUMBER OF CYLINDERS	×	NUMBER OF IGNITION COUNTS PER CYLINDER IN 200 REVOLUTIONS	=	IGNITION COUNT
4	×	100	=	400
6	×	100	=	600
8	×	100	=	800

Figure 8 Ignition Count

Cylinder # Misfire Count

This data parameter indicates how many times the cylinder has misfired every 200 revolutions. The value is from 0 to 100, where a value above 0 indicates the number of times the cylinder misfired.

For 6- and 8-cylinder engines, the ECM may not set cylinder-specific DTCs at high engine RPM and may only set DTC P0300 under this condition. **Diagnostic Tip:** First, diagnose the cylinder(s) with the highest Cylinder # Misfire Count.

All Cylinders Misfire Count

This data parameter displays the total number of misfires from all cylinders every 1,000 revolutions. The available range is from 0 to 255 misfire counts. This value resets to 0 every 1,000 revolutions.

Misfire RPM and Misfire Load

When a pending DTC sets, the Misfire RPM and Misfire Load parameters will display the values for the RPM and load where the misfire detection occurred. The values for these parameters do not update if a second trip misfire is detected and a current misfire DTC is set. For a current DTC, use the Freeze Frame Data to observe and duplicate engine operating conditions, such as calculate load, engine coolant temperature, RPM, MAF, long-term and short-term fuel trims, and throttle sensor parameters, engine run time, etc.

Misfire Load is displayed in g/rev. (grams per revolution).

To convert g/rev. to a Mass Air Flow signal in g/sec:

1. Divide Misfire RPM by 60 to get revolutions per second (RPS).
2. Multiply revolutions per second by Misfire Load (g/rev.) to get grams per second (g/sec.).

Example: Misfire RPM shows 675 rpm and Misfire Load shows 0.51 g/rev.

1. 675 rpm / 60 = 11.25 RPS
2. 11.25 RPS × 0.51 g/rev = 5.74 g/sec.

The misfire was detected at 675 rpm with a MAF Sensor signal of 5.74 g/sec.

Misfire Margin

What is "misfire margin" and how does this help me with misfire diagnosis?

Misfire margin is the difference between the predicted change in crankshaft acceleration to the actual change in crankshaft acceleration and this is displayed as a positive (+) or negative (-) percentage. This parameter is useful because it will change as the chance of a misfire increases. If the cylinder fires normally and the crankshaft acceleration matches the predicted change, the misfire margin value will be very high in the positive percentage range. Positive values over 30 percent are normal, which indicates that none of the cylinders are presently misfiring.

The misfire margin value will move toward the negative region when cylinder misfiring is detected. If it is under 30 percent, there is a high likelihood that a misfire is occurring. If it is in the negative zone, a misfire is occurring.

When duplicating the misfire conditions, misfire margin usually reacts before the other data list values are displayed. This value is always displayed even when the misfire count is not displayed in the data list. **See Figure 9.**

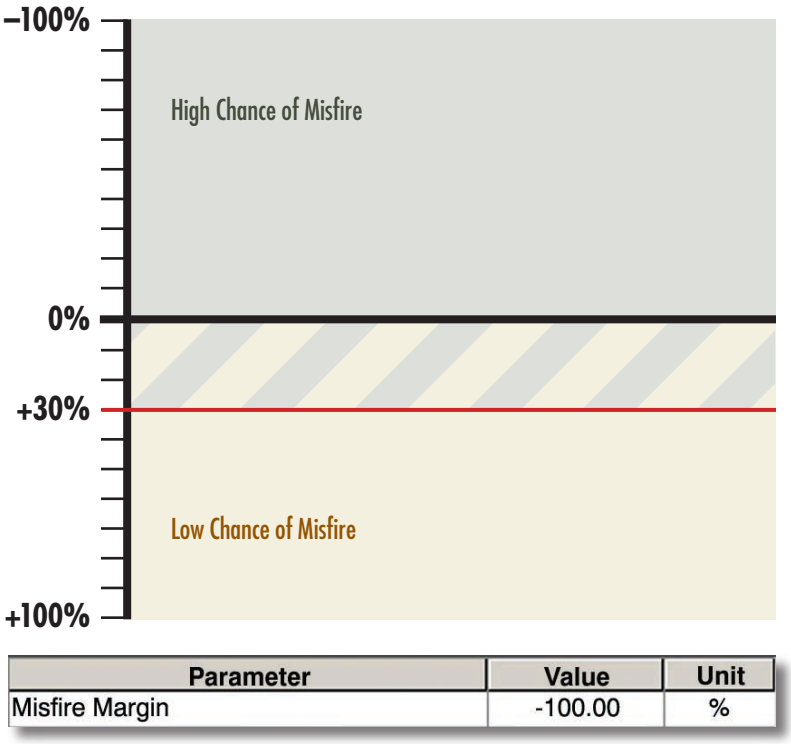


Figure 9 Misfire Margin

Check This Out: The Misfire Monitor Has a Magnifying Glass Under "Details"

What is EWMA and does this data help me with misfire diagnosis?

When misfires occur, the ECM counts and records misfires in the Misfire Monitor Test Details section. This section can identify:

- the number of misfires per cylinder,
- the total number of misfires, and
- the average of misfires from previous drive cycles.

EWMA Misfire (Exponentially Weighted Moving Average)

This represents an average of cylinder misfires from previous trips. This value represents 10 percent of the last trip's misfires plus 90 percent of the average of the previous trips.

EWMA MISFIRE (Exponentially Weighted Moving Average)	
EWMA MISFIRE	average misfire count for all cylinders
EWMA MISFIRE 1 through 8	average misfire count for cylinders 1-8

Misfire Rate

Each count in MISFIRE RATE represents a cylinder misfire. Before the engine is started, with the key on, engine off, the MISFIRE RATE will report the number of misfires from the last trip. This counter is reset to 0 after the engine has started.

MISFIRE RATE	
MISFIRE RATE	total misfire count for all cylinders
MISFIRE RATE 1 through 8	number of misfire counts for cylinders 1-8

Monitor

The misfire monitor provides additional information that can be useful for diagnosis.

The cylinder misfire rate count can be useful in the following situations:

1. A customer reports the MIL was blinking, but now it does not blink. There is no current DTC and the MIL is off. The EWMA can report which cylinder(s) had the misfire.
2. The vehicle has DTC P0300. Test Details can show which cylinder had the most misfires.

This data, along with all the other monitor data, will be saved when you save the file by using the disk symbol. **See Figure 10.**

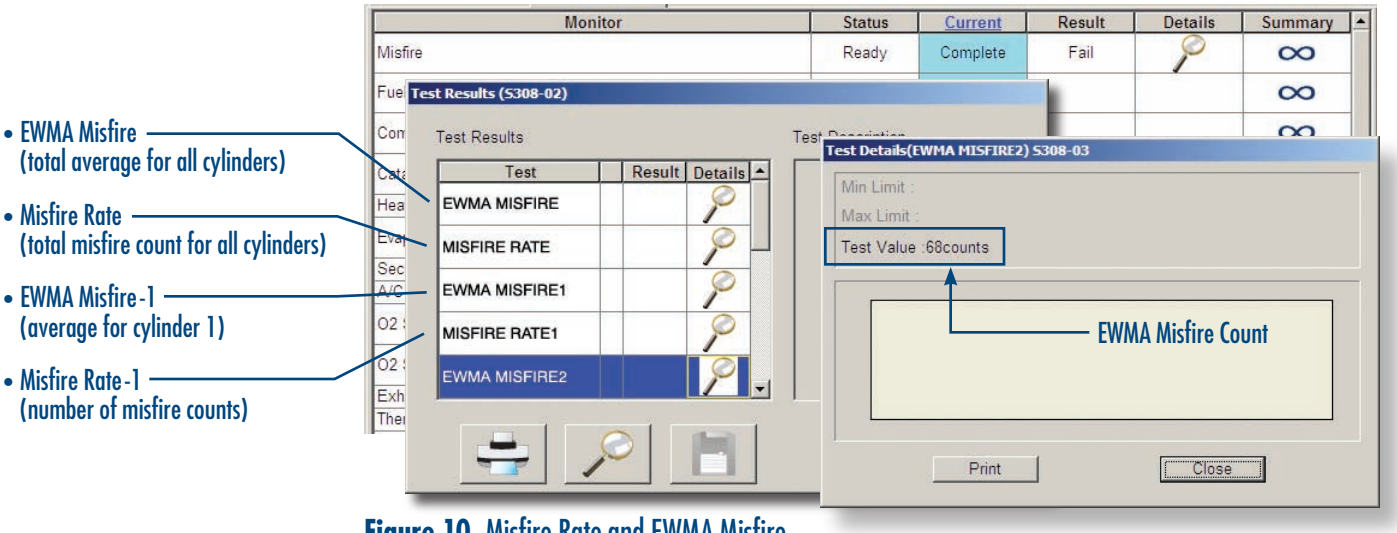


Figure 10 Misfire Rate and EWMA Misfire

How is the EWMA calculated?

Figure 9 illustrates how the ECM calculates EWMA MISFIRE averages. The first trip report shows 100 misfires.

Using the EWMA misfire formula:

$$0.1 \times \text{MISFIRE RATE (current counts)} + 0.9 \times \text{EWMA MISFIRE (current average)} = \text{EWMA Misfire Count}$$

$$(0.1 \times 100) + (0.9 \times 0) = 10 \text{ EWMA Misfire Counts}$$

The second trip report shows another 100 misfires.

$$(0.1 \times 100) + (0.9 \times 10) = 19 \text{ EWMA Misfire Counts}$$

On each trip, the misfires are calculated. If misfires are not detected, 0 is entered into the current counts. The example goes through four drive cycles.

If you want to see the total number of misfires for each cylinder from the last trip, you must look at the misfire count before the engine is started. Once the engine has started, the misfire count resets to 0. **See Figure 11.**

		KEY ON	START ENGINE	ENGINE RUNNING	KEY OFF
DRIVE 1	Cycle 1 Counts	0	N/A	100	100
	Cycle 1 EWMA	0	N/A	0	0
DRIVE 2	Cycle 1 Counts	100	0	100	100
	Cycle 1 EWMA	10	10	10	10
DRIVE 3	Cycle 1 Counts	100	0	200	200
	Cycle 1 EWMA	19	19	19	19
DRIVE 4	Cycle 1 Counts	200	0	200	200
	Cycle 1 EWMA	37	37	37	37

Figure 11 Example of EWMA Misfire Count

More Data List Parameters

Engine Live Data List parameters can help you identify:

- How many miles the vehicle covered after the MIL was turned on.
- How many minutes the engine ran after the MIL was turned on.
- How many minutes since DTCs were cleared.
- How many miles since DTCs were cleared.
- How many warm up cycles since DTCs were cleared. This value will go up to 255 and will remain there until DTCs are cleared.

Since the above information is in the engine live section, you must save the Data List as well as the DTC/Monitor.

Another useful parameter is calculate load (Calculated Load). Briefly, calculate load corresponds to intake manifold pressure. The higher the percentage, the higher the pressure in the intake manifold. Typically, wide open throttle would have the highest pressure. **See Figure 12.**

When driving the vehicle to duplicate the misfire conditions, use calculate load parameter with engine coolant temperature, RPM, MAF, long-term and short-term fuel trims, and throttle sensor, engine run time, etc.; this will serve as a guide for duplicating the conditions under which the misfire occurred.

Knowing the conditions under which the misfire occurred by using the data parameters and an understanding of how misfire monitor detection works can reduce the time it takes to diagnose a vehicle.

Ed Ralbovsky — Technical Training

Parameter	Value	Unit
# Codes(Include History)	1	
MIL ON Run Distance	21	mile
Running Time from MIL ON	50	min
Time after DTC Cleared	16419	min
Distance from DTC Cleared	6948	mile
Warmup Cycle Cleared DTC	255	

Parameter	Value	Unit
Calculate Load	25.4	%

Figure 12 MIL ON Data List