TOYOTA

Toyota Motor Engineering & Manufacturing North America, Inc.

Vehicle Safety & Compliance
Liaison Office
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Plano, TX 75024

October 4, 2018

DEFECT INFORMATION REPORT

1. Vehicle Manufacturer Name:

Toyota Motor Corporation ["TMC"]
1, Toyota-cho, Toyota-city, Aichi-pref., 471-8571, Japan

Affiliated U.S. Sales Company:

Toyota Motor North America, Inc. ["TMNA"]
6565 Headquarters Drive, Plano, TX 75024

Manufacturer of Hybrid Control ECU:

DENSO CORPORATION
1-1, Showa-cho, Kariya-city, Aichi, 448-8661, Japan
Telephone: + 81-566-25-5511

DENSO TEN Limited
2-28, Gosho-dori 1-chome, Hyogo-ku, Kobe-city, Hyogo, 652-8510, Japan
Phone: +81-78-671-5081

Country of Origin: Japan

2. Identification of Involved Vehicles:

Make/Car Line	Model Year	Manufacturer	Production Period
Toyota / Prius	2010-2014	TMC	March 31, 2009 through February 4, 2014
Toyota / Prius V	2012-2014		August 22, 2011 through June 30, 2014

Applicability	Part Number	Part Name	Component Description
MY2010-2014 Toyota Prius	89681-47080 89681-47081 89681-47082 89681-47083 89681-47210 89681-47211 89681-47212 89681-47300 89681-47301 89681-47302 89681-47440 89681-47441 89681-47250 89681-47251	Computer, Power Management Control	Hybrid Control ECU
MY2012-2014 Toyota Prius V	89681-47181 89681-47340 89681-47341 89681-47420 89681-47421 89681-47422		

NOTE: (1) Although the involved vehicles are within the above production period, not all vehicles in this range were sold in the U.S.

(2) Other Toyota or Lexus vehicles do not use the same hybrid control ECU and software as the involved vehicles or had improved software as original equipment to reduce thermal stress to certain hybrid inverter components as described in the recalls 14V-053 and 15V-449.

3. Total Number of Vehicles Potentially Involved:

807,329

4. Percentage of Vehicles Estimated to Actually Contain the Defect:

Unknown. Toyota is unable to provide an estimate of the percentage of vehicles to actually contain the defect. Whether the issue in each case will lead to damage of the transistor within the inverter assembly and subsequently lead to a shutdown of the hybrid system, creating an unreasonable risk to safety, depends on each vehicle's operating conditions.

5. Description of Problem:

The subject vehicles contain software used to control the Intelligent Power Module (IPM) within the inverter assembly, a part of the vehicle's hybrid system. Due to certain characteristics of the software used to control the boost converter in the IPM, higher thermal stress could occur in specific transistors in the IPM under high-load driving such as accelerating during highway driving. If this occurs, it could damage those transistors over time, illuminating various warning lights and display a warning message on the instrument panel. In limited instances, the motor/generator ECU could reset. In addition, if a specific transistor within the IPM fails in a certain way during a high-load driving condition, such as during hard acceleration, there is a possibility for an abnormally high voltage to be generated that could exceed a certain limit in the software and IPM circuit design. If the motor/generator ECU resets or this abnormally high voltage is generated, there is the possibility that the hybrid system could shut down instead of entering a failsafe driving mode that would provide reduced motive power and allow the vehicle to be driven for certain distances. In this condition, where the hybrid system shuts down instead of entering a failsafe driving mode, power steering and braking will not be affected. However, a hybrid system that shuts down without entering a failsafe mode could result in the vehicle losing motive power while driving at higher speeds, increasing the risk of a crash.

6. Chronology of Principal Events:

January – Mid-March 2018

Based on VOQs and other available information, NHTSA contacted Toyota about allegations of potential incidents where vehicles experienced a loss of motive power while driving at some time after having received the software updates from recalls 14V-053 and 15V-449. The remedy for these recalls involved software updates to both the motor/generator ECU (to reduce potential damage to transistors within the inverter caused by higher thermal stress) and the hybrid control ECU (to transition the vehicle into a failsafe driving mode instead of a hybrid system shutdown in the event the motor/generator ECU reset as a result of a transistor failure). Toyota began reviewing the information and also began recovering parts from the field.

Subsequently, Toyota received a specific request from the Agency to provide an assessment for five hybrid inverter allegations provided to NHTSA. The five incidents involved allegations of hybrid inverter failure and, in some cases, "shut-down" at some time after completion of the remedy for the aforementioned recalls.

Toyota reviewed the information received through the Agency on these five incidents, in addition to other available information (such as field reports, customer complaints, and warranty), to assess the allegations further. Toyota found that, in two of the incidents, the vehicles likely entered a failsafe mode as intended by design. One matter alleged a warning light without an allegation of shutdown. Another occurred prior to the performance of the remedy for 14V-053. Finally, the fifth matter, alleged loss of power while driving during heavy traffic. This driver stated that she was able to maneuver the vehicle out of the flow of traffic and pull over to a side street to park the vehicle. Data retrieved from this vehicle by the

servicing dealer (freeze frame data contained within the hybrid control ECU) indicated that the ready signal status of the vehicle changed from "ON" to "OFF" ("ready off") while the vehicle was being driven after a hybrid inverter related trouble code was triggered. However, based on the driver's description of the distance traveled and the maneuvers performed after the alleged loss of power (including maneuvering the vehicle out of traffic and onto a side street in order to park the vehicle), the vehicle behavior more likely indicated that the vehicle entered a failsafe mode. Toyota did not have an opportunity to inspect the vehicle and was unable to further assess the allegation at this time. Additionally, Toyota did not have the same data in its systems as the servicing dealer, which indicated a ready off status for this vehicle. The data was not transmitted to Toyota's systems by the dealer.

Although Toyota did not have corresponding information of a "ready off" status in its systems for the aforementioned vehicle, Toyota began a review of available information to identify if there were any other potential cases of "ready off" while driving for vehicles with updated software.

Mid-March – April End

Toyota conducted a search of available freeze frame data in its systems for vehicles involved in 14V-053 and 15V-449, looking for instances of a "ready off" status with a vehicle speed greater than zero. While not all freeze frame data is transmitted to Toyota, depending on the practices of the servicing dealer in each case, Toyota identified a limited number of instances where the data in connection with certain inverter-related trouble codes suggested a possible "ready off." Based on a review of available information for VINs identified in this search, it was found that a majority of cases generally described warning lights as the condition present at the time of diagnosis and repair. The remaining had some allegation of reduced power, "no start," or stall. Of this population, Toyota did not identify any matters with a corresponding non-dealer field technical report related to the inverter and only limited cases with an associated technical assistance contact or customer complaint.

In order to investigate and better understand the possibility of a "ready off" condition in a vehicle with updated software, a fault tree analysis was begun. In addition, recovered parts were sent to Toyota in Japan for further analysis. This activity included both failed inverters and inverters from vehicles where no failure had occurred. Toyota also sought to inspect vehicles where inverter-related failure occurred and available freeze frame data suggested a "ready off" status while the vehicle was being driven.

Early May – June End

In early May, Toyota attempted an inspection of the fifth VIN identified in NHTSA's inquiry from February to obtain information from the hybrid control and motor/generator ECUs. However, the inverter was removed from the vehicle and Toyota was unable to retrieve any data or recover parts for further investigation, and thus could not learn more. Nonetheless, Toyota continued its analysis of recovered parts and available freeze frame data. Based on an initial analysis of recovered failed parts, damage was observed in certain transistors, but the extent of the damage prevented an identification of the cause of failure at this time. Further analysis of

non-failed parts and freeze frame data was needed to identify any potential for "ready off" in vehicles which contained updated software.

Additional analysis of the freeze frame data for the limited matters described above (where the data indicated a "ready off" while driving) found that roughly half occurred after the recall remedy was completed. The remaining ones occurred prior to the recall remedy. Additionally, some of the incidents occurring after the recall remedy was completed had software calibration identifiers (IDs) inconsistent with the recall remedy software. At this time, it was unclear if the inconsistent calibration IDs were due to limited or incorrect information in Toyota systems or if the vehicles actually contained incorrect versions of the software.

July – August

In consideration of new information obtained from the freeze frame data analysis, Toyota pursued investigations in parallel. To understand the potential for a vehicle not to have updated software after completion of the recall remedy, Toyota surveyed vehicles to identify the software version present in field vehicles, and, in those cases where an inverter failure occurred, Toyota also surveyed the customer to understand the vehicle behavior at the time of failure. Separately, to understand the potential for "ready off" in those vehicles with updated software, Toyota evaluated possible theories in relation to the fault tree analysis, such as possible manufacturing issues that may contribute to transistor failure. However, based on component parts analysis of non-failed inverters recovered from the field, no component abnormalities were identified within the inverter.

Continued analysis of the recovered failed inverters and freeze frame data in a limited number of cases did identify an unexpected, abnormally high voltage value related to the hybrid boost converter. A technical review was conducted to identify a possible mechanism where such an abnormally high voltage could occur.

September 2018

A design review of the software used to control the hybrid system components in addition to a review of the inverter circuit design identified a potential mechanism for the hybrid system to shutdown instead of entering a failsafe mode based on the observation of an abnormally high voltage in extremely rare cases. It was found that, in the event a specific transistor within the hybrid inverter becomes damaged while full throttle is applied, a large counter-electromotive voltage could be generated by the motor/generator at a capacitor within the IPM. This large voltage, higher than the system limit, could be generated by the increase in RPM of the internal combustion engine and the motor generator attached to the engine. If this were to occur, the hybrid system could shutdown, by design, in order to protect the system from electrical damage.

In addition to the design review, Toyota completed an initial survey of vehicles and customers related to software calibration performed in the earlier recall. Based on the initial results of this survey and the available freeze frame data that Toyota has for these vehicles, Toyota could not exclude the possibility that a limited population of vehicles did not successfully receive a software update in one or both of the ECUs.

September 28, 2018

Based on the results of the above investigations, Toyota decided to conduct a voluntary safety recall campaign.

As of September 25, 2018, based on a diligent review of records, Toyota's best engineering judgment is that there are 0 Toyota Field Technical Reports and 135 warranty claims that have been received from U.S. sources that relate to the abnormal voltage condition investigated in this chronology and which were considered in the decision to submit this report.

7. Description of Corrective Repair Action:

To address the safety defect, all known owners of the subject vehicles will be notified by first class mail to return their vehicles to a Toyota dealer to have the software updated for the motor/generator control ECU and the hybrid control ECU, as necessary.

To support increased customer satisfaction, as a separate Consumer Support Program previously initiated, the dealer will repair or replace the inverter assembly (depending on the failure diagnosis) if an owner experiences a hybrid inverter component failure related to the conditions described above, at no charge (up to 15 years from the date of first use of the vehicle with no mileage restrictions). In addition, the new software for the hybrid control ECUs will support a further enhancement to the failsafe driving modes to provide for increased available speed and range under more circumstances in the event of a failure requiring failsafe driving.

Reimbursement Plan for pre-notification remedies

The owner letter will instruct vehicle owners who have paid to have this condition remedied prior to this campaign to seek reimbursement pursuant to Toyota's General Reimbursement Plan.

8. Recall Schedule:

Notifications to owners will be sent by December 3, 2018. A copy of the draft owner notification will be submitted as soon as it is available.

9. Distributor/Dealer Notification Schedule:

Notifications to distributors/dealers will be sent on October 5, 2018. Copies of dealer communications will be submitted as they are issued.

10. Manufacturer's Campaign Number:

Interim: J1V
Final: J0V