

The New Generation Front Wheel Drive Hybrid System

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ABSTRACT

Introducing all-new front wheel drive hybrid system installed in the 2016 Toyota Prius. This system was completely re-designed to maximize the potential of THS-II (Toyota Hybrid System-II). This system was designed to be able to minimize the mechanical and electrical losses from the previous generation system, improve environmental performance, and also tried to reduce size and weight. We'd like to take this opportunity to introduce the new technology of each component, and hybrid system performance.

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INTRODUCTION

The Hybrid vehicle became popular after releasing the 3rd generation Prius, especially in the Japanese market; consequently CO₂ environment was greatly improved. But Hybrid vehicles need to be released more to save our planet and to meet the world's severe emission regulations which will be established in United States, Japan, Europe, BRICS and Middle East countries. On the other hand, driving comfort and "Hybrid drive ability" performance are also essential functions to increase the market share for hybrid vehicles. This paper describes the new generation hybrid system, which achieved extremely high efficiency, is compact and light, and has "Hybrid drive ability" performance.

1. OBJECTIVE OF THE DEVELOPMENT

1-1. Fuel Economy

The previous hybrid system which is installed in 3rd Gen Prius, had a target to improve the high speed and cold ambient condition's fuel economy. This system target is to maximize the potential of THS-II by re-design of all hybrid units to be able to improve the fuel economy. Specifically, mechanical and electrical losses were dramatically reduced for the transaxle, motor, and PCU. (Power Control Unit.) Also, the hybrid system including battery and software were designed to be able to maximize each unit's performance.

Li-ion and NiMH batteries are adopted for this system. The Li-ion battery has improved charge & discharge performance over the one which is adopted for Prius V (Japan market only). NiMH battery also has improved charging performance and durability.

1-2. Compact and Versatile

This system is the base design for all future TOYOTA front wheel drive hybrid vehicles. Therefore, compactness and versatility is a crucial theme for this system. Trunk space utility improvements have been achieved due to minimization of the hybrid system.

1-3. Hybrid System Structure

Figure 1 shows the system structure.

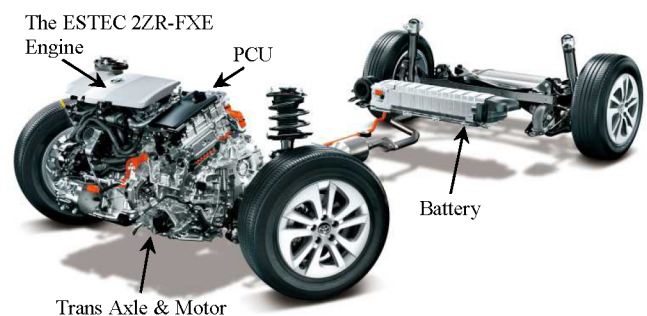
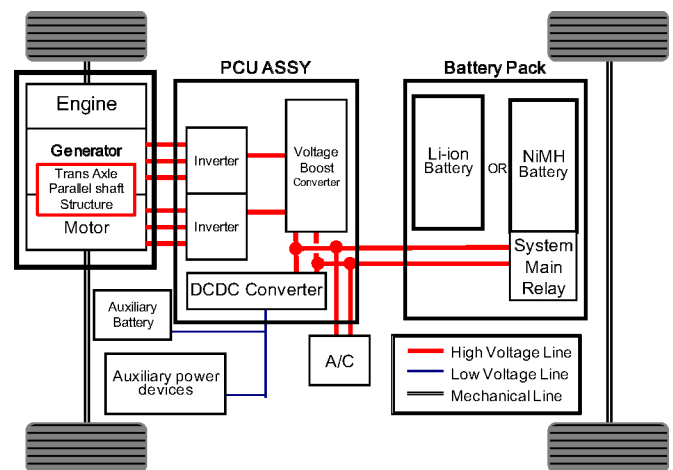


Figure 1. Hybrid System

2ZR-FXE Engine has improved fuel economy by achieving 40% brake thermal efficiency.

Basic structure of this hybrid is the same as the previous one, but all units have been improved by minimizing size and achieving less friction for fuel economy.

NiMH and Li-ion batteries are both adopted in the newly designed cell and a re-designed optimum layout is used to improve the size, weight and performance.

2. FEATURES OF MAIN COMPONENTS

2-1. Transaxle

Figure.2 shows the section of new transaxle.

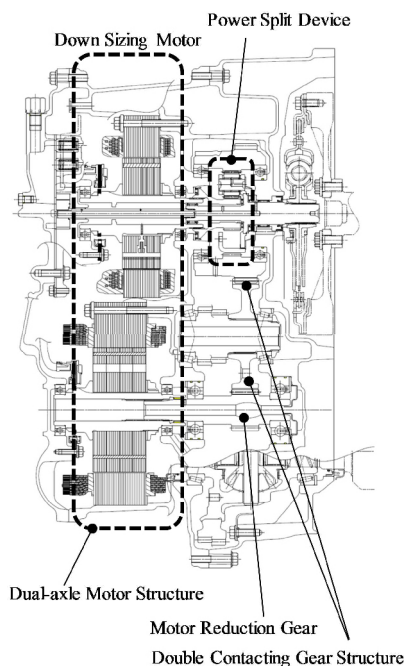


Figure.2. Transaxle Structure

A gear train structure has been adopted for the hybrid system. Including,

1. Parallel shaft gear type motor speed reduction device
2. Counter-driven gear using a double contacting structure
3. Compact motor

The transaxle length has been shortened, and mechanical friction has been reduced based on these new structures.

The Planetary system was adopted for the motor reduction device in the previous hybrid system. The new hybrid system utilizes a parallel shaft gear type instead of the former planetary system.

By using this structure, this system was able to use a wider reduction ratio without increasing mechanical friction. The wider reduction ratio helps make the motor size smaller than the previous one. Figure 3 shows the differences in motor characteristics. (P610 ; New transaxle. P410 ; Previous transaxle.) The new motor character is more compact with higher motor speed.

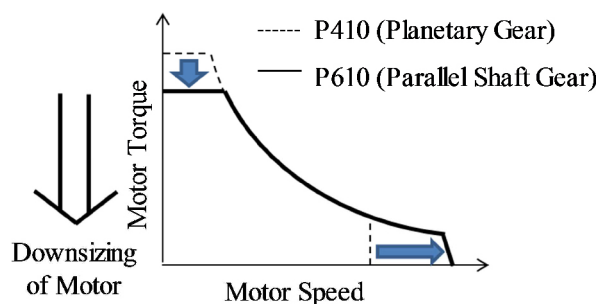


Figure. 3. Motor Characteristics Differences

Figure 4 shows the gear layout of the motor counter and engine counter gears. The transaxle length was shortened through the adoption of the double gear continuous connection layout.

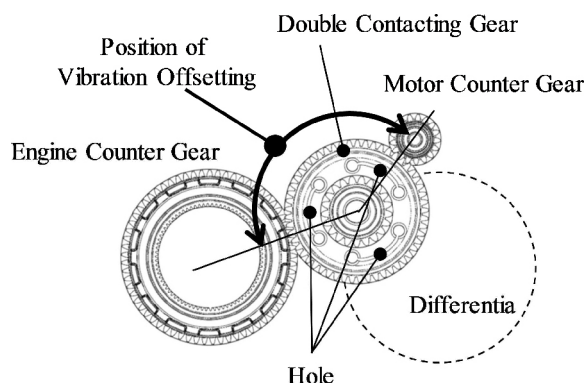


Figure. 4. Transaxle Gear Layout

2-2. Motor

Table 1 shows the motor specifications. Smaller size was crucial to be able to install inside the dual axle structure transaxle. Segment coil type distributed wiring was adopted for the stator, and high speed type rotor was also adopted for this motor.

The losses have been reduced based on 3 items, such as copper loss, steel loss and higher harmonic wave loss. These losses have been reduced because of new motor structure and core design. More than 20% loss reduction was achieved than previous motor. Also motor weight reduced 21% than previous one.

Table.1. New Motor Specifications

	New Motor	Previous Motor
Max Power	53kW	60kW
Max Torque	163Nm	207Nm
Max Motor Speed	17000rpm	13500rpm

Figure 5 shows the newly designed stator. Rectangular copper wires help the coil space factor by over 15% by adopting rectangular copper wire instead of solid one. Also, this new distributed wiring helps to reduce the coil's own volume. The coil was redesigned to meet the demand of this wiring.