LEXUS TECH: INSIDE THE MULTI-STAGE HYBRID SYSTEM

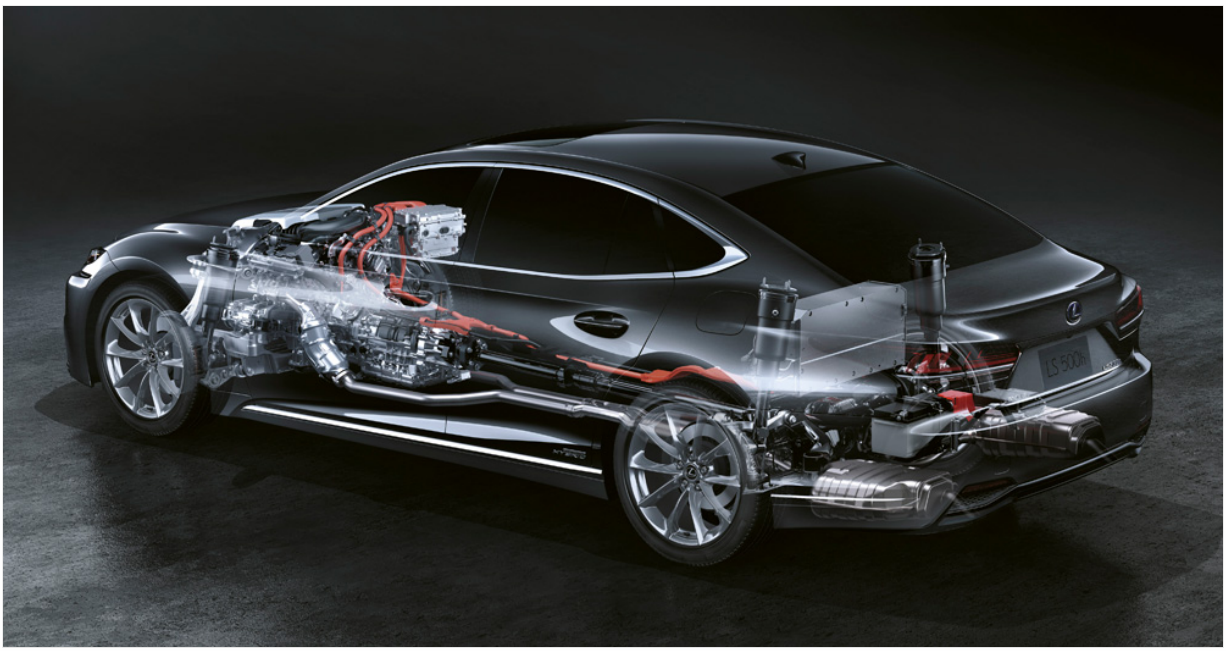
Posted by Kevin on December 14th, 2017

Welcome to the start of a new series diving into the technical side of Lexus vehicles, presented in collaboration with Lexus International.

All-new for the flagship LC 500h coupe and LS 500h sedan, the Multi-stage Hybrid system is the sixth generation of hybrid vehicle (HV) technology from Lexus. The entire system is all-new, from the front of the engine through the gearbox, and all the way back to the rear drive axle.

The Multi-stage Hybrid system was developed for the LC 500h and LS 500h to expand the range of conditions under which the internal combustion engine (ICE) can operate, both into lower RPM and to higher RPM. The system includes the following new advances:

- An all-new direct-injected 3.5 L V6 (type 8GR-FXS) with dual variable valve timing, 13.0:1 compression ratio and Atkinson-cycle operation produces 220 kW (295 HP or 299 PS);
- Lithium-Ion battery pack with 84 cells totaling 310 V and producing 44 kW (equivalent to 59 HP or 60 PS). This first use of lithium-ion batteries in a Lexus hybrid delivers more power to the drive wheels, reducing battery weight by over 30% and battery volume by 20% compared to the previous nickel-metal hydride (NiMH) battery chemistry.
- Coupling the 295 HP internal combustion engine with the power available from the battery pack through the two motor/generators, the Multi-stage Hybrid system of the LC 500h and LS 500h deliver total power of 264 kW (354 HP or 359 PS)1.
- An all-new transmission couples the electronically-controlled planetary power-split device that has been at the core of every Lexus hybrid2 with a new 4-speed planetary automatic final drive; special control logic of both elements simulates a 10-speed automatic transmission.

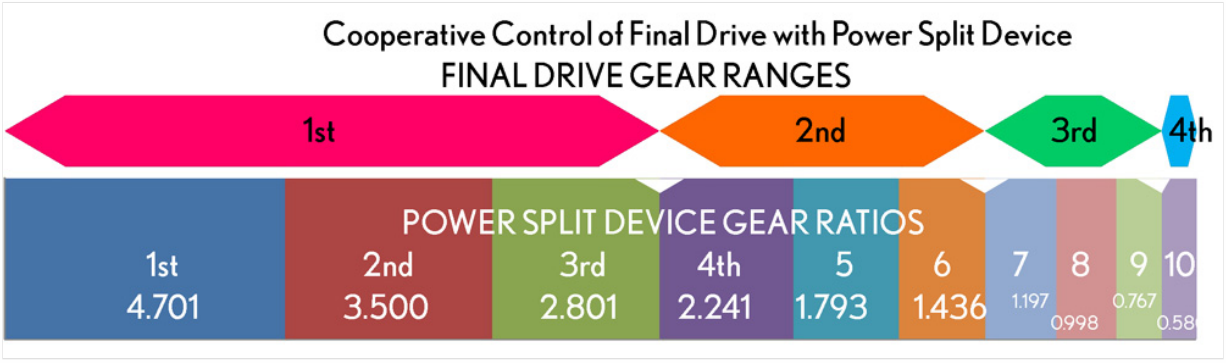


The new Multi-stage Hybrid transmission still incorporates two motor-generators, just like other Lexus hybrid vehicles. The primary motor-generator, MG1, primarily functions as a generator but can also provide power to start the engine and for propulsion. The second motor-generator, MG2, primarily acts as a motor to drive the vehicle but can also act as a generator during deceleration and braking. The motor-generators are coupled to each other and to the internal combustion engine (ICE) by a planetary gearset power-split device.

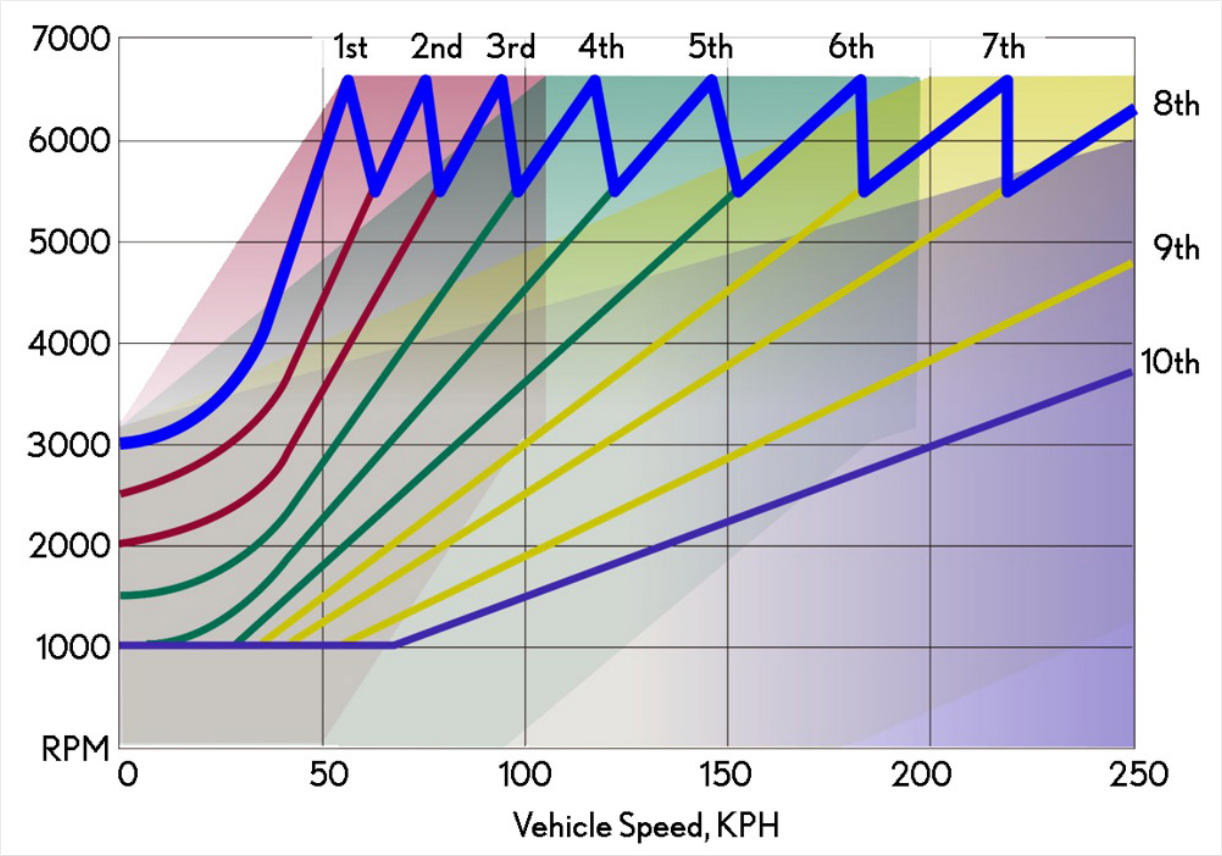
In other Lexus hybrids, the planetary power-split device holds the ICE speed nearly constant during high loads such as acceleration, acting like an electronically-controlled continuously-variable gear ratio transmission for maximum efficiency.

The Multi-stage Hybrid system of the flagship LC coupe and LS sedan controls the planetary power-split device in specific steps to deliver three specific gear ratios with power, then flowing through the new multi-speed final drive. Three ratios from the power-split device are coupled with the first three ratios from the final-drive to produce 3 X 3 or 9 unique gears ratios; another higher ratio from the power-split device is used only in combination with the top gear of the final-drive for the 10th ratio.

The following graphic details the combinations and specific numeric gear ratios of all ten speeds:



The exact gear ratios were selected to provide even, rhythmic shifts with the about the same amount of RPM change at each upshift and downshift.



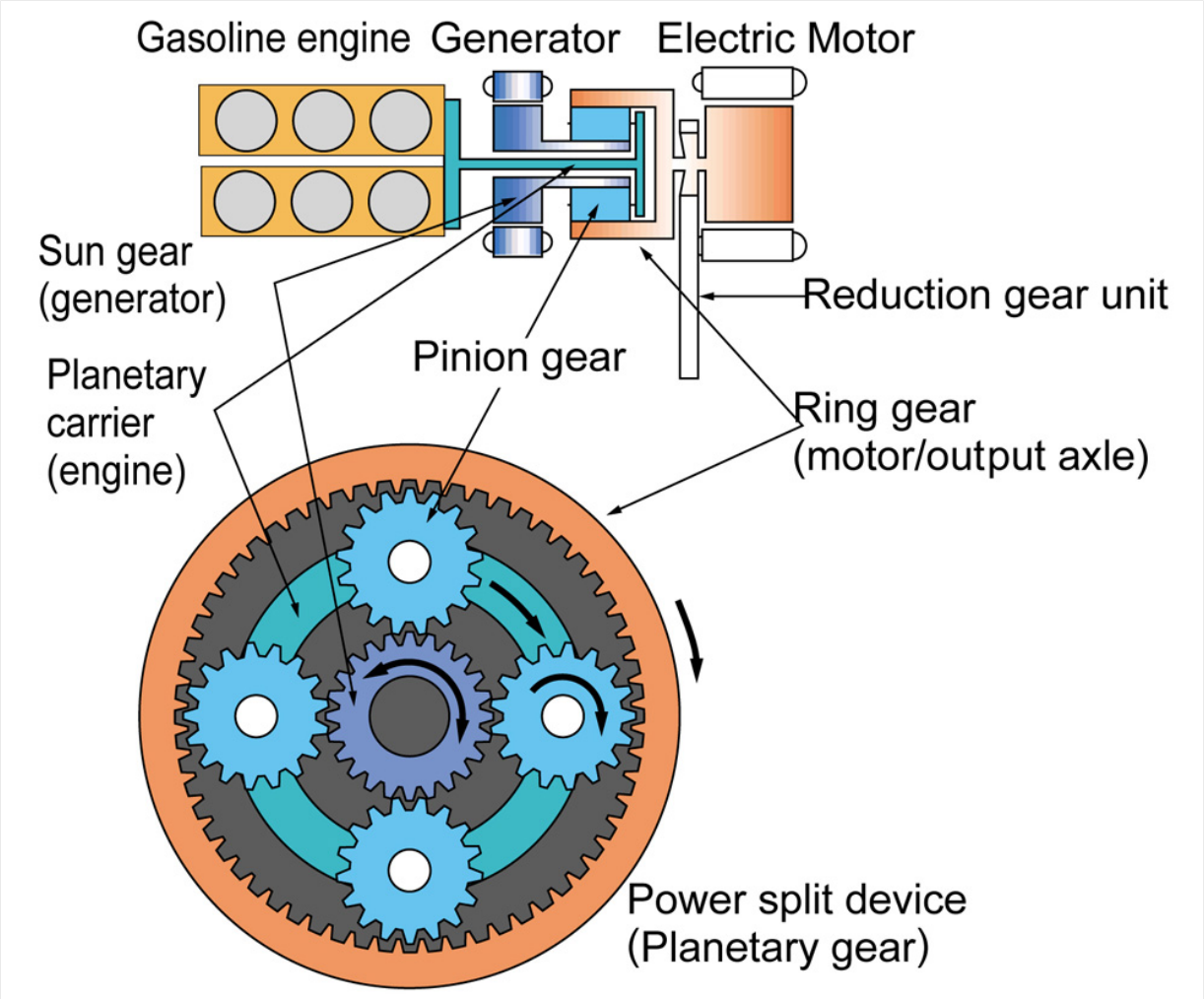
The Multi-stage Hybrid transmission control uses artificial intelligence to control shifting. With the Mode Control in ECO or Normal and the shift lever in D, control of the rate of changing MG1 speeds gives smooth shifts between each gear similar to other Lexus automatic transmissions. A special *Driver's Mind Index* function calculates the vehicle's acceleration to determine the intention of the driver and inhibit unnecessary shifts on winding roads, even in auto mode.

New Manual (M-mode) shifting allows the driver to freely select and hold the system in specific gear ratios using paddle shifters. During strong acceleration in Sport or Sport S+ mode MG1 is controlled to deliver shifts that are nearly instantaneous.

Like other Lexus hybrids, the Multi-stage Hybrid System can use MG2 for pure-EV propulsion at low speeds: but the LC 500h and LS 500h can go to much higher roads speeds in electric-only propulsion than previous systems, and are the first-ever Lexus hybrids that can use ICE power at launch.

BACKGROUND

The heart of every generation of Lexus Hybrid Drive since 2006 (and all Toyota hybrid systems since 1998) is the power-split device, a planetary gearset that couples the output of the internal combustion engine (ICE) with that of the final-stage Motor/Generator (MG2, which is the primary drive motor), controlled by holding torque applied by another Motor/Generator (MG1, which typically acts as a generator).



This system allows completely continuously-variable mixing of engine power and electric motor power and creates an infinite range of gear ratios between the ICE crankshaft and the final drive. Since it is all-electric, with no friction elements or sliding pulley, it has none of the friction or loss of old-fashioned belt- type variable transmissions. In fact, to the contrary, when MG1 is working to hold an element of the planetary and produce a specific ratio, MG1 is acting as a generator producing power that goes into the battery pack. This is one part of why Lexus hybrid systems are so efficient.).

One of the core technologies necessary for advanced hybrid vehicles are very precise speed “resolvers,” special speed sensors in each motor-generator. Unlike conventional speed sensors that cannot distinguish the direction of rotation and only capture a single data point per revolution (thus requiring at least three full revolutions to indicate a trend), resolvers can tell which direction the motor is turning and are far more discrete, producing many speed measurements per rotation.

Coupled with powerful high-current control circuits and high-efficiency low-mass motors, these resolvers allow the Lexus Hybrid system to exert extremely precise control of power and rotational speed of both motor-generators and enables instantaneous continuously-variable mixing of engine power and electric motor power with an infinite range of gear ratios between the internal combustion engine and the final drive.

GENERATIONS OF HYBRID VEHICLE TECHNOLOGY

GEN	YEAR	MODEL	ENGINE		HYBRID SYSTEM
1	1998	Prius	1NZ-FXE	1.5 L I4	Toyota Hybrid System (THS)
2	2004	Prius	1NZ-FXE	1.5 L I4	Toyota Hybrid System-II (THS-II)
3	2006	RX 400h	3MZ-FE	3.3 L V6	Lexus Hybrid Drive (LHD) & AWD-i
	2006	Highlander HV	3MZ-FE	3.3 L V6	THS with Reduction Gear (THS-R)
	2007	Camry HV	2AR-FXE	2.5L I4	Toyota Hybrid System - II (THS-II)
	2010	HS 250h	2AZ-FXE	2.4 L I4	Lexus Hybrid Drive (LHD)
	2011	CT 200h	2ZR-FXE	1.8 L I4	Lexus Hybrid Drive (LHD)
4	2007	GS 450h	2GR-FXE	3.5L V6	LHD for RWD
	2008	LS 600h	2UR-FSE	5.0L V8	LHD for RWD
	2010	RX 450h	2GR-FXE	3.5 L V6	LHD-R & AWD-i
5	2013	ES 300h	2AR-FXE	2.5 L I4	LHD
	2014	IS 300h	2AR-FSE	2.5 L I4	LHD
	2015	NX 300h	2AR-FXE	2.5 L I4	LHD
	2016	GS 300h	2AR-FSE	2.5 L I4	LHD
	2016	GS 450h	2GR-FXS	3.5 L V6	LHD
	2016	RX 450h	2GR-FXS	3.5 L V6	LHD
6	2018	LC 500h	2GR-FXS	3.5 L V6	Multi-Stage Hybrid
	2018	LS 500h	2GR-FXS	3.5 L V6	Multi-Stage Hybrid

Tech

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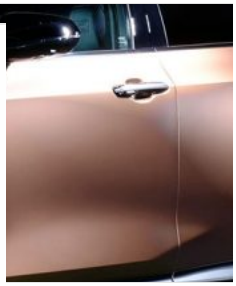

SALON

LEXUS GLOBAL 2021 SALES REPORT

760,000 sales worldwide.

Kevin · February 1st, 2022

COMMENTS

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Motor Trend just tested the LS500 and were not impressed. The performance was well below what Lexus claims.....
http://www.motortrend.com/cars/lexus/ls/2018/2018-lexus-ls-500-first-test-review/

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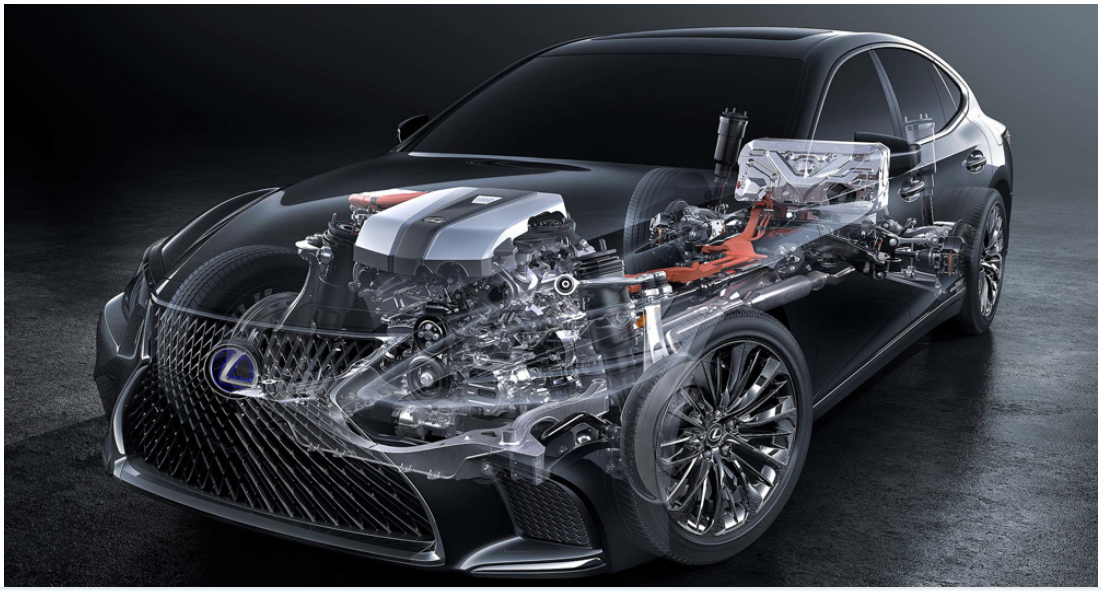

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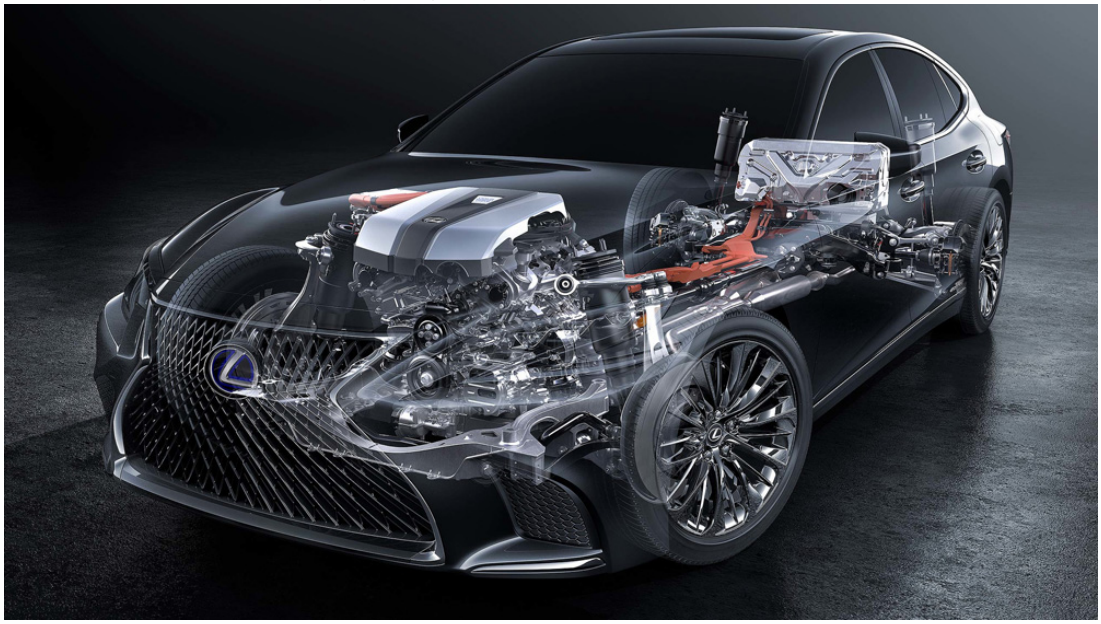

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