Nissan Puts Steer-by-Wire on the Road: 
An In-Depth Look at the Technology

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Abstract:
Steer-by-wire is no longer a technology for the future: Nissan Motor has put it in a full-production car, the Skyline hybrid. Nissan has positioned steer-by-wire as a strategic technology vital to global competitiveness, developing the software in-house, and offering improved reliability with full mechanical backup. Unpleasant road impacts are eliminated, but the rack force from the wheels, essential for safe driving, is transmitted accurately to the driver through a resistance feedback motor. Nissan engineers developed a new technology to estimate rack force with high precision. Independent electrical and mechanical systems boost reliability with full redundancy, and three ECUs monitor the system and each other.
Nissan Motor Co., Ltd. of Japan released its Infiniti-branded Q50 in the United States in August 2013. In February 2014 it was released to the Japan market under the Skyline name, as the first production car in the world with steer-by-wire (SBW) technology (Fig. 1).

In SBW, the wheels are not connected to the steering mechanically, but instead are angled by motors controlled by electrical signals. The driver’s seat is much roomier with the steering column gone, and the steering ratio can be easily adjusted. Many manufacturers have been working on the technology for years, recognizing the user benefit and heightened mobility it offers.

The general consensus some time ago was summed up by one engineer at a major steering mechanism manufacturer: “We can make working prototypes, but it will take some time before it enters volume production.” It was positioned as a technology for tomorrow, because it demands very high electrical system reliability. In addition to upgrading the system to provide the needed reliability, added the same engineer, “An automotive manufacturer will want to see actual deliveries and cars on the road before taking that risk.” Cars on the road means volume production, but no manufacturer was going to risk putting a new technology into a volume-production automobile.

Most people in the industry figured that the first application of SBW in a

Fig. 1   New Skyline

Only the hybrid model is available in Japan, with a list price starting at ¥4,496,100 (tax included). The specification for the US market is gasoline-fueled.
volume-production model would have a redundant backup system in addition to the electrical system. Redundancy would improve reliability while building up a performance history for the electrical system. And, in fact, the SBW system in the Nissan Skyline has a mechanical backup mechanism that instantly links wheels and steering wheel mechanically in the event of a problem with the electrical system.

A backup mechanism, unfortunately, makes it impossible to expand the cabin space, defeating one of the key advantages of SBW. Most manufacturers have been hesitant to put the technology into a volume-production model for exactly this reason, explains a high-level manager at a major manufacturer: “It was a lot harder to come up with meaningful benefits without the extra space.”

Nissan was able to move ahead with SBW technology because it came up with a simple, easy-to-understand advantage for users: delivering the firm’s promised “Driving as Intended” slogan. In practical terms, this means rapid turns at low and medium speeds coupled with improved linearity at higher speeds (combining two characteristics generally considered to be contradictory), and providing a smoother steering feel by minimizing the amount of correction needed when driving over rough roads.

Nissan selected its Skyline as the first vehicle for SBW technology because it already places major emphasis on mobility, making it easier to fully leverage the above two advantages. The firm plans to adopt SBW in other models as well, and once it is in widespread use in volume-production vehicles and electrical system reliability has been confirmed, they plan to eliminate the backup mechanism entirely.

**Visual references via onboard cameras**

Nissan refers to SBW as “direct adaptive steering,” but the essential components are identical: two motors to angle the wheels and another to synthesize steering resistance, along with the mechanical clutch in the backup mechanism (Fig. 2). The rack-and-pinion assembly is pretty much the same as the one used in electric power steering (EPS).

The SBW control software was developed in-house, according to Takeshi Kimura, manager of the Chassis Technology Development Division, Automotive Parts Technology Development main branch at Nissan. There are not many other examples of a