PROTEAN Drive

Test Sheet

We have faced and overcome important technical issues on our journey to develop ProteanDrive. Here is a summary of the key challenges associated with In-Wheel motor technology and how we approached them:

Area	Challenge	Protean Approach
Unsprung Mass	Perception that additional weight in wheels impairs driver handling, comfort and safety	- With fine-tuning of the suspension, unsprung mass is not a limitation of IWM technology - Protean has commissioned several independent studies from renowned third parties - Work from Lotus Engineering and on the Protean-MAHLE Golf independently arrived at a similar conclusion: - Typical vehicle tuning recovers any minor performance deficit from unsprung mass
Integration of Friction Brake	Packaging a foundation brake within the motor that matches standard vehicle performance	- Mounting the brake disc to the motor with the brake caliper attached to the suspension has been successfully integrated and tested on a variety of vehicles - Development work has been conducted with OEM brake specialist Alcon since 2011 - Braking performance matching that of a traditional non-EV vehicle successfully achieved on vehicles up to 3,500 kg
Thermal Management	Cooling multiple electronic subsystems effectively when closely packaged together	- Effective thermal management has been achieved through novel design and development of hardware and software - patented cooling design - The cooling of multiple subsystems (power electronics, electrical machine) has been achieved by utilizing both direct and indirect cooling in a single cooling circuit - The motor temperatures are constantly monitored and stabilized if necessary
Ingress Protection	Protecting internal motor components from water debris ingress whilst in the harsh in-wheel environment	- Compact self energizing seal that protects against water and debris ingress and accommodates misalignment, operating temperature changes and minimizes wear - Stator potting in composite insulation system with layering for enhanced protection and durability improvement
Vehicle Control	Perceived complexity of software communicating with individual wheel modules instead of single unit system	- Protean developed vehicle control software to demonstrate per-axle wheel control achievable in existing vehicle architectures; supporting customers in taking this software into production - Integration with ABS/ESP systems possible and completed on a number of vehicles - Protean following ISO 26262 to ensure compliance with OEM standards and systems

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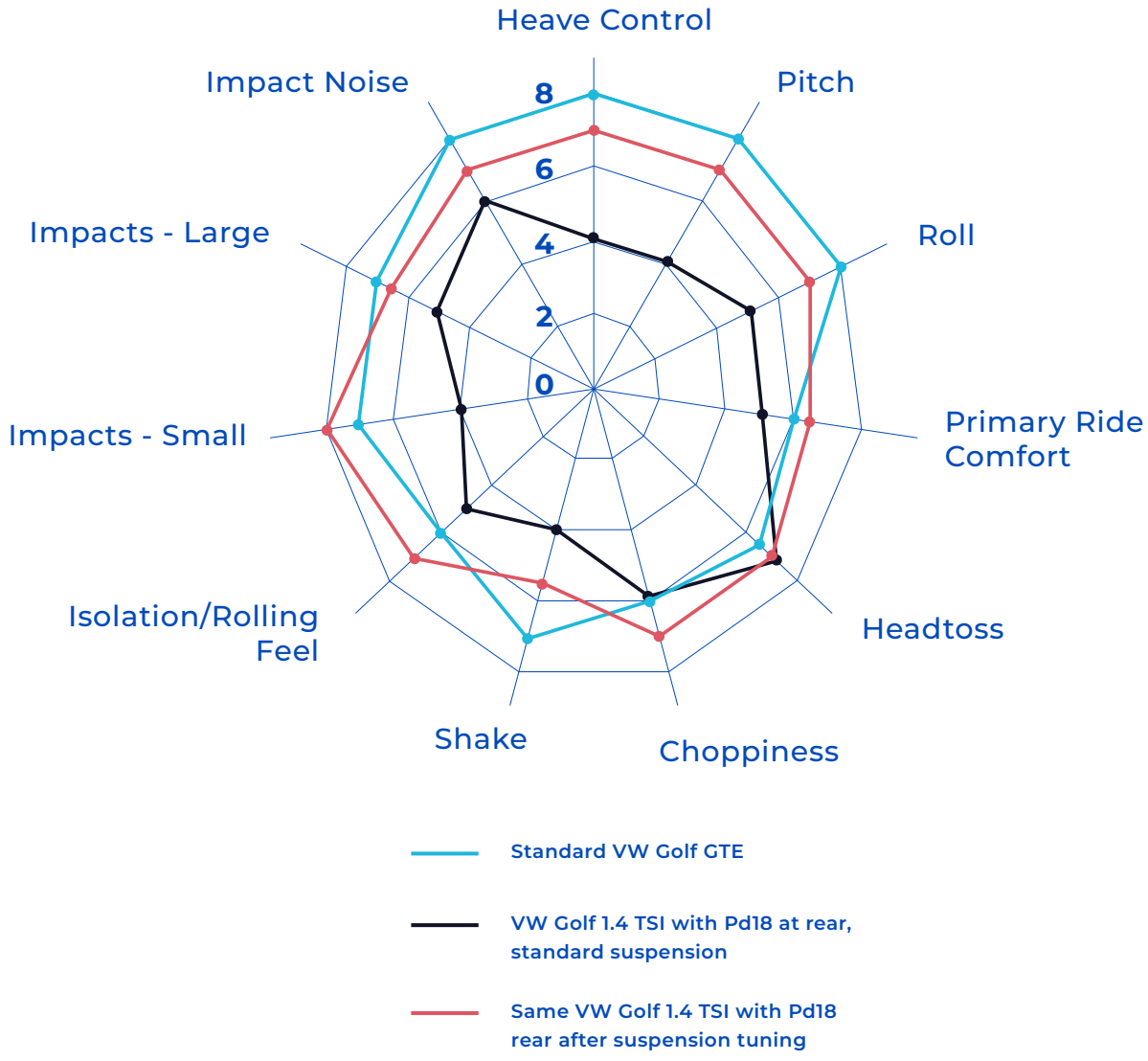
More on Unsprung Mass

There is no question that the ratio of unsprung to sprung mass is an important parameter in determining ride and handling performance, and consequently one of the first objectives in our 10 year R&D program was to test thoroughly and understand these effects.

We have continued to commission a number of external expert studies to assess the impact of adding in-wheel motors. As an example here are the results from a Corum Technology Vehicle Evaluation Rating (VER) for a VW Golf GTE:



The key conclusion was ride and handling effects of added USM are substantially recovered by adopting stiffer suspension components. A number of studies have concluded that tuning suspension in a stiffer direction recovers wheel hop frequencies and ride and handling performance, and tuning recovers performance close to that of the original.

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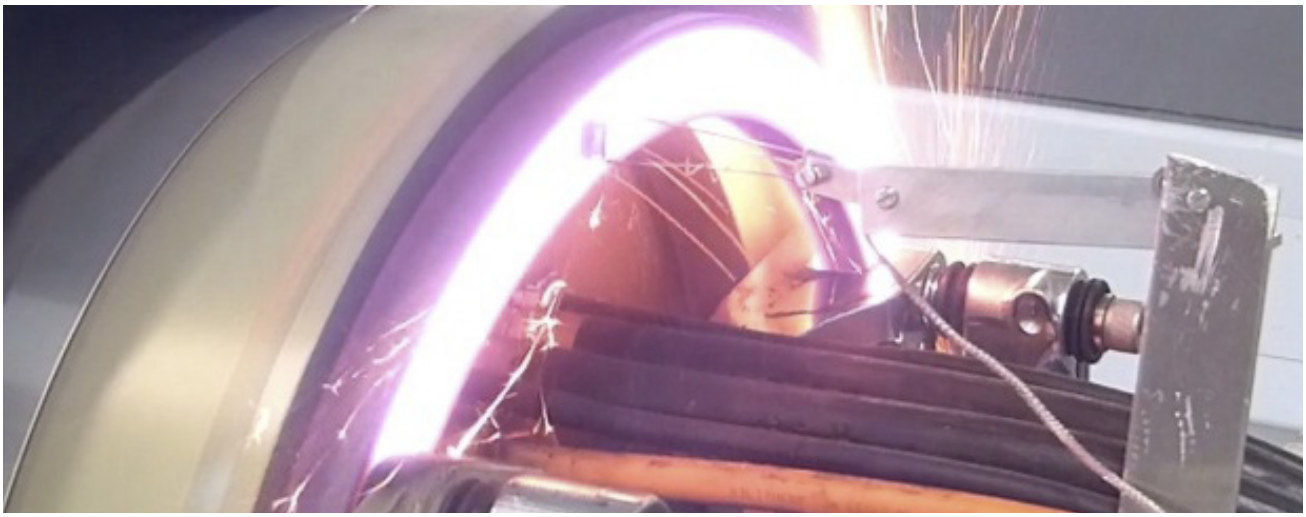
More on Integrated Friction Brake

Our integrated brake and motor match standard vehicle performance and has been successfully validated on a variety of vehicles. Testing included:

- A simulation of “the Grossglockner” extreme condition brake test in which the discs run hot with hard driving for 23 minutes simulating a 2,500 meter steep descent.
- The “AMS” braking test used to assess brake fade which consists of 15 repeats of hard accelerating from 0-100km/hr and braking as fast as possible to 0km/hr.

In all cases the packaged brake and motor operated to specification throughout and after each test.



Contact

For more information please visit our website or email enquiries@proteanelectric.