

# **TOrque Vectoring Electric Differential TOVED**

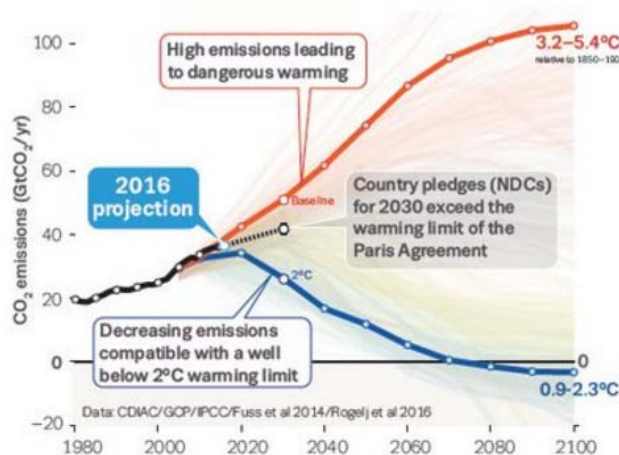


## Executive Summary

Electric/hybrid vehicles are far from a mature technology, and innovations and improvements are coming rapidly. Improved batteries designed with high power density for electric/hybrid applications will start arriving soon. Even the electric/hybrid vehicles are still expensive, in the future, lower cost, electric/hybrid powertrain will be able to compete directly against conventional technology improvements on a cost-benefit basis.

Thus, electrified vehicle market penetration will likely increase only modestly in the near term, but as costs drop electric/hybrid vehicles will become just another technology that manufacturers sell on its positive efficiency and drivability impacts, not on the technology itself, similar to what is currently occurring with turbocharged gasoline engines. Consequently the costs of full-function electrified powertrain are likely to drop to half the cost of their 2010 counterparts before 2025.

On the other hand the electric/hybrid vehicle using the proposed concept will contribute radically to lower global warming which became stringent in the last years.



## State of the art

One of the most important components of the electric powertrain is the transmission system to the wheels which incorporate the differential. Because the differential is electrified we can name it „electric differential”. We present bellow few types of electric differentials.

Recently Xtrac has introduced its P1227 gearbox family, developed to address the growing market requirement for single-speed, lightweight and power-dense electric vehicle (EV) transmissions. It offers a range of installation possibilities for fast and powerful electric supercars with front-wheel drive, rear-wheel drive or four-wheel drive configuration.

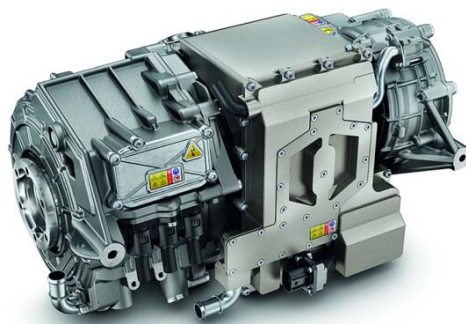
The new transmission system can be integrated with motors supplied by BorgWarner, GKN and YASA, all of which worked with Xtrac on the integration of their technology into this transmission. The dual electric motors of the transmission system also provide an inherent torque vectoring capabilities.



GKN Driveline, which works as a development partner on all-wheel drive and plug-in hybrid systems for Volvo Cars, is producing an eAxle system for the new Volvo S90 plug-in hybrid. The eAxle system fits in the same space as a standard rear drive module, enabling Volvo Cars to offer customers a plug-in hybrid as a simple, high-performance upgrade. GKN's eAxle takes power from a 65 kW, 240 N·m electric machine with a nominal maximum input speed of 13,000 rpm and, via a two-stage single speed gearbox with a ratio of 10:1, delivers a nominal output torque of 2400 N·m.



Schaeffler is also developing a two-speed electric axle (P4) for hybrid and fully electric vehicles. Marc McGrath, Schaeffler's President Automotive Americas, says that the company is targeting the system to the US small SUV and crossover market as an alternative to conventional all-wheel drive.



The ESKAM(Electric Scalable Axle Module, Elektrische SKalierbare AchsantriebsModule) consortium in Germany, sponsored by the German Federal Ministry of Education and Research (BMBF), is completing the development of an optimized electric drive axle module for commercial vehicles, consisting of two motors, transmissions and power electronics. All components fit neatly and compactly into a shared housing, which is fitted in the vehicle using a special frame construction also developed by the project engineers.



All these „electric differentials” seem to be very complex, costly and heavy increasing proportionally the vehicle cost.

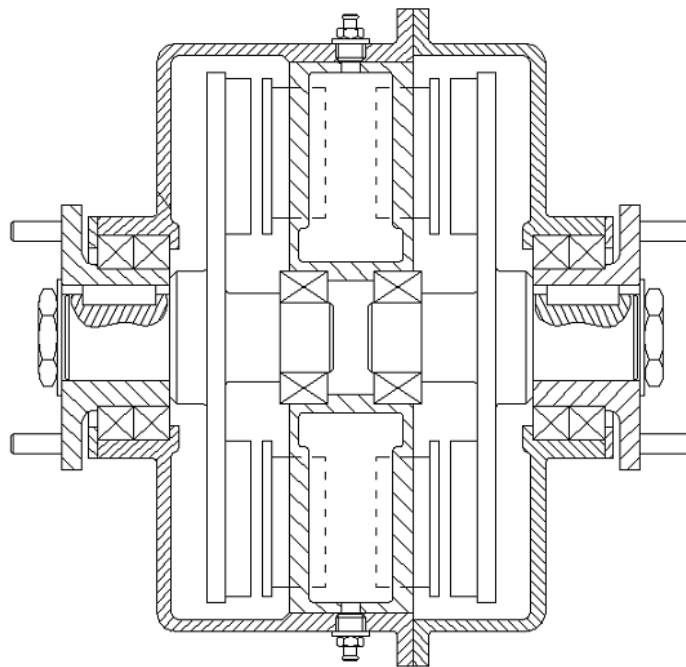
That is why it is becoming a desideratum to build an electric differential with torque vectoring, having a reduced number of components, and which must to be lightly and cheap, designed for the new generation of affordable electric/hybrid vehicles.

### **New Torque Vectoring Electric Differential – TOVED**

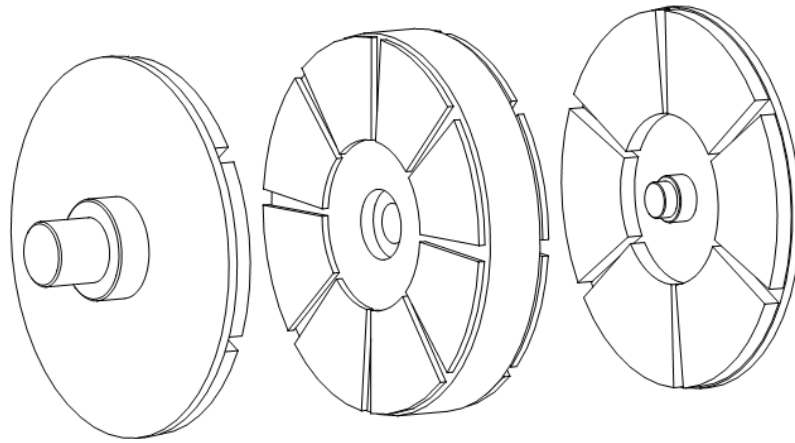
Electric differential represents advancement in electric vehicles technology along with the more traction control. The electric differential provides the required torque for each driving wheel and allows different wheel speeds

electronically. It is used in place of the mechanical differential in multi-drive systems. When cornering the inner and outer wheels rotate at different speeds, because the inner wheels describe a smaller turning radius. The electronic differential uses the steering wheel command signal, throttle position signals and the motor speed signals to control the power to each wheel so that all wheels are supplied with the torque they need. Whereas drive torque conventionally is distributed evenly to the wheels of the drive axle, a torque vectoring system allocates torque between the wheels as required. This provides particularly good drive dynamics. As an example, when a vehicle accelerates in a curve, greater torque is applied to the outside wheel. The car steers itself into the curve. The result: greater agility and, at the same time, safer road handling.

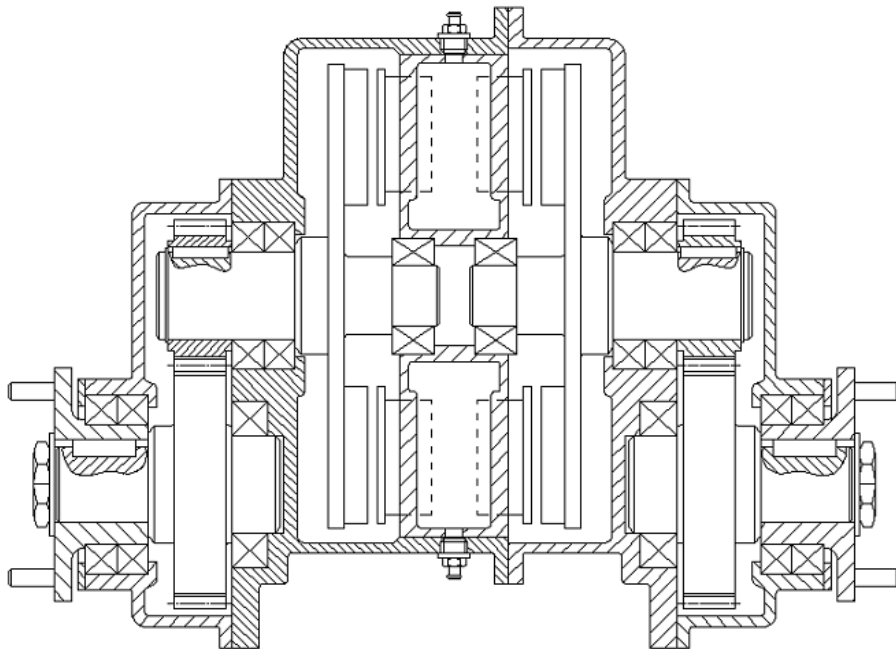
TOVED is a new type of electric differential that provides torque vectoring in a simple and easy manner. Metaphorically we can say TOVED use only 1.5 electric motors and without be coupled with a mechanical differential. Why 1.5 electric motors?



In fact TOVED uses two axially electric motors but these motors have two simple independent rotors with permanent magnets acted by a single stator. In a first variant the rotors are directly coupled with the wheels by means the half shafts.

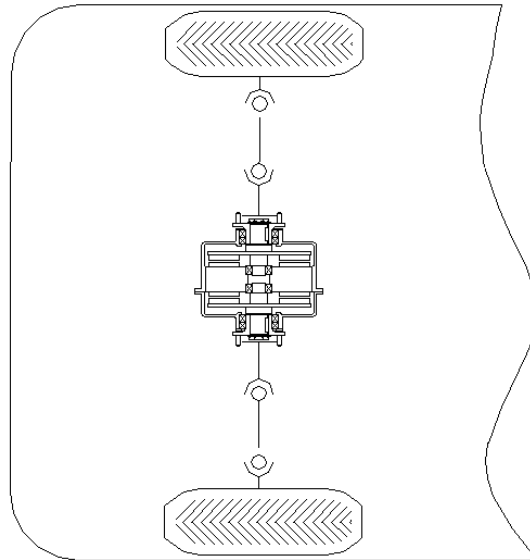


In a second variant the rotors are coupled with the wheels using a single gear reduction. In this case the motors operate in a more efficient area and the stator can have a lower volume and weight.

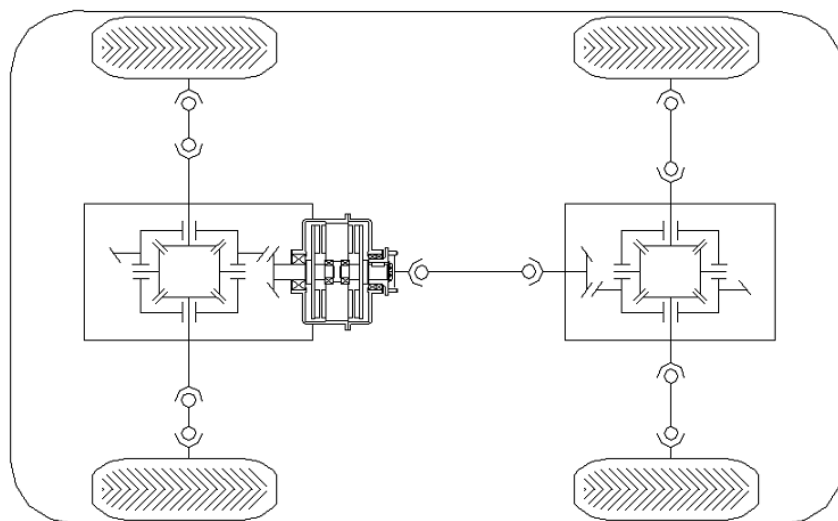


In the both cases the stator is cooled by a unitary cooling system which also simplifies the construction and saves the costs.

TOVED can be used on the front axle, on the rear axle or on both front and rear axle when the vehicle is of the 4x4 type.



Also TOVED can be used as inter-axial device when it directs the power through two conventional differentials, one located in the front and the other in the rear.





TOVED has the advantages of replacing loosely, heavy and inefficient mechanical transmission and mechanical differential with a more efficient, light and small electric motors directly coupled to the wheels using or not a single gear reduction.

TOVED takes advantages even compared with other electric differentials from the point of views of complexity and costs.

TOVED is a patent pending technology.

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