CASE STUDY: COMMERCIAL VEHICLES

The Challenge: Electrification of the commercial vehicle sector is lagging behind the development of passenger car solutions. Previous market entries have been focused on adopting technologies designed for the passenger car market, often resulting in compromises in performance or price when applied to a commercial vehicle platform.


Tevva motors Hybrid

The commercial vehicle (CV) sector often has significantly higher vehicle utilisation than a passenger car and often operates at the peak of its performance range, being speed limited, for many hours at a time while covering a large number of motorway miles. A physically robust technology which can operate at peak efficiency and performance for long durations.

The CV sector is also heavily focused on total cost of ownership and the commercial case for new technology adoption. While clean air and climate change legislation is beginning to accelerate the rate of EV technology adoption, the winning technologies will be those which deliver a cost advantage as well as environmental benefits. Key measures for the sector will include initial purchase price but will also consider the efficiency of the system during its standard operating conditions, its complexity and cost of servicing as well as any potential disposal costs.

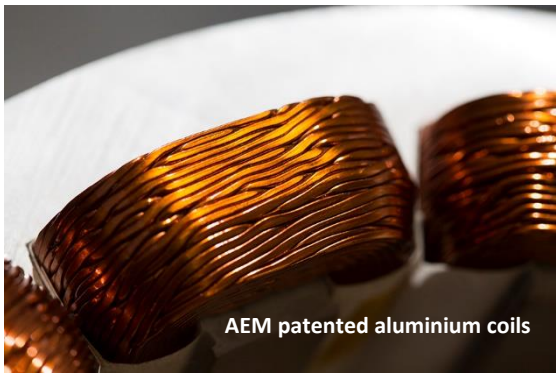
AEM Solution: High Density Switch Reluctance Motor (HDSRM) is the culmination of six years of research to deliver a magnet free commercial vehicle traction motor which offers market leading sustainability and cost but requires no compromise in performance when compared to market leading permanent magnet (PM) machines.

Switched Reluctance (SR) motor technologies have been around almost as long as the internal combustion engine, however they have always had significant weaknesses in performance which has limited their use in electric vehicles. Traditional SR technologies are known to be both noisy and to suffer from torque ripple making them unsuitable for traction applications. In addition, a traditional SR motor requires a different control solution to permanent magnet machines, requiring different power electronics to drive them. The ubiquitous nature of PM machines in traction applications has driven the price of the power electronics down through economies of scale, meaning that a unique SR power electronics solution is considerably more expensive.


HDSRM300

HDSRM addresses all of these problems through its innovative design.
Clever integrated electronics mean that the motor can be driven through the same power electronics as those which drive a PM machine. Moreover the design of the machine means that, although it appears to the power electronics as a standard three phase motor, it has an additional three phases which smooth out the torque ripple and reduce noise.

This key innovation means that HDSRM is then able to take advantage of the inherent benefits of a SR machine including: no permanent magnets, simplified system design and reduced manufacturing cost.
Advantages: Because permanent magnets are no longer required the system level improvements continue to deliver real world benefits when integrating the motor into a vehicle platform. Permanent magnets will demagnetise at high temperatures meaning they need significant cooling to ensure they continue to work. This requires a cooling system which is independent of an internal combustion engine in a hybrid application adding further complexity and cost to an already complex system. HDSRM has no such requirement and can easily be connected to the cooling loop of the engine.


AEM patented aluminium coils

As well as removing the magnets the team at AEM have developed a patented manufacturing process which allows HDSRM to use aluminium windings in place of copper. Copper is an expensive material and dense material which increases the difficulty of recycling the overall motor. The removal of the copper from the system means that the windings in HDSRM can be 90% cheaper, 90% lighter and that the whole motor can be upcycled by re-melting through an electric arc furnace into high grade steels without the need for any disassembly.

A key feature of permanent magnet motors is that they are never 'off'. The motor will always generate either current or torque while rotating meaning a level of control and safety electronics always need to be in operation. When HDSRM is not being driven it is truly 'off', acting as a freely rotating mass which does not generate current or torque. Using this feature the team at AEM have patented a multi-motor design approach which allows one or more motors to be turned on our off depending on the performance requirements of the vehicle at the time. In turn this means that the multi-motor system can be operated at peak efficiency across a much broader part of the vehicle drive cycle – offering the electric vehicle equivalent of cylinder deactivation. These efficiencies translate into a real world increase in range or battery size reduction.

Collaboration: Collaboration is at the heart of the development of HDSRM, driving and focusing its design and accelerating its route to market. The development process has seen the concept handed from partnership to partnership coordinated by the AEM team throughout.

The development of the system began before the HDSRM concept was conceived. The initial programme was developed to understand the potential for a motor focused on utilising the properties

of the latest electrical steels to deliver a traction solution that could outperform PM machines while consisting of predominantly steel and aluminium. The motor aimed to be more cost effective than any other motor technology while delivering higher levels of performance and to be completely recyclable at the end of its life.

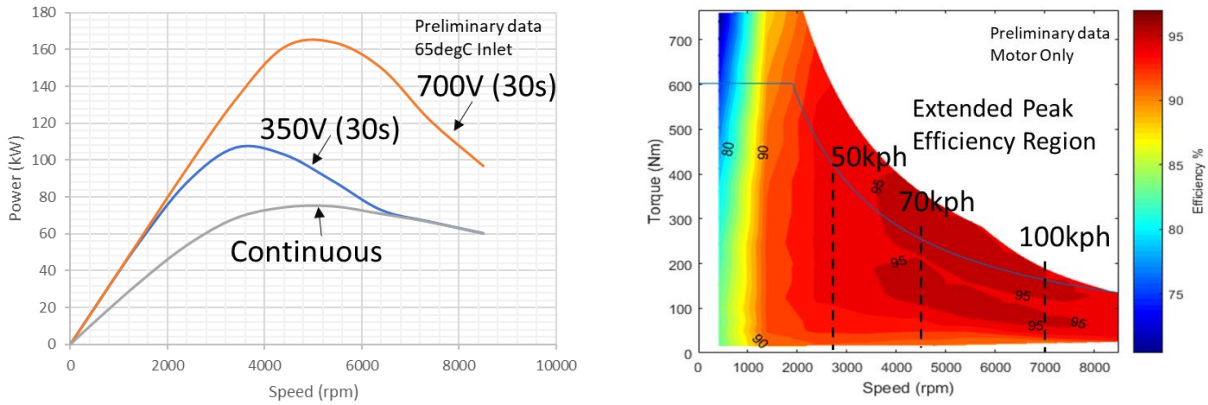
Prototype Commercial Vehicle Motor

The learning and concepts from this project were applied with the fundamental aim of replacing an existing Commercial Vehicle PM motor with a 'like for like' SR based technology to reduce costs. From day one the development of the system was focused on the challenges and operating cycles of commercial vehicles with the plan to fit the concept motor into an existing powertrain to prove its performance. The programme successfully demonstrated a system which fitted into the existing motor housing and delivered the same, or slightly improved, levels of performance as the drive it replaced. HDSRM was born!

The final phase of commercialisation began in 2017 when AEM, in partnership with Tevva Motors, developed a programme to deliver a highly efficient and cost effective complete commercial vehicle focused powertrain solution. Coupling HDSRM drive motors and generators, with Tevva's leading edge battery systems and vehicle control and diagnostics solutions, to deliver a market leading solution for both Electrified and Range Extended Commercial Vehicles. TevvaDrive 3.0 was completed in April 2019 with HDSRM once again demonstrating its capability to meet all the key performance targets required by the sector. The system is now in production with the first vehicles due in the field in Q2 2020.

Today: Our first motor is now available to the market 'off the shelf' as HDSRM300 and is already creating interest in the Commercial Vehicle Sector and beyond, with the current design being evaluated for applications in six different sectors across 4 continents.

Key power and efficiency curves for HDSRM300 are:



HDSRM300 Performance & Efficiency Curves

The Commercial Vehicle sector remains a core focus and two new variants of the motor are already available for integration into current and future product development programmes. The specifications of the current and new machines are as follows:

Product	Torque (@425Arms)	Power		Peak Efficiency	Mass (kg)
		Peak (@700V)	Continuous		
HDSRM300	325Nm	160kW	75kW	>95%	80
HDSRM300T	>600Nm	160kW	75kW		
HDSRM300X	>1500Nm	300kW	150kW		140

The work we completed in developing the HDSRM technology was recognised by The Engineer magazine as a leading example of collaborative innovation, winning both the automotive and overall 'Collaborate to Innovate' award in 2019. If you are interested in working with us to deliver our market leading magnet free technologies into your product then please drop one of our commercial team a line at:
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