

# NEXT GENERATION ELECTRIC POWERTRAINS: AN OVERVIEW OF TRENDS, CHALLENGES AND OPPORTUNITIES

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Powertrain Innovation Webinar whitepaper series

## PART OF A SERIES

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This whitepaper is a distillation of the discussion at the first in a series of Powertrain Innovation webinars co-hosted by McLaren Applied and Arrow Electronics in December 2020.

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## INTRODUCTION

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This white paper is a distillation of the discussion at the first in a series of Powertrain Innovation webinars co-hosted by McLaren Applied and Arrow Electronics in December 2020.

Jon Beasley, Director, Technology and Projects at the Advanced Propulsion Centre UK, hosted an insightful and thought-provoking session, where he was joined by the following speakers:

- Stephen Lambert, Head of Electrification, McLaren Applied
- David Bock, Advanced Development E-Powertrain, BMW
- Josh Giegl, Co-Founder and CTO, Virgin Hyperloop
- Filippo Di Giovanni, Strategic Marketing, Innovation and Key Programs Manager, ST

## EXECUTIVE SUMMARY

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- This is an exciting time to be involved in automotive technology. With electrification driving rapid development in products being manufactured, there are huge opportunities for suppliers and OEMs as the world moves towards cleaner transport solutions.
- Silicon Carbide technology is at the heart of that progress and will be a driver for significant change in the next decade.
- The evolution of the electric vehicle is approaching an inflection point, by the middle of the 2020s, where efficiency will be the key market driver.
- Standardisation of products and their supporting technology will be highly desirable for the smooth and rapid upscaling of electric vehicle numbers.
- Cutting-edge products should not stand alone; they need to be supported by an equally innovative ecosystem and supply chain.
- Innovation driven by electrification is already driving extraordinary advances in transportation, Virgin Hyperloop being just one example.

## KEY FINDINGS

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### SILICON CARBIDE – THE KEY TO INCREASED EFFICIENCY AND ENHANCED PERFORMANCE

In the first decade of this century, most battery electric vehicles were 200V; today, state of the art is 400V. As electric vehicles start to penetrate the market there is a need to increase the efficiency and performance of vehicles while reducing cost and mass. Silicon Carbide technologies using 800V, with high integration, are the path to this.

Silicon Carbide based inverters offer considerable efficiency gains versus conventional inverters because they produce less heat during operation. Combined with a move to 800V, further efficiency gains can be realised.

Silicon Carbide also enables faster switching, which, when used and optimised correctly, increases overall efficiency in vehicles. This allows OEMs to develop vehicles with greater ranges, faster charging times and better acceleration at a comparable cost.

The inverter accounts for about half the cost of a motor and inverter solution, which makes Silicon Carbide a high-value investment for electric vehicle OEMs and suppliers and choosing the right inverter is crucial.

### TECHNOLOGY THAT SUPPORTS SILICON CARBIDE IS KEY TO ITS SUCCESS

It is essential that technology is developed that can move alongside fast-emerging innovations. This is a rapidly evolving market place with a pace that will only increase as competitions amongst electric vehicle manufacturers increases.

OEMs and suppliers need to understand:

- How to deliver a fast response to emerging technologies
- How the architecture can be designed to allow for implementation of these emerging technologies
- How they can deliver high efficiency targets for customers

Furthermore, the quality of the system is of upmost importance, with complimentary systems, such as measurement of voltage, current and temperature being key to adding value.

If you lose 10 per cent of the capability of the inverter because the sensors are weak, the solution loses value.

Ideally there should not be a single source of core components; such a reliance poses risks for businesses. There needs to be flexibility in the supply chain.

Suppliers are developing new motor architectures and increased motor speeds, with improved power density and thermal management. The trend is for higher switching frequency, to 16kHz, 24kHz, 32kHz and beyond. The only way to achieve this is through the use of Silicon Carbide.

Using a Silicon Carbide MOSFET in an inverter has several further benefits. Total semiconductor area is reduced by a factor of five, which is significant and combined with the higher efficiency allows for significant size reductions.

This is because in Silicon IGBTs, 20 per cent of the package is taken up by the power module and 50 per cent by the cooling system. In a Silicon Carbide MOSFET those numbers reduce to six per cent and 20 per cent respectively.

## STANDARDISATION WILL DRIVE MASS ADOPTION OF NEW TECHNOLOGY

In the wider electronic world there are standard packages for electronic components. You can find the part you need anywhere in the world and that accelerates the delivery of these technologies to market.

With regard to the successful development of electric powertrains, similar standardisation and widespread availability of parts is key.

From an OEM point of view, there should be a unified view of the whole system. That way, OEMs could design their systems and know that there will be stable supply of power electronics that can fit.

Currently there is little uniformity across suppliers, which means OEMs are locked in with a supplier and left hoping the relationship stays healthy for the complete development cycle.

The ability to use multiple suppliers, to be able to source local content and build cars all over the world would be a significant boost for OEMs. There are 4,000 parts in an inverter, of which the power electronics are arguably the most important. Reliability of the original parts, and a supply of replacements, is therefore critical.

## IMPROVING POWERTRAIN EFFICIENCY IS A KEY TREND FOR OEMS

OEMs face a conundrum over the development of electric vehicles. They are reluctant to bring EVs out because the infrastructure has not been installed yet; but one of the reasons that infrastructure is not there is that OEMs are not bringing out EVs yet. However, this situation is changing.

EV market penetration is growing rapidly and sales of EVs bucked the downward trend during the Covid-19 lockdown.

The 800V Silicon Carbide inverter will be key to addressing issues such as cost, weight, packaging and thermal management.

It will also address anxiety over reliability and range, which deters many potential buyers and have traditionally been barriers to entry.

However, some analysts predict that by as early as 2024 sales of passenger EVs with Silicon Carbide-based transistors will outnumber IGBTs.

With more and more OEMs bringing out drivetrains based around 800V and Silicon Carbide, the industry could reach an inflection point in 2024-25.

For OEMs as the EV industry matures, it will not be enough simply to have an EV solution available; the level of its efficiency will be a key differentiator in the industry.

Future powertrains will need to have:

- 800V inverters, which enable fast charging and enhanced range
- Silicon Carbide, which means the virtuous circle of higher efficiency and reduced thermal emissions, as well as faster switching frequency and smaller, higher-speed motors
- Reduced overall system costs

Smaller motors will mean lower cost and easier mass production, further reducing barriers to entry.

## THE FUTURE OF TRANSPORT IS UP FOR DEBATE: VIRGIN HYPERLOOP: A REVOLUTIONARY NEW CLASS OF VEHICLE

While technology has changed the world in so many areas, transportation has largely been left behind. Trains, cars and boats look much the same as they did 100 years ago.

However, electrification has driven the innovation behind a new class of vehicle and mass transportation system that could define how we live, work and move around in the 21st century.

Virgin Hyperloop, based in Los Angeles, is a project to create transportation that moves at the speed of an aircraft but uses a fraction of the energy.

### What is it?

A high-powered, long-range, autonomous, safety-critical electric vehicle, or “pod”, designed to move very large numbers of people at high speed.

### How does it work?

It uses a form of contactless electro-magnetic propulsion to get up to speed, using a new type of magnetic levitation to provide lift and guidance.

The pod, which travels in a tube and holds up to 25 people, has no other parts apart from the doors and is fully electrically controlled.

The tube itself is an enclosed environment with a pressure of 0.1 per cent of an atmosphere. The pod can travel at the speed of an aeroplane, up to 900kmh, with minimal drag.

A fleet of pods is managed through machine intelligence, allowing vehicles to travel at high speed and in close proximity to each other.

### Key performance impacts

- The levitation engine is ten times more efficient than traditional maglev systems.
- The motor has 50 per cent better power factor, is 50 per cent more compact and can go two to three times faster than competing systems.
- The emergency braking system is up to nine times more efficient, meaning vehicles can travel closely but safely.
- Massive reduction in power electronics, reduced energy loss, increased efficiency and reduced recharge time – thanks to Silicon Carbide switches.

The project engineers were considering IGBTs but then realised Silicon Carbide was a significant opportunity. Their adoption of the technology has had the following results:

- 40 per cent more electrically efficient, meaning smaller batteries and powertrain
- 40 per cent higher thermal efficiency, particularly relevant in a tube where dissipating thermal energy is a significant challenge
- Significant reduction in energy consumption and increase in battery life, which has made the system scalable and helped with maintenance and replacement costs.

# WHAT DOES THIS ALL MEAN FOR THE FUTURE OF POWERTRAIN INNOVATION?

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- It is clear that Silicon Carbide technology – and the products it powers such as the 800V inverter – is fundamental to the future success of OEMs looking to move towards electrification and cleaner transport solutions.
- To facilitate this development, it is essential that the technology that supports Silicon Carbide moves at a similarly rapid pace.
- It is important to consider the standardisation of supply chains to ensure the smooth and widespread development and adoption of Silicon Carbide Solutions.
- New, revolutionary modes of transport can be a catalyst for accelerating this move to future technology.
- Having the right partner is essential – McLaren Applied has extensive and well-established relationships with OEMs and has developed an 800V Silicon Carbide inverter.
- To find out more, please visit <https://www.mclaren.com/applied/products/electrification/>



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