Higher voltage programmable power supplies assist 800V electric vehicle development

Electric vehicle (EV) unit sales are expected to reach 17.07 million by 2028[1]. This will, of course, result in a similar surge in demand for components, subassemblies, and test capability. However, the purchase price, charge time, and availability of charging stations remain significant barriers to EV adoption.

Automotive manufacturers are already working to extend EV ranges and reduce charge times. However, when comparing an internal combustion engine (ICE) to battery-powered vehicles, 'range anxiety' is a common concern. This concern is expedited because the EV's heating and cooling systems for passenger comfort require power from the battery, and the media has recently publicised how cold weather further reduces battery range and performance.

In this article, TDK-Lambda explores how higher voltage systems, advanced battery technologies, and programmable power supplies are paving the way for the next generation of 800V electric vehicles.

[1] https://www.statista.com/outlook/mmo/electric-vehicles/worldwide

How modular and configurable power supplies can help engineers streamline power system design

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Recent battery innovations

Battery manufacturers are heavily investing in research and development costs and performance improvements. Many advancements have come from cell chemistry or design changes, pack engineering, and manufacturing processes.

Lithium-ion is currently the most popular battery chemistry to use, but these often contain cobalt – a toxic metal that comes with significant financial, environmental, and social implications. However, there are efforts to develop cobalt-free batteries where the cathode is, instead, based on organic materials. Early research suggests that this material is not only cheaper, but it can also conduct electricity at similar rates. Researchers claim that the cobalt-free battery will have an equivalent storage capacity and can be charged more quickly than cobalt batteries[3].

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[2] https://www.statista.com/outlook/mmo/electric-vehicles/worldwide
[3] https://news.mit.edu/2024/cobalt-free-batteries-could-power-future-cars-0118

OEMs are increasingly focused on the potential of solid-state batteries. These batteries, which do not include a liquid electrolyte, can be lighter, safer, faster to recharge, and more energy-dense while still delivering ranges exceeding 600 miles (965 km)[4].

But there is another way to boost the range and speed up the charging time of an EV, and that is to increase the working voltage of the battery.

Increasing battery voltage

EVs today mainly use a 400V system, but manufacturers are redesigning their vehicles to operate on 800V. When the battery voltage falls within the 300V to 500V range, it is commonly referred to as having a 400V architecture. Batteries within the 600V to 900V range are said to have an 800V architecture.

Several EV manufacturers are already supplying cars with an 800V system. Upping the battery voltage is necessary because 50kW of power at 400V equates to 125A of current drawn. At 800V, this reduces the current to 62.5A. A lower current means fewer losses in the conductor, both in the cable harness and in the motors (I^2R - current squared x resistance).

A lower gauge wire is also lighter in weight and runs cooler, improving the vehicle's efficiency. It also reduces the amount of copper needed to build the EV and the associated charging infrastructure, including the electricity substations and step-down transformers, which has been a major concern. Unfortunately, OEMs cannot simply swap out a 400V battery with a higher voltage battery - there are knock-on effects.

Implications of higher battery voltages

Adopting higher-voltage batteries requires more advanced silicon power semiconductors, such as silicon carbide (SiC), to enable higher-frequency switching and reduce power losses, thereby obtaining higher efficiencies. Despite the higher costs associated with SiC components compared to traditional silicon devices, they are crucial when it comes to enhancing the performance of EVs.

[4] https://www.sae.org/news/2023/11/solid-state-battery-status

Furthermore, as seen in power supply design, a higher voltage requires greater creepage and clearance spacings to ensure safety. And, at 800V, the passive components are much larger, taking up valuable real-estate.

An EV uses roughly double the number of semiconductors compared to a traditional ICE model. These devices sit primarily in the electric powertrain, specifically within the regenerative braking system. All of these new 800V parts will require intrinsic design and rigorous testing before being put into mass production.

Testing 800V EV components and systems

Carmakers employ ISO (International Organization for Standardisation) standards, such as ISO 16750-2, ISO 7637-2, and DIN 40839, to test 800V EV components and systems. Developed over time, these standards ensure that automotive systems will operate and continue to operate reliably through various scenarios across many years of customer use.

Tests include voltage surges, temperature assessments and full system testing. Furthermore, these electronic components, systems and software will require extensive simulation using hardware-in-the-loop (HIL) software. Significant testing during the development and production of new vehicles is crucial to ensuring top performance and durability.

Programmable power supplies, like TDK-Lambda’s 5kW and 7.5kW 1U high models in its GENESYS+™ series, which are capable of operating from 0 to 1000V and 0 to 1500V, can effectively test these 800V EV powertrains, see **Figure 1**. These units offer test engineers additional capability to apply surge testing above the system’s nominal 800V.

Figure 1: High power programmable power supplies in TDK-Lambda's GENESYS+™ series operate from 0 to 1000V and 0 to 1500V

Many programmable power supplies offer the ability to parallel units to provide additional output power. Typically, this involves using an analogue signal for communication to ensure the load current is shared between each unit. However, this can impact the transient load response times, degrading the output voltage performance when the load is rapidly changed from high to lower currents. Additional programming may, therefore, be required to set the main controller between the power supply units.

To overcome this challenge, the GENESYS™ power supplies employ a simple parallel data-link cable to connect multiple units together, supplying up to 60kW. The units automatically configure and set their parameters accordingly, displaying the total current in the uppermost unit. This digital control reacts faster to dynamic load changes than an analog signal can, resulting in much smaller over and undershooting of the output voltage.

Utilising higher voltages at high power levels can provide significant safety challenges. It is, therefore, important to have suitable safety features available in the programmable power supply. For example, programming in safe or automatic re-start conditions on the GENESYS+™ power supplies ensures that, after an AC supply outage, the units will or will not automatically continue to supply the output voltage. Last-setting memory and built-in protection functions for voltage, current and temperature are also provided. EV test engineers also have the option to lock the front panel controls from unauthorised adjustment or select a blank front panel if the unit is programmed remotely. Furthermore, arbitrary waveform test profiles of up to 100 steps can be generated and stored in the four memory cells.

The road ahead

EV manufacturers are shifting towards 800V systems to reduce current draw, improve efficiency, and decrease the weight of vehicles. However, this transition requires advanced silicon power semiconductors like SiC and adherence to safety standards such as ISO 16750-2 and ISO 7637-2 for testing. Programmable power supplies are crucial for testing these high-voltage EV powertrains effectively and ensuring reliable testing and development of 800V EV components and systems.

For more information about power supplies from TDK-Lambda, please visit:

www.emea.lambda.tdk.com/industrial

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