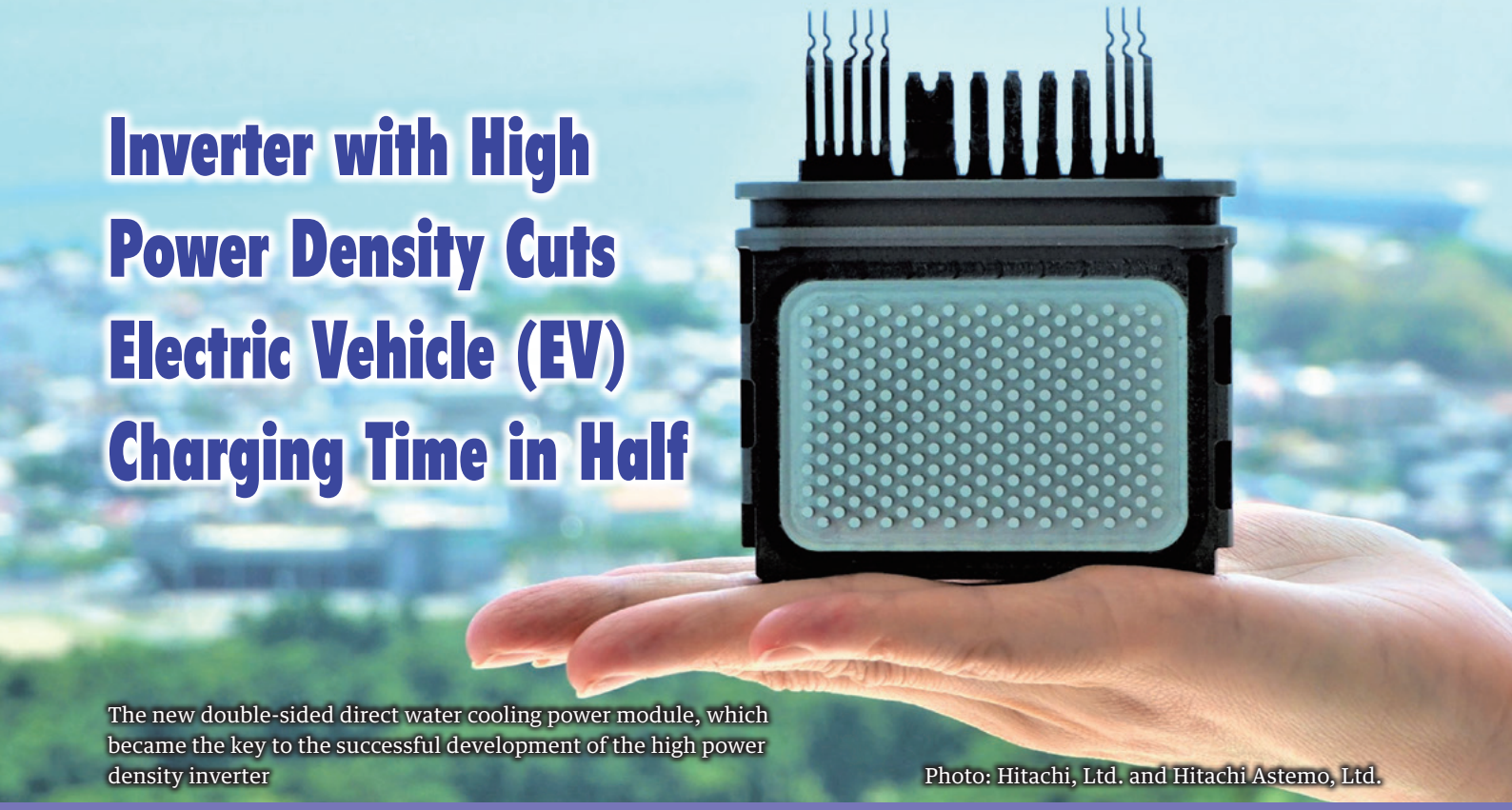
Inverter with High Power Density Cuts Electric Vehicle (EV) Charging Time in Half



The new double-sided direct water cooling power module, which became the key to the successful development of the high power density inverter

Photo: Hitachi, Ltd. and Hitachi Astemo, Ltd.

In the global fight against climate change, there is an urgent need to mainstream electric vehicles (EVs), which do not emit carbon dioxide on the road, and plug-in hybrid vehicles (PHVs). The long time required to recharge EVs, however, has posed a serious hurdle. A new inverter with high power density is solving the problem. The engineer in charge of its development, Nakatsu Kinya, and his team of four other engineers at the companies that developed the inverter, were awarded by the Japanese Government, and that was the "Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology" Science and Technology Award[1] for fiscal 2021.

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Technological development in the field of mobility is urgently required in order to slow the advance global warming. Currently, there is one major barrier to the widespread use of EVs and PHVs, which are considered to be the key to achieving carbon neutrality,[2] and that is the recharging time. Conventional EVs require about 40 minutes of recharging to travel 400 km, for instance, and many people, especially in countries and regions where long-distance travel by car is required on a daily basis, have been hesitant to switch to EVs due to concerns about running out of battery.

To overcome this barrier, Hitachi, Ltd. and Hitachi Astemo, Ltd. have developed an inverter with high power density. By increasing the voltage of the EV system from the conventional 400V to 800V, the new inverter has made it possible to recharge twice as much energy in the same amount of time. This halves the recharging time from about 40 minutes to about 20 minutes for a vehicle with a driving range of 400 km. As a result, it is now possible to recharge an EV in only five minutes for a 100-kilometer daily drive.

However, raising the voltage of EV systems to 800V has been considered difficult due to numerous technical challenges. In fact, it was not just a matter of raising the voltage. Many other related tasks had to be confronted, such as reviewing the insulation technology in the device, downsizing the inverter module, which is the heart of the system, and improving the performance of the cooling system for the power module, the part responsible for switching between direct current and alternating current power and other power conversions. The main challenge was improving the cooling system for the power module. Controlling the motor of an EV generates a conversion loss[3] roughly equivalent to the power consumption of a standard household air conditioner for a room with a floor area of about 15 to 20 square meters, so the heat that is produced in this process must be cooled efficiently. Hitachi, Ltd. and Hitachi Astemo, Ltd.

The developer, Nakatsu Kinya, conducts performance verification.

Production line for high power density inverters for EVs/PHVs

Photo: Hitachi, Ltd. and Hitachi Astemo, Ltd.

High power density inverters for EVs/PHVs (two types of products)

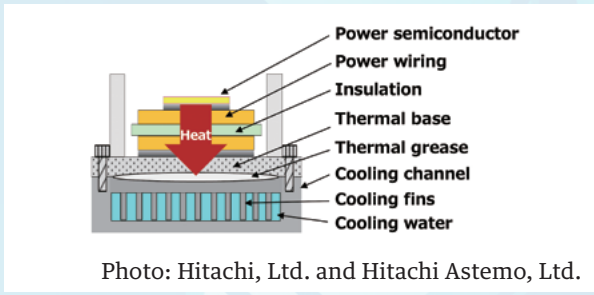

Photo: Hitachi, Ltd. and Hitachi Astemo, Ltd.

Structure of power modules inside conventional inverters

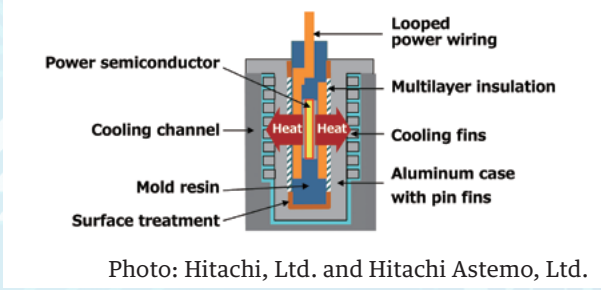

Photo: Hitachi, Ltd. and Hitachi Astemo, Ltd.

Structure of the newly-developed double-sided direct water cooling power module

solved this problem by developing an innovative power module that cools from both sides, replacing the conventional single-side cooling structure. In that development project, through a process of trial and error, they also arrived at a unique method of efficiently cooling power semiconductors by immersing them in cooling water (see attached figure). This innovative double-sided direct water cooling power module, a world-first, became the key to the successful effort to develop the inverter with high power density.

In addition to the high power density inverters for EVs and PHVs, the two companies intend to continue to develop in-wheel motors for EVs,[4] and electrification of various aircraft, including passenger planes, looking to contribute broadly to the entire field of mobility.

Further efforts to build a carbon-neutral world are needed, and quickly. Hopes are high that similarly groundbreaking technologies will be continuously developed in the relentless pursuit of this goal.

1. An award presented by Japan's Ministry of Education, Culture, Sports, Science and Technology to those who have achieved significant success in research, development, public understanding, and so on in science and technology.
2. Carbon neutrality means achieving a balance between emitting and absorbing greenhouse gases. In October 2020, the Government of Japan declared Japan's aim to reduce greenhouse gas emissions to net-zero by 2050, thereby helping to build a carbon-neutral world.
3. A state in which electricity is not effectively converted and energy is released in the form of waste heat, etc.
4. Motors that can be installed inside the wheels of vehicles. This configuration can provide a multitude of benefits for passengers and the surrounding environment in a variety of situations. Such benefits may include reduction of the size and weight of the vehicle, energy loss alleviation, expansion of the interior space, and improved ride comfort. Development is still underway, and future social implementation will be funded under the Green Innovation Fund Projects of Japan's New Energy and Industrial Technology Development Organization (NEDO).