

Technology Innovation: Smart Life

1 Novel Variable-energy Accelerator for Particle Beam Therapy

Particle beam therapy is a form of radiation treatment for cancer that works by irradiating a tumor with an ion beam generated by an accelerator at an energy determined by the tumor's shape and its depth below the skin. Hitachi is currently developing a new VEMIC accelerator that can provide precise high-dose irradiation while also featuring small size and low cost that make it suitable for installation at hospitals.

Past practice has been to use either synchrotron or cyclotron accelerators. The former provide high beam energy and easy on/off control while the latter can be made smaller by the use of superconducting electromagnets.

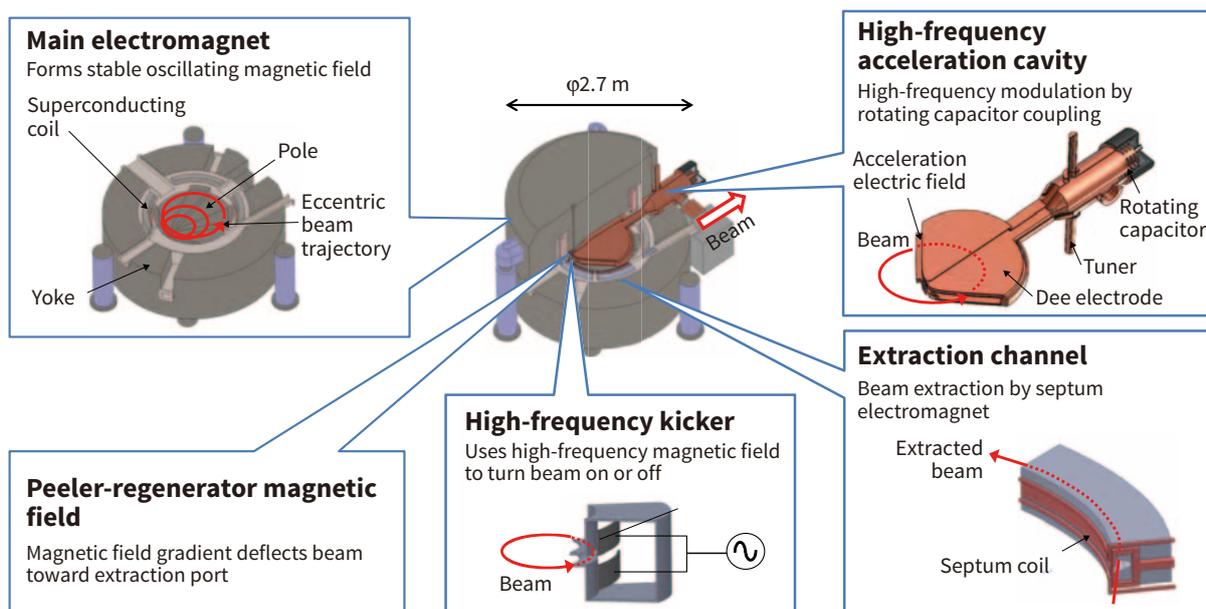
Combining the advantages of these previously used accelerators, a VEMIC accelerator uses the magnetic field produced by a superconducting electromagnet to accelerate the beam in an eccentric trajectory. A beam

at the desired energy is then extracted using a high-frequency kicker by locating the extraction channel on the outer edge of a narrow region through which beams of all energies pass.

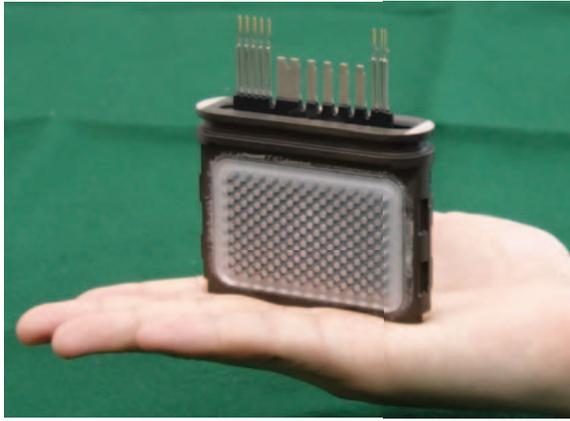
The principle of acceleration has already been demonstrated under ideal electromagnetic field conditions and further work toward commercialization will proceed on the basis of hardware prototype testing.

2 Automotive Traction Inverter with Double-sided Direct Water Cooling Power Module

Wider adoption of electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs) with low CO₂ emissions will be essential for preventing global warming. In EVs and PHEVs that use batteries as their main power source, providing longer cruising range and wider room are issues. In order to resolve these issues, the vehicles'



1 Diagram of novel variable-energy accelerator



2 Double-sided direct water cooling power module

electric power train motor and inverter with smaller size and higher output are required.

As the power module and its cooling system account for a large amount of the space inside an inverter, Hitachi has developed a power module that uses direct water cooling on both side surfaces of the internal power semiconductors, without intermediary grease. The power module entered mass production in 2013.

A newly developed version of the power module features lower inductance in the heavy current wiring and better heat dissipation from the power semiconductors so that they can operate at maximum performance. The lower inductance was achieved by a circuit layout that induces eddy currents in the cooling fins on both side surfaces of the power semiconductors and by running multiple wires next to each other to cancel out their surrounding magnetic flux. Similarly, high heat dissipation was achieved by reducing the thermal resistance of the internal insulation layer.

An inverter equipped with the power modules has an output power density of 54 kVA/L, about 1.6 times higher than the previous model, and was selected for

use in the e-tron*, the first mass-production EV from Audi AG. Future plans are to expand the product range to contribute to reducing the load on the environment through EVs and PHEVs.

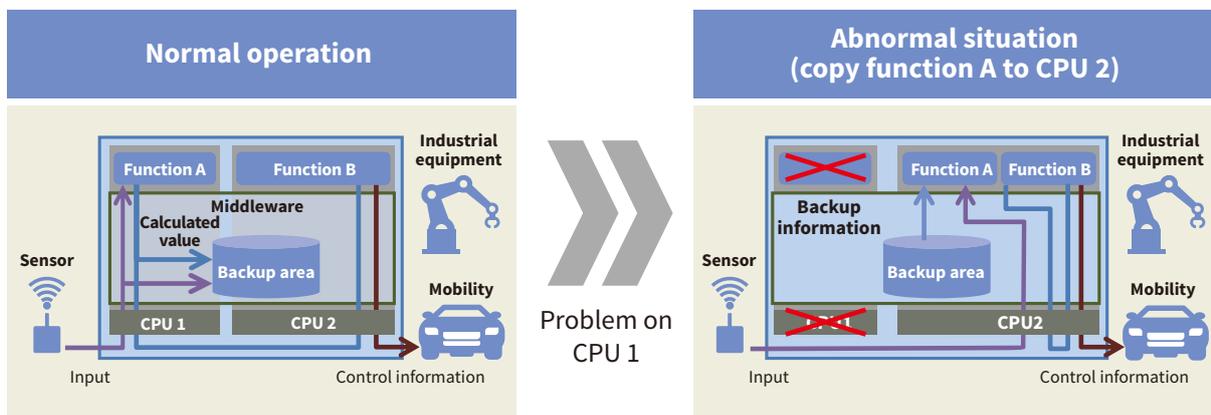
(Hitachi Automotive Systems, Ltd.)

* See "Trademarks" on page 151.

3 Technology for Autonomous Systems with High Levels of Reliability and Safety

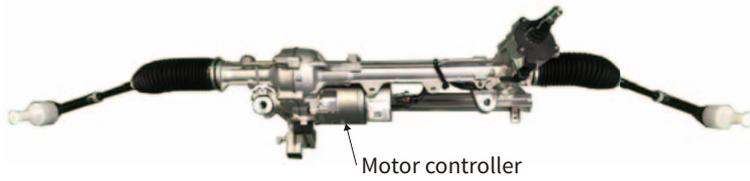
With Japan and many other developed nations forecast to face such social challenges as shrinking workforces and mobility issues for the elderly, hope is being placed on the use of autonomous operation for cars and industrial equipment as a means of overcoming these challenges. If such autonomous capabilities are to become widely adopted, the systems used will require even higher levels of reliability and safety. This in turn will require the modification or upgrading of control system functions in response to changing circumstances so that they respond safely to abnormal situations.

Hitachi has drawn on knowledge of equipment control gained from experience in IT to develop a technique that uses middleware to provide a flexible way to modify control system functions by software. The technique works by using a backup area to save sensor inputs and control calculation results obtained while the control system is operating automatically. When a control system function is modified, the backup area is used to regenerate the inputs and adjust the calculated values at high speed. This enables automatic operation to work reliably and safely.



CPU: central processing unit

3 Rapid modification technique for control system software



4 Belt-drive electric power steering

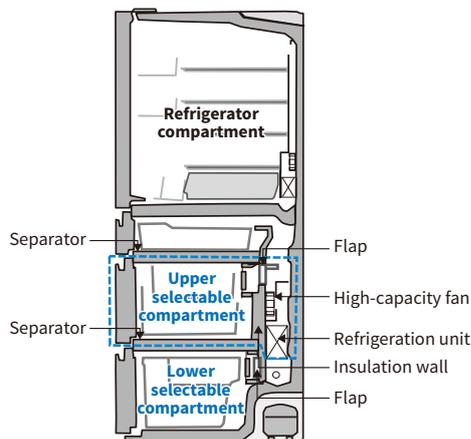
4 Miniaturization of Motor Controller with Built-in Redundancy for Highly Reliable Electric Power Steering

Vehicle steering systems are demanding higher levels of reliability to support more advanced levels of autonomous driving as well as the incorporation of driving assist functions that involve steering input such as lane keeping.

Hitachi has now developed a way of miniaturizing the motor and controller that features two levels of built-in redundancy to improve reliability. The technique has been applied to belt-drive electric power steering. The motor has a dual winding and a configuration that maximizes its resistance to demagnetization achieved by using magnetic field analysis to obtain an optimal design, reducing the quantity of permanent magnet used. The controller in turn has been upgraded to no longer require a heat sink, featuring greater cooling efficiency by using separate power modules that are mounted away from each other. Rather than the increase in size that would be expected from incorporating redundancy, these methods have succeeded in reducing the size by 20% compared to previous models.

In the future, Hitachi intends to satisfy sophisticated customer needs with small motors and controllers featuring even greater reliability suitable for level 3 and higher autonomous driving.

(Hitachi Automotive Systems, Ltd.)



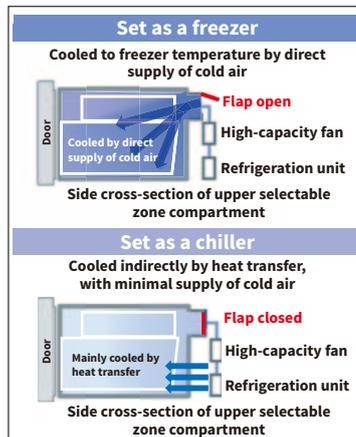
5 Thermal fluid control system for providing selectable temperature ranges

5 Thermal Fluid Control for Refrigerators

Recent years have seen growing diversity in how people live, with an aging population, low birthrate, and an increasing number of households in which both partners work. With these changes come changing needs, leading Hitachi to develop a customizable refrigerator in which the functions of the two lower pull-out drawers can be selected by the user to suit their requirements. Each of these selectable compartments can be configured as either a freezer, chiller, or vegetable compartment.

The thermal fluid control system used to provide this function selects the temperature ranges by using the high-power fan and two flaps at the rear of the refrigerator to change the path by which cold air flows to the selectable compartments. When operating a compartment as a freezer, the system keeps the flap open so that cold air from the refrigeration unit can enter the compartment directly. When operating as a chiller or vegetable compartment, the flap is mainly kept closed and the compartment is chilled by means of thermal conduction through the insulating wall at the rear, without direct entry of cold air into the compartment.

In the future, Hitachi intends to pay close attention to the needs of individual users to develop features that enhance their quality of life, including customization.



6

Collaboration with External Partners on Home Appliance Design

The Global Center for Social Innovation – Tokyo of Hitachi's Research & Development Group has been partnering with Hitachi Global Life Solutions, Inc. on a design improvement initiative entitled the "Hitachi meets design PROJECT." One of the features of this initiative is the creation of design value through collaboration with external designers and other experts.

Open-plan designs in which the kitchen is part of a wider living area have become mainstream, with growing interest in interior designs for "visible kitchens." In

response to this trend, Hitachi has designed a refrigerator with an extensive range of variations to suit the preferences of users whose concerns vary widely. For the design and development of the HWS refrigerator that went on sale in December 2019, Hitachi partnered with ACTUS Co., Ltd., a firm with experience in interior furniture and other household goods. The model is available in seven versions, all of which feature a color scheme and finish that conveys an understated impression not found in past home appliances.

In the future, Hitachi intends to continue pursuing design improvements so as to anticipate social change and create designs that light up people's lives.



6 Some of the variations available for the HWS refrigerator