Products for Electric and Hybrid Vehicles

DENSO offers a wide range of products to optimally control the large amount of electric motor power needed by hybrid and electric vehicles. To increase the energy efficiency of vehicles these products are compact, lightweight, and have highly efficient electric and electronic circuits to economically use the energy stored in batteries.

Key Points

- Downsizing an inverter using DENSO’s own double-sided cooling power module and stacked double-sided cooler, both designed to efficiently cool power semiconductor chips.
- Reducing power converter circuits in size and weight by integrating two inverters, a boost converter, and a DC-DC converter (power control unit).
- Miniaturizing a motor-generator using a rectangular wire for motor coil winding with DENSO’s own motor coil winding technique and motor core structure.
- Maximizing the charging capacity of a lithium-ion battery pack with a battery monitoring unit that uses a circuit to equalize the voltage of each battery cell.

Hybrid Vehicle System Structure
Products for Electric and Hybrid Vehicles

Electric and Hybrid Vehicles that reduce CO₂ emissions are equipped with some specific products not found in conventional gasoline powered vehicles. DENSO provides products based on its cutting-edge technologies. These include traction inverters for controlling electric drive motors and regenerating energy, and drive battery monitoring units for power electronics systems.

Traction inverters are critical to the control of electric motors. DENSO provides inverters boasting the world’s top discharge power density with a new cooling technology that limits temperature levels in built-in semiconductor power devices*. This cooling technology is based on both radiator cooling technologies and electronics technologies that have been developed through in-house production of semiconductor devices.

DENSO will continue to assist the advancement of hybrid vehicles by developing new technologies and products.

*Power devices are electronic components that act as switches to turn on and off the flow of high current.
Products for Electric and Hybrid Vehicles

Press the button to see your selected product.

- Power Control Unit
- DC-DC Converter
- Hybrid Vehicle Electronic Control Unit
- System Main Relay
- Battery Current Sensor
- Motor Stator for Small Hybrid Vehicle
- Electric Compressor
- Battery Monitoring Unit for Lithium-ion Batteries
Power Control Unit

Outline

- Higher output power is required for luxury hybrid vehicles, as well as smaller packaging for full-line implementation of hybrid systems.
- DENSO has achieved 60% increase in power density (output power per unit volume) from conventional models by a dramatic improvement of cooling performance.

Feature

- Double-Sided Power Module
- Power Chips
- Cooling Tubes
- Coolant
- Inlet
- Outlet
- Diaphragm Construction
- Stacked Double-Sided Cooler
- Double-Sided Cooler
- Section A-A
- Section B-B
Power Control Unit

Engineering Key Point

- Double-sided power module for improved cooling
- Stacked double-sided cooler for improved cooling
- Diaphragm construction for improved adhesion of power module and cooler

Benefit

![Graph showing comparison between DENSO Inverters (double sided cooling) and Conventional Inverters (single sided cooling) in terms of ratio of power density and output power. The graph indicates that DENSO Inverters have higher power density and output power compared to Conventional Inverters.]
System Main Relay (SMR)

High voltage relay for the safety and protection of hybrid systems.

- By arranging magnets opposite each other and lengthening the arc path with magnetic force, it allows the arc to be extinguished in a smaller space.
- Reduced size by using an unsealed contact chamber.

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Contact rating</th>
<th>DC360V 60A</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-off cycle life</td>
<td>More than 100,000 times</td>
<td></td>
</tr>
<tr>
<td>Dimensions</td>
<td>40mm × 37mm × 50mm</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>0.17kg</td>
<td></td>
</tr>
</tbody>
</table>
Electric Compressor

Co-development product with TOYOTA INDUSTRIES CORPORATION

Outline

● A conventional compressor is hardly possible to be applied to EV and HV because it is driven by engine.

● It is not necessary to drive engine for air conditioning. → Fuel efficiency improved.

Feature

● The world first Mass-production electric compressor integrated inverter and motor.

● Compact size almost same as a conventional compressor.

● Minimizing mass increase for vehicle fuel/power efficiency.

● Low noise/vibration design for quiet environment.

● 3 varieties covering from small-class vehicle to luxury-class.

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Electric Compressor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luxury</td>
<td>34cc/rev.</td>
</tr>
<tr>
<td>Large</td>
<td>27cc/rev.</td>
</tr>
<tr>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>Compact</td>
<td>14cc/rev.</td>
</tr>
<tr>
<td>Small</td>
<td></td>
</tr>
</tbody>
</table>

cc/rev : Voluminal displacement per revolution
Electric Compressor

Engineering Key Point

- Small displacement / High speed / Small internal loss scroll
- Compact Inverter
- Inverter / Motor cooled by suction refrigerant gas (low temperature)
- High Efficiency / Low Vibration Motor
- Refrigerant flow

Benefit

Electric compressor improves fuel consumption by maximum 19%, compared to conventional compressor (Belt-driven compressor) for HV.
DC-DC Converter

DC-DC converter designed to recharge the auxiliary battery
Can be integrated into a power control unit

● Reduced conversion loss by using
  DENSO’s original dual transformer system
  (fewer circuit elements, synchronous rectification)
● Simplified structure and reduced transformer
  winding loss by integrating magnetic parts
● Improved heat dissipation efficiency
  by optimally arranging circuit elements

<table>
<thead>
<tr>
<th>Specifications</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal input voltage</td>
<td>288V</td>
</tr>
<tr>
<td>Output voltage</td>
<td>13V to 15V Controllable</td>
</tr>
<tr>
<td>Max. output current</td>
<td>120A</td>
</tr>
<tr>
<td>Max. efficiency</td>
<td>96%</td>
</tr>
<tr>
<td>Dimensions</td>
<td>360mm × 95mm × 105mm</td>
</tr>
<tr>
<td>Weight</td>
<td>2.7kg</td>
</tr>
</tbody>
</table>
Battery Current Sensor

Current sensor to detect the current flow and monitor the state of the main battery charge.

- Simple structure consisting only of a Hall IC and a core
- No printed board or soldering required
- Input and output terminals with capacitors for improved noise reduction

<table>
<thead>
<tr>
<th>Specifications</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage range</td>
<td>DC5.0 ± 0.5V</td>
</tr>
<tr>
<td>Measured current range</td>
<td>−200 ~ +200A</td>
</tr>
<tr>
<td>Accuracy after reliability test</td>
<td>3%FS</td>
</tr>
<tr>
<td>Dimensions</td>
<td>47mm × 37mm × 17mm</td>
</tr>
<tr>
<td>Weight</td>
<td>34g</td>
</tr>
</tbody>
</table>
Battery Monitoring Unit for Lithium-ion Batteries

Outline

- It is expected for Battery Monitoring Unit to control the battery’s voltage highly accurately in order to operate lithium-ion batteries safely and efficiently.

- Compared to the conventional voltage control method, DENSO’s new method enables to control the voltage of each cell and eliminate the fluctuation among the cells at lower cost.
Battery Monitoring Unit for Lithium-ion Batteries

Feature

Compare the cell voltage with the average for cell’s discharge by using a simple circuit.

Measure the voltage of each cell and detect the cells which have higher-voltage than the target level using a microcomputer and enable all cells to discharge at the same level.

Engineering Key Point

The function of new voltage control method is to compare the single cell voltage with the average voltage of all cells for cell’s discharge by using a simple circuit.
Hybrid Vehicle Electronic Control Unit (HV-ECU)

ECU to control overall hybrid system in a hybrid vehicle

- Control traction of motor and engine, HV battery, regenerative braking and other functions.

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Nominal input voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal input voltage</td>
<td>12V</td>
</tr>
<tr>
<td>CPU</td>
<td>32-bit Processor</td>
</tr>
<tr>
<td></td>
<td>Multi-core Lock step</td>
</tr>
<tr>
<td>Clock speed</td>
<td>200MHz</td>
</tr>
<tr>
<td>Dimensions</td>
<td>160mm × 150mm × 35mm</td>
</tr>
<tr>
<td>Weight</td>
<td>0.3kg</td>
</tr>
</tbody>
</table>
Motor Stator for Small Hybrid Vehicle

Outline

- Low fuel consumption and low emission small size HV is expected so that a high voltage downsized motor is required to be carried by small size HV.
- A downsized stator for small HV can be developed by utilizing a newly developed coil, winding structure and production method. The stator contributes to development of small size HV.

Feature

Reduction in size of end winding by utilizing newly winding structure and insulation

Cross sections of core

Increase of space factor of coil by utilizing rectangular coils

Separated cores inserted into a group of completed winding
Motor Stator for Small Hybrid Vehicle

### Engineering Key Point

<table>
<thead>
<tr>
<th>Newly developed coil</th>
<th>Coil with stair like shape</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stator coil</strong></td>
<td><strong>Shape of end winding</strong></td>
</tr>
<tr>
<td>Enamel layer</td>
<td>Reduction in size of end winding</td>
</tr>
<tr>
<td>Conductor</td>
<td>Stair shaped Coil</td>
</tr>
<tr>
<td>[Conventional]</td>
<td></td>
</tr>
<tr>
<td>Conductor</td>
<td></td>
</tr>
<tr>
<td>[Developed]</td>
<td></td>
</tr>
</tbody>
</table>

### Benefit

Downsizing of stator
- Width: -10%
- Height: -15%

Cross section of T/A
- Front side
- Rear side