Product Introduction of CVT Control ECU that is Directly Mounted on Transmission

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Abstract

Powertrain ECU (Electronic Control Unit), which controls the engine and transmission was previously mounted into the cabin, but its location has been shifting to an engine room near control objects such as engine and transmission since 2000.

Recently, in accordance with the decrease of space in engine room due to the optimization of allocation of functions and electrification of vehicle, the case where ECU is directly mounted on the engine and the transmission also increases. Therefore, ECU that can withstand more severe environment such as heat, vibration and others, is required.

In this paper, we introduce the ECU that is directly mounted on a transmission which is developed in DENSO TEN for the first time.

1. Introduction

This Review introduces an outline for the commercialization of our company's first ECU mounted directly on the transmission as a control ECU for CVT (Continuously Variable Transmission) **(Fig. 1)**.

Conventionally, powertrain ECU was installed in the vehicle cabin due to favorable temperature and vibration conditions. However, they are now starting to be mounted in the engine room in order to eliminate wire harnesses, reduce harness length, and optimize the location of control functions with the goal of creating lighter-weight vehicles.

Here, to further optimize the location of control functions, we have separated the CVT function from the powertrain ECU, which was unified for engine transmission functions, successfully resulted in mounting the ECU directly on the transmission.

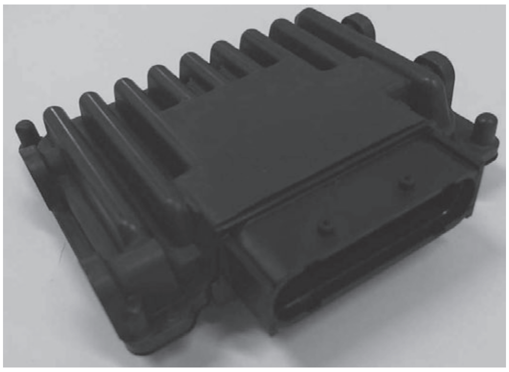

Fig. 1　Appearance of the transmission-mounted ECU

2. Outline of CVT control

A CVT control ECU refers to a device that controls the CVT control solenoid valve to optimize gear changes with high accuracy based on input signals from various switches and sensors that indicate the status of the engine, transmission, and vehicle, with the goal of improving fuel efficiency, drive performance, and drivability. The following shows the structure of the CVT control ECU **(Fig. 2)**.

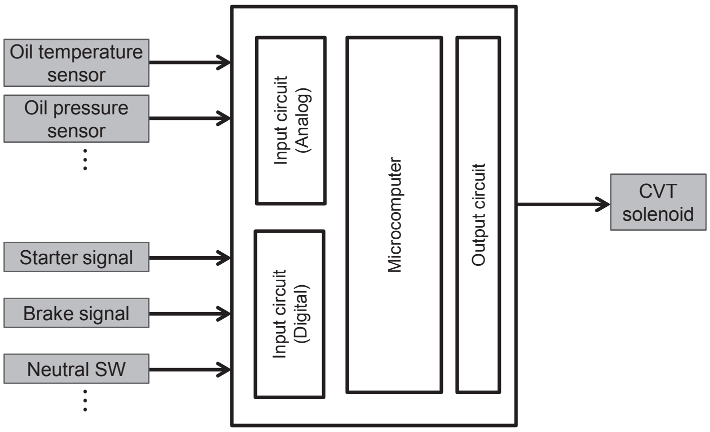

Fig. 2 Structure of CVT control ECU

3. Goal of development

Compared to mounting in the engine room, the environment of direct mounting on the transmission is more severe in terms of both heat and vibration **(Table 1)**.

Table 1 Comparison of mounting environments

ECU / Item	Conventional (Engine room)	CVT-ECU (Transmission-mounted)
Storage temperature	-40 to 120°C	-40 to 120°C
Operating temperature	-30 to 110°C	-30 to 120°C
Waterproofness	Temporary submersion	Temporary submersion
Vibration*	1	Approx. 3.5

*With conventional vibration condition set as 1

In addition to the above, there are also matters in feasibility unique to the environment of direct transmission mounting, such as considerations for load due to flying stones and for vehicle collisions.

Therefore, in developing a transmission-mounted ECU, we set the goal of development to the following items.

(1) Meeting reliability needed for heat, vibration, and mounting conditions for the environment directly mounted on the transmission.
(2) Successfully reducing the size while still meeting the above requirement.

The following describes an outline of the development task for heat, vibration, and mounting.

3.1 Feasibility for the heat environment

Compared to conventional engine room mounting, the environment for direct mounting on the transmission is a more severe heat environment due to easily-transferred heat from the engine and transmission.

Also, as the place where the ECU is to be mounted is between the transmission and the dash panel (barrier separating the vehicle interior and engine room), and this space was particularly narrow in compact to mid-range class vehicles equipped with this product, it was necessary to reduce the size of the ECU. As a result, the amount of heat generated per unit volume of the ECU was approx. 1.3 times the conventional value.

Accordingly, for this product, we used heat dissipating material with a heat transfer rate higher than that of the conventional product, preventing local temperature increases in the electronic components. Furthermore, we used an anodized aluminum die-cast for the upper casing which would be the heat sink, as well as improved the radiation rate for a design that ensured heat dissipation with a smaller heat sink.

We utilized heat simulations to verify the part alignment, heat dissipation material application position, and heat sink shape, and confirmed that the electronic components remained within permissible temperatures even under the worst assumed mounting environment temperatures and ECU operating conditions **(Fig. 3)**.

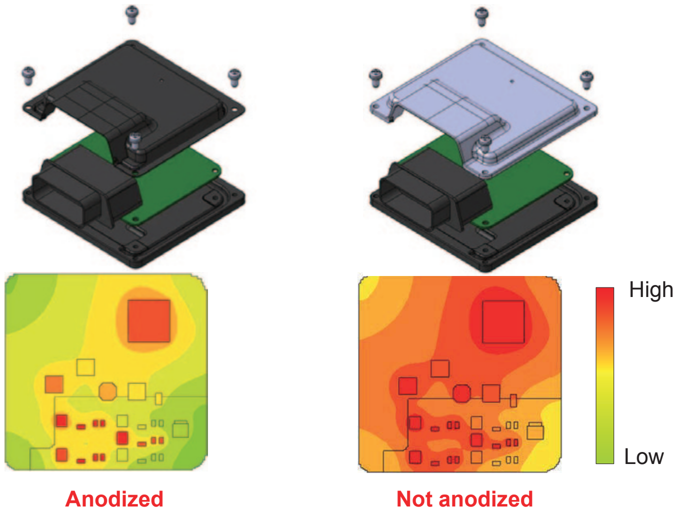

Fig. 3 Heat simulation result

3.2 Vibration resistance performance

To ensure that electronic components embedded on the board do not break under vibration acceleration approx. 3.5 times that of the conventional case, it was necessary to ensure the stress applied to components during vibration would be below the permissible stress. As we were going through verification using an actual device, we needed to implement measures for the electrolytic capacitor, which has more weight and height than the other components embedded on the board. Generally, the following kinds of measures can be considered.

① Raising the fixing strength of the ECU
(Reducing input G on the ECU)

② Raising the fixing strength of the electronic components
(Reducing the vibration on component units)

③ Raising the vibration resistance of components
(Developing components that are compact/have low profiles and have high vibration resistance)

For these measures, we did the following：

① While this could be achieved by raising the strength of the ECU mounting bracket, the trade-off was increased weight that ran counter to efforts for lighter-weight vehicles. Therefore, we decided to pass over this measure.

② We considered using adhesive to fix electronic components, but there were matters in selecting the material (cost and long-term reliability) as well as in assembly work. Therefore, we decided to pass over this measure.

③With manufacturer cooperation, we developed compact components with vibration resistant specifications, and confirmed they meet the vibration performance required in a direct mounting environment.

In future, we will consider the possibilities of expanding to ECUs mounted even in harsher vibration environments, such as direct mounting on the engine.

3.3 Feasibility for restrictions on mounting location

This product is mounted between the transmission and dash panel at a position lower than the conventional ECU.

3.3.1 Casing thickness and shape

As it is mounted in a location closer to the road than the conventional product, there is a possibility that flying stones picked up by the tires when driving on rough roads might hit the ECU. Then it is necessary to ensure the ECU does not break from that impact. On the other hand, in the event of a front collision, there is a risk that the ECU, pushed by the transmission, would force the dash panel into the vehicle cabin to damage the passenger's feet. Therefore, it is necessary to make the ECU break under the impact load from a collision.

We cleverly adjusted the casing thickness and shape, designing a strength that could achieve both these goals.

3.3.2 Fin shape

In order to prevent the heat dissipation fins from damaging the fuel line and causing a fuel leak in the event of a vehicle collision, we made the fin edge round radius larger than that of the conventional ECU **(Fig. 4)**.

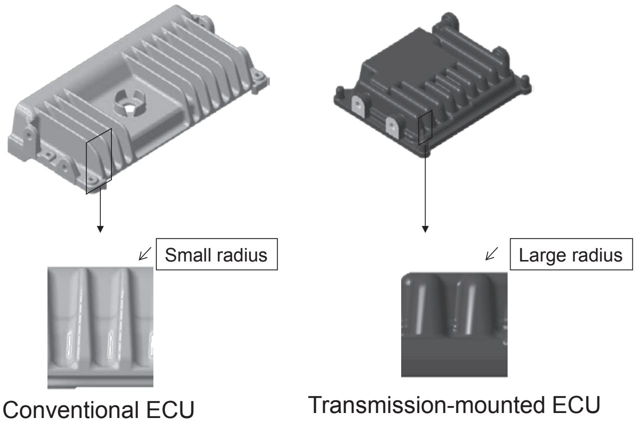

Fig. 4 Difference in fin shape from conventional ECU

4. Conclusion

As vehicle control becomes more sophisticated, we expect that the number of vehicle-mounted ECU will increase and there will be increased demand for products that can respond to high-temperature, high-vibration environments such as direct engine mounting and electro-mechanical integration in future.

We will continue to research and development in order to solve matters related to the installation of vehicle-mounted ECUs.

Lastly, we would like to express our gratitude to those both inside and outside our company who offered their cooperation and advice in the development of this product.

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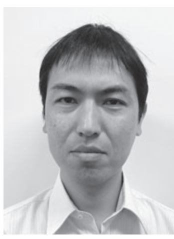

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