Future In-Vehicle Electronic Platform

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Automobiles and the environment surrounding them have been rapidly changing. The value that vehicles offer will change significantly as the concept of “connected” is added to the basic vehicle functions of “driving,” “turning,” and “stopping.” In short, vehicles will evolve from a simple means of transportation to a social terminal that provides mobility and various related services. Thus, not only individual users, but also the whole society may benefit from the added value. As vehicles are used as social terminals that will create new industries in the automobile society of the 2030s, new values may arise as management resources. Therefore, it is necessary to build key technologies adaptable to the newly created social needs in addition to the functional value of conventional vehicles. This paper outlines a next-generation in-vehicle electronic platform that is currently being developed as a new key technology for the era of connected cars by integrating our social infrastructure and in-vehicle technologies.

Keywords: CASE, connected, EV, electronic platform, architecture

1. Introduction

While changes are taking place in the situation around automobiles, auto manufacturers and the mode of vehicle development are also undergoing a shift. The position of suppliers is also changing. Accordingly, it has become necessary to take approaches from a higher perspective in automotive society. We need to consider these matters from a higher level of the hierarchy of automotive society (Fig. 1).

To pursue development from an automotive perspective, Sumitomo Electric Industries, Ltd. began a process of defining functions and exploring architectures based on needs in society and commenced deliberations on fulfilling new needs of auto manufacturers and users. The following is an exploration of a next-generation in-vehicle electronic platform (PF).

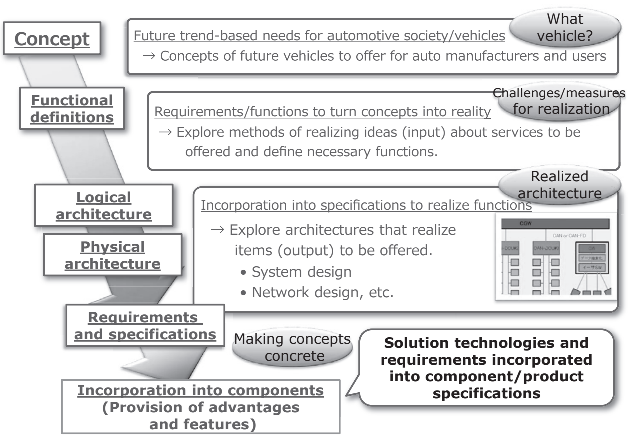

Fig. 1. Development process from an automotive perspective

2. Exploration of Architectures

Auto manufacturers need to address the rising concept of connected, autonomous, shared, and electric (electric vehicles: EVs*[1]) (CASE). Functional definition of CASE has shown that it is impossible to realize the required functions simply on the part of automobiles and it is essential to establish connectivity between vehicles and infrastructure. Sumitomo Electric has technologies for both vehicles and infrastructure and is therefore capable of meeting auto manufacturers' expectations. We examined the following three categories to explore an architecture for seamlessly connecting vehicles to infrastructure.

1) Information connectivity between vehicles and infrastructure (connected infrastructure)
2) Electric power connectivity between vehicles and infrastructure (energy infrastructure)
3) In-vehicle electric & electronic (E&E)*[2] architecture (in-vehicle infrastructure)

2-1 Connected infrastructure

Classes of information connectivity between vehicles and infrastructure include connected (for services), autonomous (for road traffic information), and shared (for personal information). Services are envisioned to increase in volume and improve in functionality, with communications evolving towards high capacity. Road traffic information is foreseen to meet the need for real-time operation, with communications evolving towards high speed. Personal information is expected to be provided with security updates to be protected from ever-evolving hacking. Advances in communications capacity and speed will be achieved by high-speed communication units [network junction boxes: NW-JBs*[3] (symbol)]. The unit will be updatable to reduce influences on vehicle functionality. An integrated antenna will be used to adapt to advances in the speed and protocol of communications with external devices (e.g. the advance from LTE*[4] to 5G*[5]). By changing the antenna, it is possible to reduce influences on in-vehicle communications. Advances in security will be supported by multi-layer protection comprising the integrated antenna and NW-JB. By changing these units, influences on vehicle functionality will be reduced (Fig. 2).

As communications systems are expected to evolve faster than vehicle functions, Sumitomo Electric will

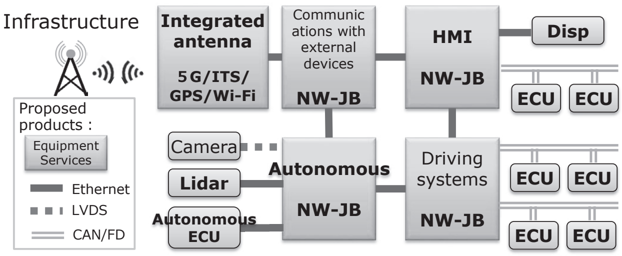

Fig. 2. In-vehicle communications network

ensure improved adaptability to connected cars by building an automotive communications network separately from vehicle functions.

2-2 Energy infrastructure

Electric power connectivity between vehicles and infrastructure refers to charging EVs and ensuring power supply-demand balance (virtual power plant: VPP). EVs are expected to be powered by higher voltages for quick charging and improvement in motor power. High-voltage batteries, DC/DC converters,*[6] high-voltage J/Bs, and high-voltage W/Hs,*[7] need combinations of components for different voltages. Battery packages with built-in components will reduce voltage variations. Moreover, use of battery packages to absorb differences in voltage between vehicles and infrastructure will reduce influences on in-vehicle power sources.

2-3 In-vehicle infrastructure

It is envisioned that in-vehicle E&E architectures will face more challenges than before to implement the CASE strategy.

<Challenge 1> Systems and equipment will increase in variety needed to realize various services.

<Challenge 2> Autonomous driving can cause accidents if in-vehicle infrastructure (power or communications) is shut down.

<Challenge 3> The structures of conventional vehicles will be changed by the widespread use of EVs.

<Challenge 4> Variation of vehicles is increasing due to differences in vehicle class, power train (EV/gasoline-driven vehicle), and function.

The above-listed challenges fall in different domains and require different solutions. Therefore, Sumitomo Electric has defined a set of E&E architecture requirements named the "3-Layer Concept."

<Solution 1> In the domains of vehicle body*[8] and infotainment*[9] with equipment increasing in variety, our solution is to realize extendable fundamental systems. The domains where this solution is implemented are termed the "customized layer."

<Solution 2> For the domain of driving & safety in which failure of a fundamental system is not permitted, our solution is to realize uninterrupted fundamental systems. The domains where this solution is implemented are termed the "driving & safety layer."

<Solution 3> EVs have resulted in changes in the power train domain. For this domain, our solution is to realize fundamental systems that absorb differences in specifications for EVs and gasoline-driven vehicles. This solution is implemented in the domain called the "high-voltage layer."

<Solution 4> Different combinations of these three layers are used to adapt to a variety of vehicles in a flexible manner (Fig. 3).

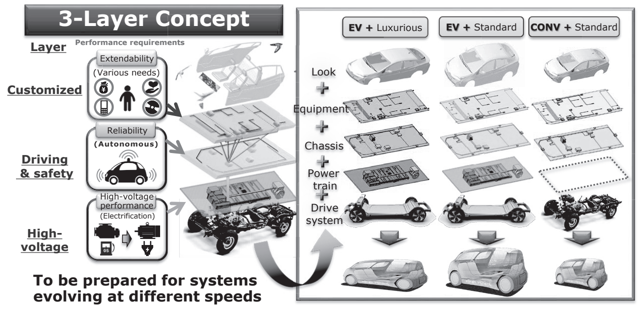

Fig. 3. 3-layer concept

2-3 (1) Customized layer

Conventionally, equipment connections were made in such a manner that a single power box and a single central gateway (GW)*[10] were used for power and communications, respectively. Therefore, changes or additions to equipment necessitated extensive changes to the power box, central GW, and W/H connecting each device. The customized layer is based on an area architecture concept by which a power and communications distribution unit [power & LAN box: PLB (symbol)] is provided in each vehicle area so as to facilitate flexible changes and additions to the equipment (Fig. 4). In this way, extendable fundamental systems are realized. When an equipment change is made, changes in power, communications, and W/Hs are absorbed by PLBs to minimize the scope of change.

2-3 (2) Driving & safety layer

Conventional vehicles were based on a philosophy that, when a failure occurs and power or communications are interrupted resulting in a system shutdown, the driver avoids accidents by means of steering and braking without electrical assist. However, at autonomous driving level 3 and higher, systems are required to function to prevent accidents even in the event of a failure. Accordingly, it is essential that no interruption occurs in power or communications. The driving & safety layer provides the following arrangements against different types of failure to ensure that no interruption occurs in power or communications simply due to a cause of failure (Fig. 4).

(a) Provide power redundancy using a sub-battery against failure of power equipment (battery, generator, etc.). Moreover, if a GND short circuit occurs, the two batteries will undergo an instantaneous voltage drop, causing a system shutdown. To counter this, provide a high-speed circuit breaker between the two batteries to detect the fault instantaneously and isolate the failed part.

(b) Provide communications redundancy against failure of communications equipment, using a backup bus*[11] to continue communications via a separate path.
(c) Provide equipment redundancy against failure of critical equipment (such as autonomous driving systems and electronic control units: ECUs*[12]), using a backup equipment.
(d) Provide path redundancy, connecting each piece of redundant equipment to each redundant power and communications device to counter W/H failure.

By incorporating the above four redundant designs, uninterrupted fundamental systems are realized.

2-3 (3) High-voltage layer

EVs, the numbers of which are increasing, have high-voltage components (battery, motor, inverter, DC/DC converter, high-voltage J/B, high-voltage W/H, etc.). These components make them substantially different from gasoline-driven vehicles in the space used to mount components, necessitating extra development efforts. In the high-voltage layer, for the mounting of high-voltage components, the following arrangements are made to avoid major differences in the components mounting space between gasoline-driven vehicles and EVs (Fig. 4).

High-voltage components are mounted under the vehicle floor where, with gasoline-driven vehicles, exhaust pipes are located. To this end, the battery package is provided with built-in components, including a battery, DC/DC converter, high-voltage J/B, and high-voltage W/H, and the components are made small and low-profile.

By achieving mounting space commonality between gasoline-driven vehicles and EVs, as described above, fundamental systems that absorb specification differences between EVs and gasoline-driven vehicles are realized.

2-3 (4) 3-layer concept

In-vehicle infrastructure supports the CASE strategy by combining three layers: customization, driving & safety, and high-voltage (Fig. 4).

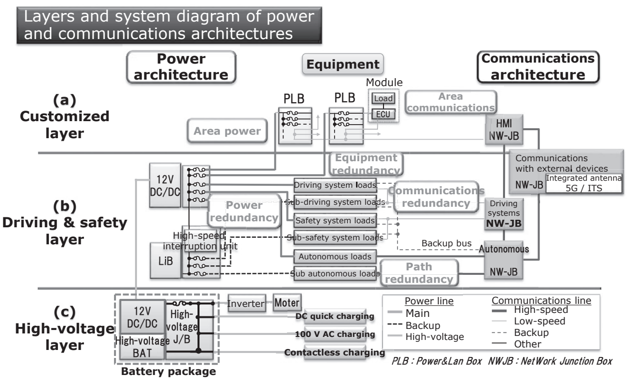

Fig. 4. Architectures (3-layer concept)

3. Course of Action to Take for Next-Generation Electronic PF

Towards the next-generation automotive society, Sumitomo Electric will continue to provide connected infrastructure, energy infrastructure, and in-vehicle infrastructure that will contribute to building novel lifestyles, bonds between people, and new industries. We consider it necessary to develop a new PF that links vehicles and society. The fundamental technology to achieve this should be the next-generation electronic PF. Sumitomo Electric will contribute to the growth of next-generation automotive society by combining its proprietary technologies (Fig. 5).

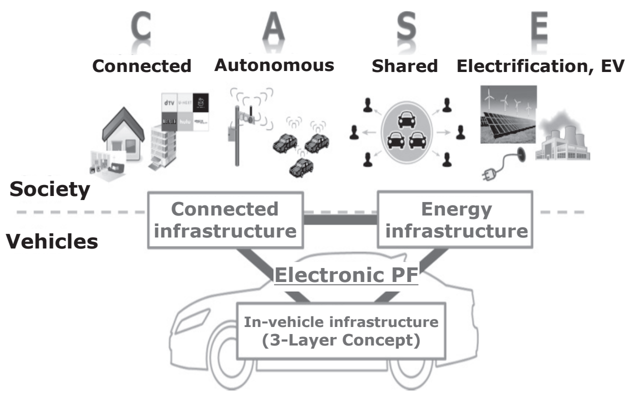

Fig. 5. Course of action for electronic PF

4. Conclusion

According to the Ministry of Economy, Trade and Industry, the times approaching the 2030s will be uncertain, with changes taking place in an exponential manner due to technologies contributing to the 4th Industrial Revolution; industrial and employment structures are likely to undergo radical reforms; therefore, in developing basic strategies for Japan, it is necessary to take an early lead in implementing measures to meet cross-industry challenges and build new economic and social systems. Based on this recognition, Sumitomo Electric will build fundamental electronic PF technology that enables the use of innovative techniques and expertise in the automotive and its supporting industries and will promote its technology development for implementing solutions for various social and structural challenges relating to mobility in Japan and abroad.

Technical Terms

*1 Electric vehicle (EV): An EV is an automobile that is driven by an electric motor instead of an engine.

*2 Electric & electronic (E&E): Electric and electronic components mounted in automobiles.

*3 Junction box (J/B): A J/B provides branches of electric wires to connect to devices.

*4 Long-Term Evolution (LTE): A standard developed by European Telecommunications Standards Institute, specifying data rates of several hundred Mbps.

*5 5G: The name of the 5th generation communication standard. 5G is under development on a global scale, as the next-generation communication method following LTE (4G). The data rates of 5G reach several tens of Gbps.

*6 DC/DC converter: A voltage conversion unit converting a DC voltage on the primary side to a DC voltage on the secondary side.

*7 Wiring harness (W/H): W/Hs are electrical wires used to connect devices such as a battery, ECU, and other electrical components.

*8 Body: The term body refers to doors, air conditioners, and other equipment intended for improved automotive comfort and convenience.

*9 Infotainment: Equipment such as a car navigation system and meter, displaying information about vehicle.

*10 Central GW: A unit that plays the role of a base station, mediating ECUs and placing the sending and receiving of signals in good order, by linking individual communications networks mounted in vehicle.

*11 Bus: A communication path in a network.

*12 Electronic control unit (ECU): A computer used to provide electronic control of equipment mounted in vehicle.

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