Automotive Semiconductor Technologies in the ITS Era

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OVERVIEW: A number of different types of semiconductors are now used for control and information applications in automobiles. There is increasing use of ITS (intelligent transport systems) and communication infrastructures such as the Internet, while collaborative operation of information and communication systems is resulting in a safe and pleasant driving environment. Hitachi, Ltd. is presenting comprehensive solutions in this field of automotive information and control systems, through the development of the SuperH RISC engine, which is an information processing CPU, the Q series graphics processors for display panels, the SH/H8S computer, which is an equipment control CPU, and power devices for mechanical control.

INTRODUCTION
TODAY, semiconductors are key elements within automobiles, performing a range of functions throughout the car, in the engine and steering, and in braking control. We believe that when these devices work together, driving efficiency and safety and driver satisfaction levels are dramatically improved. As we fast approach the 21st century, cars are becoming a movement system for a new age. Let us call this system the “automotive information and control system.” Hitachi continues to present comprehensive solutions for automotive information and control systems.

An automotive information and control system consists of ‘information systems’ and ‘control systems’ that work together. At present, car navigation systems stand for the information systems and play an

![Collaboration between information systems and control systems](image_url)

**Fig. 1—Automotive Information and Control Systems.**
The new age of car electronics has seen dramatic progress in the development and application of all types of semiconductors. Information and control systems work in concert with one another to form an automotive information and control platform.
An important role for interfaces with the driver. Control systems enable the collaborative operation of all function modules. Special technology is required in control systems not just for networks but for noise reduction, and for the high-voltage withstand large current switching used in the ignition system. The provision of operating systems, such as the European standard “OSEK-OS,” drivers, and middleware is also important.

This paper discusses some typical examples of semiconductor technology that back up the automotive information and control system through a look at Hitachi products and technology.

**HITACHI AUTOMOTIVE SEMICONDUCTOR PRODUCTS**

Below we will discuss Hitachi’s semiconductor products relating to car navigation system, networks in a car, noise reduction, and large current switching.

In car navigation system, dramatic improvements in processor performance have enabled route searching and guidance and input of information using voice recognition. Car navigation system is also important as an interface to ITS (intelligent transport systems) and the Internet. Hitachi’s SuperH RISC engine, a processor with built-in high performance, performs an important role in the system.

Hitachi has many ‘Q series’ graphics processors that are used to transmit information clearly to drivers. They are used to control small on-board screens and to display the pseudo three-dimensional map on it.

An effective network is provided in which data sharing between the rapidly increasing number of function modules is enabled using a few wire harnesses. Until now, different companies have used their own communication systems. However, the controller area network (CAN) has now become the standard network protocol because of its communication speed and reliability in real-time applications.

The technology used for noise reduction reduces radiating electromagnetic interference (EMI). As the speed of automotive control increases, it is becoming increasingly important to reduce noise. The “H8S series” computers are used to improve the power current fluctuation suppression characteristic in chips.

Power devices are used to enable high current switching. In recent cars, more than 50 motors, solenoids and lamps are used in one vehicle and to control these actuators power devices are indispensable. The power metal-oxide-semiconductor field-effect transistor (power MOSFET) has a battery voltage input of 12 V and can directly control current. Its use has become very popular because of the ease with which control is achieved. Hitachi uses a state-of-the-art trench gate construction to halve resistance loss per unit area of silicon. Hitachi has developed intelligent power MOSFET, which integrates control circuits and protection circuits, and power-ICs [IPIC (intelligent power IC)] that integrate logical circuits. It has succeeded in reducing the size and increasing the reliability of devices. Furthermore, Hitachi has developed even better network control with built-in communication functions. Insulated gate bipolar transistors (IGBT) that control high voltages are also used in inverters of electric vehicles.

The next section will discuss the features of semiconductor technology and products that are associated with automotive information and control systems.

**CAR NAVIGATION DISPLAY CONTROL**

“Q Series” Graphics Processors

In response to the requirements of car navigation, Hitachi, Ltd. created the ‘Q series’ graphics processors for use in combination with the SuperH RISC engine. Already, the Hitachi product lineup includes the HD64411 (Q2), HD64412 (Q2i), and the HD66413 (Q2SD).

![Q2SD System Configuration](image)

Use of the newly developed bus arbitration method allows video capture and graphics drawing functions to be integrated onto the one chip.
Q2SD. The Q2 processor takes part in processing the map drawing and displaying the result which is required for car navigation system. It reduces the load on the SuperH RISC engine dramatically. This enables the SuperH RISC engine to be devoted to control of the entire information system. The Q2i has functions to overlay the menu screen and map screen which can be scrolled. The Q2SD has, in addition, a video input function.

Concepts for the Q Series

The basic concepts behind the Q Series were ‘Simple,’ ‘Real time,’ and ‘Upgrade.’

‘Simple’ refers to the simplification of structure to allow installment in a limited space such as a car cabinet. We have reduced the number of memory devices required. By utilizing high speed memory, we integrated the video data, drawing commands, drawing data, and display data, which in the past were each managed by separate memories, into unified video memory.

By integrating graphics drawing and display control, video capture, and interface functions, Hitachi has enabled simultaneous display of graphics and video and various types of data including the distorted video images using graphics.

‘Real time’ refers to the acceleration of map drawing. Drawing can be processed without disruption of screen display or video input through appropriate control of access to the unified memory. A high-speed SDRAM that works at 66 MHz is used as the unified video memory of the Q2SD. 90,000 separate 25 × 20 pixel rectangular drawings can be generated every second. The Q2SD also has a command system suitable for map drawing that utilizes polygons and patterned broken lines. This enables a performance more effective than was achievable using the ordinary drawing LSI that involved mere painting out of triangles and unbroken line drawing.

‘Upgrade’ refers to the utilization of software assets. All three products in the lineup have backward command compatibility. Also, because the products were developed alongside the SuperH RISC engine, the whole system can be upgraded. This was done in the belief that improvements to usability will be made in the future.

MICROCONTROLLER FOR CONTROL SYSTEM Network Technology

Cost reduction and saving space are the two main requirements for communication ICs like CAN.

Hitachi has been working to provide the optimized solution by embedding various functions into a single chip microcontroller. Fig. 3 shows the development of Hitachi’s HCAN (Hitachi CAN).

All HCAN modules are the CAN Version 2.0B compliant and are full CANs with 16 sending or receiving buffers. The 32-bit microcontroller, such as the SH7055F, has been developed for systems which require advanced functions, such as engine management and stability control. The 16-bit microcontroller, such as the H8S/2623F, has been developed for systems which require low power consumption and high performance, for example body electronics. All microcontrollers with the embedded HCAN are provided with a selection of ‘Flexible Zero Turn Around Time (F-ZTAT)’ flash memory allowing flexible response to software modification or even programming in the field.

Hitachi will continue to develop the HCAN microcontrollers to meet the market demands in advance. As we continue to develop the SH and H8S microcontrollers, we also developing the operating system called OSEK which has been standardized by the European Standardization Group to fulfill customer
Improvements of EMI Characteristics

Fig. 4 shows the EMI characteristic for the “H8S/2128F” 16-bit microcontroller used for the control of devices such as airbags in vehicles. Compared with its old products, Hitachi has improved the characteristics by -20 dB in the FM band, where the noise makes the most influence. The resultant characteristic is of the highest industry standard. Appropriate positioning of the power terminals, optimization of the internal transistor size, and review of internal power wiring at the chip design stage have resulted in improvements from the chip design stage.

In the future, we will be promoting LSI design that improves the EMI characteristic particularly for SH and H8S series products. We thus aim to establish installation technology for inhibiting EMI and technology for LSI unit EMI evaluation that will allow us to respond to noise characteristics at the equipment level.

POWER DEVICE TECHNOLOGY

The Power MOSFET is the most commonly used power devices for automobiles. However, use of the IGBT is increasing for high voltage control.

Fig. 5 shows an intelligent IGBT that controls the current flowing in the ignition coil in a spark plug. It controls voltage and current with a gate that can be directly driven by signals from the IC or LSI and it includes an array of built-in protection circuits. Recently, intelligent IGBTs (such as the HF75117) have been used in all engine cylinders. Through the use of appropriate timing from the computer, fuel economy can be improved dramatically and exhaust gas made cleaner.

The IGBT is also used as a key device for inverter control of electric vehicles. A low loss IGBT is required here because the control power may reach some 30 kW. At the same time as developing scaling rules for miniaturizing the IGBT, Hitachi is also reducing IGBT loss each year through LSI miniaturization technology, as it did with the power MOSFET. Together with the IGBT drive circuits and protection circuits, Hitachi is developing highly reliable intelligent IGBT modules for inclusion in the same package and that will withstand the environment in which they are used. Many other power devices, such as chargers and DC-DC converters are used in electric vehicles. Use of state-of-the-art power device
technology will contribute to the reduction of loss in devices, the reduction in size of devices, and improved reliability.

CONCLUSIONS
This paper has discussed Hitachi products and technology as typical examples of semiconductor technology to support automotive information and control systems. In the future too, we hope to accurately grasp the requirements of the entire system and develop products to suit all subsystems.

REFERENCES