3 2-bit Microcontroller for HV/EV Motor Control

MB91580 Series

System LSI Optimal for Driving Assistance Indication Control

MB86R11

The MB91580 Series are microcontrollers with built-in cores and peripheral functions that are optimal for motor control in hybrid cars and electric cars. For the first time in the industry, they adopt a built-in special interface circuit for the resolver sensor that is required for motor control. These products will contribute to system cost reduction, improvement in the locomotive performance of the motor, and energy saving.

MB86R11 is a one-chip system LSI that consolidates the various peripheral interfaces required in automotive LSIs, including four video inputs and up to three display outputs. It can freely control the indicated information depending on the driving scene and can transmit various data to the driver, such as safe driving assistance that includes a full vehicle perimeter check using camera images, and eco-driving assistance.

**Introduction**

The markets for hybrid cars and electric cars have been growing rapidly in recent years, and are expected to grow even further in the future as a result of environmental problems and the steep rise in crude oil prices. Cars that support a stop-and-start system, which have come under the spotlight as environmentally friendly automobiles that still use engines, are also becoming popular. Furthermore, elements of art and a game-like sense to make eco-driving skills attractive have been added to the indication functions. In this sense, we are now in an era when consumers choose their cars on the basis of these two aspects of driving control and driving assistance.
Driving Control (Active Green)

Two of the major differences between hybrid/electric cars and cars that use engines are motor control and battery control. For motor control, the main issue is how efficiently the motor can be controlled so that the fuel efficiency (electricity consumption efficiency) is improved while maintaining torque that is equivalent to that of conventional engines. FUJITSU will contribute to Active Green on the following four axes (Figure 1):

- Knowledge of efficient motor control based on the inverter control know-how that has been accumulated for more than 15 years through our experience with home air conditioners
- System cost innovation power acquired through the semiconductor business activities carried out in the past
- Proposal of values through a combination of conventional technology and leading-edge technology that best suits the system
- System collaboration, including motor control sensor and development environment

Three Necessary Innovations

For hybrid and electric cars to become more popular and evolve further in the future, FUJITSU believes that the following three major innovations are required.

The first is innovation of the electronic control unit (ECU) to improve the locomotive performance of hybrid and electric cars whose driving force is generated by motors. This should be addressed by improving the motor controllability with the ECU while maintaining the current hardware, including the motors and inverters.

The second expected innovation to further popularize hybrid and electric cars in the market relates to the system price. We expect large system cost reduction to be realized through the overall optimization methods, including reconfiguration of the system in view.

The third innovation relates to improving the inverter module to enable it to address further power and energy saving. Great energy efficiency improvement can be expected by adopting new elements that surpass the loss characteristic of the current IGBT.

To help our customers address innovations, FUJITSU feels that it is our responsibility to develop products with a focus on LSI and software and to provide these solutions to them in a timely and continuous manner.

Figure 2 presents the three innovations that will enable hybrid and electric cars to evolve further.
Innovation in electronic control unit (ECU)

Motor control in hybrid and electric cars that address high torque response require loop control that detects the motor conditions with high precision and calculates the control level to feed the information back at a high speed.

We have provided the MB91580 Series, microcontrollers with built-in R/D converters, as a solution to address ECU innovation ahead of others in the industry. We have focused on addressing this loop control with good efficiency.

This product is a 32-bit microcontroller that combines a 160DMIPS high-performance CPU, a hardware macro for motor control, and a special interface circuit for a resolver sensor, which is essential for HV/EV motor control. Adoption of this product will enable the loop control that is necessary for motor control in hybrid and electric cars.

For example, the MB91580 Series have a built-in 12-bit A/D converter to detect the motor current and position with high speed and high precision, and an R/D converter, as shown in Figure 3. The electric degree of the resolver calculated by the R/D converter is synchronously latched on the special register to the three-phase current detected by the A/D converter. SIN (sine) and COS (cosine) values to the electric degree are also calculated automatically for internal maintenance with a single-precision floating-point number format (IEEE754-compliant). The control algorithm to calculate the estimated torque and control level from these condition values is composed of many product-sum operations, including a matrix operation. Vector transformation described using decimal points and PID control operation cords in these operations can be executed at a high speed with the special unit for floating-point operation (FPU) of the CPU core (FR81S) in this product.

It is expected that this will improve the speed by 10 to 15% compared to the algorithm using the fixed-point method, which is the conventional custom format.

Figure 4 presents the product block diagram and Table 1 the lineup of MB91580 Series products.
Figure 5 presents a comparison between the motor control processing period and our original motor control period.

To develop software assets with high versatility nowadays when automatic generation tool for control algorithm codes by model-based development and so forth are becoming more popular, we believe that the FPU with FR81S will play an important role.

Cost (system integration) innovation

One of the solutions to addressing the higher popularization of hybrid and electric cars is cost reduction. We believe it is possible through system integration.
Figures 6 and 7 present the block diagrams for innovations by system integration with battery management ECU and DC-DC control ECU, which are peripheral ECUs to the previously described motor control. These integrations will be possible by conducting ECU control to integrate with motor control on one microcontroller. As described previously, this product suppresses the CPU load rate by motor control and it is thus possible to conduct battery management control and DC-DC control simultaneously.

**Figure 6** System Cost Reduction by Consolidation of Functions: BMS Integration

**Figure 7** System Cost Reduction by Consolidation of Functions: DC/DC Integration
Energy-saving innovation

We aim to solve the problems required in the driving control of hybrid and electric cars by combining our GaN HEMT technology as energy-saving innovation.

Figure 8 presents the limitations in physical properties of Si/SiC/GaN.

Driving Assistance (Passive Green)

Indication functions can be used by the driver to check how well he or she is implementing eco-driving. Indications to encourage eco-driving, such as the addition of map image, audio song data, and so forth on the cluster display that indicates the conventional speedometer and remaining fuel level will also be an important factor.

It is MB86R11, the image display LSI with top-class performance (over 1,000MIPS), that we have developed in consideration of taking charge of this graphic control. This product is a one-chip system LSI in which four video inputs, up to three display outputs, and various peripheral interfaces required in automotive LSIs are integrated with Cortex-A9, the latest CPU core by ARM. It is capable of switching the indicated information freely depending on the driving scene, and it will support safe driving, including full vehicle perimeter check using camera images while transmitting eco-driving assistance to the driver in an easily understood fashion as Passive Green.

Feature of MB86R11

Three built-in display outputs and a built-in high-speed 2D/3D rendering function

Two of the three built-in display controllers can output by multiplexing two screens. In this way, up to five display outputs can be made.

It is possible to enable expressions that blend well with the background image by feathering the outline of the image overlaid on the background map using the eight layers of indication and the inter-layer blending function. Furthermore, it is equipped with a dither function and a gamma correction function and is capable of high-quality indication on displays with varying resolutions and color properties. The built-in programmable shader function also enables more natural graphic expressions with a high sense of quality in light reflection, shadow appearance, and so forth.

Built-in image quality correction circuit

It has a special built-in image-processing engine to implement outline enhancement, chromatic correction, and eye-friendly adjustment of contrast under backlight and nighttime conditions and improves the quality of video images. Furthermore, it will adjust the backlight brightness dynamically depending on the image data to contribute to a reduction in the power consumption of the system.

Four built-in video inputs

It is equipped with four built-in video input ports and is capable of simultaneously processing various image inputs. Built-in input function up to 1,280 × 720 dots, zoom in/out function, and interlaced progressive conversion function supporting movements can help generate images with a low noise level. Port 1 of the video ports is capable of interlaced input up to 1,920 × 1,080 dots, enabling input of digital TV images.

We have also begun preparations for an authoring tool to reduce the man-hours for graphics development and support the addressing of more artistic design in a short period regarding this product.
**Future Developments**

FUJITSU will continue to contribute to environmental protection on the global scale by addressing innovations demanded in hybrid and electric cars using our technology in the future (Figure 9). *

**NOTES**

*1: Function to express the neutral color on an indication panel with a small number of colors.

*2: Function to correct the color data depending on the properties of the display panel.

*3: Function to render the object surface realistically in three-dimensional graphics by allowing the user to freely program the shadow processing, which had been fixed in conventional products to match the subject to be expressed.

*4: Image quality correction circuit is a technology developed by FUJITSU LABORATORIES LIMITED and FUJITSU TEN LIMITED and put into practical use in automotive displays, such as automobile navigation systems.

*5: Function to improve the moving image quality when an interlaced video image is converted into a progressive one.

* ARM is the registered trademark of ARM Limited in the EU and other countries.

* Cortex-A9 is the trademark of ARM Limited in the EU and other countries.

![Figure 9](image-url)  FUJITSU’s Technology to Address Innovations Demanded in Hybrid and Electric Cars