On-Chip Flash Memory Microcomputers and Their Applications

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OVERVIEW: Flexible zero turn around time (F-ZTAT) microcomputers utilizing on-chip flash memory that is nonvolatile and can be electrically rewritten and erased are now ready for full-scale deployment. Hitachi, Ltd. developed its first such product in 1993. It now has a total of 33 on-chip flash memory microcomputer products spanning the range from 8 bits to 32 bits that fulfill the requirements of a wide variety of application fields. Especially in new products, devices have been implemented with specifications for ease of use including single power supply operation, high speed at low supply voltage operation, and the industry’s largest on-chip flash memory version with 512 kbyte. To enable customers to simply and rapidly realize an F-ZTAT microcomputer environment, application software has been made available on the Internet and development of various types of software tools is being implemented.

INTRODUCTION
TODAY’S electronic equipment with embedded microcomputers has strong requirements for field programmability to facilitate program changes or data correction at appropriate times to shorten product development cycles and implement product improvement. Thus Hitachi has been developing F-ZTAT microcomputers with nonvolatile on-chip flash memory that can be electrically rewritten and erased.

Use of F-ZTAT microcomputers provides the capability to flexibly respond to conditions at all stages of a product from development through pilot production, production ramp up, and mass production because both program and data can be changed after assembly on a printed circuit board by so-called on-board writing. In this paper we will introduce the features of F-ZTAT microprocessors that can change the flow of user system development and focus on the

Fig. 1—SuperH RISC Engine Family Microcomputer SH7055F
High-performance 32-bit reduced instruction set computer (RISC) with large-capacity single power supply flash memory on chip. On-chip peripheral blocks include 32-channel A-to-D converter and debugger. This microcomputer is suitable for automobile engine control.
specifications and applications of the latest single power supply versions.

FEATURES OF F-ZTAT MICROCOMPUTERS

Low-Voltage High-Speed Operation

Flash memory is fabricated on chip to reduce system size. The designs of the memory cells and driving circuits are optimized to permit operation at low voltage and high speed, which was difficult to achieve with previous discrete external flash memory devices. A new product in the SuperH RISC engine family, the SH7410, has a cycle time of 17 ns when operating at a frequency of 60 MHz with a 3.3-V power supply voltage and one-state access. World-class high speed access has been realized that is 3× faster than that of previous Hitachi products.

F-ZTAT Microprocessor On-Board Writing

On-board writing after assembly on a printed circuit board includes the boot-mode standard writing method proposed by Hitachi and user programming modes that execute writing programs implemented by users themselves for high-speed writing. In addition, a special socket adapter is available to facilitate writing in a general-purpose programmable read-only memory (PROM) writer.

F-ZTAT MICROCOMPUTER PRODUCT RANGE

Full Lineup

The range of F-ZTAT microcomputer products and application fields are shown in Fig. 2. Starting with the announcement of the 16-bit microcomputer H8/538F initial product in 1993, a total of 33 product types have been developed: the 8-bit microcomputer H8/300 and H8/300 series; the 16-bit microcomputer H8/300H, H8/500, and H8S/2000 series; and the 32-bit SuperH RISC engine family.

Powerful New Products

The 8-bit microcomputer H8/3644F series is coordinated with consumer applications having stringent cost restrictions, including white goods such as refrigerators and air conditioners, by a full lineup of versions with memory capacities starting at 16kbyte — and availability of an easy-to-use 64-pin dual inline package (DIP). A rich assortment of peripheral functions includes an 8-bit timer and an A-to-D converter; there is also a 32-kHz sub-block with clock functions.
The SH7055F, which is fabricated with a 0.35-µm complementary metal-oxide semiconductor (CMOS) process with 3 levels of aluminum interconnects, boasts the industry’s largest on-chip flash memory capacity of 512 kbyte for a single power supply microcomputer. Large-scale high-performance systems including automobile engine control systems can fit most of the program that must be executed at high speed in the on-chip flash memory.

Internal peripheral function blocks of the SH7055F are shown in Fig. 3. In addition to the high-performance 32-bit RISC CPU, a multiplier and single-precision FPU are implemented on chip to achieve 52 MIPS at the maximum operating frequency of 40 MHz. Various types of debugging including ROM data tuning and RAM data monitoring can be performed with the on-chip advanced user debugger (AUD). Other powerful on-chip peripheral functions include 2 channels of Bosch CAN Ver. 2.0B compliant HCAN, and a 32-channel A-to-D converter with a resolution of 10 bits and a conversion accuracy of ±2 least significant bits (LSB).

**F-ZTAT MICROCOMPUTER REWRITE CONTROL**

**Single Power Supply Version Rewrite Control**

Today there are a total of 13 16-bit and 32-bit F-ZTAT microcomputers that operate from a single 3-V or 5-V power supply with the capability of rewriting or erasing flash memory; a special power supply is not required. Including the SH7055F previously mentioned, another 10 products are being developed.

Fig. 4 shows the circuit block that controls rewrite in single power supply microcomputers. Compared with earlier 2 power supply types, the 12-volt power supply and protection circuits that were needed for rewrite and erase are eliminated, and the number of externally connected components is greatly reduced. But adequate protection circuits exceeding those used with 2 power supply versions are required for control of rewrite and erase of the on-chip flash memory of single power supply microcomputers to stop erroneous

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**DMAC**: direct memory access controller  
**FPU**: floating point unit  
**H-UDI**: Hitachi User Debugger Interface  
**SCI**: serial communication interface  
**CMT**: compare-match timer  
**RAM**: random access memory  
**HCAN**: Hitachi Control Area Network (Bosch CAN Ver. 2.0B-based)  
**WDT**: watchdog timer  
**AUD**: advanced user debugger (8 dedicated terminals enable real time debugging with an expanded debugger interface)  
**ATU-II**: 16-bit high-performance timer with a maximum of 65 pulse inputs and outputs

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![Fig. 3—SH7055F Block Diagram.](image)

This microcomputer is fabricated with a 0.35-µm process and realizes 52 MIPS when operating at 42 MHz from a 3.3-V power supply. It is encapsulated in a 256-pin quad flat package (QFP). Peripheral circuits include a 512-kbyte single power supply flash memory, 32-channel A-to-D converter with 10-bit conversion precision, and on-chip debugger facility.

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![Fig. 4—Example of On-Board Writing Circuit.](image)

Single power supply F-ZTAT microcomputer rewrite control does not need the previously required 12-V power supply circuit and protection circuits for rewrite and erase.
Several countermeasures have been provided on single power supply microcomputers to prevent erroneous write to the flash memory. Hardware measures include the addition of a terminal exclusively for protection and software measures include the addition of an exclusive bit for protection.

Multiple Rewrite Methods On-Board

Fig. 5 shows an example of a rewrite control method for microcomputers including the H8/3437SF and H8S/2138F using an on-chip serial interface FC bus*. The conditions including command error processing for the master device during writing are specific to the individual user. The user must prepare the control program used for rewrite. To reduce the burden on users, Hitachi has posted on the Internet examples of standard control programs at http://www.hitachi.co.jp/Sicd/Japanese.

Various on-board rewrite methods are shown in Fig. 6. The FC bus is a widely used interface for applications including audio and personal computer peripherals. Hitachi is also developing a number of rewrite methods in a similar manner for the HCAN and other interfaces used in automobiles and industrial applications.

CONCLUSIONS

We have discussed F-ZTAT microcomputers with on-chip flash memory. Today there are in mass production 33 product types of F-ZTAT single-chip microcomputers that meet the market needs for field programmability, and a cumulative total of 40-million units have been shipped. Future product development of even easier-to-use single power supply F-ZTAT microcomputers accurately reflects market requirements for high functionality, high performance, and low power. Hitachi is working toward providing fuller support to provide an environment facilitating immediate use of these products when they are needed.

REFERENCES

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*FC bus is a trademark of Philips Corp.