Field Programmable Microcomputers and Their Applications

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ABSTRACT: The range of microcomputer applications is rapidly expanding along with advances in high functionality and high performance in electronic equipment. This growth has caused an increase in microcomputer related demands. Recently strong demand for field programmability has emerged, in addition to the conventional requirements for high functionality and low power. Field programmability allows new products to be brought to market with appropriate timing. In order to reduce product development time and improve equipment specifications, field programmability enables the microcomputer program to be rewritten and data to be revised or adjusted easily in all production phases from development through prototype creation, test production, and mass production. Flexible zero turnaround time (F-ZTAT) microcomputer containing internal flash memory was designed and produced to meet these needs. The F-ZTAT microcomputer contains internal, nonvolatile flash memory that can be electronically rewritten or erased. When an F-ZTAT microcomputer is used, the program and data content can be changed more than 100 times even after attachment to the circuit board by on-board writing. Through the use of an F-ZTAT microcomputer, systems using microcomputers can quickly be reprogrammed for new circumstances anytime from development through mass production.

INTRODUCTION

THE range of microcomputer applications is rapidly expanding along with advances in higher functionality and performance in electronic equipment. The new applications have brought with them increased requirements on microcomputers.

In addition to the conventional needs of higher functionality and lower power, recently demand for field programmability has emerged. Field programmability allows new products to be brought to market with appropriate timing. In order to reduce product development time and improve equipment specifications, field programmability enables the microcomputer program to be rewritten and data to be revised or adjusted easily in all production phases from development through prototype fabrication, pilot production, and mass production.

The F-ZTAT microcomputer provides flexibility to meet changing conditions from development through mass production in systems using microcomputers. The features and applications of the F-ZTAT microcomputer are discussed in this report.

DEVELOPMENT BACKGROUND OF F-ZTAT MICROCOMPUTER

A comparison of the structures and processes of field programmable microcomputers is shown in Fig. 1. The history of single chip microcomputers, where miniaturization and high performance are realized in a system by providing internal programmable memory, began with internal mask ROM products. With internal mask ROM products, the user orders ROM from a semiconductor manufacturer when development of the system software (program) is complete. The semiconductor manufacturer converts the program to mask ROM format, creates a mask, fabricates some samples, and sends them to the user.

The user then tests the sample in the application. If there are no problems, delivery of mass produced chips from the manufacturer can begin. In this situation, the minimum delay required from the time the ROM is ordered from the manufacturer to the time mass production can begin is about one month. When changes become necessary after delivery of mass produced products, several months worth of time and money are required and the timing of product

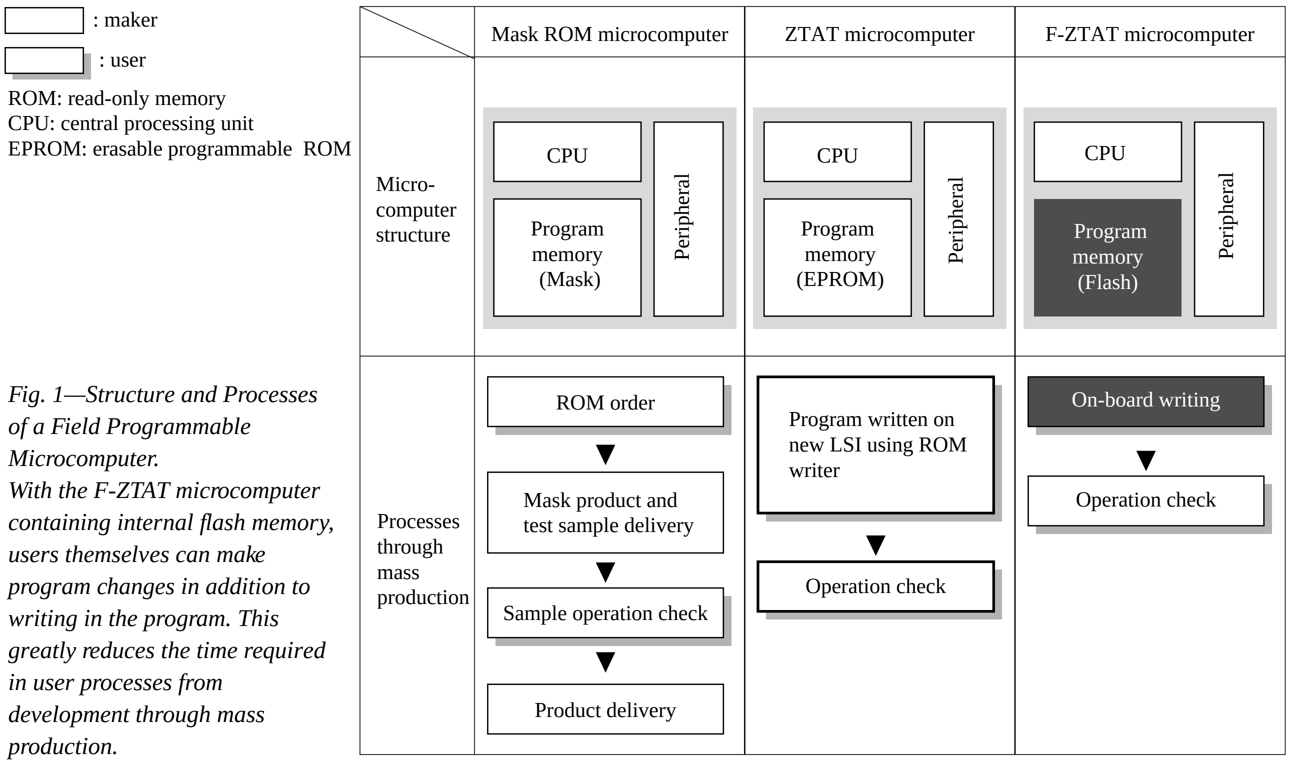

Fig. 1—Structure and Processes of a Field Programmable Microcomputer.
With the F-ZTAT microcomputer containing internal flash memory, users themselves can make program changes in addition to writing in the program. This greatly reduces the time required in user processes from development through mass production.

introduction can be delayed.

The one time programmable (OTP) single chip microcomputer, containing an internal electrically programmable ROM (EPROM) that can be programmed by the user, was developed as a method to reduce product development cycle time. In 1985 Hitachi named microcomputers containing internal EPROM ZTAT microcomputers and strongly pressed development earlier than other companies. With the ZTAT microcomputer, users themselves can easily write their own programs into the microcomputer using a general-purpose programmable ROM (PROM) writer.

The waiting time for samples prepared by a semiconductor manufacturer, previously required in order to use microcomputers with internal ROM,

TAT: turnaround time

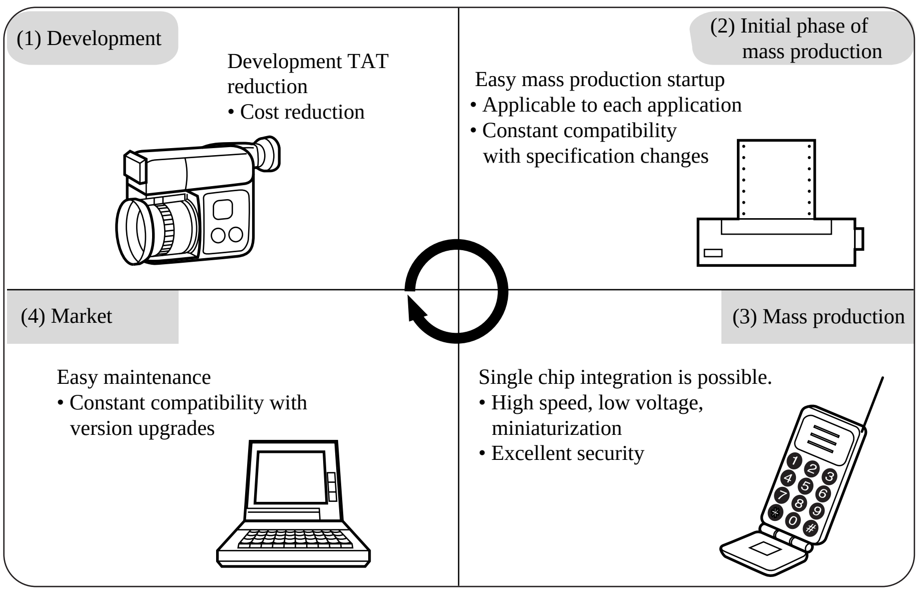

Fig. 2—Application Example of F-ZTAT Microcomputer in Process Flow from System Development Through Mass Production.
Development TAT reduction, version upgrades in the market, and further flexibility are realized through F-ZTAT microcomputer use.

became unnecessary and system evaluation time is greatly reduced. In addition, when the ZTAT microcomputer is used, impressive results are realized even with small lot diverse-type systems and in reduction of the time to mass production after specification changes. Currently Hitachi produces a broad range of ZTAT microcomputers, from the 4-bit H400 Series to the SuperH RISC (reduced instruction set computer) engine family, a group of 32-bit high-performance RISC microcomputers.

However, with conventional microcomputers containing internal OTP EPROM, users are limited to the ability to write only once. Therefore, when programs or data require changes during debugging or when specification changes occur after shipping to the market, the microcomputer must be replaced with a new one. With miniature portable equipment systems it is difficult to secure the space required to mount a socket on the board and replacement of the board itself is sometimes required.

The F-ZTAT microcomputer provides a leap forward in the field programmability of the ZTAT microcomputer that solves most of these problems. The F-ZTAT microcomputer contains an internal, nonvolatile flash memory that can be electronically written or erased. Use of the F-ZTAT microcomputer in the process flow from system development through mass production is shown in Fig. 2. When the F-ZTAT microcomputer is used, its on-board writing capability permits the program and data content to be changed more than 100 times even after attachment on the board.

FEATURES OF THE F-ZTAT MICROCOMPUTER

Low Voltage, High Speed Operation

By placing the flash memory inside the microcomputer, in addition to system miniaturization, systems operating at lower voltages (3-V operation) and higher speed can be implemented. These goals were difficult to realize with conventional flash memory placed separately outside the chip. The cycle time required to access the internal flash memory is approximately 35 ns during 5-V 28-MHz operation. This access speed is more than 2 times as fast as access with separate flash memory.

Block Separation Function

In order to realize efficient on-board writing, the flash memory consists of multiple blocks. Although there are differences among products, each product contains multiple blocks, including small blocks of about 200–300 bytes and large blocks of about 20–30 kbytes. Data rewriting and erasure can be executed for any block unit. The most appropriate writing mode can therefore be selected depending on the application.

Flash Memory Function Through RAM

A portion of the flash memory is overlapped with the internal RAM (random access memory) and has an emulation mode. Parameter data, which requires frequent rewriting during program development, can be emulated in the RAM. Flash memory rewriting time and repetitions can therefore be greatly reduced.

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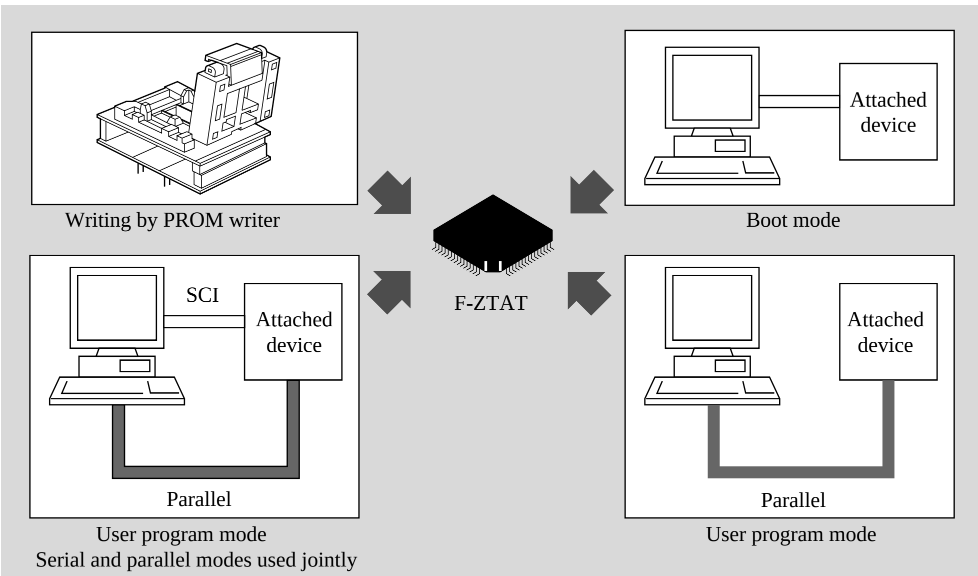

SCI: serial communication interface

Fig. 3—Writing Methods for F-ZTAT Microcomputer. Two types of writing are possible; writing by general-purpose PROM writer and writing on-board after attachment.

Writing Methods for the F-ZTAT Microcomputer

Methods for writing to the F-ZTAT microcomputer are shown in Fig. 3. Writing to the flash memory contained in the F-ZTAT microcomputer can be done by general-purpose PROM writers or by on-board writing after assembly: boot mode and user program mode.

Writing by general-use PROM writer

By using a special socket adapter, the pins of the microcomputer are converted to the same pin arrangement as standard flash memory, such as the HN28F101. After conversion writing is possible with the same specifications as writing to standard flash memory—specifications differ for some products.

On-board writing

The boot mode or user program mode can be used for on-board writing. The boot mode is a standard on-board writing method provided by Hitachi. The user program mode allows execution of an independent writing program specially prepared by users themselves in order to realize high speed writing and other special functions.

(1) Boot mode

The boot mode is the most suitable mode for initial writing. This mode erases all internal flash memory contents and then writes. First, the boot program already installed in the F-ZTAT is started up. Then, a writing control program is moved into the internal RAM from an external computer or other source through the internal serial communication interface (SCI) of the F-ZTAT microcomputer. On-board writing can then be executed using the writing control program.

(2) User program mode

Since the user program mode can erase and write in block units, it is used in parameter tuning and other small block tasks on the system production line. On-board is done by executing the writing and erasing program already contained in the internal flash memory using a general-purpose PROM writer or the boot mode.

F-ZTAT MICROCOMPUTER PRODUCTS

Full Lineup

Product development planning of F-ZTAT microcomputer products is shown in Fig. 4, while the application fields of each product are shown in Table 1. With the addition of the 8-bit H8/300 microcomputer series and the 16-bit H8/300H microcomputer series, a total of 7 products have been placed in mass production since the announcement of the H8/538F—the first product in the 16-bit H8/500 microcomputer series, in 1993.

The H8/300 series includes the 80-pin type H8/3334YF and the 100-pin type H8/3434F, both with a 32-kbyte internal flash memory, and the H8/3337YF

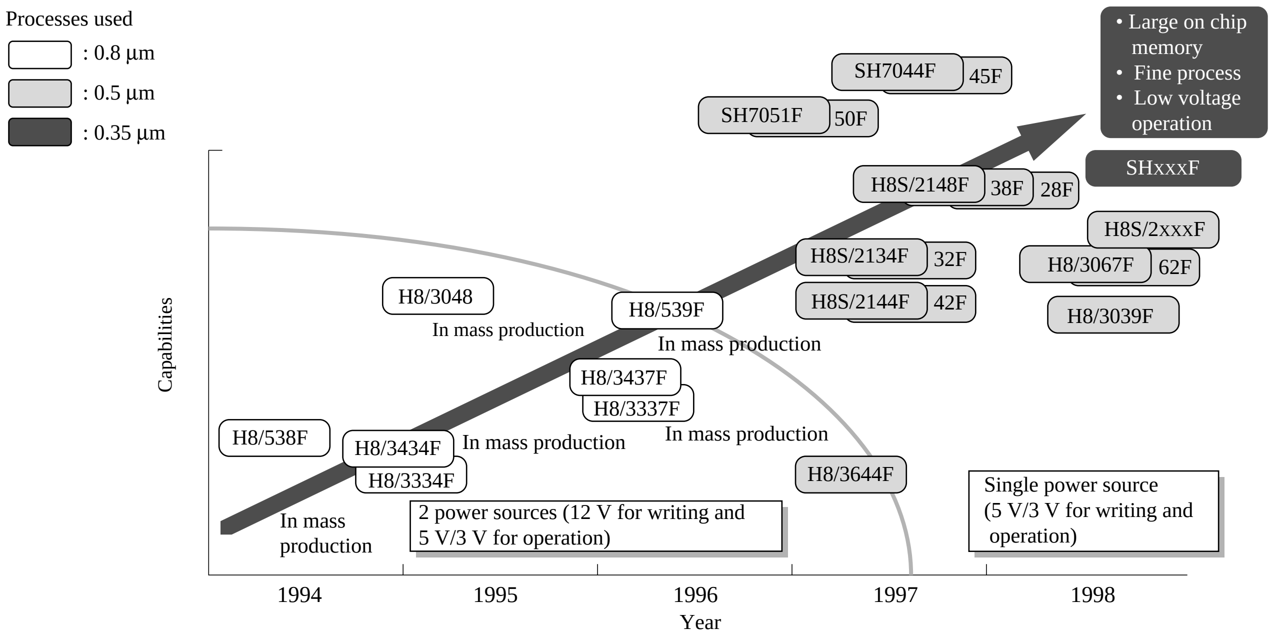

Fig. 4—F-ZTAT Microcomputer Product Development Plan.
Seven products have been put in mass production since the announcement of the H8/538F in 1993 and 15 new products are currently under development.

TABLE 1. F-ZTAT Microcomputer Products and Applicable Fields

A broad range of products are available, from 8-bit microcomputers to 32-bit RISC microcomputers, and are applicable in various fields. A product containing an internal 512-kbyte flash memory is currently in the planning phase.

Core		32 kbyte	64 kbyte	128 kbyte	256 kbyte	512 kbyte	Major application fields
8 bit	H8/300L	H8/3644F	(in planning)	——	——	——	Automobile electronics Air conditioners General home electronics OA equipment Computer peripherals
	H8/300	H8/3334YF H8/3434F	H8/3337YF H8/3437F	——	——	——	
16 bit	H8/300H	——	——	H8/3048F H8/3039F H8/3067, 62F	——	——	Automobile electronics Mobile telephones PHS Camera DVD Card readers Pachinko
	H8S	——	H8S/2132F H8S/2142F	H8S/2134, 38F H8S/2144, 48F H8S/2128F	(in planning)	(in planning)	
	H8/500	——	H8S/538F	H8/539F	——	——	Engine controller Machine processing equipment
32 bit	SH-2	——	——	SH7050F	SH7044F SH7045F SH7051F	(in planning)	Engine controller Car navigation Digital consumer appliances

PHS: personal handyphone system DVD: digital video disc

and H8/3437F with flash memory expanded to 60 kbyte with pin compatibility: terminal specifications and internal peripheral functions are compatible.

Peripheral functions of each product contain the intelligent keyboard and power management processor (IKAP) and I^{2}C bus required by keyboard controllers in notebook computers. When used as controllers for notebook computers, the microcomputers can provide quick handling of basic input/output system (BIOS) version upgrades, through internal flash memory — and flexible power management, including smart battery control, through the use of abundant peripheral functions.

The H8/300H series includes the 100-pin type H8/3048F with a 128-kbyte internal flash memory. The H8/300H CPU has upward compatibility with the H8/300 CPU and features fast calculation of 8-, 16-, and 32-bit data along with a 16-Mbyte linear address space. The H8/3048F, used with various low power motors, includes an internal DMA (direct memory access controller) to realize rapid transfer of large data volumes and an internal high functionality timer suited to motor control. This chip is suitable for portable information equipment such as digital video cameras.

The H8/500 series includes the H8/538F with 60 kbyte of internal flash memory, and the H8/539F with 128 kbyte of internal flash memory.

The high speed CPU of the H8/500 series is suited to control equipment and the H8/538F and H8/539F, with internal functions including a powerful timer and an A-D converter, are suited to automobile engine control and control of various types of production equipment.

Strong New Products

New products include the bit H8/3644F of the H8/300L microcomputer series with internal 32-kHz oscillator clock operation for consumer appliances. In the H8/300H series the 80-pin H8/3039F and 100-pin H8/3062F/H83067F were added. As 16-bit microcomputers, the H8S/2134F and H8S/2144F of the H8S series with CPU performance on the top world level were added along with 5 other models. In the SuperH RISC engine family the SH7044F, SH7045F, SH7050F, and SH7051F were added. A picture of the SH7051F chip is shown in Fig. 5. Excluding the H8/3644F, all of the new products include a single power source internal flash memory and use the 0.5-µm 2-layer aluminum wire CMOS (complementary metal-oxide semiconductor) process.

An easy to use DIP (dual in-line package) is available with the 64-pin H8/3644F, which is suited

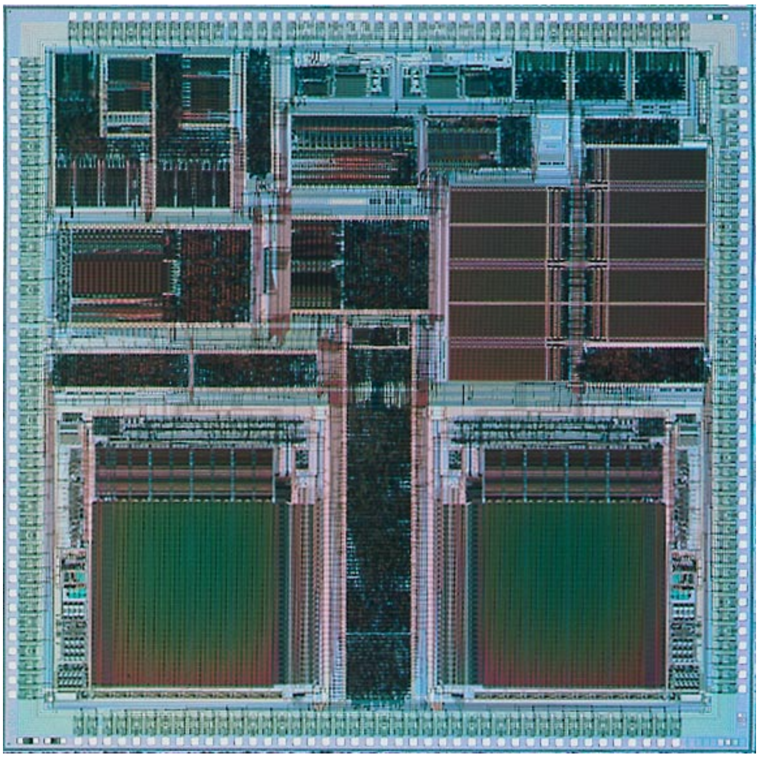

Fig. 5—SH7051F Microcomputer of the SuperH RISC Engine Family.
A 256-kbyte large-capacity single power supply flash memory is embedded on a high-performance 32-bit RISC microcomputer. The computer provides many peripheral functions, such as a 16-channel A/D converter and a high performance timer, and is suitable for automobile engine control.

to air conditioners, home electronics, and other everyday products.

The SH7044F, SH7045F, and SH7051F contain 256-kbyte, large capacity internal flash memory using a single power source. With these products a large portion of programs requiring high speed processing can be stored in the internal flash memory even with large scale, high performance systems.

In addition, the SH7044F and SH7045F can execute 28.7 MIPS (million instructions per second) at the maximum operating frequency of 28.7 MHz. Even during 3.3-V operation 16.7 MIPS can be realized and, in the future, a 33-MHz version will be available. These products are applicable in car navigation and multimedia equipment, such as digital still cameras, where expansive composite data processing is required for images, voice, and other information.

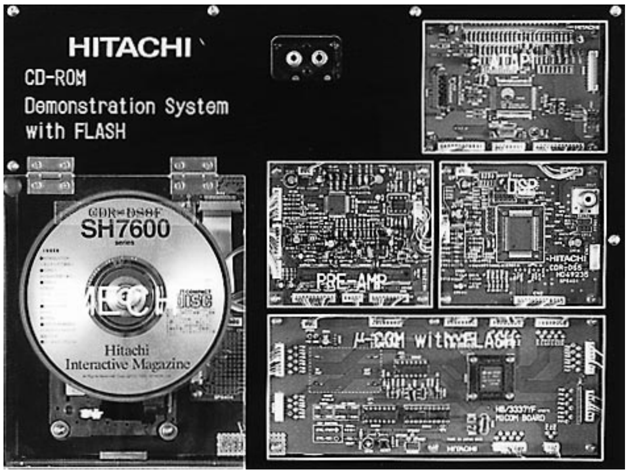

Fig. 6-CD-ROM Drive Demonstration System with H8/3337YF.
High-speed writing of the internal flash memory of the F-ZTAT microcomputer is implemented through an ATAPI bus, the standard interface between personal computers and external memory devices.

APPLICATION EXAMPLES OF F-ZTAT

A CD-ROM drive demonstration system with the H8/3337YF is shown in Fig. 6. Access speeds have rapidly increased for CD-ROM, which has nearly become standard equipment in personal computers. Therefore, reduction in product development time has become very important for the various drive makers — together with production management for each end user and its particular specifications.

In order to cope with mass production in a short time period, high-speed writing into the internal flash memory of the F-ZTAT microcomputer is implemented through an advanced technology attachment bus packet interface (ATAPI) bus — a standard interface between personal computers and external memory devices. Less than 10 seconds is required, even to rewrite the entire 64 kbyte in the internal flash

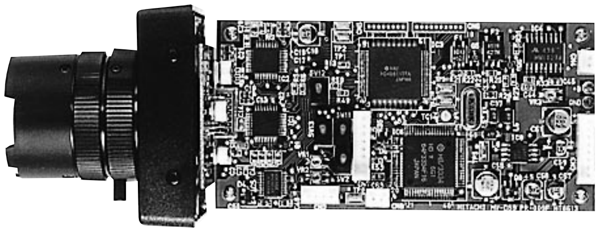

Fig. 7-Digital Camera Demonstration System with H8/3334YF. Various types of adjustment data on the production line are stored in the F- ZTAT microcomputer. The miniaturization and low-voltage high-speed operation demanded of camera systems are realized.

memory.

Program rewriting is possible using the standard interface inside the personal computer without requiring special external attachments. As an example, should rewriting of a program become necessary after shipping an internal CD-ROM in a personal computer, the end user can simply transfer the program from the Internet or some other medium and execute the rewriting.

A digital camera demonstration system with the H8/3334YF is shown in Fig. 7. Digital camera applications are rapidly growing for digital still cameras and personal computer cameras. With digital cameras some final adjustments, including image quality adjustments such as characteristic distortion, are required before shipping. Storage of the various types of adjustment data, conventionally done by an externally attached IC, is now done by the internal flash memory of the F-ZTAT.

Miniaturization demanded of the camera system is realized by decreasing the number of parts and low voltage, and high speed operation is realized by embedding the flash memory. In addition, by changing the program to satisfy the final application, small-lot diverse-product applications are possible using a standard circuit board.

CONCLUSIONS

The features and applications of the F-ZTAT microcomputer are discussed here. Currently 7 F-ZTAT products, single-chip microcomputers with excellent field programmability to meet user needs, are in mass production and 15 new products are under development. The chips have already been used in over 1,000 applications and extensive use can be expected in the future production of a wide range of products, with the scope of use extending from development and prototype creation through mass production. Development of F-ZTAT microcomputer products, which will even change the system development flow of users, will be effectively advanced by Hitachi technology in the future.

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