New Products & Technologies

KC80, a Fast Z80 Compatible CPU Core and Its Software Development Tools*

Yasuo Yamada** Hiroshi Suzuki*** Hideki Yoneda**

1 Background

A CPU core is different from a standard CPU, being a CPU circuit block that is designed especially to be part of an ASIC. ASIC products such as gate arrays and standard cells are becoming larger and more complicated by including memories and CPU peripherals as well as random logic. However, bringing a CPU into an ASIC is difficult, and not like incorporating memories and CPU peripherals. This is because program development support tools are necessary for any CPU, and offering software development tools is very difficult when a CPU is included in ASIC products. This is an especially serious problem for the software development tools called ICE (In-Circuit Emulator). The ICE is usually developed individually for each CPU after the CPU has been developed. Developing ICEs is becoming a time and money consuming task as CPUs become faster. Therefore, when a CPU is included in an ASIC product, to produce an ASIC microcontroller, there is naturally no ICE available to support the ASIC microcontroller. Demand for smaller and more portable electronic products, such as cellular phones, is increasing, which expands the demand for one-chip ASIC products that include CPUs. In this sense, the KC80 CPU core, developed in April 1993, is an epoch-making product. Compared to other 8 bit CPUs, the KC80 has much higher performance and lower power consumption, and also provides software development tools, even for the ASIC microcontroller.

2 Specifications of KC80 CPU Core

The KC80 CPU core is an 8 bit CPU core for the ASIC (custom) microcontroller. Its instruction set is compatible with Z80,**** which still has the largest share in the 8 bit CPU market at present. An example of KC80 ASIC microcontroller is shown in **Photo 1**.

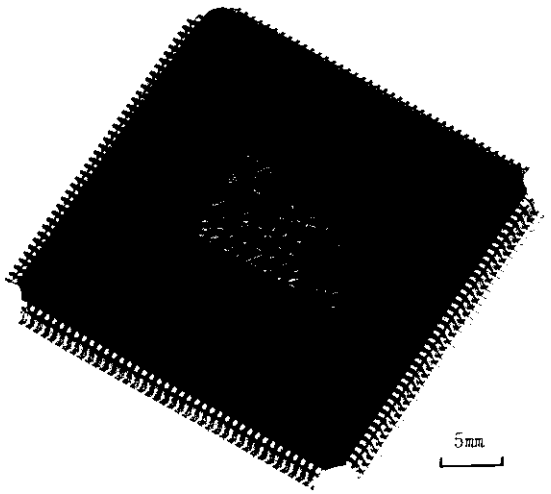

Photo 1 KC80 ASIC microcontroller

However, its performance has improved greatly. The KC80, at 10 MHz clock rate, provides performance equivalent to or better than that of the Z80 at 40 MHz, as shown in **Table 1**. This performance is more than that of typical current 16 bit one-chip microcontrollers. The power consumption of the KC80 is very small, and which is important for portable electronic products. Its address space of 64 K bytes is the same as the Z80, but its derivative, the KC82 provides 1 M bytes of address space extended by MMU. The KC80 supports high-speed 16 bit addition and subtraction operations (0.1 μs). By adding a multiplier as a random logic, KC80 can provide numeric calculation performance equivalent to a 16 bit DSP. Therefore, an application previously implemented by the combination of a one-chip microcontroller and 16 bit DSP can now be implemented by a one-chip KC80 ASIC microcontroller.

* Originally published in *Kawasaki Steel Giho*, **26**(1994)2, 88-89

** Staff Assistant Manager, Products Development Sec., Products Development & Design Dept., LSI Div.

*** Products Development Sec., Products Development & Design Dept., LSI Div.

**** Z80 is the trademark of Zilog Inc. U.S.

Table 1 Specifications of KC80 CPU core

Maximum clock frequency	10 MHz
Operational clock frequency	0~10 MHz
Performance	·5 times faster than Z80 (8 MHz) ·Minimum execution time; 0.1 μs
Instruction set	Binary compatible with Z80
Power consumption	50 mW (10 MHz, 5 V) 8.4 mW (4 MHz, 3 V)
System bus	·Clock synchronous bus ·1 clock cycle/memory access
Other characteristics	·Fast 16 bit addition/subtraction ·Internal 16 bit data path

3 Development Tools for CPU Cores

At present, most electric products include CPUs (or microprocessors or one-chip microcontrollers). Program development is necessary for these products, and the users of microprocessors or one-chip microcontrollers usually develop programs using ICEs. However, because each ICE is typically developed for only a particular microprocessor or one-chip microcontroller, requiring considerable time after the microprocessor or controller is developed, an ICE is not provided for an ASIC microcontroller. This is a major problem for most ASIC microcontrollers, and the reason that the market of ASIC microcontrollers has not grown more rapidly.

The KC80 provides sufficient software development tools, when compared to other current ASIC microcontroller, and even when compared to microprocessors and one-chip microcontrollers.

(1) ICE for ASIC Microcontrollers

As shown in **Fig. 1**, an ICE with rich functionality is provided for typical ASIC microcontrollers. This ICE works in precisely the same way as the individual user's ASIC microcontroller chip. This system is so revolutionary that the ICE for each ASIC microcontroller can be delivered in only two weeks after the sample chip is fabricated.

(2) Bug Finder

As shown in **Fig. 2**, a simple software development tool like an ICE (called a Bug Finder) for any ASIC microcontroller is also provided. The Bug Finder consists of three parts, debug software on a PC, an adapter board, and a small special circuit embedded in an ASIC microcontroller, and enables debugging on the personal computer. The debug software on the PC receives commands and communicates with a small special circuit by way of the adapter board. This Bug Finder is a flexible software development tool that can be used with all special ASIC microcontrollers, such as multi-CPU chips. It also satisfies those who want an inexpensive software development tool.

These two software development tools cover a wide range of applications, from a typical ASIC microcontroller application to multi-CPU systems.

4 Specifications of Peripheral Circuits for KC80 CPU Core

Many peripheral circuit blocks that are used with the KC80 shown in **Table 2** have been developed as ASIC microcontroller parts. There are ten peripheral circuit blocks, such as timers and parallel ports, that are often used in microcontrollers. One KC80 option circuit

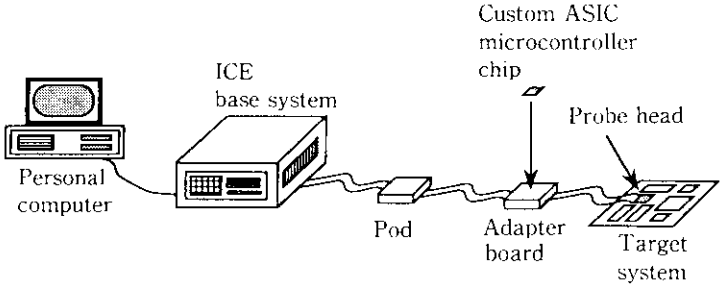

Fig. 1 ICE for KC80 ASIC microcontroller

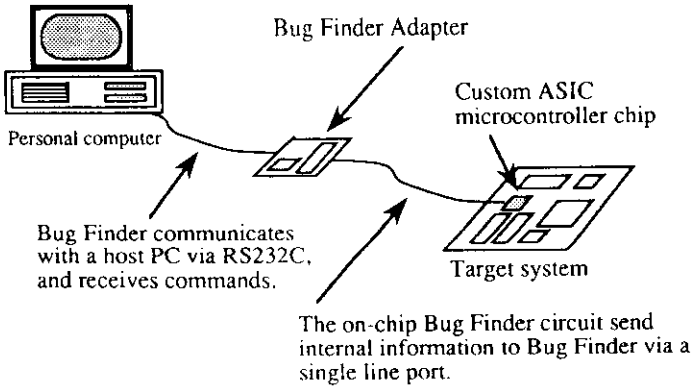

Fig. 2 Configuration of Bug Finder system in use

Table 2 Peripheral macro-cells for KC80 ASIC microcontroller

MMU (Memory Management Unit)
DMA controller
Serial port (USART)
Timer/Counter macro-cells (3 types)
Parallel port macro-cells (2 types)
Interrupt controllers (2 types)
External bus interface unit

(external bus interface unit) is also provided. More peripheral circuits are scheduled to be developed. An ASIC microcontroller that suits individual needs can be implemented by combining the KC80 with these peripheral circuits and random logic. Users can freely specify the type and number of peripheral circuits. Because the KC80 has a very flexible structure, it can be included in any of our ASIC products (0.8 μm, 1.0 μm gate arrays, standard cells, and embedded arrays).

5 Concluding Remarks

Both microcontrollers and ASICs are important components of electronic products or systems. The ASIC microcontroller, which is a combination of microcontrollers and an ASIC, will therefore be a key part of electronic products or systems. The excellent performance of the KC80 and the two related software development tools described here will play a major role in the development of end-user products with embedded microcontrollers. Standard (ready-made) products as well as ASIC microcontrollers are planned, to be introduced as the "Microcontroller 8000 series." As the first product, the KL5C8012 has already been developed and marketed.

For Further Information, Please Contact to:
Sales Dept., LSI Div., Kawasaki Steel Corp.
Phone: 03 (3597) 4619 Fax: 03 (3597) 3634