



G00002

DATA PROCESSING SYSTEM AND DATA PROCESSOR

BACKGROUND OF THE INVENTION



159159

The present invention relates to a technical field of a data transfer system of bus connecting data processors and a data transfer system in the system formed of a plurality of data processors and a plurality of system buses. For example, the present invention relates to the technique which may be applied effectively to the technique in which a data processor uses in common the built-in circuits of the other data processors and to the technique in which a data processor makes access to the external buses of the other data processors. Moreover, the present invention relates to the technique of boot control in which operation program of data processor is initially stored in the memory.

With complication of system, the number of data processors and components mounted on the system is increasing. For example, in the mobile phone system, a baseband data processor for controlling communication has controlled software (application and key control or the like) and hardware (components of RF circuit, LCD and memory or the like). However, with diversification of functions, it is now difficult that the baseband processor performs all processes. In the PC system of the prior art, this problem has been solved

by improving operation frequency of data processor but in the battery-driven type mobile terminal in these years cannot simply improve performance with higher frequency because the operation life of battery must be expanded.

It is also considered to use a method to vary the frequency with the processes executed by the data processor, but realization of the practical use is difficult because actual realization is very difficult in the system. Moreover, the data processor which can realize high speed operation tends to become large in the chip area and it is also difficult to reduce a current value during the standby state.

In order to solve this problem, applications which cannot be processed with the data processors of the prior art have been processed with the co-processor or with the other data processor. Accordingly, since it is possible to operate only the data processors suitable for particular processes when such particular processes are required, the system can be formed easily and finally power consumption of the system as a whole can also be realized.

When a plurality of data processors such as data processor and co-processor or the like are mounted to one system, a common bus is frequently used for connection of the data processors. However, when a data processor which cannot use in common the bus is

used and when full- performance cannot be exhibited through common use of bus because memory access performance is insufficient, it is required to conduct the data transfer by comprising a certain interface to one data processor and then connecting this interface to the bus of the other processor. As this interface, there is a host port interface supported, for example, by the DSP (TMS320C54x) of TI. In actual, data transfer is performed between data processors by utilizing the RAM built in the data processor and the interruption function. However, software must be executed to use the data transferred.

Not only the system but also the function itself of data processor are highly sophisticated. When a plurality of data processors are mounted to the system, it is not required for a plurality of data processors to support the duplicated same function by efficiently using the functions mounted to the data processors, such as memory interface, USB (universal serial bus), memory card, serial interface for SDRAM (Synchronous DRAM) or the like. When data processors are connected with an interface not depending on the common bus, the data transferred must be processed with software under the condition that the functions supported by respective data processors are used. For example, when a certain data processor desires to make access to a memory by utilizing a memory interface of another data processor,

it has been required that the data to be accessed with the above interface is once transferred to another data processor, a program of the other data processor is thereafter executed as the interruption process, thereby the other data processor to execute such program makes access to a memory, and the other data processor issues, after such access, an interruption to one data processor for the data transfer to one data processor via the interface.

As another problem resulting from complicated system structure, reduction of mounting area may be listed. Particularly, at a mobile information terminal, it is required to reduce the number of components used in the system in order to reduce the mounting area from the viewpoint of reduction in power consumption and cost. However, when the system is improved to have multiple functions, the number of components also increases to realize such functions. Particularly, when a plurality of data processors are comprised as described above, this problem becomes more serious.

In the case where a plurality of data processors are mounted on the system as described in regard to the technology of the prior art and such data processors cannot be connected with a common bus, it is required to comprise an interface for mutually connecting the data processors. The host interface such as DSP of TI

performs handshake to realize data transfer by utilizing the RAM built in the data processor and the interruption function. In this method, since it is required to execute the interruption process program for every data transfer, the performance may be deteriorated because the execution of the program being operated is interrupted. Particularly, there rises a problem when it is required to use only external interface supported by the data processor.

Moreover, the inventors of the present invention have discussed the technology to initially store an operation program of data processor to a memory. For example, in a microprocessor where an electrically reprogrammable flash memory is formed on a chip to store the operation program of CPU, an initial program for such flash memory is generally written, for example, using, in its fabrication stage, a write device such as EPROM writer. However, such write operation is complicated and moreover takes a longer time because such write operation is accompanied by a verify process and a rewrite process. Therefore this write operation is also considered as a cause of rise of fabrication cost of data processor.

OBJECT AND SUMMARY OF THE INVENTION

It is therefore an object of the present invention to realize that a data processor realizes a data transfer interface for data transfer in addition to a

memory interface in a data processing system which is complicated for multiple functions. Moreover, the present invention has another object to effectively use the internal function of the relevant data processor or external circuits of the relevant data processor from the other data processor or device connected to such interface. Moreover, the present invention is intended to finally realize low power consumption through improvement of system performance and realization of low cost.

The other object of the present invention is to provide a data processing system and moreover a data processor which can easily realize the process to initially write the program to be executed by the data processor to a nonvolatile memory.

The abovementioned and other objects and novel features of the present invention will become apparent from the description of the present specification and the accompanying drawings.

The typical inventions disclosed in this specification will be briefly described below.

[1] According to a first aspect of the present invention, an internal bus access of data processor is allowed to the other data processors.

According to this first aspect of the present invention, a data processor (100) is provided with an interface means (119) to enable connection with another

data processor (101) and this interface means is provided with a function to connect the other data processor as a bus master to the internal bus of one data processor to support the function to operate in direct the peripheral function memory-mapped to the internal bus with the relevant other data processors from an external side via the interface means. Thereby, the data processor is capable of utilizing the peripheral functions of the other data processor without interruption of programs being executed. When the first data processor makes access, for example, to the particular memory using the memory interface of the second data processor, the first data processor is capable of making access and then using the peripheral memory and the other peripheral circuits via the interface means of the second data processor. In short, one data processor can use in common the peripheral resources of the other data processors. In other words, the first data processor can use in direct the other interface function comprised in the second data process. Thereby, high performance of the system can be realized.

The invention according to above aspect will be described in further detail. The data processing system according to the first aspect includes the first data processor (100) and the second data processor (101). The second data processor comprises the interface means (119) which makes the first data processor obtain the

right to use the internal bus of the second data processor. The interface means makes the first data processor having obtained the right use the internal bus to access to an input/output circuit connected to the internal bus.

The input/output circuit is formed of single circuit or of a plurality of circuits selected, for example, from a SDRAM interface circuit connected to SDRAM, LCD interface circuit connected to a liquid crystal display device, memory card interface circuit connected to a memory card, serial interface circuit, nonvolatile memory, electrically reprogrammable nonvolatile memory and general purpose input/output port circuit.

The interface means may include a buffer RAM (107) which exclusively responds to realize operation to the access from the second data processor and the access from the first data processor.

[2] According to a second aspect of the present invention, the other data processor is allowed to make access to the inherent external bus of one data processor via the relevant one data processor.

The present invention according to this second aspect is provided with a means (114) which enables interface, within the second data processor, between the first data processor (100) and the external device (104) of the relevant second data processor while the

second processor (101) is in the waiting condition (power supply is off or standby state). Accordingly, the first data processor is capable of controlling the device connected to the second data processor without use of an external circuit during the waiting condition of the relevant second data processor. In short, even when the second data processor is in the waiting condition, the first data processor is capable of controlling the external circuit connected to the relevant second data processor by bypassing the internal circuits of second data processor. Thereby, the number of components forming the data processing system can be reduced and reduction in cost can also be realized.

The invention based on the above aspect will be described in further detail. The data processing system according to the second aspect includes the first data processor (100), a first bus (103) connected to the first data processor, the second data processor (101) connected to the first bus and a second bus (105) connected to the second data processor. The second data processor includes a first external interface circuit (119) which is connected to the first bus in one terminal and to the internal bus in the other terminal, a second external interface (113) which is connected to the second bus in one terminal and to the internal bus in the other terminal, and a switch circuit

(114) for connecting one terminal of the first interface circuit to the second bus in place of one terminal of the second external interface circuit while the second data processor is in the waiting condition.

In the waiting condition of the second data processor, supply of clock signal, for example, to a clock synchronization circuit included in the second data processor is suspended. Moreover, a power supply control circuit (116b) is also included in the second data processor to separate the operation power supply of the switch circuit from the operation power supply of the other circuits and to suspend supply of the operation power supply to a part or the entire part of the above-described and the other circuits in response to the waiting condition of the second data processor. Thereby, the power consumption may be reduced in the waiting condition of the second data processor.

The second external interface circuit includes an LCD interface circuit which can be connected, for example, to a liquid crystal display controller. In this case, the second bus is connected with the liquid crystal display controller. Accordingly, the first data processor is capable of controlling the liquid crystal display controller via the switch circuit.

[3] According to a third aspect, operation control for initially writing an operation program to be executed with a data processor after the reset operation is

cancelled to an on-chip nonvolatile memory and nonvolatile memory on the local bus may be realized via the relevant data processor.

The data processing system of the present invention according to this third aspect includes the first data processor (100) and the second data processor (101). The second data processor includes a nonvolatile memory (107) which is controlled to write the data with the first data processor in a first operation mode after the reset operation is cancelled, a CPU (109) which considers the nonvolatile memory as the object of instruction fetch after the write operation in the first operation mode, and an electrically reprogrammable nonvolatile memory (502) which is considered as the object of instruction fetch by the CPU in the second operation mode after the reset operation is cancelled. The first data processor designates the first operation mode to the second data processor and then stores, to the nonvolatile memory, a write control program for the nonvolatile memory and allows the CPU to fetch the instruction. Accordingly, the second data processor is capable of executing the write control program written to the nonvolatile memory and then initially writing the operation program of the first data processor to the on-chip nonvolatile memory depending on such execution. It is enough for execution of this operation program that the second

operation mode is designated after the reset operation is cancelled.

The electrically reprogrammable nonvolatile memory is never limited to the on-chip memory of the first data processor. This memory may be an electrically reprogrammable nonvolatile memory (501) connected to the local bus of the first data processor.

According to the invention of the third aspect, operation control to initially write the operation program to be executed by the data processor after the reset operation is cancelled to the on-chip nonvolatile memory and the nonvolatile memory on the local bus can be realized via the relevant data processor. In short, it is no longer required to execute the process to write the program to the on-chip program memory or the like in the fabrication process of data processor.

[4] According to a fourth aspect of the present invention, attention is paid to the data processor to be applied to the data processing system based on the first to third aspects described above.

A data processor includes the CPU (109), the internal bus connected to the CPU, a peripheral circuit (116) connected to the internal bus, the first external interface circuit (119) connected to a first external terminal in one terminal thereof and to the internal bus in the other terminal, and the second external interface circuit (113) connected to a second external

terminal in one terminal thereof and to the internal bus in the other terminal thereof. The first external interface circuit obtains the right to use the internal bus in response to an external access request and enables access to the peripheral circuit connected to the internal bus. Accordingly, a data processor is capable of making the other data processors use the on-chip peripheral circuits connected to the internal bus.

Moreover, the switch circuit (114) for connecting the first external terminal to the second external terminal in place of the second external interface circuit during the waiting condition of the CPU may also be included. The other data processors are allowed via the relevant one data processor to make access to the inherent external bus of one data processor. For example, when an LCD controller is connected to the local bus of a data processor, the other data processor can realize the time display control function for the LCD via the LCD control on the local bus via the system bus when the relevant data processor is in the waiting condition.

According to the third aspect of the present invention that a boot program of data processor is initially written, a data processor further includes a nonvolatile memory which is externally written via the first external interface circuit in the first

operation mode after the reset operation is cancelled and a program memory such as an electrically reprogrammable nonvolatile memory. The CPU can fetch an instruction from the nonvolatile memory after the write operation in the first operation mode and then execute such instruction and moreover the CPU can fetch the instruction from the program memory in the second operation mode after the reset operation is cancelled and then execute this instruction. The boot program of data processor can be initially written to the nonvolatile program memory by writing a write control program for the program memory to the nonvolatile memory in the second operation mode and then executing the written write control program in the second operation mode.

A data processor can be configured with single chip by forming, to one semiconductor substrate, the CPU, internal bus, first external interface circuit, second external interface circuit, switch circuit, nonvolatile memory and program memory. Moreover, it is also possible to form a multi-chip module by forming, on the first semiconductor substrate, the CPU, internal bus, first external interface circuit, second external interface circuit, switch circuit and nonvolatile memory, forming the program memory (501) on the second semiconductor substrate, and mounting both first and second semiconductor substrates, for example, on a high

density mounting substrate to form a sealed package.

[5] According to a fifth aspect of the present invention, a data processor to be applied to the data processing system based on the first aspect is investigated from the other aspect.

A data processor includes a first terminal connected to a first bus, a second terminal connected to a second bus, a first internal circuit and a second internal circuit which can selectively take a first condition or a second condition, a first signal route connected to the second terminal from the first terminal via the first internal circuit and second internal circuit and a second signal route connected to the second terminal from the first terminal via the second internal circuit. The second internal circuit selects a desired signal route from the first signal route or second signal route depending on the condition of the first internal circuit.

The first condition is, for example, the operating condition to be executed by the first internal circuit, while the second condition is, for example, the waiting condition in which execution of instructions is suspended. The second internal circuit selects the first route in the operating condition and also selects the second route in the waiting condition.

Moreover, a power supply control circuit is also provided to control supply of a first power source to

the first internal circuit and supply of a second power source to the second internal circuit. In this case, the power supply control circuit stops, when the second signal route is selected for the second internal circuit, supply of the first power source to the entire part or a part of the first internal circuit. In short, in the waiting condition, supply of useless operation power source to the circuit which is not requested to operate is stopped.

The first internal circuit, second internal circuit and power supply control circuit may be formed on one semiconductor substrate. Moreover, it is also possible that the first internal circuit and power supply control circuit are formed on the first substrate, the second internal circuit is formed on the second semiconductor substrate, and the first and second semiconductor substrates are sealed in one package. Thereby, a data processor can be formed as a multi-chip module or the like.

When the first internal circuit includes a clock control circuit (116a) to supply a clock signal for synchronous operation to the first internal circuit, it is recommended that the clock control circuit stops supply of the clock signal to the first internal circuit when the second signal route is selected by the second internal circuit. In the waiting condition, it is more desirable to stop the supply of clock signal to the

circuit which is not required to operate in order to prevent useless power consumption.

As the desirable profile, the power supply control circuit for controlling supply of the first power source to the first internal circuit and supply of the second power source to the second internal circuit stops the supply of power source to the entire part or a part of the first internal circuit when supply of the clock signal to the first internal circuit is stopped.

The first internal circuit, second internal circuit, clock control circuit and the power supply control circuit may be formed on one semiconductor substrate. Moreover, the first internal circuit, clock control circuit and power supply control circuit are formed on the first semiconductor substrate, the second internal circuit is formed on the second semiconductor substrate, and the first semiconductor substrate and the second semiconductor substrate may be sealed in one package to form a multi-chip module of the data processor.

[6] According to a sixth aspect of the present invention, the information processing system based on the first aspect will be discussed from a different aspect.

An information processing system comprises a first bus, a second bus and a data processor connected to the first bus and the second bus. The data processor

has a first operation profile and a second operation profile. In the first operation profile, the data processor processes the information supplied from the first bus to supply the predetermined information to the second bus. In the second operation profile, the data processor supplies in direct the information supplied from the first bus to the second bus.

Moreover, according to the other aspect of the present invention, a mobile phone system comprises first to third semiconductor integrated circuits, a first bus for connecting the first semiconductor integrated circuit and the second semiconductor integrated circuit and a second bus for connecting the second semiconductor integrated circuit and the third semiconductor integrated circuit. The second semiconductor integrated circuit includes a first operation profile and a second operation profile. In the first operation profile, the second semiconductor integrated circuit performs the predetermined process based on the information supplied from the first semiconductor integrated circuit and supplies the result of process to the third semiconductor integrated circuit. In the second operation profile, the second semiconductor integrated circuit supplies in direct the information supplied from the first semiconductor integrated circuit to the third semiconductor integrated circuit.

In the mobile phone system described above, the first semiconductor integrated circuit may supply a control signal which controls the second semiconductor integrated circuit to be shifted to any one of the first and second operation profiles. Such control signal may be given as a command.

In the mobile phone system, the first semiconductor integrated circuit is provided, for example, for process of baseband, while the third semiconductor integrated circuit is provided for display control. The predetermined processes are performed, for example, for at least the video signals.

A storage device may be connected to the second bus. For example, the storage device may store the processing program which specifies the processes to be executed in the second semiconductor integrated circuit.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram illustrating an example of the data processing system of the present invention.

Fig. 2 is a block diagram illustrating in detail a bypass region in the second data processor of Fig. 1.

Fig. 3 is a block diagram illustrating an example in the case where a data processor is formed of a multi-chip module.

Fig. 4 is a block diagram illustrating a practical

example of a first external interface circuit provided in the second data processor of Fig. 2.

Fig. 5 is a block diagram of another practical example of the first external interface circuit provided in the second data processor.

Fig. 6 is a diagram for describing the initial write operation of a boot program of the data processor in the data processing system of the present invention.

Fig. 7 is a timing chart of boot operation in the data processing system of Fig. 6.

Fig. 8 is another timing chart of boot operation in the data processing system of Fig. 6.

Fig. 9 is a timing chart for updating a boot program or adding/updating applications executed by the second data processor in the condition that the boot program is stored in the program memory.

Fig. 10 is a cross-sectional view of a multi-chip module which forms the data processor of Fig. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 illustrates an example of the data processing system of the present invention. This system is composed of a first data processor 100 connected to a first external bus 103 and a second data processor 101 connected to a second external bus 105. The first external bus 103 is connected with a plurality of external devices 102 such as RAM, ROM and flash memory (FLASH). The second external bus 105 is connected with

external devices 104 such as RAM, ROM, FLASH, and liquid crystal display (LCD) controller. The second data processor 101 is connected to the first external bus 103 via a first external interface circuit 119 as a device on the first external bus 103.

The second data processor 101 includes an internal high-speed bus 108 and an internal low-speed bus 115. The internal high-speed bus 108 is connected with a CPU 109, a cache memory 110, a digital signal processing processor (DSP) 111, a bridge circuit 112 as a bus bridge circuit between the internal high-speed bus 108 and internal low-speed bus 115, a first external interface circuit 119, a second external interface circuit 113 and a RAM 107. The internal low-speed bus 115 is connected with a serial interface circuit (SCI), a USB (Universal Serial Bus), a timer, a memory card interface circuit (MCIF), a general purpose input/output port (IOP) such as IO port, a clock pulse generator (CPG) and a peripheral circuit 116 such as flash memory. In Fig. 1, the clock pulse generator (CPG) is given the reference numeral 116a and the general purpose Input/output port (IOP) is given the reference numeral 116b.

The data processing system is configured, although not particularly restricted, as a mobile phone system. In this case, the first data processor 100 performs the baseband process. The second data processor 101 controls video display for the external

device 104 such as liquid crystal display controller and performs signal processes such as compression and expansion of signal. Controls such as display of time via the liquid crystal display controller are performed, although not particularly restricted, by the first data processor 100 via the second data processor 101.

The first external interface circuit 119 makes the first data processor 100 obtain the right for use of the internal bus of the second data processor, for example, the high-speed bus 108 and also makes the first data processor 100 having obtained the right for use of the internal bus 108 access to the input/output circuit connected to the internal bus 108. The input/output circuit means a resistor or the like of DSP 111. In short, the first data processor 100 is allowed to operate as a bus master of the internal high-speed bus 108. Such operation as the bus master is controlled by the internal bus control unit 106.

Moreover, the first external interface circuit 119 controls operation of the RAM as a common memory or a common buffer of the CPU 109 and first data processor 100. Namely, this first external interface circuit 119 operates the RAM 107 exclusively in response to the access request to the RAM 107 from the CPU and to the access request to the RAM 107 from the first data processor 100. With the common buffer function to this RAM 107, the data transfer can be realized between the

first data processor 100 and the second data processor 101. For this data transfer, the handshake control, for example, may be employed using an interruption signal 117. In more practical, when data is stored to the RAM 107 from the first data processor 100, the interruption signal 117 of the CPU 109 is given and the CPU 109 fetches the data of RAM 107 with the interruption process responding to such interruption. In the inverse occasion, the external interface circuit 119 issues an interruption request to the first data processor 100.

The second external interface circuit 113 has the interface specification to realize the interface for the external devices connected to the external bus 105. For example, when it is assumed that the FLASH and liquid crystal display (LCD) controller are connected as the external devices 104, the second external interface circuit 113 has the interface function as the flash memory interface circuit and LCD interface circuit.

In the structure of Fig. 1, a region 118 is provided with a switch circuit 114 for connecting the external bus 103 in the first external interface circuit to the external bus 105, in place of the connecting end to the external bus 105 in the second external interface circuit 113 while the second data processor 101 is in the waiting condition. Namely, the switch circuit 114 selects the connection profile to connect the first

external bus 103 to the second external bus 105 in place of the second external interface circuit 113 while the second data processor 101 is in the waiting condition. Accordingly, the first data processor 100 is capable of making access to a device on the second external bus 105 via a switching control unit 114. For example, the first data processor 100 is capable of controlling the liquid crystal display controller as the external device 104 on the external bus 105 via the switch circuit 114. Here, the circuit in the region 118 of Fig. 1 operates when the second data processor 101 is in the waiting condition.

In the waiting condition of the second data processor 101, supply of the clock signal to the CPU 109, DSP 111, serial interface circuit and clock synchronization circuit such as timer included in the relevant second data processor 101 is stopped. For example, when the CPU 109 sets a waiting condition enable bit to a waiting condition register of the clock pulse generator 116a, this clock pulse generator 116a stops the output operation of the clock signal CLK or the oscillating operation to stop the supply of clock signal.

In Fig. 1, the reference numeral 120 designates a power supply circuit. In the second data processor 101, the operation power source vdd1 of the switch circuit 114 and the operation power source vdd2 of the

other circuits can be isolated from each other. For example, an external power supply terminal and a power supply wiring of the operation power source vdd1 and an external power supply terminal and a power supply wiring of the operation power source vdd2 may be isolated physically. The power supply circuit 120 supplies the operation power sources vdd1 and vdd2 to the corresponding power supply terminals. The general purpose input/output port 116b is used as a power supply control circuit for the power supply circuit 120. The general purpose input/output port 116b stops supply of the operation power source vdd2 to the entire part or a part of the other circuits during the period where the second data processor 101 shifts to the waiting condition. The operation power source vdd1 is always supplied to the switch circuit 114 when the second data processor 101 can operate. When the second data processor 101 goes out of the waiting condition through the interruption, the operation power source is supplied to an interruption control circuit. The power supply control circuit 116b sets the power supply control register of the power supply circuit 120 to the power source supply stop instructing condition during transition to the waiting condition. Accordingly, supply of the operation power source vdd2 is stopped. Here, it is enough that the reset operation to the power source supply instructing condition for the power

supply control register is performed during the recovery process to the operating condition from the waiting condition.

Fig. 2 illustrates an example of detailed circuits in the region 118 of the second data processor 101 of Fig. 1. Moreover, in this example, the first external interface circuit 119 is connected as a bus master of the internal low-speed bus 115 with a signal line 200. As the signal line 200 of Fig. 2 illustrates, the internal bus where the first external interface circuit 119 operates as a bus master is not limited to the high-speed bus 108 and may be the low-speed bus.

In the data processor 1, a circuit formed in the region 118 is called a second circuit, while a circuit such as the CPU 109 formed in the other region is called a first circuit. The region 118 includes a first external terminal 210, a first bus 211 for connecting the first external terminal and the first circuit, a second bus 212 for connecting the first circuit and the second circuit, a third bus 213 for connecting the first external terminal and the second internal circuit, a second external terminal 215, a fourth bus 216 for connecting the second external terminal and the second circuit, a selector 217 for selecting any one of the second bus 212 and third bus 213 for connection to the fourth bus, a bus driver 218, and a fifth bus 219. The selector 217 selects the connection profile to connect

the first bus 211 to the fourth bus 216 during the period of transition to the waiting condition. When attention is paid to the condition of CPU 109, execution of instruction by the first circuit is controlled (first condition) in the waiting condition, while instruction is executed by the first circuit (second condition) in the operating condition. In the waiting condition, the second data processor 101 can connect, in direct, the first external bus 103 to the second external bus 105. In this example, data of the first external bus 103 is transferred, without any condition, to the second external bus 105 in the waiting condition of the second data processor 101, but it is also possible to connect the first external bus 103 and second external bus 105 by way of input/output buffer (not illustrated). Accordingly, input/output to the second external bus 105 from the first external bus 103 can be controlled.

In Fig. 1 and Fig. 2, the second data processor 101 is formed as the so-called single chip data processor formed on one semiconductor substrate.

Fig. 3 illustrates an example where a second data processor 300 is configured by a multi-chip module. The second data processor 300 is composed of the first external interface circuit 119, a chip 301 having the function of the switch circuit 114 and a chip 302 having the other functions. The chip 302 has a connecting unit 303 to the internal high-speed bus 108 as the first

external interface circuit 119 and the chip 301 connected to the connecting unit 303 can be operated as the bus master of the internal high-speed bus 108. The first external bus 103 can be connected to the second external bus 105 by operating only the chip 301 in the waiting condition of the second data processor 300.

Fig. 4 illustrates a practical example of the first external interface 119 of the second data processor 101. The first external interface circuit 119 is composed of an external bus access control unit 401, a bus conversion mediating unit 402, an internal bus access control unit 403, a RAM access control unit 404 and a reset/interruption control unit 405.

The access information from the first external bus 103 is inputted to the external bus access control unit 401 and is then transferred to the bus conversion mediating unit 402 through synchronization of the input information. The bus conversion mediating unit judges whether the relevant access is made to the RAM 107 or to the internal bus 108. When this access is issued to the internal bus 108, an access request is outputted to the internal bus access control unit 403 to drive the bus access operation depending on the bus access specification of the internal bus 108. In short, the address signal, bus access control signal and data are supplied to the bus 108 conforming to the bus access specification of the internal bus 108 and moreover the

data is received from the bus 108. When the access request is issued to the RAM 107, a memory access request is sent to the RAM access control unit 404 to drive the access operation conforming to the access specification of the RAM 107. In short, the address signal, memory control signal and data are supplied to the RAM 107 conforming to the memory access specification, and moreover the data is received from the RAM 107.

Issuance of interruption/reset instruction to the CPU 109 and interruption instruction from the CPU 109 are processed in the reset/interruption control unit 405 and the external bus access control unit 401 issues the corresponding request to the device on the first external bus 103. Moreover, the request from the device on the first external bus 103 and operation request from the RAM access control unit 404 are given, by the external bus access control unit 401, to the reset/interruption control unit 405 as the corresponding interruption request.

Fig. 5 illustrates another practical example of the first external interface 119 of the second data processor 101. In this figure, a practical example to realize interface for the bus 103, interface for the bus 115 and interface for the RAM 107 is illustrated. The first external interface circuit 119 includes a control circuit 410, an index register IDX and an address flag FG. The control circuit 410 includes a

register comprising a built-in control circuit such as an address register ADR, a data register DAT, a command register CMD, an access control register ACS and a status register STS. The address flag FG designates selection of the index register IDX when the logical value "1" is set and designates selection of the register comprising the built-in control circuit when the logical value "0" is set. Which register should be selected among the registers comprising a built-in control circuit when the logical value "0" is set is determined with the value of the index register IDX. The index register IDX and address flag FG are accessed via the first external bus 103. The bus 103 is composed of a data bus 103D, an address bus 103A and a control bus 103C. The register comprising a built-in control circuit is selected depending on the value of index register IDX, the address information, data information, bus access control information and command information are loaded to the corresponding register via the data bus 103D, and access to the RAM 107 and access to the bus 115 are driven depending on the command information loaded. For the access, in this case, a setting value of the register is used and the access timing is determined with the access control information. The data written to the RAM 107 via the external bus 103 can be accessed from the CPU 109 via the internal bus 108. The bus 108 is composed of a data bus 108D, an

address bus 108A and a control bus 108C. The bus 115 is composed of a data bus 115D, an address bus 115A and a control bus 115C.

Fig. 6 illustrates an example of initial write of a boot program of the data process in the data processing system of the present invention. In the example of Fig. 6, a memory 502 is allocated in the internal bus 115 of the CPU 109 and moreover a memory 501 is also allocated in the second external bus 105. In this example, although not particularly restricted, the memories 501, 502 are used as the user program storage regions. In this case, the boot program executed immediately after the second data processor 101 is reset is usually stored in the memory 501 or 502. In Fig. 6, the internal memory 502 is connected to the internal low-speed bus 115 but may also be connected to the internal high-speed bus 108. The internal memory 502 of the second data processor is an electrically reprogrammable nonvolatile memory such as a flash memory and may be formed on one semiconductor substrate together with the CPU 109 or the like or may be formed on different semiconductor substrate and also may be sealed in one package. When it is formed on the different semiconductor substrate and is then sealed in one package, it may be connected, within the package, to the second external bus 105 in place of connection to the internal buses 108, 115 of the second data

processor 101. Here, the electrically reprogrammable nonvolatile memories 501 and 502 are used as the program memory.

The initial write of program to the electrically reprogrammable nonvolatile memories 501, 502 has been performed using a write device such as an EPROM writer in the fabrication process of semiconductor integrated circuit such as a data processor 101. The example of Fig. 6 is based on the assumption that a boot program is not initially written in the nonvolatile memories 501, 502 in the initial stage where the data processor 101 is mounted on the data processing system. The data processing system of Fig. 6 enables initial write operation of the boot program from such initial stage. In short, the system for booting the second data processor 101 from the RAM 107 is comprised within the second data processor 101. Namely, the boot program of the second data processor 101 is written to the RAM 107 from the first data processor 100 via the first external bus 103 to control the second data process 101 to execute the program of the RAM 107 after such write operation. For this purpose, switching is required to drive the second data processor 101 with execution of the program of RAM 107 or with execution of the program of the memory 501 or 502. This switching operation is performed using level of a boot mode signal (BT) 503 when a reset signal (RES) 504 instructs the reset

operation. For example, when the boot mode signal 503 is in the high level during the period where the reset signal 504 is in the low level, the switching is driven by execution of program of RAM 107, while when the boot mode signal 503 is in the low level, the switching is driven by execution of program of the memories 501, 502.

A structure for initial write operation of the boot program will be described in detail. In the second data processor 101, the RAM 107 is set to the write-ready condition by the first data processor 100 in the first operation mode after the reset operation is cancelled by the reset signal 504. In the first operation mode, the boot mode signal 503 is set to the high level, for example, during the reset period where the reset signal 504 is set in the low level and thereby the reset signal 504 is negated to the high level to cancel the reset operation. In this case, the CPU 109 is controlled in the instruction fetch. In short, supply of start vector to the CPU 109 is controlled. As described above, in this case, the access to RAM 107 is extended to the first external interface circuit 106 by the first data processor 100. When write operation to the RAM 107 by the data processor 100 is completed, the start vector for designating the leading address of the RAM 107 is supplied to the CPU 109 with the command given to the first external interface circuit 119 from the data processor 100 or in response to change of the boot mode

signal 503 to the low level from the high level. Accordingly, the CPU 109 executes the program stored in the RAM 107. Here, since attention is paid to the initial write operation of a user program, it is enough when the program stored in the RAM 107 is at least the write control program of the user program. The user program itself may be transferred previously to the RAM 107 together with the program described above. Otherwise, it is also possible to initially write the user program to the memory 502 by reading this program from the serial interface circuit 116 or the like through execution of the write control program transferred to the RAM 107.

In the second operation mode after the reset operation is cancelled, the memory 501 or 502 is considered as the object of instruction fetch with the CPU 109. In the second operation mode, the boot mode signal 503 is set to the low level and the reset signal 504 is negated to the high level during the period where the reset signal 504, for example, is set to the low level, and thereby the reset operation is cancelled. Accordingly, the CPU 109 executes the user program initially stored in the memory 501 or 502 via the first operation mode.

The operation for storing the program for write control as the boot program to the RAM 107 from the first data processor 100 will be described.

First, prior to the booting the second data processor 101, the boot program inputted from the external storage such as memory 505 or memory card 506 connected to the first data processor 100 or from the serial interface (not illustrated) is written by the first data processor 100 to the RAM 107 of the second data processor 101.

The boot program transferred to the RAM 107 may include up to the application but a short boot program may be used when it includes the following processes. For example, the programs to be written to the memory 501 or 502 are stored to the program on the RAM 107 through the transfer of programs via the first external interface circuit 119 from the first data processor 100. Otherwise, the programs to be written by transferring a program to the memories 501, 502 are stored using the serial, USB terminals or memory card of the peripheral device 116 of the second data processor.

From above description, when the memories 501, 502 for boot of the second data processor 101 are flash memories, the system for initializing the flash memory has been required intrinsically in the post-process of the system assembling, but since the flash memory can be initialized in the mode for booting from the RAM 107, mass-production cost of the data processor 101 can be reduced.

Fig. 7 illustrates an example of timing chart of

the boot operation in the data processing system of Fig. 6.

The first data processor 100 supplies a boot mode signal 503 and a reset signal 504 to control the drive of the second data processor 101.

When the first data processor sets the boot mode signal 503 to the high level to cancel the reset (the reset signal shifts to the high level from the low level) and thereby the second data processor is driven in the mode of boot from the RAM 107. Accordingly, the boot program is transferred to the RAM 107 via the first external bus 103. The CPU 109 of the second data processor detects that the boot mode signal is in the high level and the boot program is fetched from the RAM 107 via the first external interface circuit 119. The CPU 109 is controlled to perform the instruction fetch during transfer of boot program and is therefore set in the waiting condition because the boot program is not supplied thereto. Upon completion of the transfer of boot program, the first data processor 100 transfers the transfer completion command to the first external interface circuit 119 and when the first external interface circuit 119 instructs fetch of the boot program to the CPU 109, the second data processor 101 is driven with the program of RAM 107. The CPU 109 executes the boot program in the RAM 107 and performs the write process of boot program to the memories 501,

502 via the internal high-speed bus 108. When the write process of the boot program to the memories 502, 502 is completed, the second data processor 101 is reset again (reset signal (RES) 504 is shifted to the low level from the high level) and this reset is cancelled under the condition that the boot mode signal (BT) 503 is set to the low level to drive the second data processor 101. Accordingly, the CPU 109 fetches the boot program from the memories 501, 502 to execute this program and thereby the data processing operation of the second data processor is driven.

The example of Fig. 7 illustrates the operation timing to supply the boot program to the memories 501, 502 from the memory 505 or memory card 506 connected to the first data processor 100 via the first external bus 103.

Fig. 8 illustrates an example of the other timing chart of the boot operation in the data processing system of Fig. 6. The timing illustrated in Fig. 8 assumes that the boot program stored in the memories 501, 502 is supplied via the serial and USB terminals 116 or the like of the second data processor 101. The others are same as that of Fig. 7.

Fig. 9 illustrates an example of the timing chart when the boot program is updated or the application executed by the second data processor 101 is added/updated under the condition that the boot program

is stored in the memory 501 or 502.

When the first data processor 100 sets the boot mode signal 503 to the low level to cancel the reset, the second data processor 101 starts the drive by fetching the boot program from the memories 501, 502. The memories 501, 502 previously store the transfer program for update of the boot program or addition/update of the application executed by the processor 2 and the transfer program is driven with drive instruction or the like from the first data processor 100. For example, the application for addition is received through radio communication via an antenna connected, for example, to the first data processor 100, the first data processor 100 transfers the received application for addition to the RAM 107 via the external bus 103. The second data processor 101 fetches the application for addition stored in the RAM 107 to the internal bus 108 via the first external interface circuit 119 and then transfers this application to the memory 501 or 502 for the write operation.

Fig. 10 illustrates an example of the cross-sectional view of a multi-chip module forming the data processor 300 of Fig. 3. On one plane of the high density mounting board 510, many bump electrodes 511 connected to the mounting surface of a printed circuit board formed of a glass epoxy substrate are allocated,

while on the other plane, many micro-bump electrodes 512 and pad electrodes 513 connected to the bump electrodes 511 are allocated. At a part of the micro-bump electrodes 512, a bonding pad of the semiconductor chip 302 is mounted on the face-down basis. The other semiconductor chip 301 is stacked for allocation on the semiconductor chip 302 and the bonding pad of this semiconductor chip 301 is connected to the corresponding pad electrode 513 with a bonding wire 515. The entire part of the bonding wire 515 and semiconductor chips 301, 302 are molded with resin 516.

The present invention has been described on the basis of the preferred embodiment thereof but the present invention is never limited thereto and allows various changes and modifications within the scope of the claims thereof.

For example, the peripheral circuits and the other circuit modules comprised in the data processor are not limited to those described with reference to Fig. 1 and may be changed as required. The internal bus of the data processor may not be sorted as the high-speed bus and low-speed bus. In addition, the operation supply systems for the first circuit and second circuit are not always separated from the external power source terminals and stop of supply of the power source may be controlled with a switch circuit. In addition, when the data processor is formed as the multi-chip module,

kind of the semiconductor integrated circuit to be loaded is not limited only to that described above and three chips in total such as a semiconductor chip like the flash memory 502, a processor core chip such as the other CPU 109 and an interface chip like the semiconductor chip 301 may be mounted. A plurality of flash memory chips may also be mounted to the multi-chip module.

As described above, the present invention may be widely applied to the data processing system which is intended to dispersion of processing loads using a plurality of data processors such as the mobile phone system, display control system, printer system and the other mobile information terminals and to the data processor which utilizes such data processing system.

WHAT IS CLAIMED IS:

1. A data processing system comprising a first data processor and a second data processor,

wherein said second data processor further comprises an interface circuit which makes said first data processor obtain a bus right for use of an internal bus of said second data processor and

wherein said interface circuit makes said first data processor having obtained said bus right for use of said internal bus access to an input/output circuit connected to said internal bus.

2. A data processing system according to claim 1, wherein said input/output circuit comprises one or more circuits selected from an SDRAM interface circuit for connecting to an SDRAM, an LCD interface circuit for connecting to a liquid crystal display device, a memory card interface circuit for connecting to a memory card, a volatile memory interface circuit, an electrically erasable/programmable nonvolatile memory interface circuit and a general purpose input/output port.

3. A data processing system according to claim 2, wherein said interface circuit includes a buffer RAM which can operate exclusively in response to access from said second data processor and access from said first data processor.

4. A data processing system comprising:
a first data processor;

a first bus connected to said first data processor;
a second data processor connected to said first bus; and

a second bus connected to said second data processor,

wherein said second data processor further comprises a first external interface circuit connected to said first bus in a one terminal and to an internal bus in an other terminal,

a second external interface circuit connected to said second bus in a one terminal and to said internal bus in an other terminal, and

a switch circuit for connecting said one terminal of said first interface circuit to said second bus in place of said one terminal of said second external interface circuit under the condition that said second data processor is in a standby condition.

5. A data processing system according to claim 4, wherein supply of a clock signal to a clock synchronization circuit included in said second data processor is stopped during said standby condition of said second data processor.

6. A data processing system according to claim 5, further comprising a power supply control circuit which is capable of separating an operation power source of said switch circuit and an operation power source of other circuits in said second data processor and is

capable of also stopping the supply of said operation power source to the entire part or a part of said other circuits in response to said standby condition of said second data processor.

7. A data processing system according to claim 6, wherein said second external interface circuit includes an LCD interface circuit which may be connected to a liquid crystal display controller,

wherein said second bus is connected with the liquid crystal display controller, and

wherein said first data processor can control said liquid crystal display controller via said switch circuit.

8. A data processing system comprising a first data processor and a second data processor,

wherein said second data processor includes a nonvolatile memory to which data may be written with said first data processor in a first operation mode after a reset operation is completed,

a CPU which fetches instruction from said nonvolatile memory after said writing in said first operation mode, and

an electrically erasable/programmable nonvolatile memory from which the CPU fetches instruction in a second operation mode after said reset operation is completed, and

wherein said first data processor designates said

first operation mode to said second data processor and stores, to said volatile memory, a write operation control program for said nonvolatile memory and then instructs said CPU to fetch instructions of said write operation control program.

9. A data processing system comprising:

a first data processor;

a second data processor; and

an electrically erasable/programmable nonvolatile memory,

wherein said second data processor includes a volatile memory to which data may be written with said first data processor in a first operation mode after a reset operation is completed, and a CPU which fetches instructions from said volatile memory after said writing in said first operation mode,

wherein said nonvolatile memory is fetched the instruction by said CPU in a second operation mode after said reset operation is completed, and

wherein said first data processor designates said first operation mode to said second data processor and stores, to said volatile memory, a write control program for said nonvolatile memory and then instructs said CPU to fetch instructions of said write control program.

10. A data processor comprising a CPU, an internal bus connected to said CPU, a peripheral circuit connected to said internal bus, a first external interface circuit

connected in one terminal to a first external terminal and in the other terminal to said internal bus, and a second external interface circuit connected in one terminal to a second external terminal and in the other terminal to said internal bus,

wherein said first external interface circuit obtains the right for use of said internal bus in response to the access request from an external side and allows said internal bus to access to said peripheral circuit connected to said internal bus.

11. A data processor according to claim 10, further comprising a switch circuit to connect said first external terminal, in place of one terminal of said second external interface circuit, to said second external terminal during the waiting condition of the CPU.

12. A data processor according to claim 11 further comprising a nonvolatile memory to which data can be written from an external side via said first external interface circuit in a first operation mode after the reset operation is cancelled and a program memory,

wherein said CPU can fetch and execute instruction from said nonvolatile memory after the write operation in said first operation mode and can also fetch and execute instruction from said program memory in a second operation mode after the reset operation is cancelled.

13. A data processor according to claim 12, wherein

said program memory is an electrically erasable/programmable nonvolatile memory.

14. A data processor according to claim 13, wherein said CPU, internal bus, first external interface circuit, second external interface circuit, switch circuit, nonvolatile memory and program memory are formed on one semiconductor substrate.

15. A data processor according to claim 13, wherein said CPU, internal bus, first external interface circuit, second external interface circuit, switch circuit and nonvolatile memory are formed on a first semiconductor substrate, said program memory is formed on a second semiconductor substrate, and said first semiconductor substrate and second semiconductor substrate are sealed in one package.

16. A data processor comprising a first terminal connected to a first bus, a second terminal connected to a second bus, a first internal circuit and a second internal circuit which can selectively take a first condition or a second condition, a first signal route connected to said second terminal from said first terminal via said first and second internal circuits and a second signal route connected to said second terminal from said first terminal via said second internal circuit,

wherein said second internal circuit selects, depending on the condition of said first internal

circuit, any signal route of said first signal route and second signal route.

17. A data processor according to claim 16,

wherein said first condition is the operating condition where said first internal circuit executes instructions and said second condition is the waiting condition where execution of instruction is suspended, and

wherein said second internal circuit selects said first route in the operating condition and selects the second route in the waiting condition.

18. A data processor according to claim 16, further comprising a power supply control circuit for controlling supply of a first power source for said first internal circuit and supply of a second power source for said second internal circuit,

wherein said power supply control circuit stops supply of the first power source to the entire part or a part of said first internal circuit when said second signal route is selected with said second internal circuit.

19. A data processor according to claim 18, wherein said first internal circuit, second internal circuit and power supply control circuit are formed on one semiconductor substrate.

20. A data processor according to claim 18,

wherein said first internal circuit and said power

supply control circuit are formed on a first semiconductor substrate, said second internal circuit is formed on a second semiconductor substrate, and

wherein said first semiconductor substrate and second semiconductor substrate are sealed in one package.

21. A data processor according to claim 16, further comprising a clock control circuit to supply a clock signal for synchronous operation to said first internal circuit,

wherein said clock control circuit stops, when said second signal route is selected with said second internal circuit, supply of the clock signal to said first internal circuit.

22. A data processor according to claim 21, further comprising a power supply control circuit for controlling supply of a first power source to said first internal circuit and supply of a second power source to said second internal circuit,

wherein said power supply control circuit stops, when supply of the clock signal to said first internal circuit is stopped, supply of power source to the entire part or a part of said first internal circuit.

23. A data processor according to claim 22, wherein said first internal circuit, second internal circuit, clock control circuit and power supply control circuit are formed on one semiconductor substrate.

24. A data processor according to claim 22, wherein said first internal circuit and clock control circuit and power supply control circuit are formed on a first semiconductor substrate, said second internal circuit is formed on a second semiconductor substrate, and said first semiconductor substrate and second semiconductor substrate are sealed in one package.

25. A data processor comprising a first terminal connected to a first bus, a second terminal connected to a second bus, a first internal circuit, a second internal circuit, a first signal wiring for connecting said first terminal and said first internal circuit, a second signal wiring for connecting said first internal circuit and second internal circuit, a third signal wiring for connecting said first terminal and said second internal circuit, and a fourth signal wiring for connecting said second internal circuit and said second terminal,

wherein said second internal circuit includes a selecting means for selecting said second signal wiring or said third signal wiring to be connected to the fourth signal wiring.

26. An information processing system comprising a first bus, a second bus and a data processor connected to said first bus and second bus,

wherein said data processor has a first operation status and a second operation status,

wherein said data processor processes, in said first operation status, the information supplied from said first bus and supplies the predetermined information to said second bus, and

wherein said data processor also supplies, in said second operation status, the information supplied from said first bus to said second bus in direct.

27. A mobile phone system comprising:

a first semiconductor integrated circuit;

a second semiconductor circuit;

a third semiconductor circuit;

a first bus for connecting said first semiconductor integrated circuit and second semiconductor integrated circuit; and

a second bus for connecting said second semiconductor integrated circuit and third semiconductor integrated circuit,

wherein said second semiconductor integrated circuit has a first operation status and a second operation status,

wherein said second semiconductor integrated circuit performs a predetermined process based on information supplied from said first semiconductor integrated circuit and then supplies a result of said process to said third semiconductor integrated circuit in said first operation status, and

wherein said second semiconductor integrated

circuit supplies in direct information supplied from said first semiconductor integrated circuit to said third semiconductor integrated circuit in said second operation status.

28. A mobile phone system according to claim 27, wherein said first semiconductor integrated circuit supplies a control signal to decide status of said second semiconductor integrated circuit between said first operation status or said second operation status.

29. A mobile phone system according to claim 28, wherein said first semiconductor integrated circuit is for baseband process, while said third semiconductor integrated circuit is for display control.

30. A mobile phone system according to claim 29, wherein said predetermined process is the signal process at least for video signal.

31. A mobile phone system according to claim 30, wherein a storage device is connected to said second bus and said storage device stores a processing program which specifies the processes to be executed with said second semiconductor integrated circuit.