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Method, adapter card and arrangement for the  
5 installation of memory modules

The invention relates to a method for an installation  
of memory modules without signal-conditioning means on  
slots of a system, whereby initially a system  
10 motherboard which has the slots and a number of memory  
modules without signal-conditioning means is provided.

In modular electronic systems with variable  
configurations, a system motherboard with one or a  
15 plurality of slots is normally provided. Depending on  
the requirements of the system or the configuration  
level of the system, the slots are in each case  
equipped with a memory module or are unequipped. The  
interfaces of the memory modules are by necessity  
20 identical or compatible with one another.

A typical example of a modular memory system of this  
type is a computer system (PC, workstation, server)  
with expandable base memory, whereby slots for memory  
25 modules in the form of plug-in sockets are provided on  
the system motherboard and, depending on the required  
size of the base memory, are equipped with memory  
modules. Furthermore, the plug-in sockets in each case  
establish an electrical connection between signal lines  
30 on the substrate and contact areas on the memory  
modules. The memory modules are normally provided in

the form of SIMMs (single inline memory modules) or DIMMs (dual inline memory modules).

The plug-in sockets enable simple exchange or simple  
5 retrofitting of the memory modules.

The requirements for the design of the bus system signal lines increase with higher clock rates and data transmission rates to and from the memory modules.

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A data transmission rate of 667 Mbit per second and per data signal (Mbit/s/pin) is proposed here for DDRII bus systems for DDR-DRAMs (double data rate dynamic random access memories), and a data transmission rate of 1.2  
15 Gbit/s/pin is proposed for DDRIII bus systems. With these data transmission rates, substantial outlay is required to ensure signal integrity at a respective receive location of data signals transmitted on the bus system signal lines, since a parasitic capacitance  
20 allocated to the signal line is too high to be able to be recharged quickly enough by a bus-monitoring chip or by memory chips arranged on the memory modules. Furthermore, signal integrity is adversely affected by reflections at interference points as the clock rate  
25 increases.

It is therefore proposed to insert buffer chips for signal conditioning between the memory chips and the bus system signal lines, similar to those already known  
30 from DDRI bus systems for control and address signals.

In DDRI bus systems, for configurations with two and more memory modules, the memory modules are provided with signal-conditioning means such as buffer chips and/or buffer memories (registered DIMMs). Since the bus system signal lines are then no longer connected to all memory chips arranged on the memory modules, but to one memory chip only, the capacitive load of the signal lines represented by the memory module and the number of interference points are reduced. The disadvantage of this solution is the need for a delay cycle (latency) between the transmission of control and address signals on the control and address lines on the one hand and the transmission of data on data lines on the other hand. In a write cycle, the control and address signals are initially transmitted to a buffer or buffer memory and are only transmitted to the memory chips in a following cycle together with the data signals which are output following a one-cycle delay.

The delay cycle significantly reduces the data transmission rate, particularly in the case of random address accesses.

If signal-conditioning means are implemented for DDRII and DDRIII bus systems, the signal-conditioning means must be provided either on the memory modules or on the system motherboard.

Both solutions result in serious disadvantages.

An arrangement of the signal-conditioning means on the memory modules on the one hand increases the cost of the memory modules and, on the other hand, testing of

the memory modules is rendered difficult. The reason for this is that, as the memory chips are no longer directly accessible via the memory module interface, the outlay required, for example, to test for adequate  
5 time conditions (time margins, skew) in the memory chips is considerably increased.

If, however, the signal-conditioning means are provided on the system motherboard, the signal-conditioning  
10 means are also functional for configurations in which they are not required, and reduce the functionality (performance) of the memory modules due to the then essentially superfluous delay cycles.

15 The object of the present invention is therefore to provide a method for installing memory modules, with which a memory volume of a system, limited by a number of slots, is in each case increased in a simple manner, and a data transmission rate within the system can be  
20 adapted to the relevant memory volume, whereby the memory modules can be designed with little outlay. The object of the invention is furthermore to provide an adapter card and an arrangement with the adapter cards for this purpose.

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This object is achieved with a method of the aforementioned type according to the invention by the features indicated in the characterizing part of patent claim 1. The object is furthermore achieved according  
30 to the invention by an adapter card with the features indicated in the characterizing part of patent claim 3 and an arrangement with the features indicated in the

characterizing part of patent claim 12. Advantageous further developments of the invention are indicated in each case in the subclaims.

- 5 In the method according to the invention, memory modules are therefore arranged on an adapter card which has signal-conditioning devices. The adapter card is then installed in a system. Here, the memory modules arranged on the adapter card are provided here without  
10 signal-conditioning means (unbuffered, unregistered, referred to below as unbuffered), but are then operated as buffered memories from the perspective of the system.
- 15 With the method according to the invention, systems can therefore be adapted in a very simple and flexible manner according to requirements. The memory volume of a system can be increased in a simple manner by a multiple. Systems with a low memory volume can be  
20 operated at very fast data transmission rates through the installation of solely unbuffered memory modules.

On the other hand, through the use of the adapter card, the load on the bus system signal lines is reduced  
25 exclusively in systems for which a large memory volume is required, at the expense of the data transmission rate, without special measures on a system motherboard or a special type of memory module being required for that purpose.

The systems can be optimized in terms of memory volume and data transmission rate with a single type of unbuffered memory module.

5 In detail, therefore, in the method according to the invention for an installation of memory modules on slots of a system, a system motherboard which has the slots, a number of memory modules without signal-conditioning means, and at least one adapter card which  
10 in each case has at least one plug-in socket and a signal-conditioning device are initially provided. A subset of the memory modules is then arranged in the plug-in sockets of the adapter card and the adapter cards, equipped in each case with one or more memory  
15 modules, are provided on the slots of the system.

The unbuffered memory modules which have no signal-conditioning means are then to be operated by the system in the manner of buffered memory modules i.e.  
20 memory modules with signal-conditioning means.

The adapter cards are preferably equipped with the memory modules before the adapter cards, which are then provided in each case with one or more memory modules,  
25 are arranged on the slots.

Here, a combined equipment of the slots is also possible for system optimization, whereby a buffered or an unbuffered memory module is provided on at least one  
30 slot and an adapter card equipped with memory modules is provided on one of the remaining slots.

An adapter card according to the invention for the installation of memory modules on slots of a system comprises a substrate, at least one plug-in socket in each case to accommodate one of the memory modules, an  
5 interface compatible with one of the slots and, in addition, a signal-conditioning device to operate unbuffered memory modules arranged in the plug-in sockets without signal-conditioning means in the manner of buffered memory modules with signal-conditioning  
10 means.

If the adapter card has more than one plug-in socket, the memory volume of the system, which is restricted by the number of slots, can be simply increased to a  
15 multiple.

The adapter card according to the invention preferably has an even number of plug-in sockets, as this then advantageously produces a symmetrical arrangement of  
20 the memory modules with identical line lengths.

According to a first preferred embodiment of the adapter card, the plug-in sockets are arranged horizontally in pairs opposite one another on the  
25 substrate for this purpose. This advantageously produces an arrangement of the memory modules which lies parallel to the substrate or a substrate surface and is therefore space-saving. Very short gaps between the slots are then possible.

30

If the horizontally-mounted plug-in sockets are provided in an area removed from the interface on the

substrate and are oriented towards the interface, the signal-conditioning device can be arranged in the immediate vicinity of the interface. This advantageously produces a short feeder line from the interface to the signal-conditioning device. A short feeder line has a favorable effect on the reflection behavior and on a change to a signal transmitted on the feeder line caused by a loss-affected signal line (transmission line).

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In a second preferred embodiment, the plug-in sockets are arranged on the adapter card according to the invention on one of the two surfaces of the substrate and are vertically mounted. The memory modules provided in the plug-in connections are then arranged perpendicular to the surface of the substrate. This embodiment also produces an advantageous short feeder line from the interface to the signal-conditioning device.

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Here, the signal-conditioning device preferably comprises two DQ buffers for the signal conditioning of data signals and one CA buffer for the signal conditioning of control and address signals. Due to the two DQ buffers, signal lines for the transmission of data signals can follow a shorter route to the respective DQ buffer with fewer reflection points. The DQ buffers are preferably arranged in a line parallel to the interface, whereby the CA buffer is provided between the two DQ buffers.

30

Each signal-conditioning device has conventionally designed buffer and/or PLL (phase locked loop) devices.

However, the adapter card according to the invention preferably has precisely two plug-in sockets, whereby an interface between the adapter card and the system motherboard compatible with the electrical interface of the memory modules can be implemented. The additionally required addressing of the plurality of memory modules arranged on an adapter card can be implemented by means of the available interface.

In addition, for the addressing of the plurality of memory modules arranged on the adapter, it is also possible to define the adapter card interface with a higher number of pins compared with the interface of the memory modules, or, in the case of an equal number of pins, with a different pin assignment.

The adapter card according to the invention preferably also has an interface which is mechanically compatible with corresponding interfaces of the memory modules. The adapter card according to the invention is then fully compatible with the memory modules and can be arranged in the system, even in combined configurations, with individual memory modules without modifying the system motherboard. There is no need to adapt the systems to the adapter cards.

In the second preferred embodiment of the adapter card according to the invention with vertically mounted plug-in sockets on one of the two surfaces of the

substrate, an adequate gap, corresponding roughly to the installation height of the memory modules, must be provided between the slots of the system motherboard. If the adapter card is then provided in two types with  
5 plug-in sockets arranged as a mirror image of one another, two adapter cards of different types can be arranged very close to each other, thus advantageously producing very short connection lengths between the slots, and therefore very small transit time  
10 differences of signals transmitted on corresponding signal lines.

The invention is explained in detail below with reference to figures, wherein the same reference  
15 symbols are used for corresponding components. In the figures:

**Fig. 1** shows schematic cross-sections through arrangements with an adapter card according to the invention according to a first  
20 exemplary embodiment of the invention.

**Fig. 2** shows a side view of an arrangement with an adapter card according to the invention according to the first exemplary embodiment  
25 of the invention, and

**Fig. 3** shows schematic cross-sections through arrangements with an adapter card according to the invention according to a second  
30 exemplary embodiment of the invention.

Figs 1a to 1c in each case show a cross-section through an arrangement with a system motherboard 3, a bus-monitoring chip 31 arranged on the system motherboard 3 and two slots 1 in each case shown as a plug-in socket.

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In Fig. 1a, both slots 1 are equipped with memory modules 2 having memory chips 21.

In Fig. 1c, on the other hand, adapter cards 4 are  
10 arranged on the two slots 1. Here, each adapter card 4 comprises a substrate 40, an interface 45, which has contact elements 44, to the slot 1, a signal-conditioning device 41, two plug-in sockets 42, and also contact devices 43, via which the memory modules 2  
15 arranged in the plug-in sockets 42 are electrically connected to lines provided on or in the substrate 40.

The plug-in sockets 42 are arranged opposite one another on the substrate 40 and are mounted  
20 horizontally for an arrangement of the memory modules 2 which is horizontal to the substrate 40. This produces the indicated, space-saving arrangement of the memory modules 2 in the plug-in sockets 42 of the adapter cards 4.

25

Fig. 1b shows an arrangement in which a left slot 1 is equipped with an adapter card 4, and a right slot is equipped with a memory module 2.

30 Fig. 2a shows a slot 1, a memory module 2 which has memory chips 21, a module interface 22 and indentations 23, and an adapter card 4. An interface 45 which has

contact elements 44 is formed along one edge of a substrate 40 of the adapter card 4. Two DQ buffers 411 and one CA buffer 412 are arranged in a line parallel to a plug-in socket 42. Contact devices 43 are arranged between the plug-in socket 42 and the substrate 40. The memory module 2 may be arranged in the plug-in socket 42. In this example, the module interface 22 and the interface 45 of the adapter card 2 are electrically compatible.

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Furthermore, the illustration shows that the adapter card 4 has indentations 23', which are formed in the same way as the indentations 23 of the memory module 2 as counterparts to fixing devices 12 of the slot 1. Mechanical compatibility between the adapter card 4 and the memory module 2 is thereby also achieved.

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This compatibility becomes clear through comparison with Fig. 2b, in which a memory module 2 with indentations 23 is shown on a slot 1 with fixing devices 12.

20

Figs 3a to 3c in turn show a cross-section through an arrangement with a system motherboard 3, a bus-monitoring chip 31 arranged on the system motherboard 3 and two slots 1 represented as plug-in sockets.

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Here, Fig. 3a differs from Fig. 1a which has already been described in terms of the shorter gap between the two slots 1, 1'.

30

The reason for this, as shown in Fig. 3b, is that the adapter cards 4 differ from the adapter cards described in Fig. 1 in terms of vertical mounting of plug-in sockets 42 arranged on a surface of the substrate 40.

5 The vertically mounted plug-in sockets 42 enable an arrangement of the memory modules 2 perpendicular to a substrate surface 401. Furthermore, a signal-conditioning device 41 is arranged on the surface opposite the plug-in sockets 42.

10

If either two mirror-image types of adapter cards 4 are then provided, or if the right slot 1' is arranged rotated through  $180^\circ$  in relation to the left slot 1, this in each case produces the arrangement shown with, 15 in a particularly advantageous manner, very short connections between the two slots 1, 1'.

Fig. 3c, corresponding to Fig. 1c, shows a combined connection arrangement, in which an adapter card 4 is 20 arranged in the left slot 1 and a memory module 2 is arranged in the right slot.

## Reference symbols

|           |                            |
|-----------|----------------------------|
| 1, 1'     | Slot                       |
| 12        | Fixing device              |
| 2         | Memory module              |
| 21        | Memory chip                |
| 22        | Module interface           |
| 23, 23'   | Indentation                |
| 3         | System motherboard         |
| 31        | Bus-monitoring chip        |
| 4, 4'     | Adapter card               |
| 40        | Substrate                  |
| 401, 401' | Substrate surface          |
| 41        | Signal-conditioning device |
| 411       | DQ buffer                  |
| 412       | CA buffer                  |
| 42        | Plug-in socket             |
| 43        | Contact device             |
| 44        | Contact element            |
| 45        | Interface                  |

## Claims

1. A method for an installation of memory modules (2) without signal-conditioning means on slots (1, 1') of a system, whereby a system motherboard (3) which has the slots (1, 1') and a number of memory modules (2) without signal-conditioning means is provided, characterized in that
- at least one adapter card (4) which has at least one plug-in socket (42) and a signal-conditioning device (41) is provided,
  - at least one subset of the memory modules (2) is arranged in the plug-in sockets (42) of the adapter card (4), and
  - the adapter cards (4) equipped in each case with at least one memory module (2) are provided on at least one of the slots (1, 1') of the system, so that the memory modules (2) without signal-conditioning means are then operated in the system in the manner of memory modules (2) with signal-conditioning means.
2. The method as claimed in claim 1, characterized in that a memory module (2) with signal-conditioning means is provided on at least one of the slots (1, 1').
3. An adapter card for the installation of memory modules (2) on slots (1, 1') of a system, comprising
- a substrate (40),
  - at least one plug-in socket (42) in each case to accommodate one of the memory modules (2), and

- an interface (45) compatible with one of the slots (1, 1'),

characterized by

a signal-conditioning device (41) for the operation of  
5 memory modules (2) arranged in the plug-in sockets (42)  
without signal-conditioning means in the manner of  
memory modules (2) with signal-conditioning means.

4. The adapter card as claimed in claim 3,

10 characterized by

an even number of plug-in sockets (42).

5. The adapter card as claimed in claim 4,

characterized in that

15 the plug-in sockets (42) are arranged horizontally in  
pairs opposite one another on the substrate (40), and  
the memory modules (2) are arranged parallel to a  
substrate surface (401).

20 6. The adapter card as claimed in one of claims 3 to 5,  
characterized in that

the plug-in sockets (42) are provided in an area  
removed from the interface (45) on the substrate (40),  
and the memory modules (2) provided in the plug-in  
25 sockets (42) are oriented towards the interface (45).

7. The adapter card as claimed in one of claims 3 or 4,  
characterized in that

the plug-in sockets (42) are arranged vertically on a  
30 surface of the substrate (40) and the memory modules  
(2) provided in the plug-in sockets (42) are arranged  
perpendicular to the surface of the substrate (40).

8. The adapter card as claimed in one of claims 3 to 7,  
characterized in that  
the signal-conditioning device (41) comprises two DQ  
5 buffers (411) arranged in a line parallel to the  
interface (45) for the signal conditioning of data  
signals, and one CA buffer (412) provided between the  
two DQ buffers (411) for signal conditioning of control  
and address signals.
- 10
9. The adapter card as claimed in one of claims 3 to 8,  
characterized in that  
the signal-conditioning device (41) comprises a buffer  
device and/or a PLL device.
- 15
10. The adapter card as claimed in one of claims 3 to  
9,  
characterized by  
precisely two plug-in sockets (42).
- 20
11. The adapter card as claimed in one of claims 3 to  
10,  
characterized by  
mechanical compatibility of the interface (45) with  
25 corresponding interfaces of the memory modules (2).
12. An arrangement with two slots (1, 1') arranged on a  
system motherboard (3) and a first (4) and a second (4')  
adapter card as claimed in one of claims 7 to 11,  
30 characterized in that  
the plug-in sockets (42) are provided on a first  
substrate surface (401) on the first adapter card (4)

and the plug-in sockets (42) are provided on a substrate surface (401') located opposite the first substrate surface (401) on the second adapter card (4'), and the slots (1, 1') are arranged immediately  
5 adjacently.