

Advanced didactic computer trainer for the simulation and checking of the functional blocks of a Personal Computer

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In this work we have developed a very useful hardware and software tool for the student: a didactic computer trainer. It is an advanced didactic tool that permits the study and configuration of all the elements present in any state-of-the-art multimedia PC. It is composed of some hardware components which are very well-known in the market, made of the most advanced technology and of high reliability. The system incorporates a block diagram over which the main functional blocks of a computer are displayed. Multiple test points allow the student to visualize the main electrical signals, both from the hardware of the PC and its peripherals, in order to facilitate the comprehension of how every module works in a computer. Finally, the student will be capable of establishing diagnosis methods and even of repairing computer faults.

Keywords Didactic computer; performance estimation; didactic trainer; fault simulator

1. Introduction

The computer trainer can be viewed as an advanced didactic tool, purposely built to be used in several areas and university degrees such as Computer Engineering and Electrical Engineering, which makes it especially suitable in the Computer & Electrical Engineering School of the University of Granada. The computer trainer can cover the theoretical and practical learning of, among other, the following matters:

- Configuration of a personal computer with its corresponding peripherals.
- Installation and configuration of the operating system.
- Verification and diagnosis of a personal computer.
- Architecture and operation of the PC hardware.
- Mono-user and multi-user operating systems.
- Introduction and removal of viruses.
- Multimedia and communications.
- Possibility of introducing real faults.

With the diagnosis software we can test and certify the correct operation of a personal computer, giving the user information about the internal content of the machine. The trainer integrates in just one module a powerful multimedia PC Pentium® IV with AGP port, with integrated audio system and equipped with video card, modem/fax, fault module and an active block diagram with which we can analyse the main hardware signals from both the PC and its peripherals. For the diagnosis and repair of the PC, a Diagnosis Kit is available, which contains the software packages and hardware necessary for:

- Checking the PCI bus.
- Visualizing the auto-checking codes (POST).
- Diagnosing failures of the floppy disk controller.
- Examining the technical data of the system.
- Checking the floppy disk operation (read / write /seek).
- Base memory and extended memory checking.
- CMOS configuration.
- Video checking.
- Parallel and serial ports checking.

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- Low level formatting.

2. Elements of the computer trainer

The computer trainer is composed of a powerful microprocessor Pentium® IV, together with some additional software and hardware elements that permit the student familiarize, recognize and diagnose the main elements of a computer, check the state of a system and simulate and locate faults. In the following sub-sections we present all these components in deeper detail.

2.1 Multimedia Pentium® IV Computer

The computer of our computer trainer has the following characteristics:

- Intel Pentium® IV 2,8 GHz processor or superior.
- INTEL motherboard with AGP port (Advanced Graphics Port).
- 256 MB DDR (333 MHz) or superior.
- BIOS Intel/AMI flash EEPROM.
- 1 AGP slot (64 bits).
- 5 PCI slots.
- 8 USB 2.0 ports (4 externally accessible).
- 2 serial ATA channels.
- 1 serial port.
- 1 parallel port.
- 1 video card 32 MB AGP or superior.
- AC'97 audio system.
- 1 floppy disk unit 3½ 1,44 MB.
- 1 hard disk unit with 80 GB (7200 rpm) or superior.
- 1 DVD unit X16 or superior.
- 1 internal Modem/Fax with 56000 bps.
- Accessories: 1 Windows keyboard.

2.2 Block diagram

To facilitate the comprehension of all the system by the student, in the internal side of the folding superior cover of the trainer, there is a colour block diagram, representing all the functional modules of the computer. Its test points permit the access to the main signals of the PC. The motherboard of the system is shown in Fig. 1, together with the schematic block diagram, which is actually hard-implemented in a panel which, by means of an LED display, shows the data flow and the modules presently being used during the execution of a computer program.

2.3 Diagnosis and repair software EXPERTCHECK

This software can check and quickly certify the correct operation of the computer, providing information about the internal content of the PC and the origin of hardware problems.

2.4 POST codes detection module

It is a board that displays the POST codes and the state of several PCI bus lines.

2.5 Serial port check module

It allows us to check the serial ports by means of an external loop. It loads some specific signals into the data lines so that a real activity of a serial peripheral can be simulated.

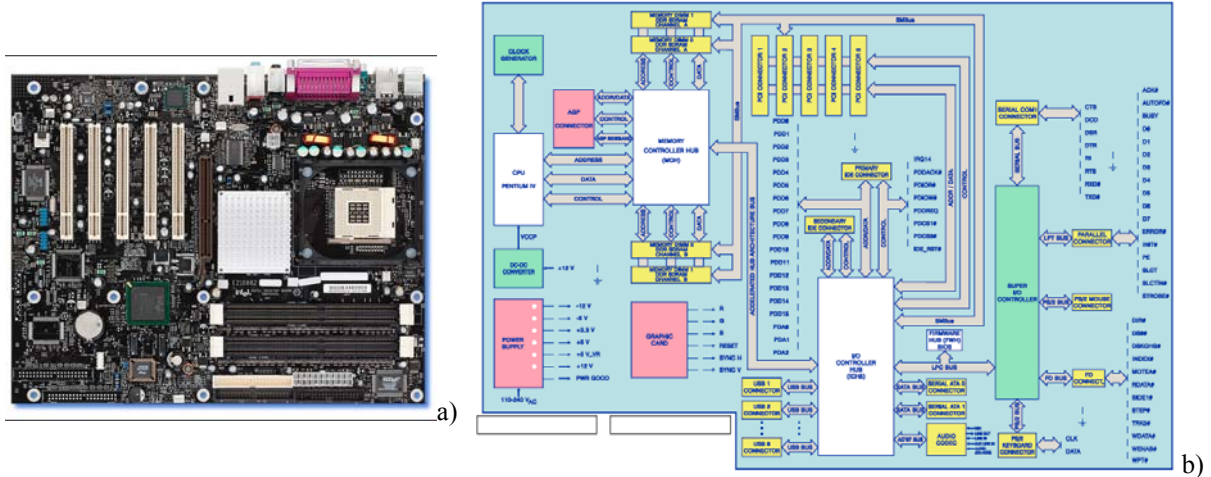


Fig. 1 a) Main board of the computer trainer b) Interactive block diagram of the computer trainer

2.6 Parallel port check module

It checks the integrity of the printer cables and the parallel port itself. It contains some LED displays to check all line signals. Eight of the LEDs display the state of the eight data bits (D1 to D8) and the other two are spares.

3. Fault module

The fault module is capable of generating faults over different modules of the computer. These faults are provoked using several micro-switches, protected with a key-lock. The test points throughout the block diagram are connected to different points throughout the PC hardware. With them it is possible to check and measure the most important signals and levels involved in the operation of the PC. To analyse all these signals it is advised to use a digital oscilloscope and an x10 probe, whose ground must be connected to the ground (GND) of the block diagram nearest the test point in question. All signals must be measured with respect to this ground (GND) of the block diagram, being the supervision from the teacher highly recommended in this case. The hardware fault generation is attained through the manipulation of certain computer signals. The teacher can generate the faults that he/she considers most convenient for the practical experiment or to evaluate the knowledge acquired by the students. It is advisable not to provoke multiple faults since it is more didactic to provoke individual faults, activating just once switch at a time. To analyse the faults provoked, the Diagnosis Kit can be used together with other necessary tools or devices (oscilloscope, multimeter, logic analyser, etc.). In the following list, we mention just a few examples of some faults that can be simulated with our computer trainer:

GRAPHIC CARD FAULT
TP: R (RED)
Signal description: Red signal.
Instrument: Oscilloscope.
Circuitry connection: Monitor terminal connector #1.
Fault switch: SW F-7 ON.
Fault description: Drift to ground of the signal.

<p>Simulated Fault: Lack of red colour in the monitor, white colour is seen as cyan colour, ...</p> <p>TP: : SYNC V (<i>SYNC VERTICAL</i>)</p> <p>Signal description: Vertical synchronism.</p> <p>Instrument: Oscilloscope.</p> <p>Circuitry connection: Monitor terminal connector #14.</p> <p>Fault switch: SW E-6 ON.</p> <p>Fault description: Drift to ground of the signal.</p> <p>Simulated Fault: Lack of vertical synchronism provoking a vertical shift of the image and then a darkening of the monitor</p>
<p>KEYBOARD FAULT</p>
<p>TP: CLK (KEYBOARD CLOCK)</p> <p>Signal description: Keyboard clock.</p> <p>Instrument: Oscilloscope.</p> <p>Circuitry connection: Primary IDE connector terminal #5.</p> <p>Fault switch: SW E-5 ON.</p> <p>Fault description: Drift to ground of the signal.</p> <p>Simulated Fault: Keyboard not working.</p>
<p>SERIAL COM1 CONNECTOR FAULT</p>
<p>Signal description: Clear to send signal.</p> <p>Instrument: Oscilloscope.</p> <p>Circuitry connection: COM1 connector terminal #8.</p> <p>Fault switch: SW B-1 ON.</p> <p>Fault description: Drift to ground of the signal.</p> <p>Simulated Fault: Serial port not working.</p>

4. Example of didactic application for the students: System Diagnosis

In this section we are going to present an example of system diagnosis, in which the student has to get used to: CMOS configuration parameters, ROM/RAM address table, input/output ports and the interrupt vectors of the hardware devices. In this section we will suppose that due to a certain fault in the PC it is not possible to run the EXPERTCHECK software. Therefore, it must be (visually and acoustically) checked the boot sequence of the system in order to try and locate the fault. Most of the systems have the following sequence of operations:

- Power supply and monitor LEDs are switched on.
- Fans start to run.
- Hard disks start to run.
- On the screen we can read the copyright messages, auto-test and/or error messages (the BIOS can be configured so as not to appear those messages during the initialization).
- The speaker can be heard while the memory test is passed (although in some computers this can be disabled with the BIOS).
- Floppy disk LEDs are momentarily switched on and the mechanism can be heard (again, using the BIOS this can be disabled in some computers)
- After the initialization stage, a beep can be heard (if there some problems are detected, several beeps will be emitted).
- The hard disk LED is switched on indicating the computer is being booted from it.

It should be noted that all the activity of the system depends on the power supply. Normally, the power supply detects its own internal problems, avoiding to be switched on. A weak or faulty power supply can provoke that the computer is restarted while in operation or that the computer stops during the POST (Power On Self Test) process. If we suspect that there is a problem with the power supply, we must check the +5 and +12 V voltages of the main board and the rest of the units. If those voltages are correct, we should verify the rest of the signals provided by the power supply. With most monitors, if the monitor is switched off and the video cable is disconnected and we then switch the monitor on again, a

white blinking screen will be seen. This indicates that the monitor is probably working right. If the monitor is blank, it can be out of order. The next points show a systematic guide for locating faults:

1. - The computer boots correctly from the hard disk, but it doesn't run EXPERTCHEK, supposing the floppy disk works fine: Some computers boot by default from the hard disk instead of giving priority to the floppy disk. To run EXPERTCHEK we should change the BIOS configuration of the computer to make it boot from the floppy disk.
2. - The power supply LED indicator of the computer is not on and the fan is not working. We must check whether the power cable is connected and that we have selected correctly the supply voltage.
3. - If when the computer is switched on, the power supply LED indicator gets on and the fan starts working but immediately the system is turned off. The cause of this problem can be a fault in the power supply or a shortcut in one board. With the computer turned off, all the expansion boards must be removed and likewise all power cables for the hard disk and the rest of units. If now when the system is switched on the power supply LED and the fan starts to work fine, the problem comes from one of the removed boards or the power supply is too weak. We should reinstall all the boards one by one and try to locate the fault. Otherwise, the problem comes from a shortcut in the power supply or in the main board.
4. - When the computer is started, the power supply LED gets on and the fan starts working but nothing more happens. In this case, the fault can be in the motherboard, in some expansion board, in the power supply or in some connection. In the first place, we should verify the expansion boards and check whether all connectors are connected. Then we should remove all expansion boards, start the computer and see if the situation changes. If now everything is ok, we should reinstall all expansion boards, one by one, starting from the video card in order to determine which one is faulty.
5. - The computer beeps once or twice, there is no video signal in the monitor, and the sound of the computer seems normal. It is possible that the video card is faulty. We should verify that the monitor is on and that the power reaches it. If there is a local printer connected, press SHIFT+PRINT SCREE. If the printer works, then the problem is without any doubt in the video card or in the monitor. Disconnect the video cable as we have explained before and check whether we get a white screen or not.
6. - The computer beeps more than once. When there is a problem during the POST, the BIOS displays an error message describing the problem. The BIOS also emits some beeps during the POST if the video configuration is no working properly, or if an external ROM module does not complete properly the checksum (summation check). From the number of beeps emitted we can determine the type of error. If you have the Diagnosis Kit, you can locate the problem using the POST Code Detector Module.

5. Conclusions

The use of tools and platforms that allow the students to manipulate, process, understand, simulate and repair the operation of a computer is of great importance, both from the didactic point of view in the training of computer engineers and electrical engineers and from the practical point of view for the management of computer systems. With the platform that we have presented, it is offered a tool that we have called the computer trainer. This system incorporates a block diagram over which all functional blocks of the computer are displayed, providing multiple test points and visualizing the main electrical signals belonging both to the PC hardware and to its peripherals, with the purpose that the student can learn how a computer works and is capable of establishing diagnosis methods and even of repairing faults.

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