DIN See Deutsches Institut für Normierung.

Direct Memory Access

In early computers the processor performed all data transfers from peripherals to the memory or from the memory to peripherals. The processor had to be interrupted from its other tasks while it took care of the data transfer. However, in many cases the data transfer can be handled without interrupting the processor: For example, when a sector from the hard disk is read to memory. The processor can continue working on the current program, and the end result is that the entire machine is faster. This technique of allowing other units to access memory directly, without the help of the processor, is called *direct memory access* (DMA).

Usually, a chip called a DMA controller takes care of the data transfer and sets the appropriate signals in the data bus (the communication pathway between the processor, the memory, and the peripherals). Some expansion boards in personal computers (PCs) use the DMA chip on the **motherboard**. When the expansion board is installed, the DMA channel has to be configured using switches. Early PCs used four DMA channels; this was later expanded to eight channels, numbered from 0 to 7: three channels are used for 8-bit transfers and another three for 16-bit transfers; there is a dedicated DMA channel for the floppy disk; and channel zero is reserved for refreshing the memory periodically.

RAM (random access memory) chips lose their contents if they are not read (*refreshed*) every few milliseconds. Usually, RAM chips use capacitors to store a bit; capacitors discharge after some time and must be refreshed. Because a special refreshing circuit starts a DMA and takes control of the **bus** while the memory is refreshed, the processor does not have to take care of refreshing the memory. This is an example in which DMA simplifies the design of the computer.

DMA can radically boost the transfer capacity of peripherals. For example, some hard drives use the IDE (*integrated drive electronics*) interface. This interface is built in the drive and then very simple circuits are needed in the motherboard. Using its own DMA controller, the IDE interface can achieve up to 33-megabytes per second transfer rates. This particular configuration is also called *ultra-DMA*.

Usually, a chip called the DMA controller takes care of the data transfer and sets the appropriate signals in the data bus. Peripherals in the first PCs used only the DMA chip set on the motherboard to transfer data to memory. However, as the IDE example shows, new DMA circuits are faster, and therefore some peripherals take direct control of the expansion bus with their own DMA circuitry. This is called *bus mastering*, since the peripheral becomes the master of the bus during the transmission.

FURTHER READING

Aspinwall, Jim. *IRQ, DMA & I/O: Resolving and Preventing PC System Conflicts.* New York: MIS Press, 1997.

Tanenbaum, Andrew S. *Structured Computer Organization.* Englewood Cliffs, N.J.: Prentice Hall, 1976; 4th ed., Upper Saddle River, N.J., 1999.

—*Raúl Rojas*

Display Modes

Modern personal computers present information on a screen called the *display*. The term *display modes* refers to the different standards available for computer screens; they differ in the total number of pixels (picture elements) available, their arrangement in rows and columns, and the maximum number of colors that can be used.

The first commercial computers employed mainly teletypes and line printers to output the computed results. Later, time-sharing systems allowed the user to interact directly with the machine, and a **cathode-ray tube** provided the necessary graphical display. With the advent of the **personal computer** (PC), computer monitors were built to provide bit-mapped graphics. This means that the dark and white spots one sees on a black-and-white screen are a copy of a bit pattern stored in memory chips connected directly to the screen's raster logic. The user's program can create any bit pattern in memory, and this is reproduced faithfully on the screen. If color is available, the user stores the color information in memory. The memory chips for the bit-mapped graphics are put on a video card, and this is added to the motherboard logic.