Computing

Computer Systems Input, Output and Backing Storage Devices

Higher

9014

Autumn 2001

HIGHER STILL

Computing

Computer Systems Input, Output and Backing Storage Devices

Higher

Support Materials

First published 2001

Learning + Teaching Scotland
Northern College
Gardyne Road
Broughty Ferry
Dundee
DD5 INY

Tel. 01382 443 600

CONTENTS

Computer System performance (Outcome 1, PC d), particularly in multimedia applications is greatly affected by the quality of the peripheral devices connected to the processor and the interfaces used by these devices. The following information sheets are designed to help you to consider the impact of data input, output and storage using the above devices in the specification of system performance.

TEACHER/LECTURER NOTES

This pack aims to summarise the technical detail of the main types of input, output and backing storage devices required for the unit Computer Systems at Higher. The pack takes the form of a series of information sheets which can be used by students as background reading, revision or as source material in problem solving or research activities.

Whilst the information sheets contain detail covering all the devices outlined in the range for Outcome 3, it should be noted that some of the detail may be beyond the level required for the unit. This is particularly the case for devices which may be used for multimedia. However, the specification of such devices and how they operate can significantly affect system performance, an important aspect of the unit. While system specification and performance are important aspects of this unit and these are critically affected by the quality of devices attached to the computer it is important that teachers/lecturers use their professional judgement in using these information sheets at an appropriate depth.

Although graphics cards are not included within the range of output devices for Outcome 3 an understanding of these is vital in relation to understanding monitors and their use in multimedia and for this reason a discussion of graphics cards has been included.

The way in which external devices are connected to the computer is also important in relating to system specification (Outcome 4) and performance (Outcome 1). For this reason there are a number of information sheets at the end of the pack outlining the main forms of interface currently in use.

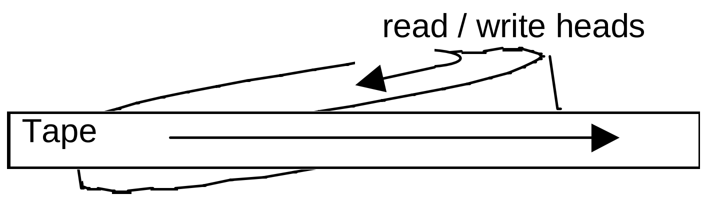
Organisation of the pack

The devices are listed alphabetically rather than being grouped by type. This allows the sheets to be used in any order.

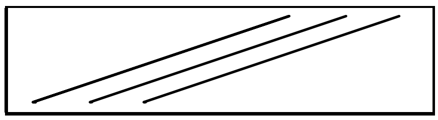
DIGITAL AUDIO TAPE

General Description

Magnetic tape is a very cheap form of backing storage. It is widely used to backup up systems such as network servers and mainframe computers. One form of magnetic tape is known as **Digital Audio Tape** (DAT). It was originally developed for recording high quality audio, but as the format is digital it is ideal for recording data from a computer system.



A 4mm tape is read using a technology called **helical scan**. Helical scan recorders write data onto the tape in narrow tracks at an angle to the edge of the tape. Short diagonal tracks are written across the width of the tape so that they are about eight times longer than the width of the tape. Each track contains about 128K of data. The read heads verify the data written by the write heads. The cylindrical head is tilted slightly in relation to the tape, and spins at a rate of 2000 revolutions per minute (rpm). The tape moves in the opposite direction to the cylindrical spin, at less than one inch per second but because it is recording more than one line at a time, it has an effective speed of 150inches per second.



Diagonal tracks on the tape

Capacity

The capacity of DAT ranges from 2Gb up to 40Gb and is dependent on the physical length of tape which can be fitted in a cartridge. Manufacturers such as Fuji, Sony and TDK produce cartridges of varying capacity. The capacity of a typical network hard disk will be about 20G so this is one of the few forms of backing storage which can back up the hold hard disk without having to use multiple cartridges.

Sequential Access

Access to data on DAT is sequential. This means that the data blocks have to be accessed in order. Access times are therefore slow in comparison to random access devices such as magnetic disks and unsuitable for data which requires to be accessed in a non-linear or random fashion such as records in a database.

To be able to access the data on DAT there must be some form of directory of files. There is normally a catalogue file at the start of the tape which details the contents of that tape. To find a particular file on DAT, the read heads read the address of the file in the directory, read through all the files preceding the required file and only begin to pass data to the processor when they reach the specified file.

Keywords
Capacity, helical scan, random access, sequential access.

See Also

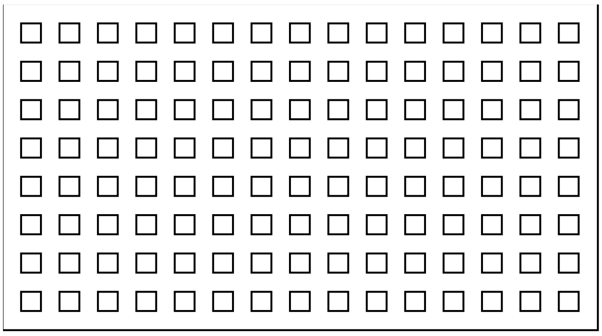
- Magnetic Tape
- Interfaces

DIGITAL CAMERA

General Description

The digital camera is an **input device** which looks similar to a conventional camera in that there is a lens and a viewfinder. An image is created of the object being photographed. The lens causes this to be generated upside down on the back plate of the camera where the film is situated. The main difference in a digital camera is that the film has been replaced with an array of image sensors and a storage device.

The image sensor is made from a two dimensional array of photosensitive cells. These cells generally use CMOS (complimentary metal-oxide semiconductor) technology. This is the same technology used to manufacture processors and memory chips. As CMOS technology is widely used these photosensitive arrays can be made fairly cheaply. Each cell converts the light which strikes it into an electrical signal which is proportional to the intensity of the light.



2-D array of photo-sensitive cells

This electrical signal from the photosensitive cell is passed through an analogue-to-digital converter to a signal processor which adjusts the contrast and detail of the image. The digital signal is then compressed and sent to the storage device.

Picture Quality

The picture quality is dependent on a number of factors:

• Optical quality of the lens	As with any camera the lens quality has a huge impact on the quality of the image. Distortion of the image and focussing are improved by improving the quality of the lens.
• Image capture chip resolution	The number of pixels in the array of photosensitive cells can vary from 640 x 480 pixels in some of the cheapest devices, through 1024 x 768, 1280 x 960 and up to resolutions as high as 1800 x 1200 pixels in professional quality cameras.
• Bit depth	The bit depth of each element of the array will affect the quality of the image. The more bits allocated to each pixel, the more colours that can be used to make up the image.
• Compression algorithm	If the image capture chip provides a high resolution image then a large amount of memory will be required to store the image. To reduce the amount of memory required, compression algorithms are used. Some manufacturer's use a proprietary compression format which can only be accessed by that manufacturers software but most will use standard formats such as JPEG which are readable in most graphics packages.

Storing the image

The storage device in the camera can either be in the form of internal RAM or a small magnetic disk. Once the device is full the data must be transferred to a computer by means of a serial cable before the camera can be used again.

Alternatively, removable storage can be used. This has the advantage that it can be replaced once it is full. Removable media is typically in the form of a Flash card. This is a form of non-volatile RAM. Once the data is written to it the card can be removed from the device without the data being wiped. The capacity of these cards varies from 128M to 300M.

Adjusting the image quality

The image quality can often be set by the user. This will allow the user to adjust the resolution and the bit depth. If high quality images are required then the resolution and bit depth can be increased. This will mean that far fewer images can be stored. If it is more important that a larger number of images are stored, then the resolution and bit depth can be reduced.

Connecting to a Computer

The digital camera is a device which does not require to be connected to a computer to use it. However, the images created by the camera must be downloaded to a computer before they can be manipulated using graphics software. Typically the data is downloaded using a serial connection. Software in the computer communicates with the camera and controls the flow of data into the computer.

Keywords
Analogue to digital converter, bit depth, CMOS, compression, resolution, serial.

See also

- Interfaces
- Magnetic disk

FILM PRINTER

General Description

Video projectors are a very common form of output device for presentations by business people and lecturers. Unfortunately, video projectors are not powerful enough or give high enough resolution in large lecture theatres. In situations such as this, slide projectors are often used to display high resolution images. A film printer (sometimes referred to as a film recorder) is a specialised **output device** which allows data from a presentation package such as PowerPoint or a graphics package such as PhotoShop to be printed on photographic film. This film is often in the form of 35mm slides which are widely available and used for presentation purposes.

A camera is set up so that it is focussed on a cathode ray tube (CRT) monitor. To create the image on film the output from the computer is separated into its red, green and blue components before being displayed on the monitor as three separate images, one after another. A filter is placed in front of the screen in the appropriate colour and an exposure taken. This process is repeated three times to make up the full picture. The film must then be developed using traditional photographic techniques.

Resolution

Film recorders are available with various resolutions. The most common ones are known as 4K and 8K. A 4K film recorder is capable of creating 4,096 pixels along the long axis of the film being exposed. Since 35mm format has a 1:1.5 aspect ratio, this means that the image would be 2,731 pixels x 4,096 pixels.

An 8K film recorder is capable of creating 8,192 pixels along the long axis. In order to attain the full available resolution of a film recorder, it is necessary to send it a file with enough information.

The optimum file size for an 8K film recorder creating 35 mm slides is calculated as follows:

8,192 (horizontal) x 5,461 (vertical) x 3 (colours - RGB) = 128M

This means that high capacity backing storage will be required if a number of images are to be transferred to film.

Keywords
Cathode ray tube, pixels, resolution.

See Also

- Interfaces
- Ink jet printers
- Laser printers
- Monitors

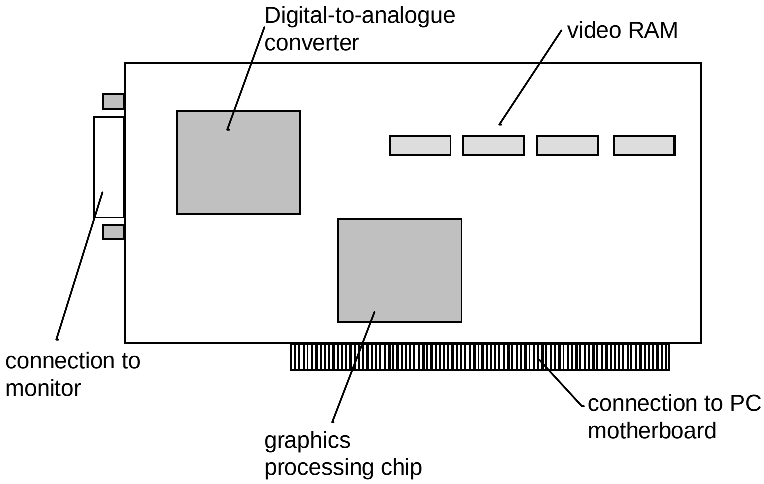
GRAPHICS CARD

General Description

A graphics card is an **output device** which is responsible for creating the picture you see on a computer screen. The operating system of most modern computers incorporates a graphical user interface (G.U.I.). This requires vast amounts of data processing which could slow down the running of the programs. Therefore the central processing unit allocates instructions relating to screen display to a graphics card to be processed and sent to the monitor.

The card will have the following main parts:

- processor to interpret the graphics instructions,
- video RAM to store the current screen image, and
- digital-to-analogue converter to turn the digital information into an analogue signal for the monitor.



This diagram shows an example of a typical graphics card as found in many modern computers. However, some computers, for example Apple Macintosh, include the functions of the graphics card on the motherboard.

Whilst the quality of the image is primarily a factor of the monitor itself, the features of the graphics card play an essential role in processing the data required for screen images. Let us look more closely at this data.

Resolution

The image on the screen is made up of a two dimensional array of pixels. The total image is made up of thousands of pixels. The resolution of the image on the screen defines the quality or sharpness of the image and is related to the number of pixels and their closeness together. To get an accurate understanding of what goes into making a screen image, we must consider the *dot pitch* and the *bit depth*.

The dot pitch is a measure of the distance between the centres of two adjacent pixels. The dot pitch affects the number of pixels which can be displayed on the screen. The smaller the dot pitch the sharper the image. If one screen has more pixels in the space than another then the resolution of the image on the first screen will be greater. Typical examples are as follows:

Type of screen	Pixels (breadth x depth)
VGA	640 x 480
SVGA	800 x 600
XGA	1024 x 768
SXGA	1280 x 1024
UXGA	1600 x 1200

The bit depth used in a screen image also affects the quality of the screen image but it also makes a significant impact on the amount of data to be stored and processed by the graphics card. For every pixel in the image there must be a corresponding area of memory in the graphics card. The number of colours which can be displayed on the screen is dependent on the amount of memory used to store the information about each pixel. The more bits of memory used for each pixel the more colours that can be displayed.

For example, if 8 bits are used for each pixel then up to 256 different colours can be displayed.

1 1 1 1 1 1 1 1	255
1 1 1 1 1 1 1 0	254
1 1 1 1 1 1 0 1	253

↑ ↑

0 0 0 0 0 0 1 1	3
0 0 0 0 0 0 1 0	2
0 0 0 0 0 0 0 1	1
0 0 0 0 0 0 0 0	0

Each binary pattern from 0 to 255 can be used to represent a different colour.

This table shows the number of colours which can be displayed for a range of bit depths.

Bit depth	Number of colours
1	2 (black and white)
4	16
8	256
16	65,536
24	16,777,216

A bit depth of 24 bits per pixel is often referred to as **true colour** as this amount of data is required to convince the human eye that the image is truly accurate. The colour of each pixel is determined by a combination of red, green and blue elements. In a bit depth of 24 bits per pixel, 8 bits are required for the reds, 8 for the greens and 8 for the blues in each pixel.

Memory Requirements

If we take resolution and bit depth together we can calculate the amount of memory required to display an image on the screen.

For example a screen image whose resolution gives 640 x 480 pixels and using a bit depth of 8 bits will require 300K of memory.

The following table give some examples of the possible outputs from the graphics card depending on the amount of memory on the graphics card.

Video memory	Resolution	Colour depth	No. of colours
1Mb	1024 x 768 800 x 600	8-bit 16-bit	256 65,536
2Mb	1024 x 768 1280 x 1024 800 x 600	8-bit 16-bit 24-bit	256 65,536 16.7 million
4Mb	1024 x 768	24-bit	16.7 million
8Mb	1600 x 1200	32-bit	16.7 million

- Graphics cards are essential to modern graphical screen images.
- High resolution screens showing true colours require the support of graphics cards with lots of on-board memory.
- A large monitor will require more video memory to be able to display a high resolution image.

Keywords

Bit depth, memory map, resolution, video RAM.

See Also

- Multi-scan Monitor
- Video Capture Card

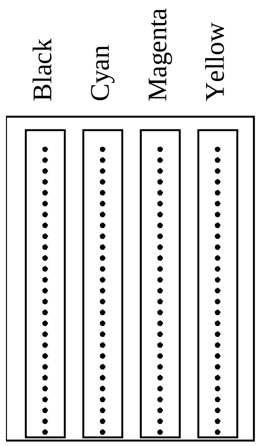
INK JET PRINTER

General Description

Ink jet (sometimes referred to as bubble jet) printers are very popular output devices with home computer users due to the fact that coloured output can be produced relatively cheaply. High quality colour output is good for printing greetings cards, party invitations, banners and photo-realistic images.

The ink jet printer works by squirting small amounts of ink through tiny nozzles. The print head scans across the page in horizontal bands using a stepper motor. With each pass of the print head a strip of the image is printed.

To print colour, the process is slightly different from displaying colour on a monitor. A monitor uses three light sources to create the colours (the primary colours: red, green and blue (RGB)), the different combinations of these three colours fools the human eye into believing a new colour has been created. A printer, however, uses the subtractive primary colours (cyan, magenta and yellow (CMY)) to create the appropriate mix. From a distance the different amounts of each colour merge to create the illusion of a single colour. This process is known as **dithering**.



The print head has a line of nozzles for each colour

Most ink jet printers are able to print in colour and black and white. These printers have four ink cartridges corresponding to cyan, magenta, yellow and black (known as CMYK). These printers can swap between printing in colour and printing in black and white on the same page without any problem.

Resolution

The quality of the printed image is measured by the number and spacing of the dots of ink on the page. The image resolution is generally measured in **dots per inch** (dpi). The higher the dpi, the better the quality or sharpness of the printed image. As already stated, the print head moves across the page delivering a band of dots horizontally. The vertical and horizontal resolutions may, therefore, be different dependent on the number of nozzles on the print head and the distance moved across the page by the stepper motor each time. Typical examples of printer resolution used for home computers range from 360 x 360 dpi up to about 1440 x 720 dpi.

Number of Colours

The number of colours which can be printed is the other important factor in the quality of the printed output. The simplest form of colour printer is one in which the cyan, magenta, yellow and black dots are either "on" or "off" and only eight colours can be printed. The data from the computer will require four bits per dot to achieve this.

To improve the number of colours a technique known as **halftoning** can be used. This divides the dot resolution into a grid of "halftone cells" and then turns on or off a varying number of dots within these cells in order to mimic a variable dot size.

Some manufacturers have increased the number of colours of ink cartridges to six thus increasing the number of colours which can be reproduced. These printers tend to produce a higher quality of photographic image.

Speed

Printer speed is measured in **pages per minute** (ppm). Ink jet printers must repeatedly move the print head across the page in horizontal bands. The print head must take a very small amount of time to decide whether a dot is to be printed or not (about 1/5000th of a second). For this reason ink jet printers appear to be quite slow. Typically they range from about 4 ppm up to 12 ppm.

Running Costs

Although an ink-jet printer is fairly cheap to purchase, the running costs are far higher than laser printers. Ink cartridges need to be replaced more frequently than laser toner cartridges and special paper is required for high quality images. Statistics suggest that ink jet printers are about ten times more expensive to run than laser printers.

Keywords

CMYK, dithering, dots per inch, halftoning, pages per minute, resolution , RGB.

See Also

- Interfaces
- Laser printers
- Monitors

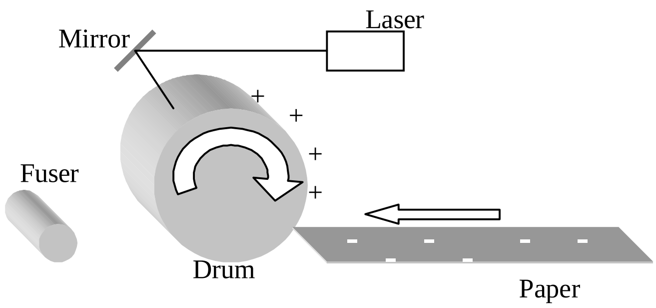
LASER PRINTER

General Description

Laser printers are **output devices** which are predominantly used in office environments where fast printing of high quality documents is required. Although most laser printers print black and white images, it is possible to adapt the technology to print colour images.

The laser printer works as follows:

- A page description language such as Postscript is used to communicate the data from the computer to the printer.
- A laser scans the surface of a specially coated drum which can hold electrostatic charge. The laser is switched on and off corresponding to whether the point in the image is black or white. Where the laser hits the drum points of positive charge are left. These points of charge represent a copy of the final image.
- As the drum rotates it picks up toner (a black powder) in the areas where there is a point of positive charge.
- A sheet of paper is pulled across another charged area making it negatively charged. As the paper comes in contact with the drum the toner is attracted to the negatively charged paper. This results in the image being transferred to the paper.
- The powder is designed to melt quickly and the final stage involves the toner being fused to the paper under pressure.
- Finally the drum must then be cleaned before the next page is printed.



Laser printers can be connected to a stand-alone computer using a parallel interface or can be connected using a **printer server** on a network. Some of the more expensive printers will have a combination of different interface options to allow flexibility in their use.

In a colour laser printer, four passes are made through the electrostatic process corresponding to the colours cyan, magenta, yellow and black. Colour laser printers are still very expensive devices to purchase and to run and are usually only used for specialised applications.

Resolution

The resolution of a printer is generally measured in dots per inch (dpi). The higher the resolution, the more dots there are in every inch and the sharper the image will appear. Most laser printers will have a resolution of 600 or 1200 dpi.

Speed

The data for the page is all sent to the printer before the printing is started. This means that it appears as though the printer is doing nothing for a period of time before the paper starts to be passed through. The printer speed is measured in **pages per minute** (ppm). Speeds vary between 6 and 20 ppm

Buffering

Laser printers are often used to print large documents and system performance can be improved dramatically by incorporating a buffer. This is an area of RAM in the printer which allows data to be downloaded from the computer to the printer and frees the processor to resume other tasks. Buffer sizes from 4M to 20M of RAM are common.

Cost

Although expensive to buy, laser printers are relatively cheap to run. The toner cartridge will produce thousands of pages, and as they are mostly used for textual data which has a lot of white space, the toner can go a long way.

Keywords

Buffer, dots per inch, pages per minute, resolution, toner.

See also

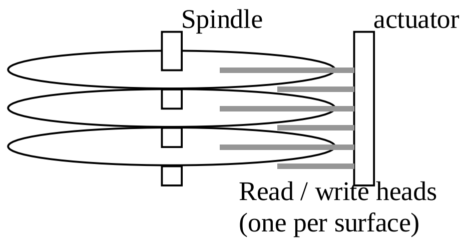
- interfaces
- ink jet printers

MAGNETIC DISK

General Description

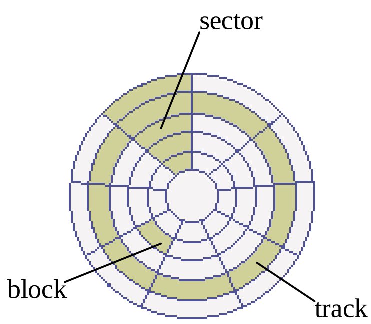
Magnetic disks are the most commonly used form of **backing storage**. They allow **random access** and range in size from removable floppy disks which can store 1.4M up to large hard disk packs able to store 8G to 100G and more.

The hard disk is normally made up of a series of platters which are covered, on both sides, in a magnetic medium. Typically two or three platters are stacked on top of each other with a spindle that turns them all at the same time. A read / write head sits very close to the surface of each platter and is moved in or out to read data from the disk surface. The heads are so close to the platter that a small particle of dust could cause the magnetic surface to be scraped.



When the disk stops spinning the heads are designed to touch down on an area called the landing zone.

Before the disk can be used it must be formatted. This involves dividing the magnetic surface into a series of tracks and sectors. The intersection between a track and a sector is known as a block. Each block on the disc stores the same amount of data.



Tracks physically above one another on different platters are grouped together and known as cylinders. The data blocks in a cylinder can all be accessed without moving the read / write heads thus speeding up data recording and retrieval.

Hard disks are usually connected to the motherboard using an IDE or SCSI interface to allow a fast transfer of large amounts of data between the disk and the computer's memory.

Speed

The time taken to access data on a disk is known as the **access time**. This figure is calculated by adding the time taken to move the read / write head to the required track on the disk (known as the **seek time**) to the time for the disk to rotate so that the correct sector is under the head (known as the **latency** and normally taken as the time taken for half a revolution of the disk).

When choosing a hard disk the technical specifications will usually give details of the spindle speed (the number of times the disk rotates per minute (rpm)) and the seek time in milliseconds.

Example

Spindle speed	=	7200 rpm
Seek time	=	6 ms

(Note that units must be changed before any calculations are carried out!)

Capacity

As already mentioned, the capacity of hard disks can be as high as many hundreds of Gigabytes. The main limiting factor in the use of many hard disks is the operating system in the attached computer. Many older operating systems have a limit to the amount of data which can be accessed. To be able to address data on the whole disk in these cases, the disk must be **partitioned**. This process involves formatting the disk so that the operating system views it as a number of separate **logical** disks.

Keywords

Blocks, capacity, cylinders, IDE, latency, partition, random access, SCSI, sectors, seek time, tracks.

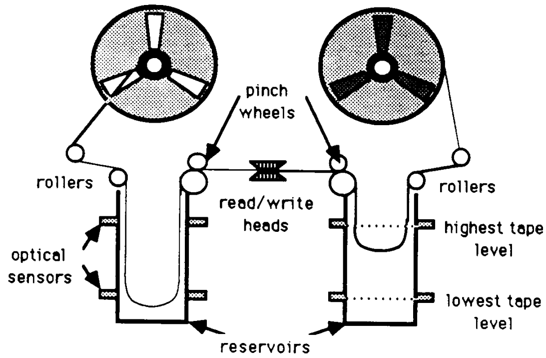
See also

- interfaces
- magnetic tape
- optical disk

MAGNETIC TAPE

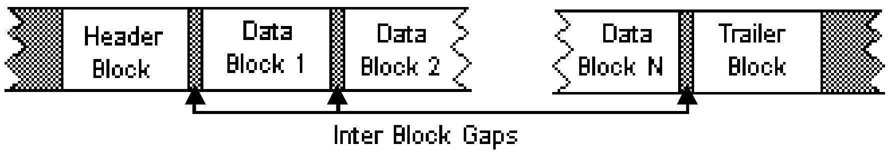
General Description

Magnetic tape is a common form of **backing storage** for making copies of large scale systems such as the hard disks in network servers. Access is **sequential** so data is normally sorted before being archived.



The magnetic tape is passed over the read / write heads at a constant speed. When the tape is not being read from or written to, it is moved away from the heads to allow faster winding. Data is read from the tape into a **buffer** which is either in the computer or in the tape unit itself.

The amount of data read from the tape in one operation is known as a block. Blocks vary in size from 10 to 10000 bytes.



Each block of data incorporates error checking to ensure accurate transfer of data. Gaps are left between each block to allow the tape unit to speed up and slow down.

Capacity

Early tape systems used on mainframe computers used large reels of tape. More recently the tape has been placed in a cartridge to make it easier to handle. A typical format using a tape of 0.25” width (a format known as Quarter Inch Cartridge or QIC) gives a capacity of about 80M up to 4G.

Keywords
Block, buffer, QIC, read write head, sequential access.

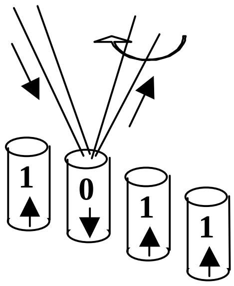
See also

- DAT
- Magnetic disk
- Interfaces

MAGNETO-OPTICAL DISK

General Description

Magneto-optical devices allow storage of data using a combination of magnetic and optical techniques. The surface of the disk is covered in a magnetic medium which can be magnetised using the heat from a laser. The magnetic material is stable at room temperature. Its state can only be changed when the temperature is raised above the **Curie Point** (the temperature at which the molecules of a material can be altered when subjected to a magnetic field). When writing data to the disk the area to be magnetised is heated by a laser with a very fine focus. Once the particles reach the Curie Point a magnetic field can be used to change their **polarity**. This means that more data can be squeezed into the same area as on conventional magnetic disks.



Data is read from the disk using a less powerful laser which does not change the data. When the laser light is reflected from the magnetic particles it is polarised depending on the orientation of the magnetic particles on the disk. This polarisation of the laser light as it is reflected is known as the **Kerr effect**.

Due to the fact that magneto-optical disks are written to and read from using a laser and because they have to be heated before the data can be changed they tend to be a very robust form of media. They are not susceptible to being damaged by magnetic fields in the same way as magnetic disks or tapes.

Capacity

A 3.5" magneto-optical disk has a capacity of 640M, although higher capacity devices are available. The 5.25" format has a capacity of 2.6G. Most manufacturers follow the ISO standard so that disks from different manufacturers can be shared.

Keywords
Curie point, Kerr effect, ISO, random access.

See also

- Interfaces
- Magnetic disks
- Optical disks

MODIFIED KEYBOARD

General Description

The keyboard is the most widely used **input device** for the computer. When a key is pressed, an 8-bit binary word representing the character is generated. This binary word is usually in ASCII (American Standard Code for Information Interchange) format. The binary data is then transferred to the computer using **serial data transmission**.

The standard keyboard uses the QWERTY layout which was originally developed to slow down typists using early typewriters. These typewriters jammed if too many keys were pressed quickly so the layout that we are all familiar with came about as a result. This layout has drawbacks for some applications so modified keyboards have been developed.

Modifications can be made for a number of reasons. Here are some:

Ergonomic design	The **ergonomic** design of the keyboard can make it easier for a typist to enter text quickly and can reduce the chance of health and safety issues such as Repetitive Strain Injury (RSI). Ergonomically designed keyboards produced by companies such as Apple and Microsoft split the keyboard into two halves and angle them slightly to allow the users elbows to rest in a more natural position. The two halves will also have wrist supports to reduce the strain on the wrist. Some will have a detachable numeric keypad to allow the mouse to be moved closer to the keyboard.
Reducing the number of keys	Experiments have been carried out to reduce the number of keys on the keyboard. Any ASCII character can then be created by pressing a combination of keys. The main drawback to this form of device is the length of time it takes to learn the key combinations required.
Disabled users	Some keyboards have been designed to allow disabled users to use the computer more effectively. Modifications include increasing the size of the keys, grouping them in different ways or increasing the size of the lettering on the keys for users with poor eyesight.
Specialist applications	Some keyboards are modified to add extra keys or to limit the range of keys for that application. Examples include CNC lathes and specific applications within call centres.

Keywords
ASCII, ergonomic, RSI, serial data transmission.

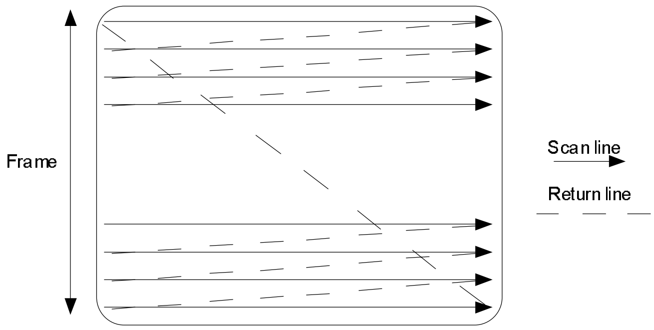
See also

- Interfaces

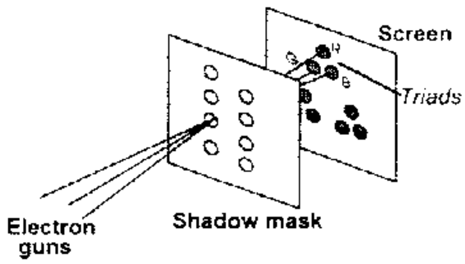
MULTI-SCAN MONITOR

General Description

Monitors can be split into two main categories: **Cathode Ray Tube** (CRT) and **flat panel** displays. CRT monitors have been around since before the invention of television. They comprise a sealed glass tube which has no air inside it. An electron gun at one end fires a stream of tiny electrons at the screen located at the other end. The inside surface of the glass screen has a special coating of phosphor which emits light when the electrons hit it. The phosphor on the screen is grouped into small "blobs" called **triads**. Each triad is made up of three dots; one emits red light, one green and one blue. The dots are very close together so appear to the eye as a single dot. The image is formed when the electron gun is fired and electrons strike different areas of the screen. The electron beam is moved across the screen in lines by magnetic fields. The beam starts in the top left of the screen and moves across each row (or **raster**) in turn. This is repeated for every row on the screen many times a second. The image which is built up fools the eye into believing that a picture is displayed on the screen all at once.



To ensure the electron beam is focussed properly before it hits the screen it passes through a perforated sheet called a **shadow** mask.



The main characteristics which need to be considered in specifying a monitor are:

- The **maximum resolution** which can be displayed
- The **refresh rate**
- **Interlacing**

Resolution

The resolution is defined as the number of pixels on the screen horizontally and vertically. The more pixels in the same space the higher the resolution. A standard VGA resolution is 640 x 480 pixels. The actual resolution is set by the graphics card but cannot exceed the maximum allowable by the screen.
The output from a graphics card is fed to a monitor to actually display the image. The quality of the graphics card has a major impact on the quality of the image displayed on the monitor.

For many applications, such as Computer Aided Design or Desk Top Publishing, the overall size of the screen is important. A larger screen allows more of the data file to be displayed at once. The resolution on a large screen follows the same rules as for smaller ones but the number of pixels required to give a reasonable quality image is far greater.

Refresh Rate

The refresh rate is a measure of how many times the screen is redrawn every second. Refresh rate is measured in Hertz. To obtain a flicker free screen, a refresh rate of 70Hz or higher is required.

The electrical signal from the graphics card is based on the resolution and refresh rate. This signal is known as the horizontal scanning frequency. Increasing the resolution or the refresh rate will increase the horizontal scanning frequency.

A monitor which can handle different horizontal scanning frequencies is known as **multi-scanning**. Multimedia applications such as viewing digital video will require a multi-scan monitor in order to reduce flicker.

Interlacing

An interlacing monitor is one which draws every other row at one time and then returns to the top and fills in the missing ones. An interlaced monitor with a refresh rate of 100Hz will only completely refresh the screen 50 times a second.

Keywords
Electron gun, interlacing, multi-scan, raster, refresh rate, triad.

See Also

- Graphics cards
- Interfaces

OPTICAL DISK

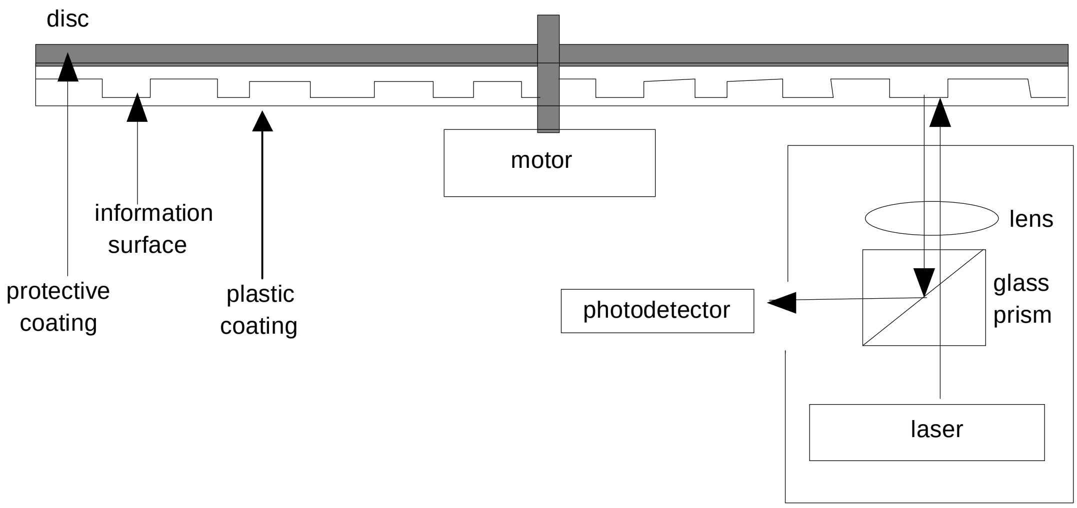
General Description

An optical disk is a form of **backing storage device** which uses optical technology to read and write data. The main types of optical device are CD-ROM, CD-Recordable and DVD.

CD-ROM

The principles involved in reading data from a CD-ROM apply to reading data from any optical disk.

A laser beam is focussed on a spot on the surface of the disk. The surface of the disk is made up of **pits** and **lands**. The light is all reflected from a land and scattered from a pit. The reflected beam is sensed by a **photo-sensitive cell**. This information is turned into an electrical signal.



The data on a CD-ROM is organised as a sequence of equal length blocks formed into a single spiral starting at the centre. Each block contains 2048 bytes of data, plus address and error detection bytes. A single speed CD-ROM reads data at 75 blocks per second. This means that the data transfer rate is 150KBps The speed of modern CD-ROM drives is normally faster than this. It is usually given as a number of times faster than a single speed drive. Examples include 16x, 32x and 48x.

CD-ROM drives are typically connected to the computer via an IDE or SCSI interface.

The International Standards Organisation (ISO) has set a standard data format for reading data from a CD-ROM. The ISO9660 format allows a CD-ROM created for one platform to be read by another platform. In this format, filenames are restricted to uppercase letters, the digits “0” to “9” and the “_” character.

A CD-ROM is a read-only device as there is no way that the laser can be used to change the pits and lands on the CD surface. To allow the CD-ROM to be written to, the material of which the disk is made had to be changed as well as the way the read/write mechanism operates.

CD-Recordable and CD-Rewritable

The CD-R (Compact Disk Recordable) and CD-RW (Compact Disk Rewritable) formats allows small businesses, multimedia designers and home recording artists to write data to CDs which are usable in standard CD-ROM drives.

Write Once / Read Many storage (WORM) has been used widely since the 1980s and is a type of optical disk drive that can be written to and read from. CD-R uses the same technology as WORM where a layer of dye replaces the reflective sheet in a standard CD-ROM. This dye is photo-sensitive and when the laser hits the surface it burns pits in the dye. When heated beyond a certain temperature the “burned” area becomes opaque and thus reflects less light than areas that have not been heated by the laser. Recently CD-Recordable devices have become much cheaper and as a result are now provided as standard in many desktop PCs specified for home or small business use.

CD-RW allows the user to record over old data on a CD. The disks are usually slightly different in colour from CD-R. The CD-RW uses a crystalline compound which has special properties. When it is heated by the laser the crystalline substance changes its properties to become opaque so that light is not reflected.

DVD

The capacity of a CD-ROM is about 650M. This means that it is not suitable for some of the very high capacity applications now becoming commonplace in multimedia and digital video applications. DVD (Digital Versatile Disk, originally known as Digital Video Disk) brought in a new standard which can provide up to 17G of storage space.

DVD looks like CD-ROM and contains a spiral track with pits and lands which are read by a laser. To achieve the increase in capacity, the tracks are closer together and the pits are much smaller than a CD-ROM. Data can also be scanned from more than one layer of DVD by changing the focus of the laser. It is also possible to create a double sided disk which uses two lasers to read the data from the two layers.

To allow a whole feature film to be stored on a DVD, video compression techniques such as MPEG are used.

Keywords
Block, CD-ROM, CD-R, CD-RW, compression, DVD, IDE, lands, MPEG, pits, SCSI.

See also

- Interfaces
- Magnetic Disk
- Magnetic Tape

SCANNER

General Description

A scanner is an **input device** which allows graphical data to be captured by the computer. This data can be in the form of photographs, line drawings or even text. To capture the data, the scanner reflects light off a paper image which is placed on a sheet of glass. The reflected light is gathered by photosensitive cells. The electrical current representing the reflected light intensity passes through an analogue-to-digital converter to create a bit map of the original image. This digital image is then sent through an interface to the computer.

A typical flat bed scanner comprises an A4 glass plate underneath which a scan head is moved down the length of the glass in small steps. The scan head includes both a light and an array of photosensitive cells. The light is reflected off the image and picked up by the sensors a strip at a time.

The control software for the scanner usually allows a number of image characteristics to be altered. It is important to be aware of these as the file size created for a single A4 page can be as high as 20M.

Resolution

The resolution of a scanner is a measurement of how close together the scanned pixels are located. It is usually measured in dots per inch (dpi). Images scanned for display purposes on a monitor (e.g. for use in a multimedia presentation) should normally be scanned at 72 dpi as this will match the resolution of most monitors. Most flat bed scanners can give a resolution of up to 1200 dpi which is appropriate for most laser printers. If the images being scanned are for use in commercial publishing applications then a higher resolution may be required.

Bit depth

The number of bits allocated to each pixel indicates the number of colours available to create the image. 8 bits will give 256 colours, 16 bits will give 65536 and so on.

Type of picture

The type of scan used will depend on the source image and the actual use to be made of the scanned image.

Line art	Line drawings can be scanned using this mode. The resultant file size is small as each pixel is either a "1" or a "0" representing black and white dots in the image.
Grey scale	Black and white photographs can be scanned without the extra data required for colours that are not used. If an 8 bit colour depth is used then 256 different shades of grey are possible. This use of a specialised colour palette will reduce the file size whilst retaining a very high quality image.
True colour	To scan colour photographs true colour is required. This means that 24 bits are used for each pixel. The resultant file size is large but gives good photo-realistic images for desk top publishing and similar applications.

Image size

An A4 image from a scanner will generate a very large file so it usually preferable to select only part of the A4 area for storage. This **cropping** will drastically reduce the file size as only the required part of the image is captured.

Compression

Once the image has been scanned it has to be stored on a backing storage medium such as a hard disk. To reduce the file size it is possible to compress the image. A number of standard data formats have been developed for compressing image files. These include JPEG (Joint Photographic Expert Group) and GIF (Graphic Interchange Format).

OCR

It is also possible to use Optical Character Recognition (OCR) software to take the text from an image and convert it into text which can be editing in a word processor. This software compares each letter which has been scanned with a library of shapes of all letters in a variety of different fonts and styles. It extracts appropriate letters from this library to create text which can be edited.

Keywords

Analogue to digital converter, bit map, compression, grey scale, line art, OCR, resolution, true colour.

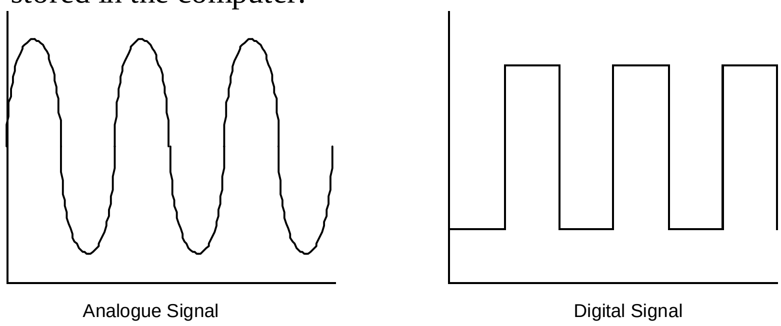
See also

- Interfaces
- Monitors
- Laser printer
- Ink jet printer

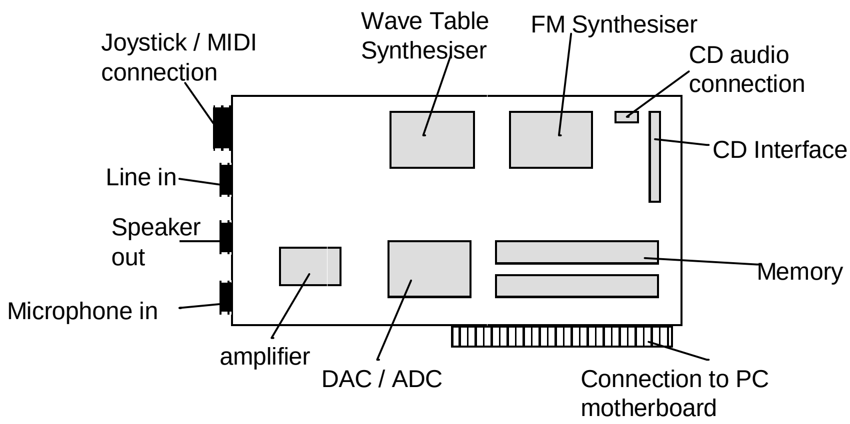
SOUND CARD

General Description

The sounds we hear are generated by air particles vibrating backwards and forwards. These are continually changing with the pitch and volume of the sound. Sound is an analogue quantity and so must be converted to a digital form before it can be processed or stored in the computer.



The sound card is a hardware component which allows sound to be **input** to, and **output** from, the computer.

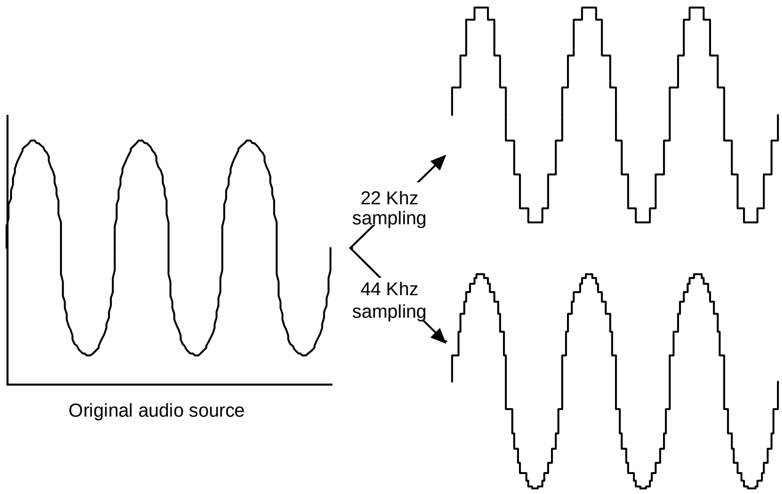


This diagram shows the main components of a sound card. Many multimedia computers (including the Apple Macintosh series) incorporate the functions of the sound card into the motherboard.

Sound Input

The sound card uses an analogue-to-digital converter (ADC) to turn the analogue signals from a microphone or other audio source into a digital form that the computer can understand and store. This device samples the size of the electrical signal generated by the microphone and represents this by a number. The number of times this sound is sampled per second is known as the **sampling frequency** (or sample rate). The sampling frequency will typically be in the range of 11kHz to 44kHz. In other words, the sound will be sampled 44000 times per second.

As each sample is represented by a binary number in the computer's memory, the number of bits used to represent this number will determine the quality of the sample. Sound cards will often use 8 or 16 bits per sample. 8 bits gives a range of 256 tones, 16 bits gives 65536. The larger the range of numbers possible, the more accurate the sample will be.



As can be seen from this diagram increasing the sampling frequency increases the quality of the audio. The example which has been sampled at 44KHz is much closer to the original sound.

The sampling frequency and sampling resolution of the sound sample will affect the amount of memory required to store the sound. If the sound sampled is in stereo then the amount of memory required will be doubled.

Let us look at the amount of data that a sound card has to process for a 5 second sample of sound to be stored on the computer. The sampling frequency is 44KHz and the sampling resolution of each sample is 16 bits. The sound is to be recorded in stereo.

1 second of audio at 44KHz and 16 bits per sample	= 88000 bytes = 86K
The sound is sampled in stereo	= 86K x 2 = 172K
5 seconds	= 172K x 5 = 860K

Compression

Audio data files tend to be very large so compression techniques are often used when the data is sampled. Whilst these techniques will reduce the overall size of the sampled data they will also cause a reduction in the final quality.

Sound Output

The output from the sound card is normally fed into an amplifier and speakers. The quality of the amplifier and speakers will have a large impact on the quality of the sound produced.

The output may be from a digital sample which is converted back into an analogue signal in the analogue-to-digital converter (ADC) or it may be synthesised using **frequency modulation** or **wave table synthesis.** MIDI (Musical Instrument Digital Interface) devices will use these synthesisers to create sound output, whereas the playback of samples will use the ADC.

Frequency Modulation

This method of generating a sound involves creating two sine waves. One acts as the carrier wave and the other is the modulator. When the two waveforms are close together in frequency a complex waveform is produced which creates a particular type of sound.

Wave Table Synthesis

This form of sound generation involves using sound samples of real instruments. The quality of the sound will depend on the quality of the original recording. When a sound sample is played at a different rate from which it was recorded then the pitch will be altered. This can be done for a number of different octaves.

Many samples have to be recorded for each instrument to recreate a full range of sounds so a lot of data will have to be stored in ROM on the sound card. Typically a sound card may use as much as 4M of ROM to store the data required.

Surround Sound

Many modern sound cards have added features to give a more life like audio experience. This is particularly the case in multimedia systems and those designed specifically for games. It is possible to use software such as Microsoft DirectX to creates sounds as though they appear anywhere in 3D space. This is known as positional audio. The audio is split up into a number of different components and fed to up to six loud speakers. A great deal of processing power is required to be able to handle this form of audio output.

Keywords

Sample, sampling frequency, sampling resolution, Analogue to Digital Converter, Digital to Analogue Converter, wave table synthesis, frequency modulation, MIDI, compression.

See also

- Interfaces

VIDEO CAPTURE BOARD

General Description

Digital video is becoming more and more widely used in a number of different application areas. To be able to transfer moving images from analogue video to the computer, a video capture card is required. This card converts each frame of the video into a bit mapped image. In the PAL system (Phase Alternating Line) each horizontal line is split into 768 sections. This results in 768 pixels per line. At each section a red, green and blue component is calculated. The standard TV has 625 lines but some of these contain information about teletext so only 576 lines are digitised.

Digital video requires huge amounts of storage space:

A full frame is made up of 768 x 576 pixels

Each pixel requires 3 bytes for true colour.

The PAL system takes two scans to make up a single picture so
1 second of video will be 768 x 576 x 3 x 25fps x 2 = 65 M.

Factors affecting system performance

A number of factors need to be considered when capturing digital video:

Frame rate	The frame rate is a measure of the number of times the picture changes every second. Television and cinema films typically use a frame rate of 25fps. The frame rate can be reduced without a noticeable reduction in viewing quality but if it drops below 15fps, the image becomes jerky.
Frame Size	The size of the image on the screen is an important factor in determining the overall size of the file created. A frame size of 320 x 240 gives an image that is a reasonable size on the screen without requiring a huge amount of storage space. Reducing the image size will reduce the overall file size.
Resolution	The resolution of the image is a measure of the quality of the image. The closer together the pixels are the higher the resolution and the sharper the image will appear on the screen.
Colour depth	The number of bits used to represent each pixel is an important factor. The more bits used the more colours can be displayed by each pixel. 8 bits per pixel will give 256 different colours. For some applications this may be acceptable but 16 bits per pixel are used to give realistic tones.
Compression	Because of the huge file sizes created by digital video it is vital that the file is compressed. The video capture card will normally incorporate hardware and software which compresses the video data.

With the advent of digital video cameras and webcams the video capture card is not as vital as it once was. These devices which produce digital data can usually be connected to the computer directly and only require software to deal with the characteristics of the video file.

Applications such as video-conferencing are possible using relatively cheap digital webcams connected directly to the computer via a USB interface.

Keywords
Compression, colour depth, frame rate, resolution.

See also

- Interfaces
- Monitors
- Graphics cards

INTERFACES

General Introduction

In order to connect input, output and backing storage devices to the computer an interface is required.

The interface acts as the boundary between the device and the CPU and provides

- data conversion,
- data storage,
- status information,
- control signals, and
- device selection.

A number of standards are used in the computer industry. Some of these are outlined briefly here.

Parallel Interface

Parallel data transmission involves transferring data between the peripheral device and the CPU one word at a time. A series of lines, one for each bit in the word are used to do this.

Data can only be transferred using parallel communication over a short distance due to the electrical differences between different lines. Once data has travelled more than a few metres skewing tends to occur which means that bits arrive at the destination unevenly.

Parallel Port - Centronics

Most computers will have a parallel port which allows direct connection to a scanner or printer using a standard 36 pin connector.

IDE

The hard disc and CD-ROM (or CD-R / DVD) in a typical computer may well be connected to the motherboard using an IDE (Integrated Drive Electronics) interface. This form of parallel interface allows data to be transferred quickly between the hard disk and the central processing unit.

There have been a number of improvements to the IDE standard in order to increase throughput and data transfer rates. Typically, a computer will be able to support up to 4 devices using an IDE interface.

SCSI

SCSI (Small Computer System Interface) allows up to eight peripheral devices to be connected to the computer in a daisy chain fashion. Each device is given a different identification number to allow data to be addressed correctly. This is particularly useful where a combination of scanners, CD-ROM drives, printers, etc are connected to one computer.

PCI

Expansion cards can often be fitted inside a computer. A common standard for this is PCI which allows graphics, sound, Ethernet and modem cards to be connected directly to the motherboard. This direct connection to the motherboard allows the attached cards to communicate via a very fast parallel port.

Serial

Serial data transmission involves data being transferred one bit after another down a single line. This is a slow way to transfer data but it is possible to use this method over far grater distances.

RS232

External modems, keyboards and mice are often connected via this form of interface. Data is transmitted one bit at a time in groups of 8 bits with extra padding and check digits to ensure data integrity.

USB

This is a relatively new form of interface which allows very fast serial communication between devices. It has a number of advantages over other forms of interface:

- It is possible to connect a large number of devices (up to 127) to the computer using USB.
- A hub can be connected which allows a large number of USB devices to be connected to a single socket in the computer.
- The USB cable carries a 5V power supply so devices requiring a low consumption power supply can be connected to the computer without the need for another 13A plug.
- It allows serial data transmission at up to 12 M/bps.
- It is a plug-and-play technology in that devices can be plugged in and unplugged without the need to restart the computer. The device is detected as soon as it is connected to the PC.

Keywords
Interface, parallel, serial, word, bit, IDE, SCSI, PCI, ISA, RS232, USB.