

## Output Devices

### Monitors

The most commonly used output device.

2 important hardware devices determine the quality of the image that you see,

- The monitor itself
- Video Controller

2 basic types of monitors used with pc's

- *CRT Cathode Ray Tube* – works in the same way as a tv screen using a large vacuum tube.
- *Flat Panel Display* – primarily used with portable computers and are becoming more popular with desktops.

Monitors can be categorised by the way they display colours,

- *Monochrome monitors* – one colour displayed against a contrasting background.
- *Greyscale monitors* – display various intensities of grey against a white background.
- *Colour monitors* – display anywhere from 16 to 16million colours.

### CRT

How a typical CRT works

1. Electron gun shoots streams of electrons towards the screen.
2. Magnetic coil guides the stream of electrons across and down the screen.
3. Phosphor dots on the back of the screen glow when the electron beam hits them.

Screen's phosphor coating is organised into a grid of dots. The smallest number of dots that the gun can focus on is called a *pixel*. Modern monitors can focus on a pixel as small as a single phosphor dot.

Electron gun systematically aims at every pixel on the screen starting at the top left corner and scanning to the right.

As the electron gun scans, the circuitry driving the monitor adjusts the intensity of each beam to determine whether a pixel is on or off.

Colour monitor has 3 electron guns representing red, green and blue, although the beams are colourless. The phosphors in each pixel have a triangle representing each colour. When the beams of the 3 guns combine to focus on a pixel the phosphors light up. Colour displayed depends on the combination of the intensities of the 3 beams.

A CRT monitor contains a *shadow-mask* which is a fine metal mesh fitted to the shape and size of the screen. The holes in the shadow-mask's mesh are used to align the electron beams to ensure that they strike precisely the correct phosphor dot. In most shadow masks these holes are arranged in triangles.

### **Flat Panel Monitors**

2 major disadvantages associated with CRT monitors,

- Big, difficult to move. Flat panel monitors are comparatively lightweight.
- CRT's require a lot of power. Not practical for notebook computers which have a built in battery.

Most common type of flat panel monitor is the *liquid crystal display (LCD)*. Creates an image with a special kind of liquid crystal that is normally transparent but becomes opaque when charged with electricity.

#### *Disadvantage*

Liquid crystal does not emit light so there is not enough contrast between the images and the background to make them legible under all conditions.

#### *Solution*

Backlight the screen, however additional power required.

#### *Another disadvantage*

Limited viewing angle.

Two main categories of LCD displays,

1. Active matrix
2. Passive matrix

### **Passive matrix LCD**

Relies on transistors for each row and each column of pixels creating a grid that defines the location of each pixel. Colour displayed by a pixel is determined by electricity coming from transistors at end of each row and the top of each column.

#### *Advantage*

Less expensive

#### *Disadvantage*

- Narrow viewing angle
- Does not refresh the pixels very often
- Move the pointer very quickly and it disappears, this effect is known as submarining.
- Animated graphics appear blurry.

Most notebooks using passive matrix technology refer to their screens as *dual-scan LCD*. Scanning the pixels twice as often lessens problem of refresh rate. Thus submarining and blurry graphics are less troublesome than before.

### **Active Matrix LCD**

Technology assigns a transistor to each pixel and each pixel is turned on or off individually. Enhancement allows pixels to be refreshed much more rapidly so submarining is not a problem. Also there is a wider viewing angle.

Often called *thin film transistor (TFT)* displays because many active matrix monitors are based on TFT technology, which employs as many as 4 transistors per pixel.

More complex → more expensive!

### **Other types of monitors**

- *Paper white displays*

Produces a very high contrast between the monitors white background and the displayed text or graphics. Utilise a special technology called super twist to create higher contrasts.

- *Electro luminescent (ELD) displays*

Similar to LCD but use a phosphorescent film between 2 sheets of glass. A grid of wires sends current through the film to create an image.

- *Plasma/Gas Plasma displays*

Thin displays created by sandwiching a special gas (neon or xenon) between 2 sheets of glass. When the gas is electrified via a small grid of electrodes, it glows. Controlling the amount of voltage applied at various points on the grid means each point acts as a pixel to display an image. Expensive but higher quality and larger than LCDs.

## Comparing Monitors

Need to check several specifications

1. Size
2. Resolution
3. Refresh rate
4. Dot Pitch

### Monitor Size

Monitors are measured diagonally in inches across the front of the screen. The picture on a 17" monitor is a little over 15". The standard size is 17".

### Resolution

The number of pixels on the screen expressed as a matrix, eg. 640x480  
→ 640 pixels horizontally and 480 vertically.

Actual resolution is determined by the video controller not the monitor so monitors specify a range of resolutions.

In the mid 80's IBM established the *Video Graphics Array (VGA)* standard of 640x480 pixels. *Super VGA (SVGA)* standard extended the resolution to 800x600 and 1024x768.

### Refresh Rate

This is neither obvious nor standard. The number of times per second that the electron guns scan every pixel on the screen and is measured in Hertz (Hz), or in cycles per second. The monitor refreshes itself at least a dozen times every second.

If the screen is not refreshed often it appears to flicker, which is one of the main causes of eyestrain. A refresh rate of 72Hz or higher should not cause eyestrain.

### **Dot Pitch**

The distance between the phosphor dots that make up a pixel. If the dots are not close enough the image will not be crisp. Difficult to detect differences in the dot pitch but blurry pixels will cause eyestrain.

Distance between dots = dot pitch average  
= 0.28mm.

### **Video Controller**

An intermediary device between the CPU and the monitor. Contains the video dedicated memory and other circuitry necessary to send info to the monitor. Consists of a circuit board which is attached to the computer's motherboard. Controls the refresh rate, resolution and the number of colours that can be displayed.

*E.g.* Max. amount of colour at 1024x768, computer must send 2,359,296 bytes to the monitor for each screen.

Result → Video controller has high power and importance.

The microprocessor on the video controller frees the CPU from the burden of calculations for displaying graphics. Most video controllers include at least 4MB of *Video RAM (VRAM)*. VRAM is dual ported → Can send data to the monitor and receive data from the CPU at the same time. Fast and expensive.

### **PC Projectors**

More common now to use software to create presentations directly to the screen. A pc projector plugs into one of the computer's ports and projects the video output onto an external surface. Most pc projectors use LCD technology to create images. Room needs to be darkened and display is blurry.

Newer technology → *Digital light processing (DLP)* displays brighter crisper images. DLP devices use a special microchip called a digital micro mirror device that uses mirrors to control the image display.

## Sound Systems

Speakers and their associated technology are now important output devices. Speakers attached to a pc system are similar to those on a stereo only on a smaller scale and they contain their own amplifiers. More complicated part → the sound card.

The sound card translates digital sound to electric current to be sent to the speakers

1. Electric current is sent to the speakers.
2. Electromagnet receives the signal.
3. Magnet vibrates due to the signal.
4. Wave created → Sound.

## Printers

Overview:

2 categories:

1. Impact
2. Non-impact

### *Impact*

Creates an image by pressing an inked ribbon against paper using pins or hammers to shape the image e.g. typewriter.

Most common type of impact printer → Dot matrix.

Slow and limited to the kinds of images that it can produce.

*Non-impact*

Use other means to create an image.

Most popular types → Inkjet printers, Laser printers.

### **Considerations when buying/comparing printers**

1. Image quality
2. Speed
3. Initial Cost
4. Cost of Operation.

#### **Image Quality**

Also known as printer resolution and is usually measured in *dots per inch (dpi)*. The more dpi a printer can produce the higher the quality.

E.g. Medium quality inkjet or lasers print 300 – 600 dpi. Professional quality printers offer resolutions of 1800 dpi or higher.

#### **Speed**

Speed is measured in the number of *pages per minute (ppm)* that the device can print. Different ppm rates for text and graphics. As speed increases so does cost.

Consumer level lasers offer speeds of 6 – 8 ppm while high volume professional printers can exceed 20 ppm.

#### **Initial Cost**

Cost of printers has fallen dramatically while capabilities and speed have improved in the last few years.

Good quality inkjet ~\$100. Low-end laser ~\$250. Professional systems range from \$1000 to \$10,000's.

#### **Cost of Operation**

Cost of ink or toner and maintenance varies with the type of printer.  
Type of paper can affect the cost of operation.

### Dot Matrix Printer

Commonly used in workplaces where physical impact with the paper is important, such as when the user is printing to carbon copy or pressure sensitive forms. Can produce sheets of plain text very quickly. Used to print very wide sheets.

Creates an image using a mechanism called a *print head*, which contains a cluster of short pins arranged in one or more columns. On receiving instructions from the pc the printer can push any of the pins out in any combination creating alphanumerics. Protruding pins' ends strike a ribbon pressing ink onto a page.

Where a single pin hits the ribbon a dot of ink is printed onto the page hence the name *dot matrix*.

More pins → higher resolution.

Lowest resolution → 9 pins

Highest resolution → 24 pins.

Speed of dot matrix printers not ppm but *characters per second (cps)*

Slowest → 50 - 70 cps

Fastest → 500 cps.

Dot matrix printers use *tractor feed paper* (also called *continuous feed paper*). Sheets of paper are joined end to end with perforations between the sheets. Rows of holes run down both long edges of each page and a tractor feed mechanism pulls the paper through.

### Other types of impact printers

#### Line Printers

Works like a dot matrix printer but prints an entire line at a time. Not very high resolution but very quick – approx 3000 lines of text per min.

#### Band Printers



Features a rotating band that is embossed with alphanumeric characters. Very fast and robust – approx 2000 lines of text per min.

### Daisy wheel printers

Almost obsolete. Spinning wheel with characters embossed around its edge. Creates clean text but no graphics and is very slow.

### Inkjet Printers

Creates an image directly onto the paper by spraying ink through tiny nozzles. Good inkjet printers typically attain print resolutions of at least 360 dpi and can print from 2 – 4 ppm.

Compared to laser printers operating costs are relatively low. Most inkjets use separate cartridges for colour and black and white printing. This saves money by reserving coloured ink only for coloured printing.

Another improvement → paper required, can now use standard photocopying paper.

Very cosy effective way to print in colour. 4 ink nozzles → cyan (blue), magenta (red), yellow and black. These 4 colours can combine to create any colour in the visible spectrum and are sometimes called the **subtractive** colours. Colour printing is sometimes called 4-colour printing.

### Laser Printers

More expensive than inkjet printers but offer a higher print quality and are faster. A separate CPU and memory are built into the printer to interpret the data received from the computer and to control the laser. Technology is similar to that of a photocopier.

Laser can aim at any point on a drum creating an electrical charge. **Toner**, which is composed of tiny particles of oppositely charged ink sticks to the drum in the places that the laser has charged. Pressure and heat transfer the toner from the drum to the paper.

Amount of memory that laser printers contain determine the speed at which documents are printed.

A colour laser works like a single colour model except that the process is repeated 4 times and a different toner colour is used for each pass. The same 4 colours as in an inkjet – cyan, magenta, yellow and black.

Single colour laser printers typically produce 4 –16 ppm of text, printing graphics is slower. Most common resolutions 300 – 600 dpi both horizontally and vertically. High end models have resolutions of 1200 – 1800 dpi. The higher resolution is much more noticeable in graphics reproduction.

#### Advantages

- Convenience

#### Disadvantages

- Price
- Cost of Operation.

Prices increase dramatically with speed and resolution. New toner cartridges every few thousand pages.

### **Snapshot Printers**

Small format printers that use special glossy paper to create medium resolution prints of 150 – 300 dpi. Best snapshot printers can create images that look nearly as good as a photo.

Very slow – printout takes between 2 and 4 mins on average – and generally creates prints no larger than standard 4x6 inch snapshot. Can take several mins to dry → smearing can be a problem.

Typical price range \$400 - \$500. Cost per print ranges from 50c - \$1.

### **Other High Quality Printers**

Special purpose printers often used by publishers or small print shops to create high quality output.

### **Thermal wax printers**

Used primarily for presentation graphics and handouts. Create bold colours and have a low percentage cost. Produces vivid colours because the inks do not bleed into each other or soak the specially coated paper.

Ribbon coated with panels of coloured wax that melts and adheres to plain paper as coloured dots when passed over a focused heat source.

### **Dye - sub printers**

Dye sublimation printers have ribbons containing panels of colours which are moved across a focused heat source capable of subtle temperature variations. Heated dyes evaporate from the ribbon and diffuse on specially coated paper creating extremely sharp images but are very slow and costly.

### **Fiery printers**

Special purpose computer - **fiery print server** - that transmits documents to a digital colour copier where they are printed. These printers are used in print shops as an alternative to press printing.

### **IRIS printers**

Used by print shops to produce high resolution presentation graphics and colour proofs resembling images. Individual sheets of paper mounted onto a drum, nozzles on the printing head pass from one end of the spinning drum to the other spraying minute drops of coloured ink to form an image. Image resolutions of 1800 dpi.

## **Plotters**

Special kind of output device, like a printer because it produces images on paper but typically used to print large format images.

- Table plotters (or flatbed) use 2 robotic arms. Complex, large and slow.
- Roller plotters (or drum plotters) uses 1 drawing arm but moves the paper instead of holding it flat and stationary.
- Mechanical plotters have been displaced by thermal, electrostatic and inkjet plotters as well as large format dye – sub printers which are all faster and cheaper.