CMPE - 310

Lecture 15 – Mass Storage And Display Technologies

Outline

Magnetic, optical and solid state:

- Hard disks
- CD-ROMs, DVDs and Blu-Ray Disks
- SSD

Display technologies

- TTL and Analog RGB Monitors
- LCD
- LED
- OLED

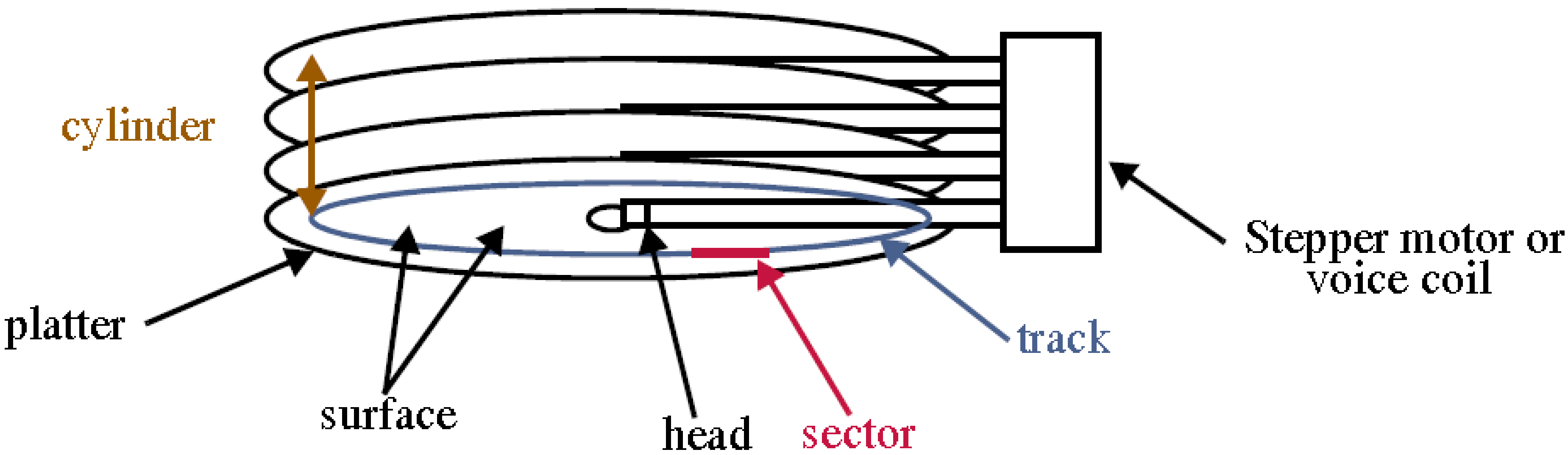
Hard Disks:

Use a flying head to store and read data from the platters and spins at 3,000 to 10,000 RPM.

Source: Wikimedia Commons

Hard Disks

Hard disks usually have at least 4 platters and can have 2 heads per surface.



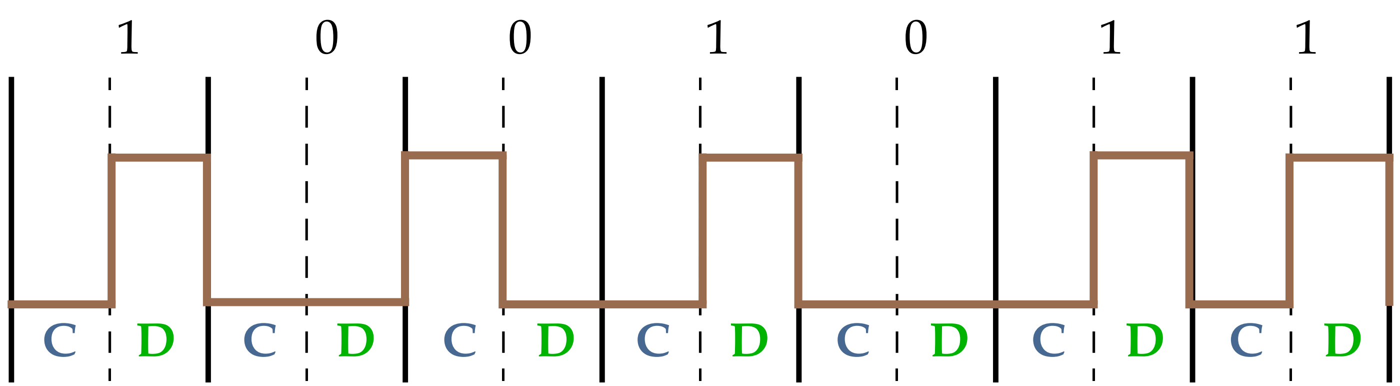
The heads are moved from cylinder to cylinder using a voice coil.

Hard Disks

Hard disks use MFM or RLL (run-length limited) to store information.

RLL 2,7 is common today -- this indicates that the number of zeros in a row is always between 2 and 7.

The recording format called **MFM** (modified frequency modulation) used to write double density format.



Hard Disks

The data is first encoded using the table given below.

Note that this encoding always guarantees at least 2 *zeros* and no more than 7 *zeros* in a row.

Input Data Stream	**RLL output**
000	000100
10	0100
010	100100
0010	00100100
11	1000
011	001000
0011	00001000

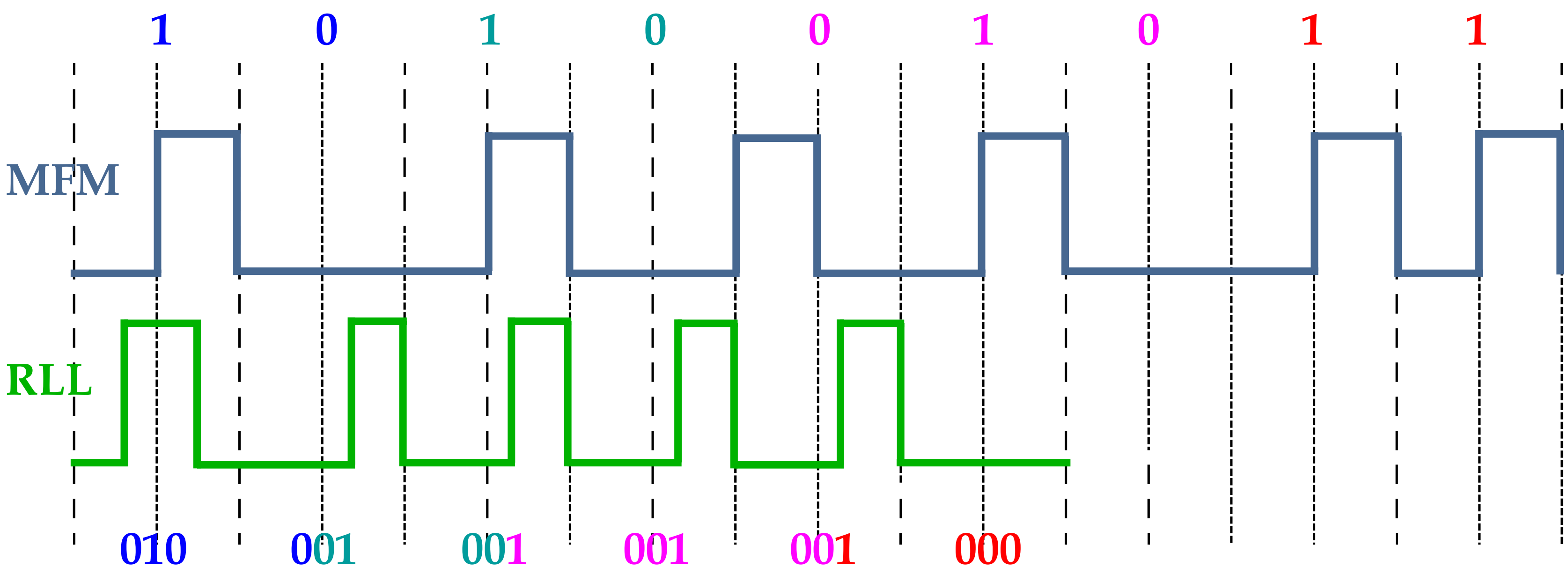
This encoding allows nearly a *50%* increase in storage capacity over MFMs without changing the driver electronics or disk surface.

RLL drives increase the number of tracks from 18 to 27 to achieve this.

40 MB -> 60 MB with better performance.

Hard Disks

For example, given the data stream 101001011:



Although all disks use MFM or RLL, disk interfaces vary.

Systems used ***ESDI*** (non-existent), ***SCSI*** (small computer system interface) and ***IDE*** (integrated drive electronics).

Today's systems use variants of ***SATA***.

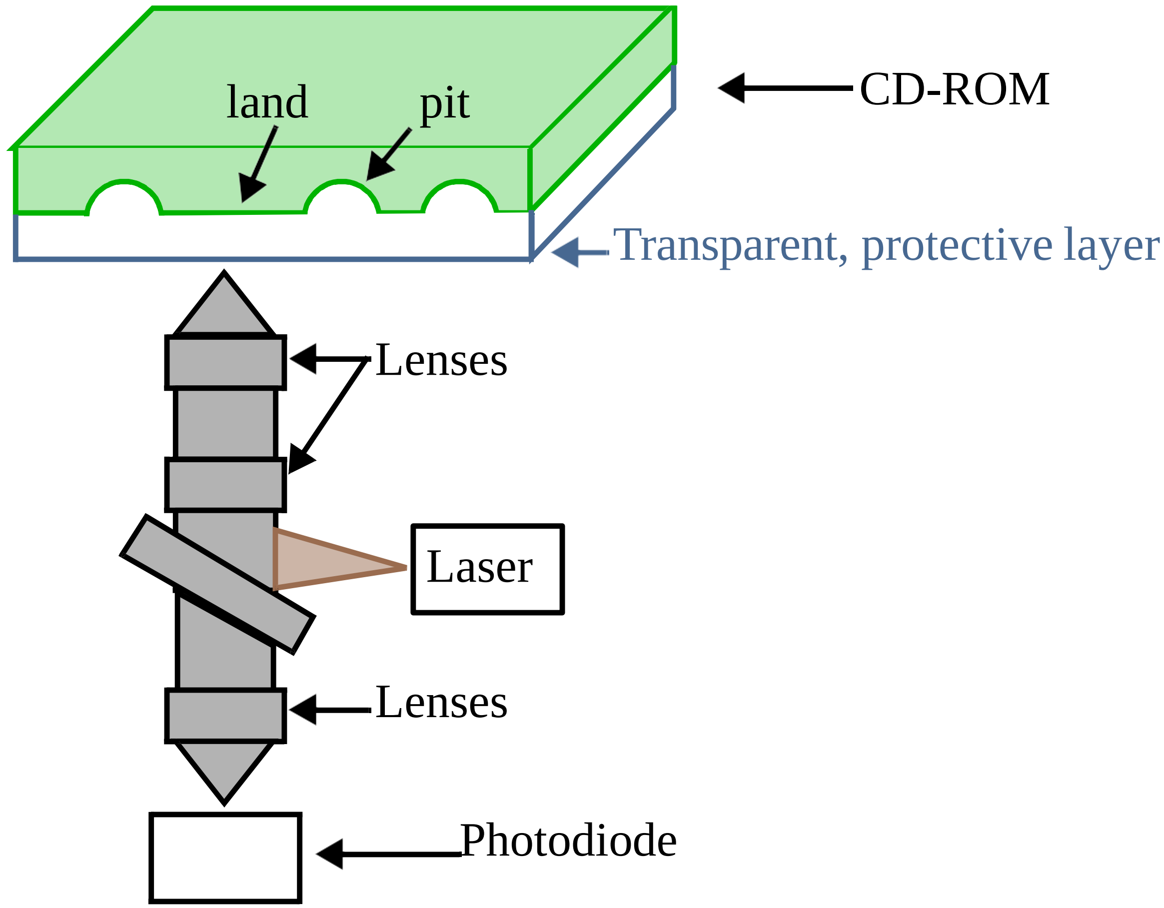
IDE incorporates the disk controller in the disk drive and usually contain a 32 KB cache.

Transfer times are from 5 MB/s up to 133 MB/s.

SATA I transfer times range up to 150 MB/s

SATA II transfer times go up to 300 MB/s

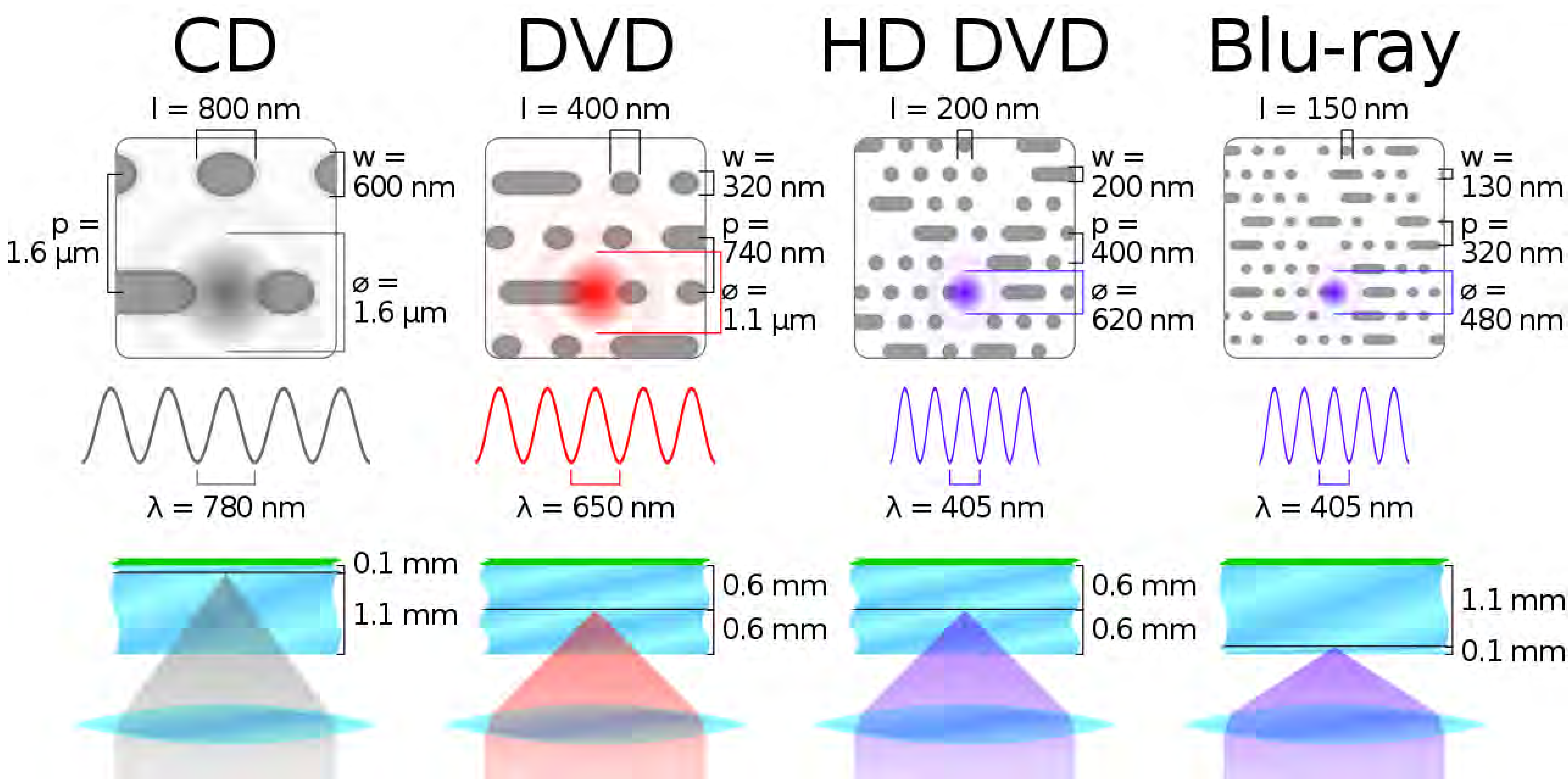
Optical Disks



CD-ROMs and WORMs store up to 660 MB of data.

DVDs are similar but have much higher bit density (4.7, 8.5 and 17 GB).

Optical Disks



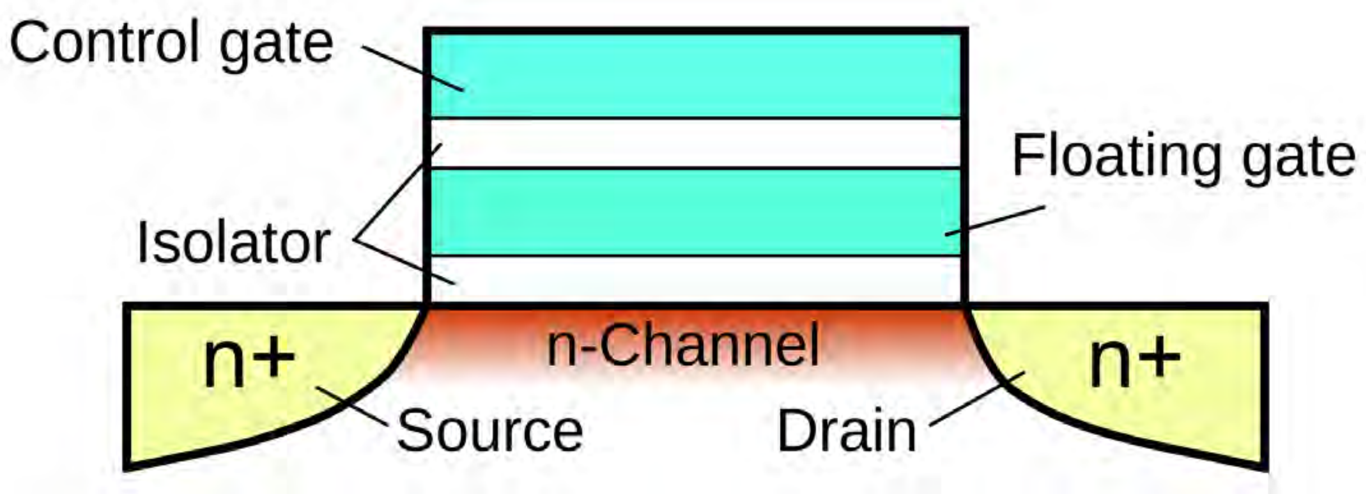
Source: Wikimedia Commons

SSDs (Solid State Drives)

Solid-state drives are called that specifically because they don't rely on moving parts or spinning disks.

Data is saved to a pool of NAND flash.

NAND itself is made up of what are called floating gate transistors.

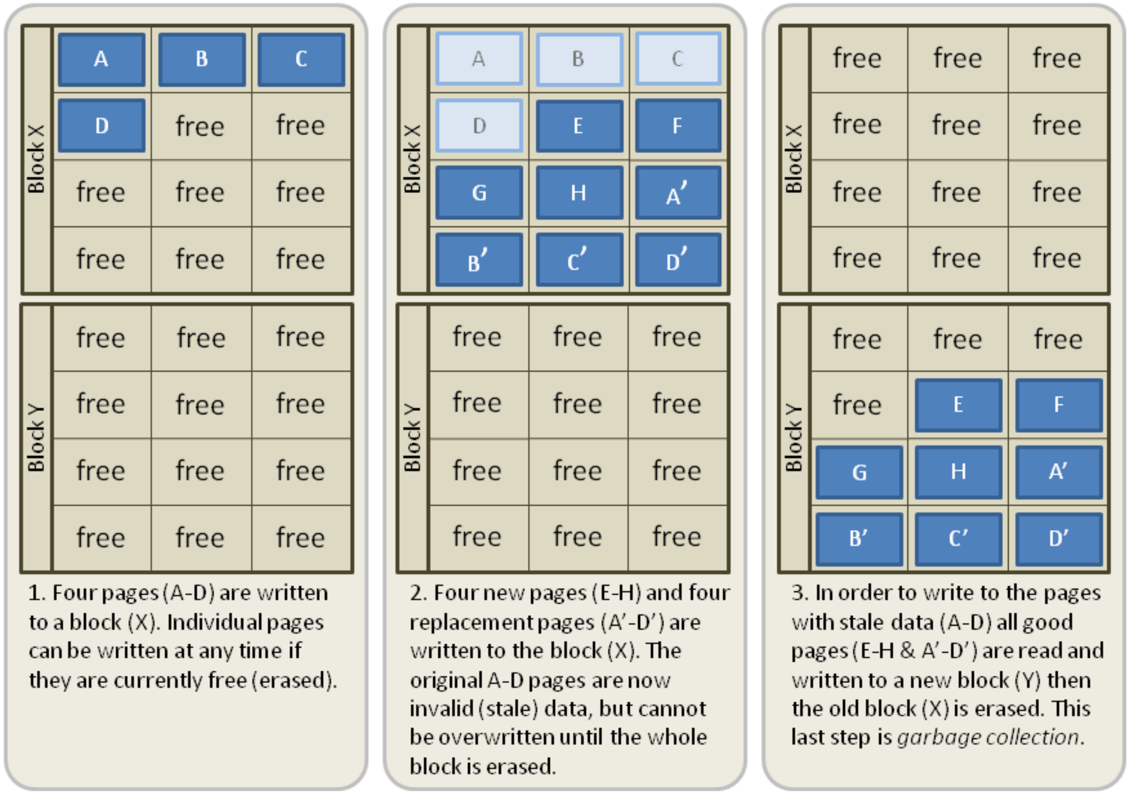


Source: Wikimedia Commons

Electrons are stored in the floating gate, which then reads as charged "0" or not charged "1.

SSDs (Solid State Drives)

NAND flash is organized in a grid.



Source: Wikimedia Commons

The entire grid layout is referred to as a block, while the individual rows that make up the grid are called a page.

Common page sizes are 2K, 4K, 8K, or 16K, with 128 to 256 pages per block. Block size therefore typically varies between 256KB and 4MB.

Video Displays

- Color displays are extremely popular.
  - Some accept information as a composite video signal (similar to TVs), as TTL voltage level signals (0 or 5V) and as analog signals (0 to 0.7V).

- Composites are disappearing since high-resolution cannot be achieved.
  - They combine the color information with other information such as sync pulses.

- Most modern systems use direct video signals with separate sync signals.
  - Monochrome monitors use one wire for video, one for horizontal sync and one for vertical sync.
  - Color monitors use three video signals, one for red, green and blue (RGB).

- The TTL RGB Monitor:
  - It uses TTL level signs (0 or 5V) as video inputs and a 4th line called intensity.
  - It can display a total of 16 different colors (CGA in older systems).

TTL RGB Monitor

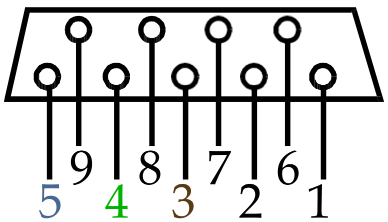
The following table gives the RGB values and colors:

Intensity	Red	Green	Blue	Color
0	0	0	0	Black
0	0	0	1	Blue
0	0	1	0	Green
0	0	1	1	Cyan
0	1	0	0	Red
0	1	0	1	Magenta
0	1	1	0	Brown
0	1	1	1	White
1	0	0	0	Gray
1	0	0	1	Bright Blue
1	0	1	0	Bright Green
1	0	1	1	Bright Cyan
1	1	0	0	Bright Red
1	1	0	1	Bright Magenta
1	1	1	0	Yellow
1	1	1	1	Bright White

Cyan is a combination of Green and Blue, Magenta - Red and Blue, etc.

TTL and Analog RGB Monitor

The connector pin definitions for either color or monochrome



1 and 2: Ground
3: Red video
4: Green video
5: Blue video

6: Intensity
7: Normal video
8: Horizontal retrace
9: Vertical retrace

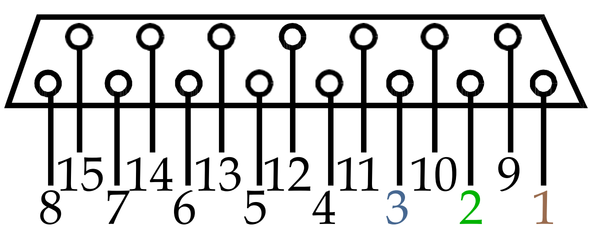
Horizontal and vertical retrace are for synchronization.

Normal video is used for 'intensity' on monochrome monitors.

Analog RGB Monitors

Analog RGB monitors have 3 video signals (no intensity) that can be driven with values between 0 and 0.7 V.

Most can display 256K, 16M or 24M colors.



1: Red
2: Green (mono)
3: Blue
4 and 5: GND
6/7/8: RGB GND
9: Female is blocked

10 and 15: GND
11: Color detect (GND mono)
12: Mono detect (GND color)
13: Horz sync
14: Vert sync
15: GND

Analog RGB Monitor

Most analog displays use a DAC to generate each color video voltage.

A common standard uses a 6-bit DAC for each video signal for 64 distinct voltage levels over 0 to 0.7 V range.

64 X 64 X 64 = 262,144 (256K) colors.

8-bit DACs yield 16M colors.

Conversion time between 25ns and 40ns is required of the DAC.

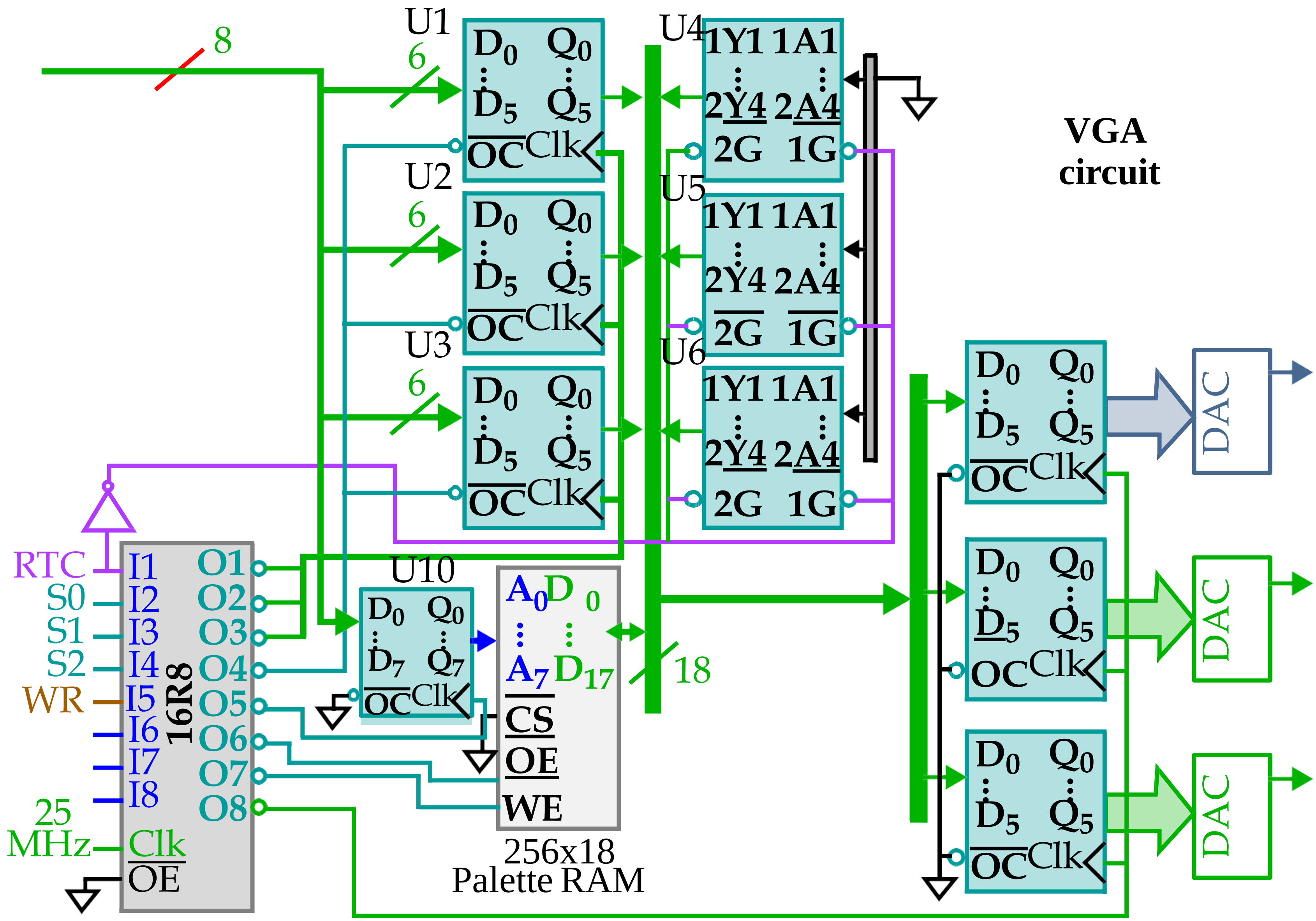
The next slide shows the video generation circuit used in VGA systems.

Each color is generated with a 18-bit digital code (6 each for RG &B).

A high speed palette SRAM (access < 40ns) is used to store 256 different 18-bit color codes (hardware colormap) out of the 256K possible (2^{18}).

The 8-bit values (8 bit depth) in the video display RAM specify one of the 256 colors for each pixel position on the screen.

Analog RGB Monitor



Analog RGB Monitor

The 8 bit values from the video RAM are each sent individually on the data bus and latched into U10 by the 16R8.

After 40ns (1/25MHz), the PAL generates a Clk pulse for the DAC latches.

This leaves enough time for the SRAM to access the 18-bit code.

The DACs then convert the 6-bit values to analog voltages for the monitor.

Changing the 18-bit color values is done during retrace, e.g. when RTC is 1.

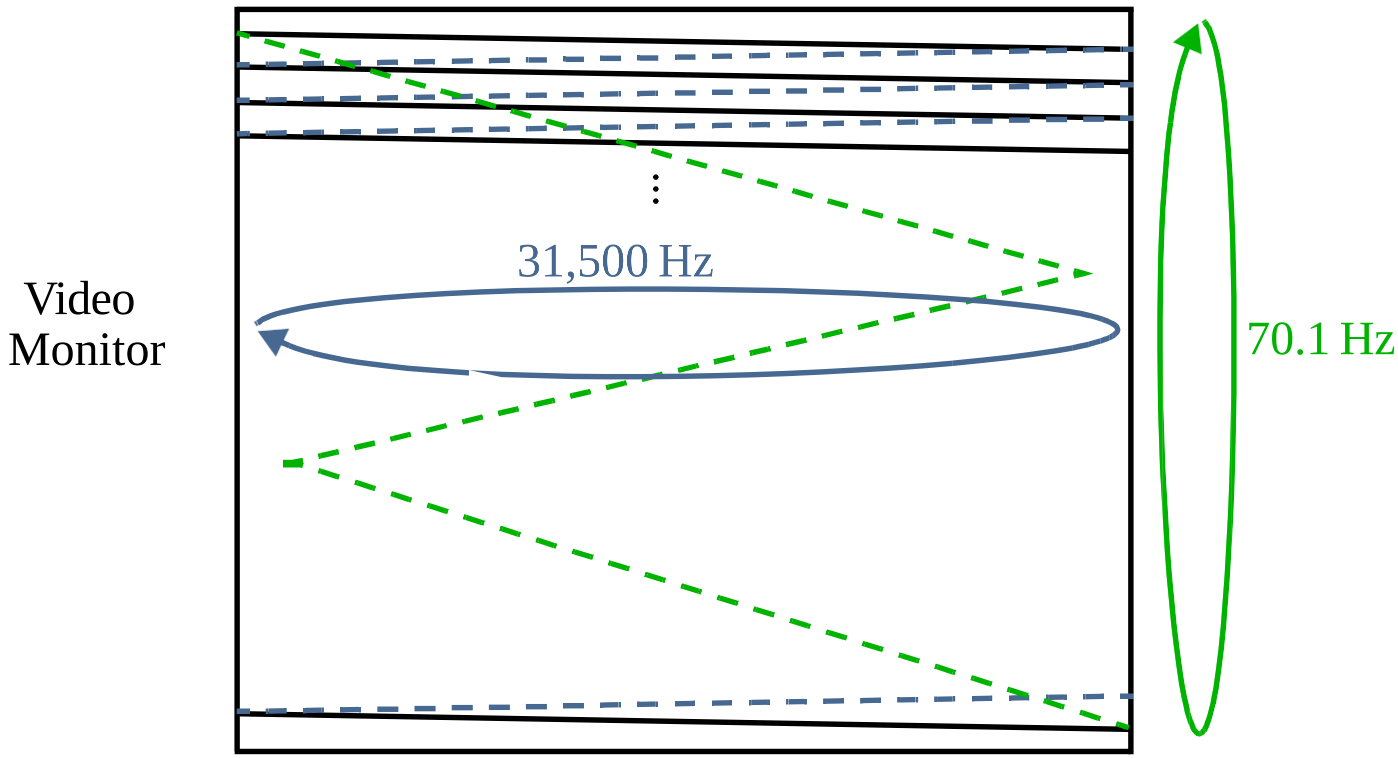
The PAL latches the address into U10 of the 18-bit cell to overwrite.

Then, S0, S1 and S2 are used to clock each of U1, U2 and U3 in succession as 6-bit values are placed on the data bus.

Finally, $\overline{\text{WE}}$ of the SRAM is pulsed and the U1-U3 outputs are input to the SRAM.

Analog RGB Monitor

Retrace occurs 70.1 times per second in the vertical direction and 31,500 times per second in the horizontal direction for a 640 x 480 display.



During retrace, the video sent to the monitor must be 0 (black).

Buffers U4, U5 and U6 are enabled during this time to force 0.

Analog RGB Monitor

The resolution of the display determine the amount of memory required.

If 256 colors are used (8-bits per pixel) then 640 (width) x 480 or 307,200 bytes of memory are required to store the image.

In order to repaint the 640 pixels of a raster line, 40ns X 640 or 25.6 us are needed.

A horizontal time of 1/31,500 gives 31.746 us.

31.746 - 25.6 = 6.146 us is allowed for horizontal retrace.

Given a vertical retrace of 70.1 Hz, the number of lines repainted is given by (1/70.1)/ 31.746 us = 449.358 lines.

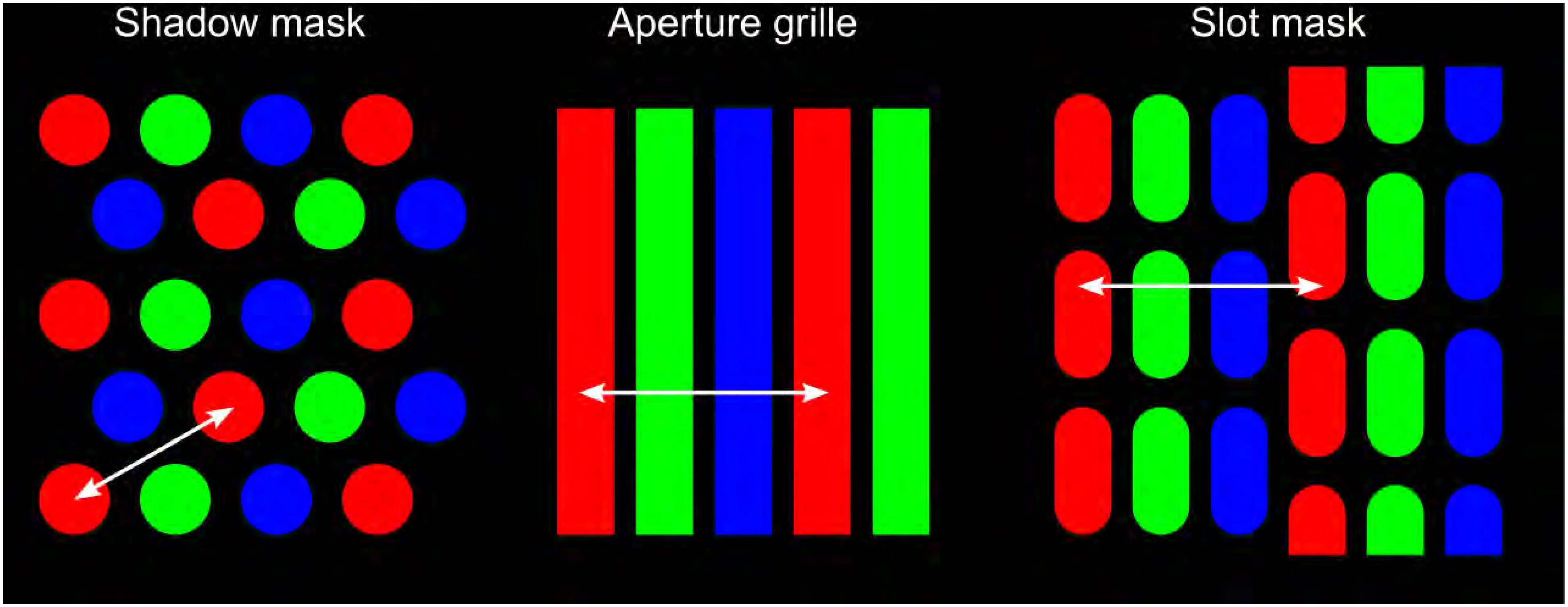
Assume 400 of these lines are used to display information and the rest are lost during retrace.

This leaves 49.358 X 31.746 = 1567 us for vertical retrace.

It is during this time that the palette can be updated or the display RAM is updated with a new image.

RGB Masks

RGB dots are usually arranged in a specific pattern (mask) after projection.

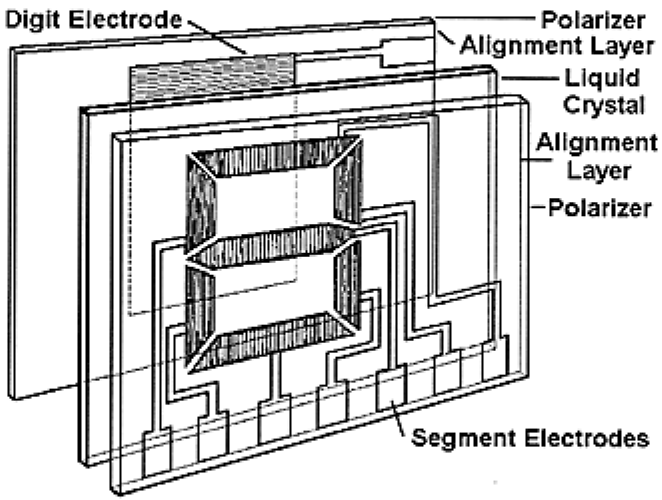


Source: Wikimedia Commons

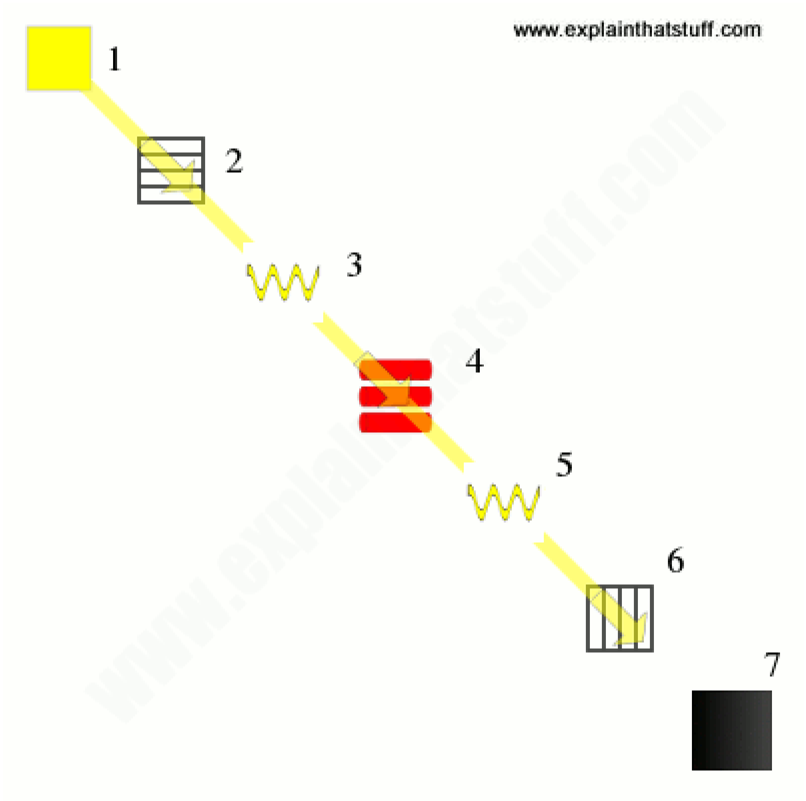
LCD (Liquid Crystal Display)

LCDs require all most no power to operate.

LCDs work from the ability of liquid crystals (LC) to rotate polarized light relative to a pair of crossed polarizers laminated to the outside of the display.



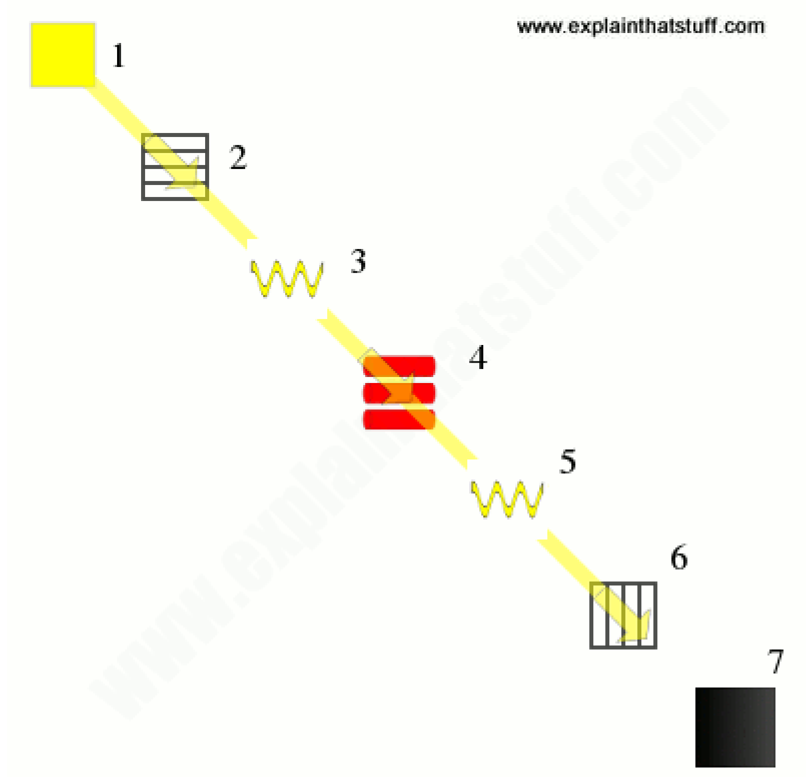
Source: Vintage Calculators, http://www.vintagecalculators.com/html/calculator_display_technology.html



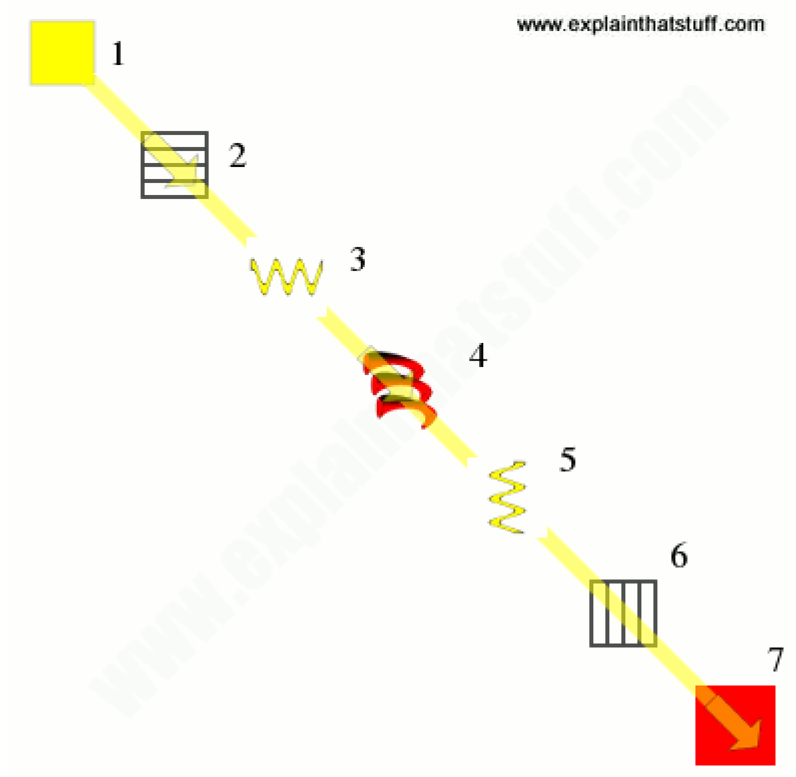
LCD (Liquid Crystal Display)

Twisted Nematic Operation

Voltage NOT applied



Voltage applied



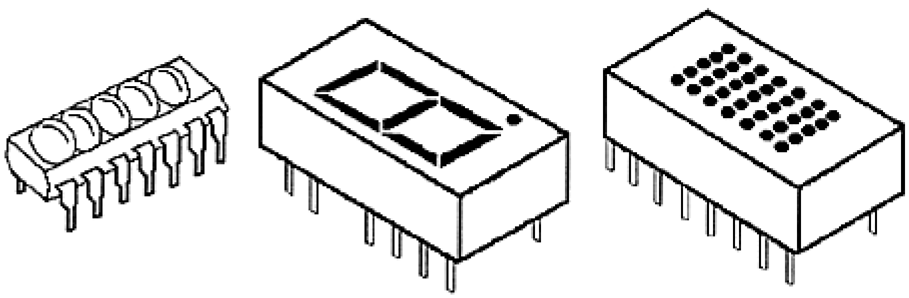
Source: explainthatstuff.com, https://www.explainthatstuff.com/lcdtv.html

LED

Essentially a diode coated with transparent resin emitting light in the visible spectrum.

Every time electrons cross the junction, they nip into holes on the other side, release surplus energy, and give off a quick flash of light.

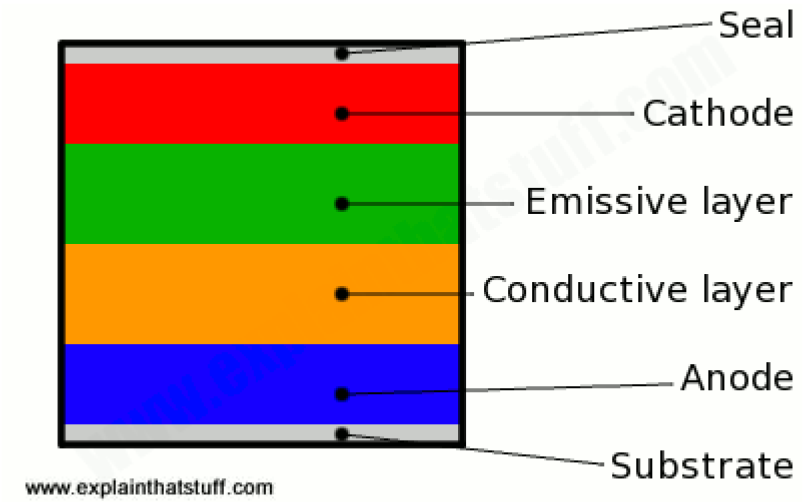
All those flashes produce the dull, continuous glow.



Source: Vintage Calculators, http://www.vintagecalculators.com/html/calculator_display_technology.html

OLED

Instead of using layers of n-type and p-type semiconductors, they use organic molecules to produce their electrons and holes.



Source: explainthatstuff.com, https://www.explainthatstuff.com/how-oleds-and-leps-work.html