

Pixels per Image and Pixels (or Dots) per Inch (dpi) (or Millimeter) (and Office Color)

Pixels per Image

Most document imaging resolution measures are in pixels (PIcture ELEment) per inch (or per mm - millimeter), and are commonly referred to as dpi (dots per inch) or dpmm (dots per mm). Most motion picture and still-photographic resolution measures are in pixels per image. This is most commonly seen in the 525 lines of NTSC (National Television System Committee), 625 lines for PAL (Phase Alternating Line) and SECAM (Sequential Couleur Avec Memoire or Sequential Colour with Memory), resolution of television images. No matter how physically large or small

an NTSC television image is displayed, there are only 525 lines of vertical resolution (480 viewable). The computer equivalent of this is 640 by 480 pixels in a standard computer image. In pixels per image the horizontal resolution is given first. If the horizontal dimension is larger than the vertical dimension in pixels, the image or display is said to be landscape, if the horizontal is smaller, the image or display is said to be portrait. See also SMPTE (Society of Motion Picture and Television Engineers) [<http://www.SMPTE.org>]

The physical size of the display is an important element in the design of a document imaging workstation. A 20 or 21 inch nominal diagonal size, or exactly a 20 ± 1/4 inch VIS (Viewable Image Size) is most commonly used for CRTs (Cathode Ray Tubes), with an equivalent 18 ± 1/4 inch VIS being the most common for flat panel displays. These sizes, or larger, are especially important for extended use, or the accommodation of viewers who use bifocal glasses.

Pixels per Image: Video Image Resolutions

Computer screen resolutions are chosen to have an aspect ratio (the ratio of width to height) of 4 to 3 (the 'golden ratio' of the art world) and to have the number of pixels be an integer multiple of a power of 2. (Powers of 2 are given here as 2**N for the Nth power of 2). When a prefix is added to the word pixel it can be shortened to pel (Picture ELEment). A 1 million pixel display is then a 1 MegaPel display. See also IEEE (The Institute of Electrical and Electronics Engineers) [<http://www.IEEE.org>] ACM (Association for Computing Machinery) [<http://www.ACM.org>] NAB (National Association of Broadcasters) [<http://www.NAB.org>]

IBM PC: CGA (Color Graphics Adapter) 320 x 200, EGA (Enhanced Graphics Adapter) 640 x 350, VGA (Video Graphics Array) 640 x 480.

IBM PC compatible: VGA 640 x 480 (This is the standard default screen resolution when a display card is reset to troubleshoot a problem with the display.), SVGA (Super VGA) or XGA (eXtended Graphics Array) 800 x 600, XVGA (eXtended VGA) 1024 x 768; and SXGA (Super XGA) or UVGA (Ultra VGA) 1280 x 1024 (although SVGA, SXGA, XVGA, and UVGA can mean anything that is more than the VGA's 640 x 480), UXGA (Ultra eXtended Graphics Adapter) is often 1600 x 1200. Because the meaning of IBM PC compatible acronyms is a marketing decision, no absolute meaning should be imputed to them.

The DVD NTSC resolution is 720 x 480 and the DVD PAL/SECAM resolution is 720 x 576. (Twentieth Century commercial television)

Pixels per Image: Single Frame (Still) Image Resolutions

The Kodak PhotoCD family of resolutions: (Based on a 2 x 3 portrait aspect ratio and an integer power of 2. The multiple of the base gives the number of pixels per image relative to the base image size in pixels.) A Kodak PhotoCD contains five resolutions for each image: 1/16

Base through 16 Base. (The average compressed file size containing all five resolutions is about 5 MegaBytes per image.) A Kodak Pro PhotoCD contains the five resolutions for each image found on a PhotoCD plus a sixth 64 Base resolution. PhotoCD images are intended for true

See also [<http://www.Kodak.com>] color, continuous tone images. 64 base Kodak Pro PhotoCD scanning does not always provide adequate resolution for 35 mm aperture card images (monotone microform images with a steep gamma curve) (nominally bi-tonal or black and white).

1/16 base (thumbnail, index print on CD cover)	.024576 megapixel image	= 128 x 192 pixels	= [2 x 3] [2** 6 x 2 ** 6]
1/4 base (largest Kodak size that is smaller than 480 x 640 for display on TV)	.098304 megapixel image	= 256 x 384 pixels	= [2 x 3] [2** 7 x 2 ** 7]
1 base	.393216 megapixel image	= 512 x 768 pixels	= [2 x 3] [2** 8 x 2 ** 8]
4 base (largest Kodak size that is smaller than 1920 x 1152 for HDTV)	1.572864 megapixel image	= 1024 x 1536 pixels	= [2 x 3] [2** 9 x 2 ** 9]
16 base (captures all the resolution on most 35 mm film images)	6.291456 megapixel image	= 2048 x 3072 pixels	= [2 x 3] [2**10 x 2 **10]
64 base (captures all the resolution for most film formats larger than 35 mm)	25.165824 megapixel image	= 4096 x 6144 pixels	= [2 x 3] [2**11 x 2 **11]

Display Resolutions

(Horizontal x Vertical measure in pixels) The first number is always horizontal. If the horizontal number is greater than vertical number, the display is called landscape and is suitable for engineering drawings and wide spreadsheets. If the vertical number is greater than horizontal number, the display is called portrait and is suitable for textual documents and tall narrow tables.

The size of scanned paper pages (P) and Kodak PhotoCD images (K) in included in landscape format for comparison.

In all cases, the actual numeric resolutions should be used in place of an acronym. The acronyms are given here for assistance in interpreting text that does not include a numeric resolution. An acronym can be used following the

(H x V) (Horizontal x Vertical) measure in pixels.

numeric resolution, for reference, but the acronym may lead to extended discussions. Fortunately, the Quad (Q) designation is helping to lock in the meaning of some of the acronyms (e.g. QXGA, QSXGA, and QUXGA).

An aspect ratio of [a x b] [c x d] is equal to [a * c x b * d] when expressed using matrix arithmetic.

VGA	640 x 480	Video Graphics Array, TV - computer version	UXGAW	1920 x 1200	UXGA Wide, HDTV - computer version
SVGA	800 x 600	Super VGA	QUXGAW	3840 x 2400	Quad UXGA Wide, Quad HDTV (IBM T220 display)
XGA	1024 x 768	eXtended Graphics Array	QXGA	2048 x 1536	Quad XGA, 4 times XGA resolution
SXGA	1280 x 1024	Super XGA	QXGAW	2732 x 1536	Quad XGA Wide, sometimes WQXGAW
XGAW	1366 x 768	XGA Wide, sometimes WXGAW	QSXGA	2560 x 2048	Quad SXGA, 4 times XGA resolution
UXGA	1600 x 1200	Ultra XGA	QSXGAW	3200 x 2048	Quad SXGA Wide, 4 times SXGAW resolution
			QUXGA	3200 x 2400	Quad UXGA, 4 times UXGA resolution (Viewsonic.com)

(Office Color) Scanned Letter Size Pages (View-only images, 100 dpi, no OCR possible)

1 scanned page (100 dpi) (8 1/2 by 11 inches, A4) = 100 KiloBytes (KByte) (on average, office color, including grayscale, compressed)

1 file cabinet (4 drawer) (10,000 pages on average) = 1 GigaByte (GByte) = 2 CDs (ROM or WORM)

4 file cabinets = 1 DVD-R (WORM) (see below)

1,000 file cabinets = 1,000 GigaBytes = 1 TeraByte (TByte); 1,000 file cabinets = 250 DVDs

1 box (in inches: 12 wide x 15 long x 10 deep) (300 x 375 x 250 mm) (2,500 pages) = 1 file drawer = 2 linear feet (500 mm) of files = 250 MegaBytes

4 boxes = 8 linear feet = 1 file cabinets = 1 GigaByte; 4,000 boxes = 8,000 linear feet = 1,000 GigaBytes = 1 TeraByte

In general, when compressed, the digital files for document images scanned in office quality view-only-color (100 dpi) (no OCR possible) are about twice the size of document images scanned in a bi-tonal, black and white format, and then G4 compressed. In office quality color scanning, the scanned color differences aid users in reading a document and in increasing the quality of OCR (Optical Character Recognition) done at 150 dpi and higher resolutions. Office quality view-only-color scanning is generally at a lower resolution (100 dpi) than black and white scanning (300 dpi, required for bi-tonal OCR). Office quality grayscale-OCR-color (150 dpi) includes (has subsumed) the process of grayscale scanning which can increase OCR accuracy (at or above 150 dpi) when using low resolution scanning (lower than the 300 dpi generally required for bi-tonal OCR). Grayscale OCR is also called 3D OCR. (3 Dimensional OCR)

For the study of color (and color perception), see also CIE, the International Commission on Illumination (Commission Internationale de l'Eclairage) (Internationale Beleuchtungskommission) [<http://members.eunet.at/CIE>] See also SPIE, the International Society for (Photo) Optical Engineering, [<http://www.SPIE.org>]

(Office Color) (Includes Grayscale Scanning) Engineering Drawings / Aperture Cards

View-only-color (100 dpi, no OCR possible): 1 E size drawing (A0) (48 inches by 36 inches, with overscan) = 16 letter size pages (8 1/2 by 11 inches, A4) = 1,600 KiloBytes (1.6 MegaBytes) D size = 8 letter size pages; C size = 4 letter size pages; B size = 2 letter size pages; A size = 1 letter size page

Grayscale-OCR-color (150 dpi color, including a separate 300 dpi bi-tonal image): 1 E size drawing (48 inches by 36 inches) = 8 MegaBytes

Visually-unaltered-color (150 dpi color, including a separate 300 dpi bi-tonal image): 1 E size drawing (48 inches by 36 inches) = 32 MegaBytes

Raw-color (uncompressed) (grayscale only, 400 dpi): 1 E size drawing (48 inches by 36 inches) = 320 MegaBytes